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CSIR-NET LIFE SCIENCES

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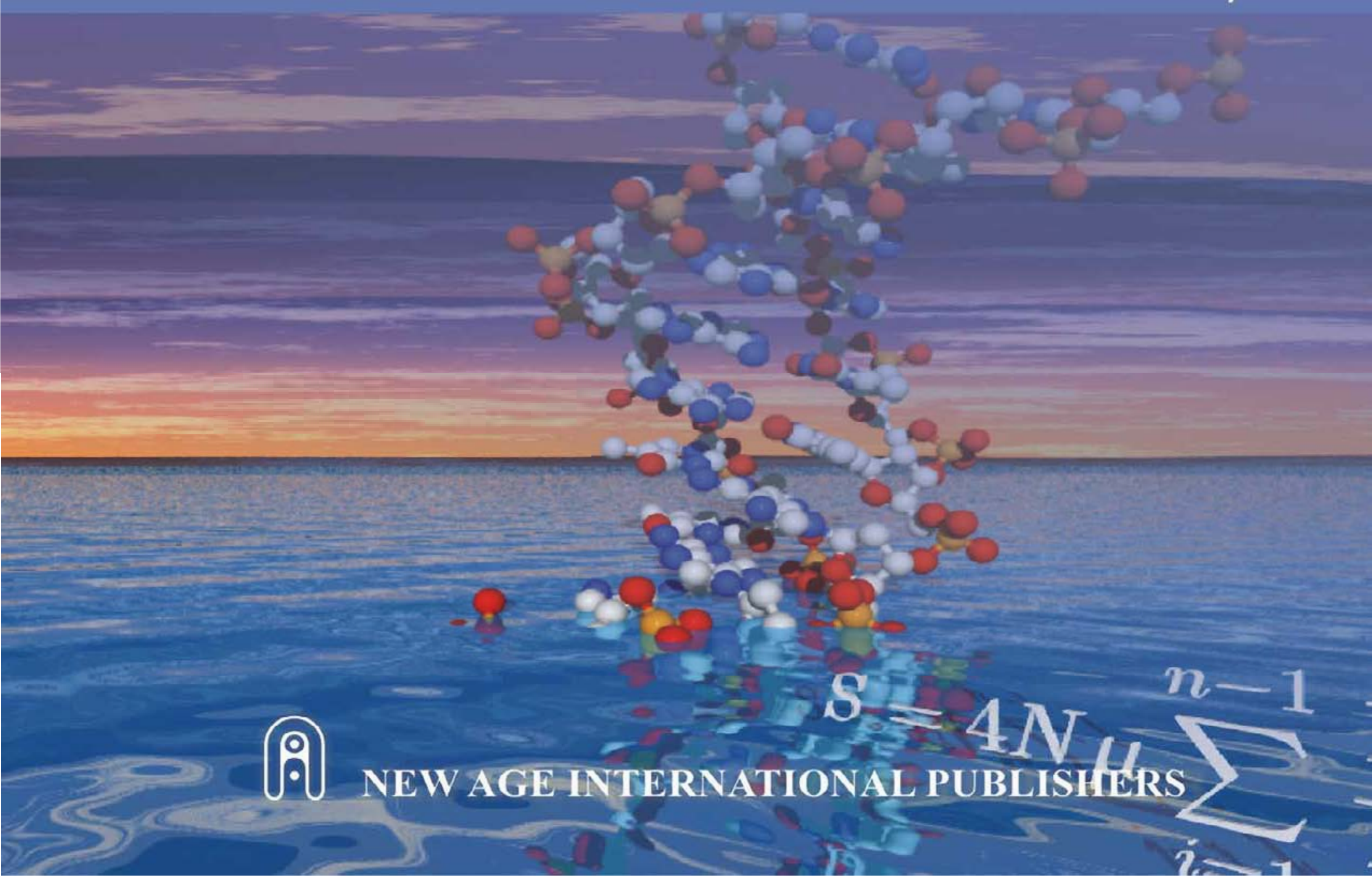

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Preface

It is a matter of immense pleasure in presenting the book, "CSIR-UGC-NET Life sciences" for CSIR-NET-SLET examinations. The present venture is an attempt to provide all available information in concise form for the students aspiring to prove their talent by their selection in CSIR-NET-SLET in the subject of Life sciences.We have tried to provide subject matter in detail as well as questions which appeared in few last examinations of NET and SLET which are memory based. In addition each unit is supplemented with two practice papers each with hundred model questions. On the basis of current practices in the CSIR-NET examinations, Ten model papers are also provided in the book.The special feature of the book is the inclusion of the various types of questions which are asked in the Section A of Paper I in Life sciences i.e. questions related to chemistry, physics, biology, geography, mathematics and computer sciences. We hope the students will find a difference from the all available books on the subject in the present book and it is the earnest request to all the aspirants to go through the subject matter as well as the questions included.

The present book will help in understanding of the subject as well as provide training to the aspirants.

Though every effort has been made to include all the available information, still inclusion of new subject matter and the suggestions for the improvement of the book are most welcomed and thankfylly acknowledged.

In the present endeavour the help rendered by different subject experts particularly of Prof. Y. D. Tyagi, Prof. N. C. Aery, Dr. S. S. Katewa, Dr. S. D. Purohit, Dr. K. C. Sonie, Dr. N. S. Shekhawat(Jodhpur) has given us all sorts of encouragement in the completion of the book. We express deep sense of gratitude to all the experts.

Publishers of the book NEW AGE INTERNATIONAL(P) LIMITED, PUBLISHERS deserves special thanks for their whole hearted cooperation in bringing this book in time.

Prof. B. L. Chaudhary
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Contents

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Cell Biology

Cell Biology: Structure and function of cells and intracellular organelles (of both prokaryotes and eukaryotes): mechanism of cell division including (mitosis and meiosis) and cell differentiation: Cell-cell interaction; Malignant growth; Immune response: Dosage compensation and mechanism of sex determination.

GENERAL INTRODUCTION

1. **Resolving Power**: Ability to distinguish two close points as two separate points by any optical system is called as its resolving power. The resolving power of human eye is 100 micron. Mathematically, resolving power = $\lambda 2$ where λ is the source of illumination. Resolving power of compound microscope & electron microscope is 0.3 microns & 10 Å respectively.
2. **Zacharis Janssens** combined lenses in an effort to improve magnifying efficiency and resolving power. He produced the first compound microscope which combines two lenses for greater magnification.
3. **About Cell Concept :**
   (*a*) **Marcello Malpighi** (1628-1694), an Italian microscopist, studied the structure of plants. He believed that the plants are composed of separate structural units which he called "**utricles**".
   (*b*) **Robert Hooke** (1635-1703), examined thin slices of cork (dead outer bark of an oak) under his microscope. He saw hundreds of very small hexagonal 'boxes' or 'chambers' which are together appeared like a 'honeycomb'. **The term 'cell' was coined by Robert Hooke** to denote these chambers. His observations, alongwith the figures, were published in 1665 in *Micrographia*.
   (*c*) **Anton von Leeuwenhoek**, 1674, using good quality simple lenses (magnifying upto 200 times) observed unicellular organisms and called them '*wild animalcules*'. In this way, he was the first to observe "living and moving individual" cells as compared to the "fixed" cells seen by earlier workers.
   (*d*) **H.J.Dutrochet** (1824), a French scientist, boiled some tissues and separated the cells from one another. He expressed the idea of individual cells i.e., cells

were not just spaces between a network of fibres, but that these were separate and separable units.

4. **Concept of Protoplasm** :

   Corti (1772) first of all observed that all cells contain a living substance. This was first observed by **Corti** (1772). **Felix Dujardin** (1836), observed it in living amoebae, and called it '*Sarcode*'. In 1839, **J.E. Purkinje** used the word '*protoplasm*' to describe the living substance. Hugo von Mohl (1846), also suggested the same name – protoplasm – for the similar substance found in plant cells.

5. **Robert Brown**, an English naturalist, described in 1828, characteristic dancing of cell particles. It is now, therefore, known as **Brownian movement**.

6. **Nucleus** : In 1831, **Robert Brown** saw that small spherical body was present in every plant cell. He used the word 'nucleus' to identify them.

7. **Cell Theory** : Two German biologists, **M.J. Schleiden** (1838) and **Theodor Schwann** (1839) proposed cell theory (or cell doctrine) – which unified the ideas prevailing at that time. He stated that –

   (*a*) living things are composed of cells and cell products.

   (*b*) cells are the fundamental structural units of living organisms.

   In fact, Schwann coined the word "**metabolism**" for all chemical processes carried on in the cell. Actually, he called cells "**the unit of life**".

8. **Rudolf Virchow** (1858), a German pathologist, developed the idea of generation to generation continuity of cell that *Omnis cellula e cellula* (i.e. cells arise from pre-existing cells). This occurs by the division of cell.

9. **Nucleolus**: In 1781, **Fontana** had seen dense spherical body inside nucleus. **Schleiden** (1838) also described it. But, it was given the name "nucleolus" by **Bowman** (1840).

10. **Nageli** and **Cramer** (1855) gave the name "cell membrane" to the outer boundary of the protoplasm. **Overton** (1899) proved its existence. **J.Q. Plowe** (1931), later on, called it 'plasmalemma'.

11. **Protoplasm Theory : Max Schultze** (1861) proposed the protoplasm theory. According to it "*cell is an accumulation of living substance (or protoplasm) which is limited by an outer membrane, and possesses a nucleus*".

12. **Plastids** : N. Pringsheim and J. Sachs (1865-1892) described coloured bodies in the cytoplasm which were called plastid by **Haeckel** in 1866.

13. **Schimper** (1883) classified plastids into three types – **Leucoplasts** (colourless), **Chloroplasts** (green) and **Chromoplasts** (colour other than green). The green plastids were also identified by **Meyer** (1883) who called them autoplasts. However, Errera gave the name *chloroplasts* to them.

14. **Mitochondria : Kollicker** (1880) was the first to observe small thread-like structures in the cytoplasm of the striated muscle cells of insect. These were called '*fila*' by **Flemming** (1882). **Altmann** (1890) described them as "bioplasts". It was **Benda** (1897) who coined the term *mitochondria*.

15. **Centrosome : Boveri** (1888) used the word "centrosome" for a body found at one pole of the cell near the nucleus in animal cells. Most of the plant cells were found to be lacking it.

16. **Golgi apparatus : Camello Golgi** (1898), an Italian scientist, discovered in the cytoplasm of nerve cells of owl/cat, a complex structure which he called '**Internal reticular apparatus**'.
17. Protoplasm is a polyphasic crystallo-colloidal solution. **Various theories about the nature of protoplasm are:**
    (*a*) *Alveolar* theory of **Butschli**;
    (*b*) *Fibrillar* theory of **Velton**;
    (*c*) *Granular* theory of **Altman**;
    (*d*) *Colloidal* theory of **Fischer**;
    (*e*) *Reticular* theory of **Fromann**, and
    (*f*) *sol* $\rightleftharpoons$ gel theory of **Hyman**.

    But colloidal theory of Fischer is best. Conversion of sol into gel and vice versa is due to colloidal nature of cytoplasm.
18. Cyclosis of cytoplasm in eukaryotic cells is due to sol $\rightleftharpoons$ gel conversion and microfilament activities.
19. In *Paramoecium*, cyclosis moves food vacuoles in '8' like manner.
20. Cytoplasm coagulates at temperature above 60°.
21. Amount of water in cell is usually not more than 3 quarters, i.e. 75%.
22. pH of cytoplasm, nucleoplasm and human blood is 6.9 ± 0.2, 7.4 ± 0.2 and 7.34 ± 0.2 respectively.
23. Proteins and enzymes in the cytoplasm are found in colloidal form. This increases their surface area. Vitamins, amino acids, minerals, sugars and nucleic acids are found in solution form.
24. Cell coat (**Glycocalyx** or extraneous coat) is made up of oligosaccharides which act as recognition-centre during organ transplantation.
25. **Swammerdam** was first to describe (RBC of frog). **Dutrochet** (1824) gave the idea of individuality of cells.

    Term cell (L. *cella* = hollow space) coined by **Hooke** (1665) is misnomer as cell is not a hollow structure. It has cytoplasm and contains organelles, inclusions and nucleus. **Leeuwenhoek** (1672) was first to see a free cell under microscope and called them tiny animalcules. **Malphigi** (1661) called cells as **saccules** (utricles).
26. **Contribution of scientists in the field of tissue culture**
    (*a*) **Haberlandt** (1902) suggested the idea of tissue culture.
    (*b*) **Steward** et al (1957) provided first evidence of cellular totipotency by growing mature problem tissue of carrot roots in a medium supplemented with coconut milk.
    (*c*) Tissue culture was raised by **White** (1932) when he grew tomato roots on artificial medium.
    (*d*) ***Callus*** by **White, Gauthret** and **Nobecourt**.
    (*e*) **Differentiation of Callus** into tissues by **Skoog and Miller**.
    (*f*) ***Single cell culture*** (cellular totipotency) by **Steward** (1957).
    (*g*) **Nurse technique** to get callus from a single cell by **Muir et al** (1958).
    (*h*) ***Microchamber technique*** for single cell culture by **Vasil & Hilderbrandt** (1965).

(*i*) ***Embryoid*** (non zygotic embryo) culture by **Steward et al** (1963), **Halperin & Wetherell** (1964).
(*j*) ***Embryo culture*** by **Laibach** (1928).
(*k*) ***Pollen/Haploid androgenic culture*** from anthers of Dature by **Guha & Maheshwari** (1966).

27. Unicellular eukaryote is 1-1000 mμ in size.
28. Ostrich egg (Largest cell) is 15-20 × 13.5-15 cm in size.
29. Human nerve cell (Longest animal cell) is 90 cm.
30. Largest acellular plant *Acetabularia* is 10 cm long.
31. Viruses do not have a cellular structure. Ostrich egg is not considered as true cell as it stores a large amount of reserve food.
32. In human beings, cells of **kidney are smallest** and of nerve fibre longest.
33. **Smallest cell** (*Mycoplasma gallisepticum* – PPLO) is 0.1 to 0.3 to mμ in size.

CELL MEMBRANE

1. All cells are enclosed by a thin, film-like membrane called the **plasma membrane** or **plasmalemma**.
2. **Danielli and Davson** (1935) proposed a "**Trilamellar model**". According to this, the plasma membrane is formed of a bimolecular layer of phospholipids (35 Å thick) sandwitched between two layers of proteins (each 20 Å thick). Thus, the total thickness of plasma membrane, as per their model, should be 20 Å + 35 Å + 20 Å = 75 Å (i.e., about 75 Å).

   The model was proposed even before the plasma membrane was seen under the electron microscope.
3. **J.D. Robertson** (1959) proposed a "**unit membrane concept**". According to this, all biological membranes shared the same basic structure :
   (*a*) These are about 75 Å thick.
   (*b*) These have a characteristics trilaminar appearance when viewed with electron microscope.
   (*c*) The three layers are a result of the same arrangement of proteins and lipids as proposed by Danielli and Davson.
4. **Singer and Nicolson** (1972) put forward the "**fluid mosaic model**" of membrane structure. It is the latest and most widely accepted model. According to this model, the cell membrane consists of a highly viscous fluid matrix of two layers of phospholipids molecules. These serve as a relatively impermeable barrier to the passage of most water soluble molecules. Protein molecules on their complexes occur in the membrane, but not in continuous layer; instead, these occur as separate particles asymmetrically arranged in a mosaic pattern. Some of these (peripheral or **extrinsic proteins**) are loosely bound at the polar surfaces of lipid layers. Others (called integral or **intrinsic proteins**), penetrate deeply into the lipid layer. Some of the integral proteins penetrate through the phospholipids layers and project on both the surfaces. These are called **Trans membranes or tunnel proteins**.
5. The plasma membrane contains lipids (32%), proteins (42%), carbohydrates (6%) and water (20%) although variations are always there.

6. The carbohydrates occur only at the outer surface of the membrane. Their molecules are covalently linked to (*i*) the polar heads of some lipid molecules (forming **glycolipids**) and (*ii*) most of the proteins exposed at outer surface (forming **glycoproteins**). The carbohydrates so bound to membrane components constitute the **glycocalyx** of cell surface.
7. **The sugar portions of glycolipids and glycoproteins are involved in recognition mechanisms:-**
   (*a*) Sugar recognition sites of two neighbouring cells may bind each other causing cell-to-cell adhesion. This enables cells to orient themselves and to form tissues.
   (*b*) Through glycoproteins, bacteria recognise each other (female bacteria are recognized by male bacteria; *Paramoecia* of different mating types recognize each other).
   (*c*) These provide the basic of immune response and various control systems, where glycoproteins act as antigens.
8. Lipids and integral proteins are **amphipathic** in nature (i.e. have both hydrophobic and hydrophilic groups). The hydrophobic ends are situated inside the bilayer while the hydrophilic groups are directed outwards. Thus, the membrane is held together primarily by hydrophobic attraction.

   However, the lipids have links in their fatty acid tails. These links prevent close packing of molecules and make the membrane structure more fluid. The fluidity increases with decreasing length of fatty acid tails.
9. Thousand of different types of proteins can occur in cell membranes. These may be purely structural (provide elasticity and mechanical support) or have additional functions as :
   (*a*) Carriers, for transporting specific molecules into or out of the cell.
   (*b*) Receptors, for immediate flow of information into the cells.
10. Gases like O_2 and CO_2 diffuse rapidly in solution through membranes.
11. Ions and small polar molecules diffuse slowly through the membranes. Unchanged and fat soluble molecules pass through membranes much more rapidly.
12. **Endocytosis** occurs by an infolding or extension of plasma membrane to form a vacuole or a vesicle (small vacuole). It is of two types :
    (*a*) **Phagocytosis** (i.e. cell eating): Material is taken up in solid form. The cells involved in phagocytosis are called **phagocytes** or **phagocytic** cells (e.g. white blood cells). The vesicle/vacuole formed is called **phagocytic vacuole**.
    (*b*) **Pinocytosis** (i.e. cell drinking): Material is taken up in liquid (solution/colloid/ suspension) form. If the vesicle formed is extremely small, the process is known as **micropinocytosis** and the vesicle is **micropinocytotic**.
13. **Exocytosis** or reverse of endocytosis by which materials are removed from the cells including reverse pinocytosis.
14. **Membrane Channels**: They are of two type's aqueous channels for the passage of water and ion channels for the passage of ions. Nehar and Sakmann got Noble prize for discovery of single ion channels.
15. **Pseudopodial Movement**: Pseudopodia are blunt outgrowths which are formed by three developments. Sol-gel changes, cytoplasmic streaming and extension of plasma membrance e.g., *Amoeba, Macrophages*, WBC, etc.

17. **Undulation**: They are small protrusions, projections or ruffings of the membrane which pass out like a regular wave in the area of contact with a solid substratum.

STRUCTURAL ORGANISATION OF A CELL

1. Smaller cells with smaller volume have more surface area. **Surface: volume ratio decreases with increasing size of cell**. Larger cells increase their surface area by developing a cylindrical shape or by forming numerous extensions of the cell membrane like microvilli, ER, etc.
2. Smaller cells have more surfaces: volume ratio and higher nucleo-cytoplasmic ratio hence are more active.
3. Position, cell wall, age, viscosity of cytoplasm, skeleton and function of the cell, control the shape of cell, e.g., RBC is biconcave to increase surface area. Nerve cells are large as they are able to conduct impulses.
4. Cells regulate their activities by flow of energy and flow of extrinsic and intrinsic (genetic) information.
5. Green cells trap radiant solar energy and convert it into chemical (potential) energy like ATP which on oxidation of food is converted into kinetic energy for doing work.
6. **Schwann** (1839) recognized that animal and plant cells are alike except that animal cells lack cell wall. Schleiden stated that cell is the unit of structure and budded off from nucleus. **Rudolf virchow** (1855) was first to modify cell theory and gave generalization- "*Omnis cellula e cellula*". Viruses are exception to cell theory. The specialized cells lose some of their autonomous activities, e.g., muscle and nerve cells do not divide and RBCs do not respire.
7. Cells show 3 types of organization:
   (*a*) **Prokaryotic cells** e.g., Bacteria, cyanobacteria, archaebacteria, mycoplasma (PPLO), rickettsiae. Size 0.1 to 5 µ; DNA : RNA ratio 1 : 2, r-RNA-65%, A + T / G + C ratio = 0.88; only one envelope system; membrane bound organelles absent; histone, nuclear membrane, nucleolus, cyclosis meiosis absent.
   (*b*) **Eukaryotic cell**. Size 3 to 30 µ, DNA : RNA is 1:1, rRNA = 45%, A + T / G + C ratio = 1.52; two envelop system, membrane bound organelles; histone and true nucleus present.
   (*c*) **Mesokaryotic cell** e.g., Dinoflagellates (a type of algae) – histone protein absent but nucleus present.
8. Cell organelles (organoids) are of four types on the basis of membranes.
   (*i*) **Organelle bounded by single unit membrane**. e.g., Microbodies (peroxisomes, sphaerosomes, glyoxysomes, lysosomes), ER, golgi bodies.
   (*ii*) **Organelle bounded by double membrane** e.g., Plastids, mitochondria and nucleus.
   (*iii*) **Organelle bounded by triple membrane** e.g. Transosomes.
   (*iv*) **Organelle without any membrane** e.g., Ribosomes, centriole, nucleolus.
9. Protoplasm of eukaryotic cells shows of streaming movements known as **cyclosis** : It is of two types.
   (*i*) **Rotation** (cytoplasm moves around a vacuole in one direction) e.g., *Hydrilla* leaf cells.

(*ii*) **Circulation** (movement in different direction around different vacuoles e.g., staminal hairs of Tradescantia (Rhoeo discolor). These movements are due to colloidal nature of cytoplasm and microfilament activities.

10. **Ribosomes** :

(*a*) Ribosomes were first discovered by **Palade** in animal cell and called them as **microsomes**. **Robinson and Brown** discovered them first in plant cell. **Claude** (1955) called these structures as **ribosomes**.

(*b*) Proteins synthesized on free ribosome are used within cell. Proteins synthesized on bound ribosomes are used outside the cell or incorporated into membrane or go out as secretory (export) protein.

(*c*) They are smallest, membraneless organelle and are called **ribo-nucleoprotein or Palade particles**. These are **negatively charged** and contained rRNA and protein and were seen only after the discovery of electron microscope. Their size is 150 to 250 A. These act as site of protein synthesis. A ribosome may be 70 S or 80 S. (S=sedimentation coefficient) and consists of a smaller and larger sub unit. 70 S are found in both prokaryotic and eukaryotic cells & lie freely in cytoplasm as in prokaryotes. 80 S ribosomes are either attached to endoplasmic reticulum or nuclear membrane or lie freely in cytoplasm. **Ergasomes** or **polyribosomes (Rich**. 1963) are formed by the combination of 5 to 6 ribosomes on a single mRNA. A 70 S ribosome has three molecules of rRNA (16 S, 5 S, 23 S) and 53 protein molecules and 80 S ribosome has 3 molecules of rRNA (18 S, 5 S, and 28 S) and 80 molecules of protein.

11. **Endoplasmic reticulum** (Ergastoplasm) : It was reported by **Porter, Claude** and **Fullman** (1945). It was named as endoplasmic reticulum by Porter (1953). In muscles, it is called **sarcoplasmic reticulum**, in eyes called **myeloid bodies** and in nerves as **Nissle granules**. ER forms intracellular transport system and provides mechanical support to cytoplasm. **GERL** (Golgi associated with ER from which lysosomes arise) system is formed by ER and golgi bodies and form lysosomes. ER is of two types – Smooth endoplasmic reticulum (SER) and Rough endoplasmic reticulum (RER). RER arises from **nuclear membrane**. RER is mainly **cisternal** and studded with ribosomes. SER consists of tubules mainly. It constitutues more than half of the total cell membranes in a cell. SER helps to synthesize lipids and helps in detoxification.

12. **Plastids**: They are double walled DNA containing **largest organelle** in plant cells, discovered by **Haeckel** (1865). These are developed from colourless proplastids found in meristems. Three types of plastids are (*i*) **Leucoplast**s: Largest, colourless, found in unexposed parts and store starch **(amyloplast), fat (claioplast)** or Protein **(aleuronplast**). (*ii*) **Chromoplasts**: Second largest plastids, have carontenoids to provide attractive colour to fruits, seeds, flowers. (*iii*) **Chloroplasts**: Green plastids discovered by **Sach**s (1862) but named **Chloroplast** by **Schimper** (1885) store starch temporarily; shape variable, maximum variation in shape is found in green algae. Shape is planoconvex or discoid; each chloroplast has two membranes. Its matrix (stroma) has prokaryotic naked circular DNA (0.5%), RNA, vitamin E and K, plastoglobules (osmiophillic globules), starch particles; 70 S ribosomes, minerals (Fe, Mg, Cu, Mn, Zn, Co) and enzymes of dark reaction of photosynthesis. 50% of matrix is filled with **Rubisco enzyme**. In matrix are found double membrane bounded tubular sacs called **thylakoids (structural unit of chloroplast)** which are stacked to form grana; number of grana per chloroplast is 40-100 and each granum has 2-100 stacked

thylakoids. Inner membrane of thylakoid bears **quantasomes** (functional unit of chloroplast, discovered by **Park and Biggins** (1962), size 180 × 150 × 100 Å, called **photosynthetic units** (PSU) where primary act of photosynthesis (i.e. release of e^-) occurs. A quantasome has 230 chlorophyll molecules (160 chl a + 70 chl b) and about 50 carotenoid molecules. One of the molecules of Chl a acts as **reaction (trap) centre**. It is P_{700} in PS I and P_{680} in PS II. Two grana are joined by **Frets channel** (stroma lamella). Chloroplasts and mitochondria are energy transducing. DNA containing, semiautonomous, double walled organelles and called cell within cell because they have their own protein machinery and show cytoplasmic inheritance. No life is possible on this earth without chloroplast.

13. Chl a is $C_{55}H_{72}O_5N_4Mg$ – blue green and has – CH_3 group.
14. Chl b is $C_{55}H_{70}O_6N_4Mg$ – greenish colour and has – CHO group.
15. Pyrenoid is a proteinaceous body around which starch is stored in green algae.
16. Chloroplasts are extremely fragile osmotically and burst in H_2O and hence, chloroplasts are isolated from green leaves using sugar solution.
17. **Golgi bodies**: Also called as (Lipochondria, Idiosome or Dalton complex):

    They are **middle man of cell** and discovered by **Camello Golgi** (1898) in cytoplasm of nerve cell of owl and cat by **silver metallic impregnation technique**. They form internal reticular apparatus (*apparato recticulare interno*) and take **black stain with Sudan III** being rich in lipids. **Dalton and Felix** (1954) observed them under TEM and confirmed their existence. In plants, golgi bodies are unconnected and scattered called **dictyosomes**. **In fungi, a dictyosome is unicisternal**. In vertebrates these are found near the nucleus. A dictyosome has a stack of usually 3-12 cisternae with swollen ends, tubules and vesicles. It shows polarity. **Concave or maturing (M) face** or **trans face** is near cell membrane and **cis** or **convex** or **forming (F) face** is towards nuclear membrane. Lysosomes and secretory vesicle arise from 'M' face. New cisternae are formed from SER.

    Root cap cells are rich in golgi bodies which secrete mucilage for lubrication of root tip. They process package and help in transport and release of secretory proteins. They also cause **glycosidation** of lipids and **glycosylation** of proteins to form glycolipids and glycoproteins. Golgi body forms acrosome in sperm, yolk and cortical granules in eggs, secretion of insulin, lactoprotein in mammary glands, cellulose, hemicellulose, mucilage, pectin, cell plate during cell division, root hairs etc. They regulate fluid balance of cell. All secretory cells are rich in golgi bodies. **Main enzyme in golgi bodies is nucleoside disphosphatase**. These bodies arise from SER mainly.

18. **Mitochondria**: They are also called as **chondriosome, sarcosome, bioplast, plastochondria**:

They are power house of cell, **largest organelle** in animal cell and **2nd largest organelle** in plant cell. These are double walled, DNA containing, self replicating, semiautonomous, organelle found only in eukaryotic aerobic cells (except mature RBC), first observed in insect striated muscles as granular structure by Kolliker (1850). He called these granules of striated muscles as sarcosomes. **Altman** (1890) studied them in detail and called them as **bioplasts**. He considered them as symbionts comparable to bacteria. **Flemming** called them file and term '**mitochondria**' was used by **Benda** (1897) who stained them with **Janus green B** (a vital stain); size 1 = 10µ × 0.2 – 1 µ; Number 1 per cell in *Microsterias and Trypanosoma*; 50,000 in Choas chaos and 30,000 to 3 lakhs in oocytes of sea urchin.

A mitochondrion has two chambers and two membranes. Inner membrane is folded to form **cristae** which bear oxysomes (F_0-F_1 particles, elementary particles, ATPase particles. (Fernandez and Moran particles). **Oxysomes** are 10^4 to 10^5 in number, called functional unit of mitochondria, discovered by **Fernandez-Moran (1961).**

Inner chamber has a double stranded, naked circular 5 µ long prokaryotic DNA with high G-C ratio, 70S ribosomes, RNA and 70 types of enzymes. 70% of total enzymes of cell are found in mitochondria. This DNA is 1% of total DNA of cell and discovered by Nass (1966). Kreb's cycle and oxidative phosphorylation occur here. Mitochondria are called cell **within cell**.

19. **Microbodies** : These are (lysosomes, sphaerosomes, glyoxysomes and peroxisomes): They are smallest single membrane bounded organelle. **Lysosomes** (suicidal bags, disposal units, scavenger of cell) are microbodies of 0.2-0.8 µ size filled with 40 types of acid hydrolases to digest (autolysis) almost every type of organic matter except cellulose. They are common in WBC, liver, spleen etc. They work at pH-5 and cause lysis of foreign body; discovered accidently by **Christian de Duve (1955)** from rat liver. **Novikoff (1956)** observed them under TEM. They show **pleomorphism (polymorphism**).

They are of four types: (*i*) **Primary lysosomes (Storage granules)** have inactive enzymes; (*ii*) **Secondary lysosomes (Heterophagosomes or Digestive vacuoles or Phagolysosomes)** cause digestion **(Heterophagy)**; (*iii*) **Tertiary lysosomes (Residual bodies or Telolysosomes)** removes wastes by ephagy from cell by acting as scavenger or disposal unit; (*iv*) **Autophagic vacuoles (Cytolysosome or Autophagosomes)** are complex lysosomes and digest old / injured / dead cells and tissues to keep cell healthy (autolysis or autodigestion). Scavenging, disappearance of tail, softening of gums, acrosomal activity of sperm are few other examples. **Autophagy** is digestion of stored food (glycogens, fat and proteins) during starvation to provide energy. Thus autophagy has no role in scavenging. If lysosomes burst and release their enzymes, the entire cell is digested and liquefied. It is called autolysis. Osteoclasts (which digest bones) are rich in lysosomes; **Plant cells lack lysosomes except Neurospora, root tip of maize, yeast and seeds of pea and cotton**. Lack of Lysosome cause Pombe's Disease. They are also involved with diseases such as Tay-Sachs Syndrome and Rheumatic Arthritis (An Autoimmune disease).

Types of Microbodies

(*a*) **Sogaerisines** (Plant lysosomes) are micro bodies filled with hydrolytic enzymes for fat synthesis. They are highly refractile and rich in fat (98%) and take black stain with Sudan iii / Osmium tetraoxide. These are abundant in endosperm of oily seeds.

(*b*) **Transosomes** are triple **layer** bounded organelle in ovary follicle cells of birds to help in yolk formation.

(*c*) **Lomasomes** are boder bodies between cell wall and cell membrane, common in fungi, discovered by **Moore and Mc Allister** (1961) and help in cell proliferation and elongation for diffusion of substances required in cell wall formation.

(*d*) **Peroxisomes** (uricosomes) are microbodies containing enzymes for peroxide formation. **Catalase and peroxidase are largest and smallest enzymes** found in peroxisomes. In plants they do photo-respiration in C_3 plants (**Tolbert**, 1972). In animals they take part in lipid synthesis (β-oxidation of fatty acids).

(*e*) **Glyoxysomes-** Largest microbody of size upto 10 μ and similar to peroxisomes as these contain catalase and other enzymes for glyoxylate cycle (a modified Krebs' cycle in which fats are converted into carbohydrates). These are common in germinating oil seeds of castor, groundnut and cucumbers and disappear after germination.

20. **Centrioles**: They are minute submicroscopic subcylindrical structures of 300-500 nm length and 150 nm diameter and usually occur in pairs (diplosome) inside a specialized fibrous cytoplasm called centrosphere. The complex is called **centrosome** or **central apparatus**. Each centriole has a whorl of nine triplet fibrils with interconnections amongst adjacent triplets (called C-A linkers) as well as with a central hub through spokes. Thus show 9 ÷ 0 organisation. Centrioles are surrounded by **massules** or nucleating centre or pericentriolar satellites for formation of new centrioles. Centrioles are required to form basal bodies, cilia, flagella and spindle poles. They occur in most animal cells except some protozoan protests like *Amoeba*, common in flagellate forms (e.g., many green algae, bryophytes, pteridophytes and cycads). Centriole is rich in **tubulin, ATP**. Centrioles are basically locomotory structures and their role in cell division to form spindle is secondary.

    Basal bodies or basal granules or blepharoplasts are microcylinders that lie below the plasmalemma at the base of flagella and cilia. The structure is exactly similar to centriole.

21. **Cilia and flagella**: They are microtubular vibratile propoplasmic processes studied by **Engleman** and have four parts: basal body, rootlets, basal plate and shaft. Shaft contains of an external membrane (extension of plasmalemma), a semifluid matrix and an **axoneme**. Axoneme has nine peripheral doublet fibrils and two central singlet fibrils. Thus show 9 + 2 fibrillar organization. All the peripheral doublet fibrils are interconnected by C-A linkers of protein **nexin**. Subfibre A of each doublet has two bent arms, the outer one with a hook. The central fibrils and side arms of subfibre A are made of **dyenin** protein with ATP-ase activity. Cilia are shorter (5-10 μm as compared to 150 μm for flagella), more numerous, have sweeping or pendular movement and beat in a coordinated rhythmic movement.

22. **Vacuoles**: Vacuoles in plants were reported by **Spallanzani**. They are noncytoplasmic fluid filled, lifeless sacs which are separated from cytoplasm by a membrane called **tonoplast**.

    (*a*) **Sap vacuoles**: They enclose sap or water with dissolved inorganic and organic substances. A mature plant cell has a single large central vacuole. Animal cells have numerous small sap vacuoles that maintain osmotic pressure. Cell sap is slightly acidic and contains acids, esters, phenols, organic acids (acetic and formic acids), enzymes, tannin crystals and pigments etc.

    (*b*) **Contractile vacuoles**: They occur in some simple fresh water forms (e.g., *Amoeba, Paramecium, Chlamydomonas*). They pick up water from surrounding cytoplasm, expand (diastole) and collapse (systole) to throw water outside. Contractile vacuoles perform osmoregulation and excretion.

(*c*) **Gas vacuoles (= pseudovacuoles)**: Gas or air vacuoles occur in some prokaryotes. Gas vacuoles store metabolic gases and take part in buoyancy regulation.

23. **Nucleus**: A cell may be uni or multinucleated. If a multinucleated condition arises due to fusion of cells, it is called **syncytium** e.g., *plasmodium*, body of slime moulds, young xylem vessels and if due to repeated nuclear divisions without cytokinesis, it is called **coenocytic** e.g. *Vaucheria, Rhizopus*. Nucleus was reported by **Robert Brown** (1831) in orchid cells. **Strasburger** (1882) proved that nucleus arises from pre existing nucleus by division. **Hertwig** and **van Beneden** showed the role of nucleus in fertilization. **Hammerling** (1953) by his grafting experiments on *Acetabularia* (largest unicellular green, marine alga) proved the role of nucleus in heredity, growth and morphology. $1/10^{th}$ of volume of cell is occupied by nucleus. In a cell, there is a definite nucleo-cytoplasmic ratio. Nucleocytoplasmic index is Volume of nucleus/ (Volume of cell – Volume of nucleus).

About 10% of nuclear membrane bears simple of compound pores. Nucleus has 80% proteins (65% **non histone**, Mol. Wt. high, rich in **tyrosine** and **tryptophan**, acidic and forms enzymes and helps in RNA transaction. 15% proteins are basic, **histone** proteins, Mol. Wt. low, rich in **lysine** and **arginine**. DNA : histone ratio 1 : 1. **Nucleosomes** are structural units of chromatin. Term was given by **Outdet**. A nucleosome is an **octamer of histone** proteins and has a core of 8 molecules of histone proteins (two each of H_2A, H_2B, H_3, H_4) bounded by 13/4 turns of DNA having about 166 base pairs. H_1 histone does not form nucleosome. Size of a chromosome varies from 0.5 to 32 µ. Minimum number of chromosomes n = 2 e.g., *Haplopappus*. Maximum number is 2n = 1262 in Adder's fern (*Ophioglossuin*). In animals, minimum number is 2n = 2 in *Ascaris* sp. And maximum number is 2n = 1600 in *Aulacantha* and Radiolarians.

24. **Giant Chromosomes are**: (*i*) Salivary gland chromosomes (size 2000 μ_m) (*ii*) lampbrush chromosomes (size 5900 μ_m). Those chromosomes help in rapid synthesis of proteins.

25. **Nucleolus**: It is a site of ribosome synthesis. Nucleolus was discovered by **Fontana (1781)**, described by **Wagner** and numbed by **Bowman**. There is at least one nucleolus per haploid set of chromosomes in a cell.

26. **Cell inclusions**: Ergastic, deutoplasmic, paraplasmic bodies are non living, non cytoplasmic substances in vacuoles or cell wall or cytoplasm of eukaryotic cells also called metaplast or deutoplast and are of three types:

(*a*) **Reserve food materials**: It can be starch as in plant cells, glycogen as in animal cells and fungi, fat or aleurone grains (protein rich, found as outermost layer of cells or endosperms or cereal grains). An aleurone grain in made up of a large part called **crystalloid** and a small part called **globoid**. Crystalloid contains nitrogen as amides. Starch is found as grains; simple or compound, concentric or acentric.

(*b*) **Excretory products**: These are waste (end) products and useless to plant. They get accumulated in bark, old leaves, vacuoles and flowers e.g., alkaloids (Quinine, Atropine, Canada Balsam: a mounting agent from *Abies* stem), gums, organic acids, cow milk, latex from Cow tree (*Brosimum*) and mineral crystals.

Mineral crystals are:

(*i*) $CaCO_3$ crystals occurring as a mass of crystals in a cellulose wall to form bunch of grapes called **cystolith**, e.g., banyan leaf cell. In *Momordica*, cystolith is double and in Justicia it is worm like.

(*ii*) Crystals of calcium oxalate are very common and called **raphides** (needles like e.g., *Lemna, Pistia*), star like (**sphaeraphides or druse** e.g. *Colocasia, Nerium*), prism like in onion scales or crystal sand in Atropa. A cell with raphides is called **idioblast**.

(*iii*) Silica on margin of leaves of grasses.

(*c*) **Secretory products**: They are useful to plants e.g., pigments, nectar, essential oil, enzymes etc. Essential oils are ethereal oils and used in perfumery.

27. **Cytoskeltal structures**: These are fibrous or fine tubular structures which form the supportive structures of the cell. These are of three types – microtubules, microfilaments and Intermediate filaments

(*a*) **Microtubules discovered by Robertis and Franchi, (1953)** term coined by **Slautterback (1963)**, are unbranched hollow non contractile tubules of indefinite length, 25 nm in thickness with 15 nm core and formed of 13 helically arranged **protofilaments** of α and β-tubilin protein. Microtubules grow from nucleating centres. Microtubules are basic structures of spindle apparatus, centrioles, basal bodies, cilia and flagella and are responsible for cell motility and maintenance of shape. Their tips can grow and shorten quickly. GTP, Ca2+, Mg2+ and a calmodulin bound protein are required for assembly. Colchicine prevents it. Microtubules are basic structures of spindle apparatus, centrioles, basal bodies, cilia and flagella. They are also present in other cellular structures like sensory hair, nerve processes, sperm tail, etc. Microtubules present in cytoplasm provide shape and polarity to cells. Microtubules are absent in procaryotes *(except Anabaena),Amoeba* and Slime Moulds.

(*b*) **Microfilaments** are cylindrical solid, contractile rods or filaments of actin and myosin protein with a diameter of 6 to 10 nm. Microfilaments can form hexagonal bundles, take part in cytoplasmic streaming, membrane undulations, cleavage, contraction of muscles, movement of microvilli to absorb food and endocytosis.

(*c*) **Intermediate Filaments** are intermediate in size having diameter around 10-15 nm and are composed of non-contractile proteins. Intermediate fibres (IF) are of four types–keratin filaments, neurofibrils, glial filaments and heterogeneous filaments *(viz.*, desmin filaments, vimentin filaments, synemin filaments).They privide rigidity to cell and maintains the cell structure

CELL CYCLE

I. Interphase and the Control of Cell Division

1. Interphase is the period between divisions of the cytoplasm. A typical eukaryotic cell will spend most of its life in interphase. Some cells lose the capacity to divide altogether and stay in interphase indefinitely. Examples of such cells in humans are nerve cells and muscle cells. Other cells divide regularly, others occasionally.
2. Most cells have two major phases: mitosis and interphase often referred to as the *cell cycle*.

3. For most tissues at any given time, only a few cells are in mitosis, and most are in interphase.
4. Interphase consists of three sub-phases.
   - G1 is Gap 1, the period just after mitosis and before the beginning of DNA synthesis.
   - Next is S (synthesis), which is the time when the cell's DNA is replicated.
   - G2 is the time after S and prior to mitosis.
5. Mitosis and cytokinesis are referred to as M phase.
6. The G1-to-S transition commits the cell to enter another cell cycle.

II. Cyclins and other proteins signal events in the cell cycle

1. Transitions from G1 to S and G2 to M depend on activation of a protein called cyclin-dependent kinase, or Cdk.
2. A kinase is an enzyme that transfers a phosphate from ATP to different protein(s). This is called phosphorylation.
3. Activated Cdk transfers phosphates from ATP to certain amino acids of proteins that then move the cell in the direction of cycling.
4. The Cdk effect on the cell cycle is a common mechanism in eukaryotic cells.
   - Studies in sea urchin eggs uncovered a protein called the maturation promoting factor.
   - A mutant yeast that lacked Cdk was found, which stalled at the G1–S boundary.
   - These two proteins, one from sea urchins and the other from yeast, were similar in structure and function. Other Cdks have been found in other organisms, including humans.
5. Cyclin is a protein that interacts with Cdk. Cyclin binding of Cdk exposes the active site of the kinase.
6. The cyclin-Cdk complex acts as a protein kinase that triggers transition from G1 to S. The cyclin then breaks down and the Cdk becomes inactive. Several different cyclins exist, which, when bound to Cdk, phosphorylate different target proteins.
   - Cyclin D-Cdk4 acts during the middle of G1. This is the restriction point in G1, beyond which the rest of the cell cycle is inevitable.
   - Cyclin E-Cdk2 acts at the boundary of G1 to S to initiate DNA replication.
   - Cyclin A-Cdk2 acts during S and also stimulates DNA replication.
   - Cyclin B-Cdk1 acts at the G2-to-M boundary, initiating mitosis.
7. Cyclin-Cdk complexes act as checkpoints. When functioning properly, they allow or prevent the passage to the next cell cycle stage, depending on the extra- and intracellular conditions.
   - An example is the effect of p21 on the G1-to-S phase transition.
   - If DNA is damaged by UV radiation, p21 is synthesized (a protein of 21,000 daltons).
   - It binds to the two different types of G1 Cdk molecules, preventing their activation until damaged DNA is repaired. The p21 is then degraded, allowing the cell cycle to proceed.

8. Some targets for cyclin-Cdk complexes include proteins that condense chromosomes and others that cause fragmentation of the nuclear envelope.
9. Cyclin-Cdk defects have been found in some cancer cells.
   - A breast cancer with too much cyclin D has been found.
   - The protein p53, which inhibits activation of Cdk, is found defective in half of all human cancers.

III. Growth factors can stimulate cells to divide

1. Cyclin-Cdk complexes provide internal control for cell cycle decisions.
2. Cells in multicellular organisms must divide only when appropriate. They must respond to external signals, controls called growth factors.
3. Some cells respond to growth factors provided by other cells.
   - Platelets release platelet-derived growth factor, which diffuses to the surface of cells to stimulate wound healing.
   - Interleukins are released from one type of blood cell to stimulate division of another type resulting in body immune system defenses.
   - The cells of the kidney make erythropoietin, which stimulates bone marrow cells to divide and differentiate into red blood cells.
4. Cancer cells cycle inappropriately because they either make their own growth factors or no longer require them to start cycling.

IV. Regulation of the Cell Cycle

1. Cell cycle is driven by specific chemical signals in the cytoplasm.
2. M phase cells that are fused with any other phase cell, the latter cell will enter mitosis.
3. **Cell cycle control system** triggers and coordinates key events in the cell cycle.
4. Cell cycle **checkpoints** act as stop and go signals. Three major checkpoints found in $\mathbf{G_1}$**,** $\mathbf{G_2}$, and **M phases.**
   (*a*) G_1 is critical checkpoint. If cells make it past G1, the entire cell cycle is completed.
   (*b*) Non-dividing cells are in $\mathbf{G_0}$ **state**.
5. Fluctuations in cell cycle control molecules abundance and activity control cell cycle.
   - **Protein kinases** are activated by **cyclin** proteins.
   - Activity of protein kinase is correlated with concentration of specific cyclin (cyclin dependent kinase or "**Cdk**").
6. **MPF** (maturation promoting factor) was first Cdk described.
   - Cyclin level rises during interphase.
   - At G2, enough active MPF (cyclin + Cdk) is present to promote mitosis.
     - Numerous phosphorylation events that cause nuclear envelope to fragment and activate other enzymes.
   - Cyclin is broken down by proteolytic cleavage (MPF inactive) and Cdk is recycled.
   - Proteolysis also drives M-phase past anaphase by breaking down proteins that hold sister chromatids together.

7. **Internal and External Cues Regulate Cell Cycle Internal signal** delays start of anaphase (separation of chromosomes) until all kinetochores are attached to spindle fibers.
   - Anaphase promoting complex (APC) is kept in inactive state by proteins associated with kinetochores.
   - Signal ceases when all kinetochores are attached.
8. **Growth factors** are **external signals** that stimulate cells to divide.
   - Platelet derived growth factor (PDGF) is required for division of fibroblasts.
   - PDGF binds to tyrosine kinase receptors on surface of cells and triggers signal transduction pathway.
9. **Density dependent inhibition** describes phenomenon whereby cells stop growing after reaching a certain density. Growth is limited by availability of growth factor.
10. **Cancer Cells Have Escaped Cell Cycle Controls**
    - Cancer cells do not exhibit density dependent inhibition.
    - Cancer cells do not stop growing when growth factor is depleted.
    - Cancer cells stop at random points in cell cycle (not checkpoints).
    - Some cancer cell lines are **immortal** and can divide indefinitely given the right ingredients.e.g. HeLa cells.
    - p53 gene mutations in tumor suppressor genes (e.g. p53) result in cancer functional p53 aids cell in checkpoint control at G1 and G2

CELL REPRODUCTION & CELL DIVISION

I. Systems of Cell Reproduction

1. Four events occur before and during cell division.
   - A signal to reproduce must be received.
   - Replication of DNA and vital cell components must occur.
   - DNA must distribute to the new cells.
   - The cell membrane (and cell wall in some organisms) must separate the two new cells.

II. Prokaryotes divide by fission

1. Prokaryotic cells grow in size, replicate DNA, and divide into two new cells. This process is called *fission*.
2. *Escherichia coli* (a bacterium) simply divides as quickly as resources permit. At 37ºC, this is about once every 40 minutes. When resources are abundant, *E. coli* can divide every 20 minutes.
3. Prokaryotes generally have just one circular chromosome.
   - The *E. coli* chromosome is 1.6 mm in diameter, making the unfolded circle 100 times greater than the size of the cell. The molecule is packaged by folding in on itself with the aid of basic proteins that associate with the acidic DNA.
   - Circular chromosomes appear to be characteristic of all prokaryotes.

4. The prokaryotes have a site called *ori*, where DNA replication begins, and a site *ter*, where it ends.
   - *Ori* is short for origin of replication.
   - *Ter* is short for terminus of replication.
5. As DNA replicates, each of the two resulting DNA molecules attaches to the plasma membrane. As the bacterium grows, new plasma membrane is added between the attachment points, and the DNA molecules are moved apart.
6. Cytokinesis, which is cell partitioning, begins around 20 minutes after chromosome duplication is completed. A pinching of the plasma membrane to form a constricting ring separates the one cell into two, each with a complete chromosome.
   - A tubulin-like fiber is involved in the purse-string constriction.

III. Eukaryotic cells divide by mitosis or meiosis

1. All reproduction involves reproduction signals, DNA replication, segregation, and cytokinesis.
2. Unlike prokaryotes, eukaryotic cells do not constantly divide whenever environmental conditions are adequate, although unicellular eukaryotes do so more often than the cells of multicellular organisms.
   - Some differentiated cells of multicellular organisms rarely or never divide.
   - Signals to divide are related to the needs of the entire organism, not simply the opportunity created by resources.
3. Eukaryotes usually have many chromosomes. Eukaryotes have a nucleus, which must replicate and, with few exceptions, divide during cell division. Mitosis generates two cells with the same genetic information as the original cell.
4. Meiosis is a specialized cell division used for sexual reproduction. The genetic information of the chromosomes is shuffled, and the cells, called gametes, typically get one-half of the original DNA complement.

IV. Mitosis: Distributing Exact Copies of Genetic Information

1. A single nucleus gives rise to two genetically identical nuclei, one for each of the two new daughter cells.
2. Mitosis is a continuous event, but it is convenient to look at it as a series of steps.
   - When the cell enters S phase and DNA is replicated, the centrosome replicates to form two centrosomes. This event is controlled by cyclin E-Cdk2, whose concentration peaks at the G1-to-S transition. This is the key event initiating the direction of mitosis.
   - During G2-to-M transition, the two centrosomes separate from each other and move to opposite ends of the nuclear envelope. The orientation of the centrosomes determines the cell's plane of division.
   - In many organisms, each centrosome contains a pair of centrioles that have replicated during interphase. Centrosomes are regions where microtubules form. These microtubules will orchestrate the movement of chromosomes.

The spindle forms during prophase

3. In prophase, polar microtubules form between the two centrosomes and make up the developing spindle.
4. Each polar microtubule runs from one mitotic center to just beyond the middle of the spindle, where it overlaps and interacts with a microtubule from the other side. Initially, these microtubules are constantly forming and *depolymerizing* ("falling apart") during this period. Recall that microtubules grow by addition of tubulin dimers to the + end of the microtubule. When microtubules from one centrosome contact microtubules from the other, they become more stable.
5. The mitotic spindle serves as a "railroad track" along which chromosomes will move later in mitosis.

A prophase chromosome consists of two chromatids

6. During prophase, chromosomes compact and coil, becoming more dense. Prophase chromosomes consist of two chromatids, held together over much of their length. The region of tight binding between the chromatids, the centromere, is where the microtubules will associate with the chromatids.
7. Late in prophase, the kinetochores develop. The kinetochore is located in the region around the centromere and is the site where microtubules attach to the chromatids.

Chromosome movements are highly organized

8. The movement phases of chromosomes are designated pro-metaphase, metaphase, and anaphase.
9. During pro-metaphase, the nuclear lamina disintegrates and the nuclear envelope breaks into small vesicles permitting the fibers of the spindle to "invade" the nuclear region.
   - The spindle microtubules then associate with kinetochores.
   - These are called kinetochore microtubules.
   - The microtubules from one pole associate with the kinetochore of one of the members of a pair of chromatids. Microtubules from the other pole associate with the kinetochore of the other member.
   - Repulsive forces from the poles push chromosomes toward the center, or equatorial plate, in a rather aimless back and forth motion.
   - The two chromatids are held together, presumably by proteins called **cohesins**.
10. During metaphase, the kinetochores arrive at the equatorial plate.
    - Chromosomes are fully condensed and have distinguishable shapes.
    - Cohesins break down.
    - DNA topoisomerase II unravels the interconnected DNA molecules at the centromere, and all the chromatids separate simultaneously.
11. Anaphase begins when the centromeres separate.
    - The process takes 10 to 60 minutes for the chromosomes to move to opposite poles.
    - Molecular motors at the kinetochores move the chromosomes toward the poles, accounting for about 75% of the motion.
    - About 25% of the motion comes from shortening of the microtubules at the poles.

- Additional distance is gained by the separating of the mitotic centers. This increase in distance between the poles is done by the polar microtubules, which have motor proteins associated in the overlapping regions. By this process the distance between the poles doubles.

Nuclei re-form during telophase

12. When chromosomes finish moving, telophase begins. Nuclear envelopes and nucleoli coalesce and re-form.

V. Cytokinesis: The Division of the Cytoplasm

1. Animal cells divide by a furrowing (a "pinching in" or constriction) of the plasma membrane.
2. Microfilaments of actin and the motor protein filament myosin first form a ring beneath the plasma membrane.
3. Actin and myosin contract to produce the constriction.
4. Plants have cell walls and the cytoplasm divides differently.
   - After the spindle breaks down, vesicles from the Golgi apparatus appear in the equatorial region.
   - The vesicles fuse to form a new plasma membrane, and the contents of the vesicles combine to form the cell plate, which is the beginning of the new cell wall.
5. Organelles and other cytoplasmic resources do not need to be distributed equally in daughter cells, as long as some of each are present in both new cells to assure additional generation of organelles as needed.

VI. Reproduction: Sexual and Asexual

1. Mitosis by repeated cell cycles can give rise to vast numbers of identical cells.
2. Meiosis results in just four progeny, which usually do not further duplicate. The cells can be genetically different.

Reproduction by mitosis results in genetic constancy

3. *Asexual reproduction* involves the generation of a new individual that is essentially genetically identical to the parent. It involves a cell or cells that were generated by mitosis.
   - Variation of cells is likely due to mutations or environmental effects.
4. *Sexual reproduction* involves meiosis.
   - Two parents each contribute one cell that is genetically different from the parents.
   - These cells often combine to create variety among the offspring beyond that attributed to mutations or the environment.

Reproduction by meiosis results in genetic diversity

5. Sexual reproduction fosters genetic diversity among progeny. Two parents each contribute a set of chromosomes in a sex cell or gamete. Gametes fuse to produce a single cell, the zygote, or fertilized egg. Fusion of gametes is called fertilization.

6. In each recognizable pair of chromosomes, one comes from each of the two parents. The members of the pair are called homologous chromosomes and are similar, but not identical, in size and appearance. (An exception for sex chromosomes exists in some species.)
7. The homologous chromosomes have corresponding but generally not identical genetic information.
8. *Haploid* cells contain just one homolog of each pair. The number of chromosomes in a single set is denoted by *n*. When haploid gametes fuse in fertilization, they create the zygote, which is 2*n*, or *diploid*.
9. Some organisms have a predominant life cycle in a 1*n* (haploid) state. (Algae & fungi)
10. Some organisms have both a 1*n* vegetative life stage and a 2*n* vegetative life stage. (Bryophyte/pteridophytes)
11. In diplontic organisms, which include animals, the organism is usually diploid. (Some insects are excepted.)
12. Homologous chromosomes exchange parts and recombine during meiosis so that the chromosomes passed on to gametes are mixtures of those received from two parents. The two chromosomes of a mixed homologous pair then segregate randomly into haploid gametes. This shuffling greatly increases the diversity of the population and opportunities for evolution.

The number, shapes, and sizes of the metaphase chromosomes constitute the karyotype

13. It is possible to count and characterize individual chromosomes.
14. Cells in metaphase can be killed and prepared in a way that spreads the chromosomes around a region on a glass slide. A photograph of the slide can be taken, and images of each chromosome can be organized based on size, number and shape. This spread is called a *karyotype*.

VII. Meiosis: A Pair of Nuclear Divisions

1. Meiosis consists of two nuclear divisions that reduce the number of chromosomes to the haploid number.
2. The nucleus divides twice, but the DNA is replicated only once.
3. The functions of meiosis are to reduce the chromosome number from diploid to haploid, to ensure each gamete gets a complete set, and to promote genetic diversity among products.
4. Meiosis I is unique for the pairing and synapsis of homologous chromosomes in prophase I of the first nuclear division. After metaphase I, homologous chromosomes separate into different cells.
5. Individual chromosomes, each with two chromatids, remain intact until metaphase of meiosis II (second nuclear division) is completed and the chromatids separate to become chromosomes.

The first meiotic division reduces the chromosome number

6. Like mitosis, meiosis I is preceded by an interphase in which DNA is replicated. Meiosis I begins with a long prophase.

7. During prophase I, *synapse* occurs: The two homologs are joined together held by a synaptonemal complex of proteins. This forms a tetrad, or "bundle of four," which consists of two homologous chromosomes with two sister chromatids.
8. At a later point, the chromosomes appear to repel each other except at the centromere and at points of attachments, called *chiasmata*, which appear X-shaped. These chiasmata reflect the exchange of genetic material between homologous chromosomes, a phenomenon called *crossing-over*.
9. This crossing-over increases genetic variation by "mixing and watching" the genes on the homologs.
10. In the testis cells of human males, prophase I takes about a week.
11. In the egg cells of human females, prophase I begins before birth in some eggs and can continue for 50 years in others depending on their release in the monthly ovarian cycle.
12. Following telophase I, in some species, there is a reappearance of nuclear envelopes. If this occurs, it is called interkinesis, a stage similar to mitotic interphase, but there is no replication of genetic material and no crossing-over in subsequent stages.

The second meiotic division separates the chromatids

13. Meiosis II is similar to mitosis.
14. One difference is that DNA does not replicate before meiosis II. The number of chromosomes is therefore half that found in diploid mitotic cells.
15. In meiosis II, sister chromatids are not identical and there is no crossing-over.

Meiosis leads to genetic diversity

16. The products of meiosis I are genetically diverse.
17. Synapsis and crossing over during prophase I mix genetic material of the maternal with that of the paternal homologous chromosomes.
18. Which member of a homologous pair segregates or goes to which daughter cell at anaphase I is simply chance.
19. Since most species of diploid organisms have more than two pairs of chromosomes, the possibilities for variation in combinations becomes huge.

EXTRA CONCEPTS: Cell Reproduction or Cell Division

1. Cell Division was first studied by **Strasburger (1875)** in plants, **W. Flemming (1882)** in animal cells and **Prevost and Dumas (1824)** in frog egg.
2. Any agent that stimulates cell division is called **mitogen**. Temperature, cytokinin, auxin, gibberllin, insulin, steroids and mitogens.
3. The continuation of species from one generation to next is governed by two processes; syngamy (union of gametes) and division of cells (meiosis and mitosis).
4. A cell divides to have high surface area per unit of volume and high nucleocytoplasmic ratio. The smaller the size of cell, more the surface area and nucleo-cytoplasmic ratio it has.
5. Genetic continuity is due to duplication of DNA in cell division that occurs in S-phase.

6. **Mitotic poisons** are inhibitors of cell divisions. **Azides** and **cyanides** inhibit prophase; **colchicines** checks spindle formation; **chalones** inhibit cell division *in vivo and in vitro* both; **ribonuclease** blocks prophase; **heat shocks** prevent cell division and **Mustard** gas agglutinate all chromosomes.
7. Animal cytokinesis is centripetal and plant cytokinesis is centrifugal.
8. In fungi, spindle is formed inside nucleus (*intranuclear division*); nuclear membrane remains intact; nucleus divides by furrow (*karyochoriosis*).
9. **Endomitosis** is duplication of chromosomes without division of nucleus.
10. Non-disjunction is failure of migration of chromatids at anaphase; discovered by **Bridges** (1961).
11. **Brachymeiosis:** It is believed by some mycologists that in some ascomycetes, fertilization takes place in single celled stage resulting in a diploid nucleus which then undergoes free nuclear divisions followed by pairing (dikaryon formation). These dikaryons then fuse and thus become a tetraploid nucleus. This is ascus mother cell. If it has to form haploid ascospores it must now undergo two reductional & one equational division. This is knows as **brachymeiosis**.
12. **Acetocarmine** is made by dissolving carmine dye (obtained from cochineal *Coccus* insect) in acetic acid. It gives purple red colour to chromosomes.
13. **C-mitosis** is colchicines induced mitosis. **Colchicine** is an alkaloid, obtained from underground corms of autumn crocus – *Colchicum autumnale*. It was discovered by **Dustin** (1934) and used by **Blakeslee** (1937) to induce polyploidy. **Granosan** is similar to colchicines in action. Both inhibit spindle formation.
14. In *Cyperus*, one meiosis produces one pollen grain instead of four.
15. Cell doubles in size and then stops growing in G_1 phase. G_1 is longest, most variable phase in which maximum growth occurs. Circumstances which induce a cell to divide arise in G_1 under the influence of some cytoplasmic clock. **Decision for cell division also occurs here.**
16. Size of nucleus increases in interphase; size of nucleolus increases in first four substages of Prophase-I of meiosis.
17. *Aristolochia* (duck weed) has all types of tetrads.
18. Protein (histone) for DNA synthesis is formed in S-phase while tubulin protein required for spindle is synthesized in G_2.
19. All organelles (organoids) including centrioles are doubled in G_2.
20. Amount of DNA doubles in S-phase.
21. Interphase is most active phase followed by prophase. This interphase takes 70-95% of total time of cell cycle. M-phase takes very less time.
22. **Amitosis** is called direct or incipient cell division and is found in yeasts, protozoans, monerans (prokaryotes), cartilage and degenerated/old tissues.
23. Mitosis forms 2 daughter cells that are morphologically and genetically similar. It distributes chromosomes equally both quantitatively and qualitatively. **Term mitosis** was given by **W. Flemming** (1870). Meristems, cells of bone marrow, base of nails and skin are used to study mitosis.

24. Spindle is astral (amphiastral) and arises from centriole in animal cell and in plant cell; it is anastral and arise from cytoplasmic proteins by gelation. It consists of microtubules made up of sulphur rich tubulin protein (95-97%), RNA (3-5%) and ATPase. **Spindle is seen with polarizing microscope only**.
25. Prophase is of longest duration.
26. Metaphasic chromosomes are least coiled. **The structure of chromosomes is best studied at metaphase while shape of chromosomes is best studied at anaphase**.
27. **Anaphase is of shortest duration**; centromere divides and disjunction occurs here. About 30 molecules of ATP are needed to move one chromosome from equator to pole.
28. Telophase is reverse of prophase. Nuclear membrane reappears from ER and remnants of original nuclear membrane.
29. **Meiosis** was first discovered by **Boveri (1892)**, studied by **Strasburger (1883)** and **Winiwarter (1990); term by Farmer and Moore (1905)**. It is double division in which nucleus divides twice but chromosomes only once. It is antithesis of fertilization and havles the number of chromosomes. It maintains number of chromosomes constant through successive generations.
30. Meiosis occurs in diploid reproductive cells (meiocytes) at the time of reproduction.
31. Anthers of unopened young flowers and testes of grasshopper are widely used to study meiosis.
32. **Zygotene** is zipping or synapsis or pairing of homologous chromosomes.
33. Tetrad formation occurs at pachytene stage.
34. **Diplotene is of longest duration** and involves chiasmata formation very distinctly. Crossing over begins at pachytene but chiasmata becomes distinct at diplotene, hence we can say crossing over occurs at diplotene.
35. **Transportation** is exchange and rejoining of chromatids parts during crossing over.
36. In metaphase-I, migrating chromosomes are **dyad**, i.e., each chromosome has 2 chromatids.
37. Reduction in number of chromosomes occur in anaphase-I but haploidy (reduction) in terms of DNA occur during anaphase-II.
38. In *Trillium*, anaphase-I directly enters into metaphase-II.
39. Tetrad is a group of 4 haploid cells formed during meiosis. It can be tetrahedral, isobilateral, linear, decussate or T-shaped but **tetrahedral tetrad is most common in plants.**
40. **Kinetochore** is a proteinaceous region of the centromere in chromosome to which spindle fibres attach.
41. Nucleoprotein complex present between synapsed chromosomes is called synaptinemal complex.
42. Karyokinesis is division of nucleus. It was first studied by **Schleiden**.
43. Chromatids move towards the pole at a speed of 1 µm per minute.
44. Chiasmata are the result of crossing over and first observed by **Janseens** (1909).

45. **He La** cells are human cancer cells of a patient **Henrietta Lack**; maintained in tissue culture since 1953. They divide and double their number in every 24 hrs & widely used in research.
46. During G2, a cell contains double the amount of DNA (4n) as compared to original diploid cell (2n).
47. **Repair of damaged DNA also takes place in the interphase**.
48. In plants, mitosis occur in meristematic tissues (shoot & root tips). Root tip is the most preferred regions to observe mitosis.
49. **Anaphase is a rapid phase lasting only 2-3 minutes**. It starts abruptly. The centromere splits into two; each chromatid is pulled slowly towards a spindle pole (each chromatid with own centromere now becomes a separate single stranded (1 DNA) chromosome. The chromatids are moved (towards the pole they face) at a speed of 1µm/minute. The separation of the chromatids starts at the centromeres while the arms trail behind it. As a result, the chromosomes are pulled into V, J and T shapes.
50. The telophase lasts for an hour or so.
51. **Stimulation of mitosis**: Kinetin (6-furturyl amino purine) increases the mitotic rate in meristems of *Allium*. At low concentration, it reduces the duration of interphase and increases the mitotic rate.
52. In human males, meiosis starts after puberty.
53. In human females, meiosis starts at the end of 3^{rd} month of prenatal life. In the fifth month of prenatal life, the oocytes reach the diplotene stage and remain arrested at this stage for many (About 12) years, when ovulation occurs.
54. Number of meiosis required to form n number of seeds/grains = n + n/4 (for all cases except cyperus); in cyperus, it is = n + n.

CELL DIFFERENTIATION AND CELL-CELL INTERACTION:

Specializations of Plasmalemma

They are of three types:

(*i*) Outpushings (Evaginations) - microvilli, flagellar or ciliary sheaths, stereocilia.

(*ii*) Inpushings (Invaginations) - pores, mesosomes, lomasomes and transfer cells.

(*iii*) Junctional Complexes. They are connections between adjacent cells, across intervening space of 15 - 20 nm width which is often filled with tissue fluid. Cementing material is called adherenes, fusion as occludens, spot as macula and strip as zonula. Common junctional complexes are plasmodesmata, gap junctions, interdigitations, intercellular bridges, tight junctions, desmosomes and terminal bars.

1. **Microvilli** (Singular-Microvillus). They are numerous (upto 3000) fine plasmalemma evaginations (each O' 6 - 0,8 ,*um* long and 0.1 ,*um* in diameter) which gives striated or brush border appearance under optical microscope. Microvilli are supported internally by micro filaments. Externally they possess glycocalyx. Areas in between the microvilli are specialised for absorption. Surface area is increased several times, *e.g.*, intestinal epithelium, hepatic cells, convoluted regions of renal tubules, lining of gall bladder and uterus.

2. **Stereocilia**. Nonmotile elongated evaginations of plasma membrane, secretory or sensory, *e.g.*, macula, crista, epididymus. True cilia and flagella are covered by plasma membrane sheaths. Evaginations also occur during formation of phagocytic vesicles.
3. **Pores.** At places plasma membrane is connected with endoplasmic reticulum forming pores leading to channels of E.R. Infolds also develop during formation of endocytotic vesicles.
4. **Mesosome.** Complex infolding of plasma membrane in bacteria that is connected with nucleoid and is believed to help in nucleoid replication, septum formation and even respiration. A similar infolding found in fungi is called lomasome.
5. **Transfer cells.** Both cell wall and plasmalemma show infoldings. Cells are specialized for solute transfer.
6. **Plasmodesmata**. They are cytoplasmic bridges between adjacent plant cells that occur in very fine pores or pits in the cell wall.
7. **Gap Junctions** (Nexus, Maculae Occludentes)**.** Fine hydrophilic channels formed by special protein cylinders or connexons of two adjacent cells. Ca^{2+} is required for their opening, they are very common.
8. **Intercellular Bridges.** Plasma projections from adjacent cells that come in contact in the intercellular space for quick transfer of stimuli.
9. **Interdigitations.** Membrane outgrowths of adjacent cells which fit into one another, increase adherence and surface area for exchange of materials.
10. **Desmosomes** (Spot Desmosomes, Maculae Adherentes)**.** They are just like welded areas between adjacent cells having intercellular thickening materials, transmembrane linkers, disc-shaped intracellular thickening adjacent to each membrane, with tonofibrils. Desmosomes occur in epithelia subjected to disruption. In hemidesmosome, disc-shaped intracellular thickening occurs in one cell. Collagen firbils are found in place of intercellular thickening. Septate desmosomes possess transverse septa in between cells instead of intercellular cement. Tonofibrils are absent. Septate desmosomes occur in invertebrates.
11. **Tight Junctions** (Zonulae Occludentes)**.** Plasmalemmae of two cells fused to form impermeable or occluding junctions, *e.g.*, epithelial cells or capillaries and brain cells. Function of tight junctions is different in different tissues.
12. **Terminal Bars** (= Belt Desmosomes, Zonulae Adherentes)**.** Desmosomes which lack tonofibrils and where discoid thickenings are replaced by bands of microfilaments and intermediate filaments.

CANCER AND MALIGNANT GROWTH

1. Cancer is a disease of the body's cells. It occurs when cells in the body become abnormal and grow out of control. A change which makes the gene faulty is called a mutation. Some special genes, called control genes, instruct the cell to copy its genes correctly, and to divide in an orderly manner. They stop controlling cell division, which is cancer.
2. **Benign Tumors:** Tumors arise with great frequency, especially in older animals and humans, but most pose little risk to their host because they are localized and of small size. The surface interaction molecules that hold tissues together keep benign tumor

cells, like normal cells, localized to appropriate tissues. A fibrous capsule usually delineates the extent of a benign tumor.

3. **Malignant tumor:** In contrast, the cells composing a malignant tumor, or cancer, express some proteins characteristic of the cell type from which it arose, and a high fraction of the cells grow and divide more rapidly than normal.
4. Some malignant tumors remain localized and encapsulated, at least for a time; an example is carcinoma in situ in the ovary or breast.
5. Most, however, do not remain in their original site; instead, they invade surrounding tissues, get into the body's circulatory system, and set up areas of proliferation away from the site of their original appearance.
6. The spread of tumor cells and establishment of secondary areas of growth is called **metastasis**; most malignant cells eventually acquire the ability to metastasize.
7. Thus the major characteristics that differentiate metastatic (or malignant) tumors from benign ones are their invasiveness and spread.

Characteristics of Cancer Cells

1. They are usually less well differentiated than normal cells or benign tumor cells. The presence of invading cells is the most diagnostic indication of a malignancy.
2. Cancer cells can multiply in the absence of growth-promoting factors required for proliferation of normal cells and are resistant to signals that normally program cell death (apoptosis).
3. Cancer cells also invade surrounding tissues, often breaking through the basal laminas that define the boundaries of tissues and spreading through the body to establish secondary areas of growth, a process called *metastasis*
4. Both primary and secondary tumors require angiogenesis, the recruitment of new blood vessels, in order to grow to a large mass.
5. Cancer cells, which are closer in their properties to stem cells than to more mature differentiated cell types, usually arise from stem cells and other proliferating cells

Types of Cancer

1. **Carcinoma**: It includes tumors of brain, breast, skin, cervical region. These are derived from epithelial tissue, originating from either ectoderm or endoderm. These occurs as solid tumors, located in the nervous tissue on the body surface or associated glands.
2. **Sarcoma**: They are the cancers of connective tissues, cartilage, bone or muscles which are mesodermal in origin.
3. **The leukemias**: A class of sarcomas, grow as individual cells in the blood, whereas most other tumors are solid masses. (The name *leukemia* is derived from the Latin for "white blood": the massive proliferation of leukemic cells can cause a patient's blood to appear milky)
4. **Lymphoma**: Lymph nodes, bone marrow, liver and spleen produces excessive lymphocytes. Cancer in them are called as lymphomas eg. Hodgkin's disease.

Proto-Oncogenes and Tumor-Suppressor Genes

1. Two broad classes of genes—proto-oncogenes (e.g., *ras*) and tumor-suppressor genes (e.g., *APC*) play a key role in cancer induction. These genes encode many kinds of proteins that help control cell growth and proliferation; mutations in these genes can contribute to the development of cancer.
2. Most cancers have inactivating mutations in one or more proteins that normally function to restrict progression through the G_1 stage of the cell cycle (e.g., Rb and p16). Virtually all human tumors have inactivating mutations in proteins such as **p53** that normally function at crucial cell-cycle checkpoints, stopping the cycle if a previous step has occurred incorrectly or if DNA has been damaged. Likewise, a constitutively active Ras is found in several human tumors of different origin. Thus normal growth control and malignancy are two faces of the same coin.
3. An oncogene is any gene that encodes a protein able to transform cells in culture or to induce cancer in animals.
4. Of the many known oncogenes, all but a few are derived from normal cellular genes (i.e., proto-oncogenes) whose products participate in cellular growth-controlling pathways. For example, the *ras* gene is a proto-oncogene that encodes an intracellular signal-transduction protein;
5. Conversion, or activation, of a proto-oncogene into an oncogene generally involves a *gain-of-function* mutation.
6. Tumor-suppressor genes generally encode proteins that in one way or another inhibit cell proliferation. Loss of one or more of these “brakes” contributes to the development of many cancers.
7. Five broad classes of proteins are generally recognized as being encoded by tumor-suppressor genes:
   - Intracellular proteins, such as the p16 cyclin-kinase inhibitor, that regulate or inhibit progression through a specific stage of the cell cycle
   - Receptors for secreted hormones (e.g., tumor derived growth factor ?) that function to inhibit cell proliferation
   - Checkpoint-control proteins that arrest the cell cycle if DNA is damaged or chromosomes are abnormal
   - Proteins that promote apoptosis and Enzymes that participate in DNA repair

Some of the characteristics of Oncogenes and tumour suppressor genes can be summarized as follows

1. Dominant gain-of-function mutations in proto-oncogenes and recessive loss-of-function mutations in tumor-suppressor genes are oncogenic.
2. Among the proteins encoded by proto-oncogenes are positive-acting growth factors and their receptors, signal-transduction proteins, transcription factors, and cell-cycle control proteins.
3. An activating mutation of one of the two alleles of a proto-oncogene converts it to an oncogene, which can induce transformation in cultured cells or cancer in animals.
4. Activation of a proto-oncogene into an oncogene can occur by point mutation, gene amplification, and gene translocation.

5. The first recognized oncogene, v-*src,* was identified in Rous sarcoma virus, a cancer-causing retrovirus. Retroviral oncogenes arose by transduction of cellular proto-oncogenes into the viral genome and subsequent mutation.
6. The first human oncogene to be identified encodes a constitutively active form of Ras, a signal-transduction protein. This oncogene was isolated from a human bladder carcinoma.
7. Slow-acting retroviruses can cause cancer by integrating near a proto-oncogene in such a way that gene transcription is activated continuously and inappropriately.
8. Tumor-suppressor genes encode proteins cell cycle if DNA is damaged or chromosomes are abnormal, receptors for secreted hormones that function to inhibit cell proliferation, proteins that promote apoptosis, and DNA repair enzymes.
9. Inherited mutations causing retinoblastoma led to the identification of *RB,* the first tumor-suppressor gene to be recognized.

IMMUNE RESPONSE

1. Immunity means protection from disease and especially infectious disease. Cells and molecules involved in such protection constitute the **immune system** and the response to introduction of a foreign agent is known as the **immune response**.
2. Not all immune responses protect from disease; some foreign agents, such as the **allergens** found in house dust mite, cat dander or rye grass pollen, cause disease as a consequence of inducing an immune response.
3. Likewise some individuals mount immune responses to their own tissues as if they were foreign agents. Thus, the immune response can cause the **autoimmune** diseases common to man such as multiple sclerosis, diabetes, rheumatoid arthritis or myasthenia gravis.
4. Most individuals do not suffer from autoimmune disease because they have developed **tolerance** towards their own (**self**) tissues.

Innate (or natural) immunity: This is made up of several components.

1. **Physical barriers are the first line of defense against infection.** The skin and mucous membranes provide a continous surface which must be breached and back this up with mechanical protection through cilia and mucous.
2. **Physiological factors** such as pH, temperature and oxygen tension limit microbial growth. The acid environment of the stomach combined with microbial competion from the commensal flora inhibits gut infection.
3. **Protein secretions** into external body fluids such as lysozyme also help resist invasion. Soluble factors within the body such as **complement**, **interferons** and collectins and other “broadly specific” molecules such as C-reactive protein are of considerable importance in protection against infection.
4. **Phagocytic cells** are critical in the defense against bacterial and simple eukaryotic pathogens. **Macrophages** and **Polymorphonuclear leucocytes (PMN)** can recognise bacterial and yeast cell walls through broadly specific receptors (usually for carbohydrate structures) and this recognition is greatly enhanced by activated complement (opsonin) [as well as by specific antibody].

5. **Acute Inflammation:** The acute inflammatory response which has been described in previous lectures is a key part of the innate immune system. Many infections, especially where small wounds are the route of entry, are eliminated by the combination of complement and recruitment of phagocytes, which flow from the acute inflammatory response.

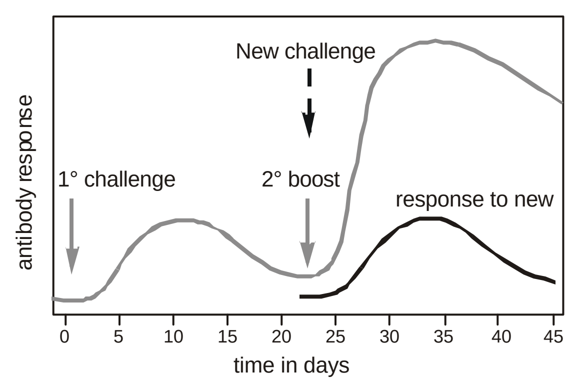
   A defining aspect of the innate immune system is that it carries no memory of an encounter with a foreign organism.

What is an antigen?

1. An **antigen** is defined as "anything that can be bound by an antibody". This can be an enormous range of substances from simple chemicals, sugars, small peptides to complex protein complexes such as viruses.
2. The small antigens are not, however **immunogenic** in themselves and need to be coupled to a **carrier** to elicit an immune response. Such small antigens are referred to as **haptens**.
3. Requirement of Antigen to cause immune response are: Non-self, Complex in structure, should more then 5 KD in size and must have atleast on epitope.
4. In fact antibodies interact specifically with relatively small parts of molecules. These are known as antigenic **determinants** or **epitopes**.
5. Sometimes the epitope is composed of a string of amino acids as might be found in a short peptide, such epitopes are said to be **linear**. Other epitopes are formed by more complex 3-dimensional structures present only as part of a native protein, such epitopes are called **conformational**.

Adaptive immunity

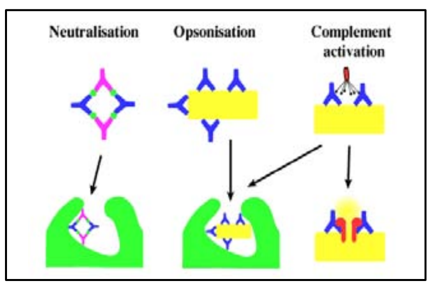
Specific memory is the hallmark of the adaptive immune response



1. The second level of defence increases in strength and effectiveness with each encounter. The foreign agent is recognised in a **specific** manner and the immune system **acquires** memory towards it.

2. The first encounter with an antigen is known as the **primary response**. Re-encounter with the same antigen causes a **secondary response** that is more rapid and powerful.
3. Acquired immunity is a useful evolutionary adaptation because it improves the efficacy of the innate immune response by focusing the response to the site of invasion/ infection as well as providing additional effector mechanisms that are unique to **lymphocytes**.
4. The difference between innate and acquired immunity lies in the **antigen specificity** of lymphocytes. This property is conferred upon lymphocytes by the expression of cell surface receptors that recognise discrete parts of the antigen known as **antigenic epitopes**.
5. The cell surface receptor of **B lymphocytes**, (derived and mature in **Bone marrow** in mammals or the **Bursa of fabricius** in chickens) is an **immunoglobulin** molecule which, when secreted by the B cell, is known as an **antibody**.
6. Immunity provided by Immunoglobulins (antibodies) is termed as humoral immunity (Humor=fluid/blood)

Antibodies work in three ways



1. **Agglutination**: Antibodies bind to antigens to produce large insoluble complexes, which render them harmless and facilitate their destruction by other cells of the immune system.
2. **Opsoniation**: I_gG molecules coat the surface of antigens and this stimulates their recognition and digestion by phagocytes.
3. **Complement mediated cell lysis**: Complement system is a group of enzymes. They are triggered by I_gM - I_gG bound to the surface of foreign cells. The activity of some of these enzymes leads to the formation of pores on the plasma membrane of the invading cell causing them to lyse.

Structure of Antibody: Antibodies have two ends. One end interacts with the antigen (the **variable** part) leaving the other (**constant**) end free to interact with the immunoglobulin receptors on these cells. During an immune response, a complex lattice of interlinked antigens and antibodies, known as an **immune complex**, will present an array of constant regions which can activate the various cells mentioned above through ligation of their immunoglobulin receptors.

1. **Antibodies**: Immunoglycoproteins secreted by B-lymphocytes in response to antigens. They are Y shaped molecule made up of two heavy and two light chains [Kappa or lambda either one of them. They occur in the ratio of 2:1 in human's era]. The antigen combining site of molecule is aminoterminus. It is composed of both L and H chains. The regions in the L and H variable portion that actually combines with the antigenic determinants are called hot spots or ioditypes. The carboxyterminus of light chain has a small constant region. The heavy chain also has two to three constant regions at its carboxy terminus. Depending upon different types of constant regions, five isotypes of I_g have been identified: I_gG, I_gA, I_gM, I_gD, I_gE

	I_gG	I_gA	I_gM	I_gD	I_gE
Sedimentation Coefficient	7	7	19	7	8
Molecular weight	150,000	160,000 (2 Chains) of I_gA	900,000 (5 Chains)	180,000	190,000
Serum concentration (mg / ml)	12	2	1.2	0.03	0.00004
Half life (days)	23	6	10	2.8	2.3
Carbohydrate %	45	42	80	75	50
Complement fixation	⊕	–	+	–	–
Placental transport	⊕	–	–	–	–
Present in breast milk	+	+	–	–	–
Selective secretion of seromucous glands	–	+	–	–	–
Heat stability	+	+	+	+	–

2. **Lymphocytes**: Lymphocytes that are critical for immune reactions are of two types: B-cells and T-cells. Both develop from stern cells located in the liver of the foetus and in the bone marrow cells of the adult. Those that migrate to the thymus, differentiate under its influence and are known as “T-cells”; while those that continue to remain in the bone marrow are called “B-cells”. The young lymphocytes migrate to thymus and later on lymphoid tissues such as spleen lymph nodes and tonsils where they undergo final maturation.

HUMORAL AND CELL MEDIATED IMMUNE RESPONSES

1. **Humoral immunity** produces antibodies in response to toxins (ex bee venom), free bacteria, and viruses present in the body fluids.
2. "Humor” is medieval term for body fluids. Here it refers to the fluid of the blood and the lymph.

3. Antibodies to these types of antigens are synthesized by B- lymphocytes and then secreted as soluble proteins which circulate through the body in blood plasma and lymph.
4. **Cell-mediated immunity** is the response to intracellular bacteria and viruses, fungi, protozoans, worms, transplanted tissues, and cancer cells.
5. Depends on the direct action of various types of T-lymphocytes rather than antibodies.
6. T-lymphocytes differentiate into 4 different varieties of T-cells.
   - Helper/inducer T-cells (Links Cell meduated and Humoral Immunity)
   - Suppressor T cells (Suppresses the immune response when antigens are disposed off)
   - Cytotoxic T cells or killer cells (Effector cells of cell mediated immunity)
   - Memory T-cells.
7. “Memory B and T cells” are cells that have been exposed to an antigen and are readily converted to “Effector cells” by a later encounter with the same antigen. Unlike other lymphocytes, they persist in the body for months or even years.
8. The killer T-cells directly attack and destroy antigens. They move to the site of invasion and produce chemicals that attract phagocytes. Helper T-cells act to stimulate antibody production by B-cells, while suppressor T-cells suppresses the total immune system from attacking the body’s own cells.
9. **Thymus-Independent Antigens:** Some bacterial polysaccharides can active B-cells. Antigens capable of doing so are called thymus independent antigens because these antigens do not require the cooperation of Helper T-cells for activating B-cells.

   Thymus dependent antigens; many antigens require the cooperation of T-cells for activating B-cells. The antigens present on organ transplant are thymus dependent antigens. So a person whose thymus gland is removed is not able to reject organ transplant.
10. **MHC** are major histocompatibilty complex (glycoproteins) prensent on cells which present processed intracellular antigen to T-Lymphocytes. They are also called as Human Leucocyte Antigen (HLA) in humans.
11. **MHC-I** is present on all nucleated cells and are recognized by **CD 8^+** arms of T-Cytotoxic cells and present processed antigen to T-cytotoxic cells while **MHC-II** are present on T & B lymphocytes, dendritic cells and mast cells and recognized via **CD 4^+** arm present on T-Helper cell.
12. **Lymphokines:** They are a family of soluble chemical mediator released by helper T-cells. Lymphokines have two broad functions. One group of lymphokines is concerned with growth and differentiation of B and T cells. The other group helps phagocytosis by attracting phagocytic cells when required through chemotaxis and by activating the phagocytic cells.

VACCINES

The introduction of vaccination has been one of the most decisive advances leading to the dramatic downward trend in the incidence of many viral diseases.

The principle of vaccination is to induce a **"primed" state** in the vaccinated subject so that, following exposure to a pathogen, a rapid **secondary immune response** is generated leading to the accelerated elimination of the organism and protection from clinical disease. Success depends on the generation of **memory T and B cells** and the presence in the serum of **neutralizing antibody**.

Attributes of a good vaccine

- **Ability to elicit the appropriate immune response** for the particular pathogen:
  Tuberculosis—cell mediated response
  Most bacterial and viral infections—antibody
- **Long term protection** ideally life-long
- **Safety** vaccine itself should not cause disease
- **Stable** retain immunogenicity, despite adverse storage conditions prior to administration
- **Inexpensive**

Types of Vaccine: Vaccines in general use includes: LIVE vaccines; and KILLED vaccines

A. Live Vaccines

1. Live attenuated organisms

Organisms whose **virulence has been artificially reduced** by *in vitro* culture under adverse conditions, such as reduced temperature. This results in the selection of **mutants** which replicate poorly in the human host and are therefore of reduced virulence. Replication of the vaccine strain in the host reproduces many of the features of wild type infection, **without causing clinical disease.** Most successful viral vaccines belong to this group.

The immune response is usually good—when the virus replicates in the host cells, both **antibody** as well as **cell mediated immune responses** are generated and immunity is generally long lived. Often, only a **single dose** is needed to induce long term immunity.

Potential drawbacks to these vaccines include: the danger of reversion to virulence and the possibility of causing extensive disease in immuno-compromised individuals.

2. Heterologous vaccines

Closely related organism of lesser virulence, which shares many antigens with the virulent organism. The vaccine strain replicates in the host and induces an immune response that cross reacts with antigens of the virulent organism. The most famous example of this type of vaccine is vaccinia virus: Both cowpox virus and vaccinia virus are closely related to variola virus, the causitive agent of smallpox. The eighteenth centuary physician, Edward Jenner observed that milkmaids who had been infected with cowpox virus were immune to smallpox. Widespread use of vaccinia virus as a vaccine has lead to the world-wide eradication of smallpox.

3. Live recombinant vaccines

It is possible, using genetic engineering, to introduce a gene coding for an immunogenic protein from one organism into the genome of another (such as vaccinia virus). The organism expressing a foreign gene is called a recombinant. Following injection into the subject, the recombinant organism will replicate and express sufficient amounts of the foreign protein to induce a specific immune response to the protein.

B. Killed (inactivated) vaccines

1. When safe live vaccines are not available, either because attenuated strains have not been developed or else because reversion to wild type occurs too readily, it may be possible to use an **inactivated** preparation of the virulent organism to immunize the host.
2. The organism is propagated in bulk, *in vitro*, and inactivated with either *beta*-propiolactone or formaldehyde. These vaccines are not infectious and are therefore relatively safe. However, they are usually of lower immunogenicity and multiple doses may be needed to induce immunity. In addition, they are usually expensive to prepare.

   Subcellular fractions
3. When protective immunity is known to be directed against only one or two proteins of an organism, it may be possible to use a purified preparation of these proteins as a vaccine. The organism is grown in bulk and inactivated, and then the protein of interest is purified and concentrated from the culture suspension. These vaccines are safe and fewer local reactions occur at the injection site. However, the same disadvantages of poor immunogenicity and the need for multiple boosters apply.

C. Recombinant proteins

Immunogenic proteins of virulent organisms may be synthesized artificially by introducing the gene coding for the protein into an expression vector, such as *E-coli* or yeasts. The protein of interest can be extracted from lysates of the expression vector, then concentrated and purified for use as a vaccine. The only example of such a vaccine, in current use, is the hepatitis B vaccine.

D. DNA Vaccines

DNA vaccines are at present experimental, but hold promise for future therapy since they will evoke both humoral and cell-mediated immunity, without the dangers associated with live virus vaccines.

The gene for an antigenic determinant of a pathogenic organism is inserted into a plasmid. This genetically engineered plasmid comprises the DNA vaccine which is then injected into the host. Within the host cells, the foreign gene can be expressed (transcribed and translated) from the plasmid DNA, and if sufficient amounts of the foreign protein are produced, they will elicit an immune response.

E. Vaccines in general use

1. **Measles**: Live attenuated virus grown in chick embryo fibroblasts, first introduced in the 1960's. In developed countries, the vaccine is administered to all children in the second year of life (at about 15 months). If the vaccine is administered too early, however, there is a poor take rate due to the interference by maternal antibody. For

this reason, when vaccine is administered before the age of one year, a booster dose is recommended at 15 months.

2. **Mumps:** Live attenuated virus developed in the 1960's. In first world countries it is administered together with measles and rubella at 15 months in the MMR vaccine.
3. **Rubella:** Live attenuated virus. Rubella causes a mild febrile illness in children, but if infection occurs during pregnancy, the foetus may develop severe congenital abnormalities.
4. **Polio:** Two highly effective vaccines containing all 3 strains of poliovirus are in general use:

   The **killed virus vaccine** (Salk, 1954) is used mainly in Sweden, Finland, Holland and Iceland.

   The **live attenuated oral polio vaccine** (Sabin, 1957) has been adopted in most parts of the world; its chief advantages being: low cost, the fact that it induces mucosal immunity and the possibility that, in poorly immunized communities, vaccine strains might replace circulating wild strains and improve herd immunity.

   The inactivated Salk vaccine is recommended for children who are **immunosuppressed.**
5. **Hepatitis B:** Two vaccines are in current use: a serum derived vaccine and a recombinant vaccine. Both contain purified preparations of the hepatitis B surface protein. The serum derived vaccine is prepared from hepatitis B surface protein, purified from the serum of hepatitis B carriers. This protein is synthesised in vast excess by infected hepatocytes and secreted into the blood of infected individuals. A second vaccine, produced by recombinant DNA technology, has since become available. Three doses are given; at 6, 10, and 14 weeks of age. As with any killed viral vaccines, a booster will be required at some interval (not yet determined, but about 5 years) to provide protection in later life from hepatitis B infection as a venereal disease.
5. **Hepatitis A:** A vaccine for hepatitis A has been developed from formalin-inactivated, cell culture-derived virus.
6. **Varicella-Zoster virus:** A live attenuated strain of varicella zoster virus has been developed.

DOSAGE COMPENSATION

Dosage Compensation by X-inactivation in female mammals

1. How does an organism compensate for the fact that some individuals have a double dosage of sex-linked genes while others have only one? In female mammals, most diploid cells have only one fully functional X chromosome.
2. The explanation for this process is known as the Lyon hypothesis, proposed by the British geneticist Mary F. Lyon. In females, each of the embryonic cells inactivates one of the two X chromosomes. The inactive X chromosome contracts into a dense object called a Barr body.

3. **<u>Barr body</u>** = Located inside the nuclear envelope, it is a densely staining object that is an inactivated X chromosome in female mammalian cells. Most Barr body genes are not expressed. They are reactivated in gonadal cells that undergo meiosis to form gametes. Female mammals are a mosaic of two types of cells, those with an active maternal X and those with an active paternal X. Which of the two Xs will be inactivated is determined randomly in embryonic cells. After an X is inactivated, all mitotic descendants will have the same inactive X. As a consequence, if a female is heterozygous for a sex-linked trait, about half of her cells will express one allele and the other cells well express the alternate allele. Examples of this type of mosaicism are coloration in calico cats and normal sweat gland development in humans. A woman who is heterozygous for this trait has patches of normal skin and patches of skin lacking sweat glands.
4. X chromosome inactivation is associated with **DNA methylation**. **Methyl groups (-CH_3) attach to cytosine**, one of DNA's nitrogenous bases. Barr bodies are highly methylated compared to actively transcribed DNA. What determines which of the two X chromosomes will be methylated? A recently discovered gene, **XIST** is active only on the Barr body. The product of the XIST gene, X-inactive specific transcript, is an RNA; multiple copies of XIST attach to the X chromosome inactivating it.

Dosage Compensation by X-hyper activation in Male of Drossophila

1. In Drossophila Dosage compensation is achieved by hyperactivation of single x chromosome present in males. The hyperactivity is polytenization of X chromosome and hypoacetylation of Histones attached to DNA. So Genes are always accessible for transcription.

SEX DETERMINATION

1. Chromosomal Basis of Sex determination:
   - **XX-XY** is that type of sex determination in which Y determines sex of maleness. It is found in mammals, several insects.
   - **XX-XO** type in which O determines sex of maleness *e.g.,* bugs, cockroach, grasshopper, roundworms.
   - **ZZ-ZW** type – W determines sex of femaleness *e.g.,* birds, reptiles, fish, silkworm.
   - **ZO-ZZ** type – O determines sex of femaleness. It is opposite to XX-XO type *e.g.,* butterflies, moth, pigeon, ducks.
2. **Haploidy- diploidy** *e.g.,* ants, wasps, bees. Males are haploid and females are diploid.
3. **Gynandromorph** is a sex mosaic (an individual with one half of the body male and the other half female). These are common in silk moth and *Drosophila*. A gynander may be male or female with patches of tissues of other sex on it. Gynandromorphism is developed due to **non-disjunction of X-chromosome/aneuploidy.**

4. **Genic Balance Theory** for sex determination in Drossophilla was given by **Bridges** (on the basis of ratio of number of X chromosome to sets of autosomes)

Chromosome Constitution	**X/A ratio**	**Sex index**
AA + XXX	3/2 = 1.50	Super
AA + XX	2/2 = 1.00	Normal
AAA + XXY	2/3 = 0.67	Intersex
AA + XY	1/2 = 0.50	Normal
AA + X	1/2 = 0.50	Normal
AAA + XY	1/3 = 0.33	Super

5. It was concluded that X/A ratio of > 1.0 expresses super femaleness, 1.0 femaleness, 1.0 femaleness, below 1.0 and above .05 intersexes, maleness and <0.5 super maleness.
6. Y-chromosome is male determiner in man but not in *Drossophila*.
7. Environmental control of sex determination occurs in Turtles, Crocodiles, Certain lizards and Alligators.
8. Hormonal Sex determination occurs in Screw's Cock/ Hen, Free Martin in cattle, Bonnelia

Practice Test Paper-I

1. In a cell if acidity of Lysome is lost, then loss of:
   (*a*) Phagocytosis of invading bacteria
   (*b*) Elevated phosphatase level
   (*c*) Glycogen degradation
   (*d*) No major effect

2. Bacterial genomes is prevented by its own endonucleases by-
   (*a*) Methylation at restriction sites
   (*b*) Immune mechanism
   (*c*) Nuclease resistant genome
   (*d*) Are not much effective on bacterial genome

3. The function of macrophages is to-
   (*a*) Enzyme Secretion
   (*b*) Engulf Cell organelles
   (*c*) Engulf Foreign Material
   (*d*) Kills Invading Bacteria

4. The difference which distinguish prokaryotic cell from eukaryotic is-
   (*a*) ER (*b*) Mesosome
   (*c*) Nuclear Membrane (*d*) Plasma membrane

5. Extra nuclear genetic material is found-
   (*a*) Ribosome (*b*) ER
   (*c*) Chloroplast (*d*) Centriole

6. The acrosome of the sperm is formed from the
   (*a*) mitochondria (*b*) centrosome
   (*c*) lysomome (*d*) golgi bodies

7. Holiday junction is observed during:
   (*a*) Mitosis (*b*) Interphase
   (*c*) Recombination (*d*) DNA Repair

8. A caretenoid less mutant plant was grown under normal sunlight then-
   (*a*) Increased photosynthesis rate
   (*b*) Increased chlorophyll synthesis
   (*c*) Reduced photorespiration
   (*d*) Increased chlorophyll oxidation and necrosis

9. A C3 mustard plant was grown at 300 ppm of CO_2 in 14 h light and 10 h dark cycles, it was transferred to 1000 ppm CO_2. This will lead to (other environmental parameters remaining identical)-
   (*a*) Increased photosynthesis
   (*b*) Decreased Photosynthesis
   (*c*) Increase in Respiration
   (*d*) No Change

10. Presence of AIDS virus cannot be detected by-
   (*a*) ELISA
   (*b*) Western blotting
   (*c*) Northern Blot
   (*d*) Assay of full-length ds DNA

11. Which part of translational modification of proteins does not occur in lumen of ER-
   (*a*) Glycosylation
   (*b*) Ubiquitnation
   (*c*) Conformation folding & formation of quaternary structure
   (*d*) Formation of Disulphide bonds

12. Freshly broken chromosome ends are sticky & tend to fuse, however ends of intact chromosomes are stable. Their stability is due to presence of-
   (*a*) Centromeres
   (*b*) Telomeres
   (*c*) Special membrane around chromosomes
   (*d*) Kinetochores

13. Plant cell wall is generally made up of-
   (*a*) Cellulose and pectin
   (*b*) Cellulose
   (*c*) Chitin
   (*d*) Murin

14. Which one of the following is correct for structure of cell wall of fungi and Bacteria?
   (*a*) Both have glycopeptide
   (*b*) Both are made up of N-acetylglucasamine
   (*c*) Both are made up of murin
   (*d*) Both are made up of chitin

15. Nucleus is absent in-
   (*a*) Sieve tube
   (*b*) cambium
   (*c*) Phloem parenchyma
   (*d*) None of these

16. Among the following which is true cell according cell theory-
   (*a*) Virus
   (*b*) Monerans
   (*c*) Protestans
   (*d*) Bacteria

17. The characteristic property of metabolically active cell is-
   (*a*) Low nucleo-cytoplasmic ratio
   (*b*) High nucleo-cytoplasmic ratio
   (*c*) High volume to surface area ratio
   (*d*) Small nucleus

18. Plasma membrane the functional as well as structural role is played by-
   (*a*) Proteins (*b*) Lipids
   (*c*) Cholesterol (*d*) Oligosaccharides

19. Lipid nature of plasma membrane can be destroyed by-
   (*a*) Hexane (*b*) Benzene
   (*c*) Chloroform (*d*) NaOH

20. The plasma membrane of intestine is highly folded into microvilli. The main function of Microvilli is-
   (*a*) To Secrete digestive enzymes (*b*) To help in blood circulation
   (*c*) To increase its absorptive surface (*d*) For ageing of worn out cells

21. The structure formed where two adjacent membrane are thickened with disc shaped adhesive material in between and tonofibrils radiating out from adhesive region is-
   (*a*) Gap junction (*b*) Tight junctions
   (*c*) Desmosomes (*d*) Plasmodesmata

22. The outer part of cytoplasm is usually termed as-
   (*a*) Plasmasol (*b*) Plasmagel
   (*c*) Nucleoplasm (*d*) Protoplasm

23. Endoplasmic reticulum originates from-
   (*a*) Nuclues (*b*) Nucleulous
   (*c*) Golgi Complex (*d*) Plasma membrane.

24. The endoplasmic reticulum which constitute 50 % of cell is absent in-
   (*a*) Ova (*b*) Embryonic cells
   (*c*) Mature erythrocytes (*d*) All of the above

25. Ribosome are attached to endoplasmic reticulum through glycoprotein known as Ribophorin I & II. The Subunit of ribosome which get attached to ER is-
   (*a*) P site (*b*) A site
   (*c*) Large subunit (*d*) Small subunit

26. How you can separate Gram + ve bacteria from Gram –ve bacteria-
   (*a*) Presence of Techoic Acid (*b*) Absence of periplasmic Space
   (*c*) Exotoxin Produced (*d*) All of the above

27. Lysosomes are polymorphous organelles enclosed by a single membrane. They contain vast array of hydrolytic enzymes which can digest any foreign material except-
   (*a*) Cellulose (*b*) Starch
   (*c*) Glycogen (*d*) Lipids

28. Spectrin of erythrocytes and cytochrome c of mitochondria, which can be easily dissociated by high ionic strength and metal ion chelating agent are example of-
   (*a*) Extrinsic Protein (*b*) Intrinsic protein
   (*c*) Tunnel Protein (*d*) Cytoplasmic Protein

29. Fats, Sterol and detoxification are found abundant in-
    (*a*) Adipose cells
    (*b*) Muscle cells
    (*c*) Liver cells
    (*d*) All of above

30. RER is found abundantly in goblet cells, pancreatic cells and liver cells is mainly engaged in-
    (*a*) Glycosylation of protein
    (*b*) Folding and Secondary Structure formation
    (*c*) Production of Secretory & cytosolic protein
    (*d*) Production and Excretion of protein

31. Microsomes are not found in cell in natural condition. They are-
    (*a*) Present only in certain bacteria
    (*b*) Broken pieces of ER during centrifugation
    (*c*) Broken pieces of golgi during centrifugation
    (*d*) Present in certain fungi

32. Among the following which is not present in smaller subunit of ribosome-
    (*a*) Peptidyl transferase
    (*b*) Binding site for t RNA
    (*c*) A Site
    (*d*) P site

33. Polyribosome are seen in-
    (*a*) Bacteria
    (*b*) Fungi
    (*c*) Angiosperms
    (*d*) Mammals

34. r-RNA originates from-
    (*a*) Nucleus
    (*b*) Nucleolous
    (*c*) Cytoplasm
    (*d*) ER

35. Which organelle is presenting zone of exclusion and have definite polarity-
    (*a*) Golgi
    (*b*) ER
    (*c*) Nucleus
    (*d*) Ribosome

36. Lysosomes are abundant in-
    (*a*) WBC and osteoblasts
    (*b*) RBC and Spleen
    (*c*) Liver and Spleen
    (*d*) WBC and Spleen

37. Lysosome membrane is strengthened by cortisol, cortisone, antihistamine, heparin, chloroquinone and cholesterol but becomes fragile-
    (*a*) Low bile salts and energy radiations
    (*b*) In absence of oxygen
    (c) Low Vitamin A & E
    (*d*) Low Progestrone and estrogen

38. Fruit rotting can be checked by slowing down the action of enzyme polygalactouronose of the organelle-
    (*a*) Golgi
    (*b*) Lysosomes
    (*c*) Glyoxysome
    (*d*) Peroxisome

39. In prokaryotes where the mitochondria is absent, the site of oxidative phosphorylation and electron transport chain including dehydrogenases is-
(*a*) Mesosomes (*b*) Endosomes
(*c*) Plasma membrane (*d*) Microsomes

40. Water soluble phycobillin pigment occur in-
(*a*) BGA and Green algae (*b*) BGA and Red algae
(*c*) Green algae and Red algae (*d*) Green algae and Brown algae

41. Photosynthetic pigments are located in membrane on specific areas called as-
(*a*) Oxysomes (*b*) Quantosomes
(*c*) Photosystem (*d*) Antenna molecules

42. Microtubules are 25 nm thick, 15nm core formed of 13 helically arranged protofilaments made up of-
(*a*) α tubulin (*b*) β-tubulin
(*c*) Myosin (*d*) both a & b

43. Intermediate filaments are made up of-
(*a*) Non-contractile proteins (*b*) β-tubulin
(*c*) Myosin (*d*) Actin

44. In hexose m onophosphate shunt, the CO_2 molecules evolved is-
(*a*) Same as in glycolysis (*b*) Less then glycolysis
(*c*) More then glycolysis (*d*) Much lesser then glycolysis

45. The electron donor during nitrogen fixation is-
(*a*) Water (*b*) Ferrocynide
(*c*) Ferodoxin (*d*) CO_2

46. The chromatin is made up of repitative units known-
(*a*) Chromosomes (*b*) Chromonemata
(*c*) Nucleosomes (*d*) Nucleotides

47. Exocytosis and endocytosis is absent in-
(*a*) Amoeba (*b*) Euglena
(*c*) Mycoplasma (*d*) Algae

48. Cytochrome oxidase and cytochrome c deficiency in mitochondria causes-
(*a*) Menke's disease
(*b*) Kearns-says syndrome and Menke's disease
(*c*) Kearns-says syndrome
(*d*) Leber's optic neuropathy

49. Photophosophorylation occurs in-
(*a*) Plastids (*b*) Mitochondria
(*c*) Cytoplasm (*d*) Cell membrane

50. Which of the following is correct with regard to aneuploidy?
   (*a*) inversion
   (*b*) 2n + 1
   (*c*) All aneuploid individuals die before birth.
   (*d*) 4n

51. If a fragment of a chromosome breaks off and then reattaches to the original chromosome but in the reverse direction, the resulting chromosomal abnormality is called
   (*a*) a deletion.
   (*b*) an inversion.
   (*c*) a translocation.
   (*d*) a nondisjunction.

52. Why are individuals with an extra chromosome 21, which causes Down syndrome, more numerous than individuals with an extra chromosome 3 or chromosome 16?
   (*a*) There are probably more genes on chromosome 21 than on the others.
   (*b*) Chromosome 21 is a sex chromosome and 3 and 16 are not.
   (*c*) Down syndrome is not more common, just more serious.
   (*d*) Extra copies of the other chromosomes are probably fatal.

53. Humans have 23 pairs of chromosomes, while our closest relatives, chimpanzees, have 24. Chromosome studies indicate that at some point early in human evolution, two chromosomes simultaneously broke into a large portion and a small portion. The large parts combined to form a large chromosome, and the small parts combined to form a much smaller chromosome (which was subsequently lost). This important chromosomal change could best be described as
   (*a*) nondisjunction followed by deletion.
   (*b*) translocation followed by deletion.
   (*c*) duplication followed by deletion.
   (*d*) translocation followed by inversion.

54. Each cell in an individual with Down syndrome contains ____ chromosomes.
   (*a*) 3
   (*b*) 22
   (*c*) 24
   (*d*) 47

55. Disorders involving unusual numbers of sex chromosomes show that maleness is caused by the
   (*a*) presence of an X chromosome.
   (*b*) presence of a Y chromosome.
   (*c*) absence of an X chromosome.
   (*d*) absence of a Y chromosome.

56. A particular allele can have different effects if it was inherited from a male rather than a female. This phenomenon is known as
   (*a*) extranuclear inheritance.
   (*b*) aneuploidy.
   (*c*) sex-linkage.
   (*d*) genome imprinting.

57. Human mitochondria
    (*a*) are inherited as an X-linked trait.
    (*b*) are all inherited from the father.
    (*c*) have linear DNA.
    (*d*) are all inherited from the mother.

58. Both chloroplasts and mitochondria
    (*a*) are found within the nucleus.
    (*b*) have linear DNA.
    (*c*) carry extranuclear genes.
    (*d*) are inherited from both parents.

59. Damaged DNA is excised by
    (*a*) restriction enzymes. (*b*) helicase.
    (*c*) primase. (*d*) DNA polymerase.

60. Unlike prokaryotic DNA replication, eukaryotic DNA replication
    (*a*) is completed by DNA polymerase.
    (*b*) cannot be completed by DNA polymerase.
    (*c*) is semiconservative.
    (*d*) has a multiple origin.

61. Which of the following is an example of a hydrophobic material?
    (*a*) Paper (*b*) Sugar
    (*c*) Pasta (*d*) Wax

62. We can be sure that a mole of table sugar and a mole of vitamin C are equal in their
    (*a*) weight in daltons
    (*b*) number of molecules
    (*c*) volume
    (*d*) number of atoms

63. Among the following which is longest cell-
    (*a*) Hemp (*b*) Ramie
    (*c*) Jute (*d*) Nerve fibre

64. The middle lamella of plant cells is made up of calcium magnesium pectate. Pectic Acid is polymer of-
    (*a*) α-1,4 D-Glucose (*b*) β-1,6-D Glucose
    (*c*) α-1,4 D-Galactouronic acid (*d*) β-1,4 D-Galactouronic acid

65. Acid precipitation has lowered the pH of a particular lake to 4.0. What is the hydrogen ion concentration of the lake
    (*a*) 10^{-4} M (*b*) 4.0 M
    (*c*) 10^{-10} M (*d*) 10^{4} M

66. The percentage amount of Integral protein of plasma membrane is-
(*a*) 40 % (*b*) 50 %
(*c*) 60 % (*d*) 70 %

67. Oligosaccharide are usely attached to extrinsic phase of plasma membrane by-
(*a*) Proteins (*b*) Lipids
(*c*) Both a & b (*d*) Not specific

68. Maximum number of enzymes in a eukaryotic cell is present inside
(*a*) Cytosol (*b*) Mitocondria
(*c*) Lysosome (*d*) ER

69. Which of the following term includes all others in the list?
(*a*) Monosaccharide (*b*) Carbohydrate
(*c*) Disaccharide (*d*) Starch

70. The structural level of a protein least affected by a disruption in hydrogen bond is the
(*a*) secondary level (*b*) tertiary level
(*c*) primary level (*d*) quaternary level

71. To convert a nucleoside to a nucleotide, it would be necessary to:
(*a*) remove the pentose from the nucleoside (*b*) add phosphate to the nucleoside
(*c*) replace purine with pyrimidine (*d*) replace ribose with deoxyribose

72. Choose the pair of terms that correctly completes this sentence:
Nucleotides are to _______________ as _______________ are to proteins.
(*a*) amino acids; polypeptides (*b*) genes; enzymes
(*c*) nucleic acids; amino acids (*d*) polymers, polypeptides

73. Post translation modification of secretary proteins occurs in:
(*a*) RER (*b*) SER
(*c*) Mitocondria (*d*) nucleus

74. Most cells cannot harness heat in order to perform work because
(*a*) heat is not a form of energy
(*b*) Cells do not have much heat; they are relatively cool
(*c*) heat denatures enzymes
(*d*) temperature is usually uniform throughout a cell

75. Choose the pair of terms that correctly completes this sentence; Catabolism is to anabolism as ––––––––– is to ––––––––––.
(*a*) exergonic ; spontaneous (*b*) free energy ; entropy
(*c*) exergonic ; endergonic (*d*) work ; energy

76. According to the first law of thermodynamics
(*a*) matter can be neither created nor destroyed.
(*b*) all processes increase the order of the universe.
(*c*) systems rich in energy are intrinsically stable
(*d*) energy is conserved in all processes

77. How you can separate Gram + ve bacteria from Gram –ve bacteria-
(*a*) Presence of Techoic Acid
(*b*) Absence of periplasmic Space
(*c*) Exotoxin Produced
(*d*) All of the above

78. The main Phagocytotic cell in immune response is-
(*a*) Neutrophils
(*b*) Basophils
(*c*) Monocytes
(*d*) Lymphocytes

79. The phagocytes are attracted toward microorganisms by-
(*a*) Chemotaxis
(*b*) Rheotaxis
(*c*) Diapedesis
(*d*) Thogmotaxis

80. The cell wall of microorganisms is coated with certain plasma protein promoting the attachment of microbe to phagocytes, only then they can be phagocytosised. The coat protein are called as-
(*a*) Globins
(*b*) Opsonins
(*c*) Ovulbumins
(*d*) Phagosonins

81. After the damage of body tissues, blood vessel is dilated where damage has occurred, due to which permeability of blood vessel also increases. Vasodilation is caused by-
(*a*) Histamine
(*b*) Kinin
(*c*) Prostaglandin
(*d*) All of above

82. The process of sneezing of phagocytes between the endothelial cells of blood vessels and reaching to damaged area is known as-
(*a*) Margination
(*b*) Metastasis
(*c*) Diapedesis
(*d*) Angiobiosis

83. In humans interferon is produced by leucocytes, fibroblasts in connective tissue and lymphocytes and are termed as a-IFN, b-IFN and g-INF resp. The interferons are-
(*a*) Antibacterial proteins
(*b*) Antiviral Protein
(*c*) Anti cancerous protein
(*d*) Anticancer protein

84. During embryonic stage of human B-lymphocytes are produced in-
(*a*) Bone marrow
(*b*) Spleen
(c) Liver
(*d*) Bursa

85. Haptens are –
(*a*) Immunogenic antigen
(*b*) Non Immunogenic Antigen
(*c*) High molecular weight non immunogenic antigen
(*d*) Low molecular weight immunogenic antigen

86. Lysosomes are polymorphous organelles containing vast array of hydrolytic enzymes which can digest any foreign material only at pH-
(*a*) 5
(*b*) 6
(c) 9
(*d*) 7

87. Number of antigen functional binding site in human Immunoglobin-M are-
(*a*) 2
(*b*) 5
(*c*) 10
(*d*) 20

88. Number of amino acids in light and heavy chain of typical immunoglobin are respectively-
(*a*) 110, 220
(*b*) 220, 440
(*c*) 440, 880
(*d*) 880, 1760

89. Among the following which is not essential property of immunoglobin-
(*a*) Memory
(*b*) Specificity
(*c*) Diversity
(*d*) Reactivity

90. Spectrin of erythrocytes and cytochrome c of mitochondria, which can be easily dissociated by high ionic strength and metal ion chelating agent are example of-
(*a*) Extrinsic Protein
(*b*) Intrinsic protein
(*c*) Tunnel Protein
(*d*) Cytoplasmic Protein

91. Polyclonal antibodies are-
(*a*) Clones against single antigen by many B-cells
(*b*) Clones against single antigen by single B-cells
(*c*) Clones against many antigen by single B-cells
(*d*) Clones against many antigen by many B-cells

92. Lymphokines that recruit the macrophages for Phagocytosis are secreted by-
(*a*) T-cells
(*b*) B-cells
(*c*) Complement system
(*d*) MHC

93. Liposomes are-
(*a*) Lipid filled bags
(*b*) Artificial membranes
(*c*) Liver Fat bodies
(*d*) Eukaryotic organelle

94. Which among the following act as bridge between cell mediated and humoral immunity-
(*a*) T-cytoxic cells
(*b*) T-suppressor cells
(*c*) B-cells
(*d*) T-helper cells

95. In humans cell recognition molecules are-
(*a*) HLA
(*b*) B-cells
(*c*) T-Cells
(*d*) Immunoglobins

96. Cancers cell are monoclonal, are characterized by uncontrolled growth, invasion of other tissues and dissemination to other tissues. The phenomenon of invasion to other tissues is termed as-
(*a*) Angiobiogenesis
(*b*) Metastasis
(*c*) Diapedesis
(*d*) Transformation

97. A major protease secreted by cancer cells acts on plasminogen and converts it into plasmin. Plasmin is proteolytic enzyme that dissolves blood clots and also removes exposed protein groups at cell surface. If the plasminogen is removed form the medium, then-
 (*a*) The morphology of cancer cells returns to normal.
 (*b*) The cancer cell will show more exponential growth.
 (*c*) Cancer cell will die
 (*d*) No change will be seen

98. One of the major higher molecular weight glycoprotein component which can be easily isolated from normal cultured fibroblast by mild treatment of urea, also occur at "foot prints" that moving culture cells leaves, is totally absent in cancerous cell is-
 (*a*) Fibronectin (*b*) Albumin
 (*c*) Ferritin (*d*) Transferin

99. The sex determination in drossophila is based on-
 (*a*) X-Chromosome (*b*) Y chromosome
 (*c*) Autosome (*d*) Both a & c

100. Environmental control of sex determination is seen in-
 (*a*) Melandrium (*b*) Drosophila
 (*c*) Bonelia (*d*) Apes indica

Practice Test Paper-II

1. Which of the following is not a function of mitotic cell division in
   (*a*) repair of damaged organs
   (*b*) production of gametes
   (*c*) asexual reproduction
   (*d*) growth

2. Which of the following would not be considered part of a cell's cytoplasm?
   (*a*) a ribosome
   (*b*) the nucleus
   (*c*) a mitochondrion
   (*d*) a microtubule

3. It is difficult to observe individual chromosomes with a light microscope during interphase because:
   (*a*) they have uncoiled to form long, thin strands
   (*b*) they leave the nucleus and are dispersed to other parts of the cell
   (*c*) the DNA has not been replicated yet
   (*d*) the spindle must move them to the metaphase plate before they become

4. The maximum size of a cell is limited by
   (*a*) its need for enough surface area for exchange with its environment.
   (*b*) the number of organelles that can be packed inside.
   (*c*) the materials needed to build it.
   (*d*) the amount of flexibility it needs to be able to move.

5. You would expect a cell with an extensive Golgi apparatus to
   (*a*) make a lot of ATP.
   (*b*) secrete a lot of material.
   (*c*) move actively.
   (*d*) perform photosynthesis.

6. Which of the following correctly matches an organelle with its function?
   (*a*) mitochondrion . . . photosynthesis
   (*b*) nucleus . . . cellular respiration
   (*c*) ribosome . . . manufacture of lipids
   (*d*) central vacuole . . . storage

7. Mitochondria and cholorplasts share several common features, for example,
   (*a*) both are capable of semiautonomous growth and reproduction.
   (*b*) neither are components of the endomembrane system.
   (*c*) each contains a small amount of DNA
   (*d*) all of the above.

8. In muscle cells the ____ is specialized for the storage and release of calcium.
   (*a*) smooth ER
   (*b*) the Golgi apparatus
   (*c*) contractile vacuoles
   (*d*) rough ER

9. Of the following organelles, which group is involved in manufacturing substances needed by the cell?
   (*a*) lysosome, vacuole, ribosome
   (*b*) ribosome, rough ER, smooth ER
   (*c*) vacuole, rough ER, smooth ER
   (*d*) smooth ER, ribosome, vacuole

10. The internal skeleton of a cell is composed of
   (*a*) microtubules, intermediate filaments, and microfilaments.
   (*b*) cellulose and intermediate filaments.
   (*c*) cellulose, microtubules, and centrioles.
   (*d*) microfilaments.

11. Cells will usually divide if they receive the proper signal at a
   (*a*) M (*b*) S
   (*c*) G2 (*d*) G1

12. Dye injected into a plant cell might be able to enter an adjacent cell through a
   (*a*) tight junction. (*b*) microtubule.
   (*c*) desmosome. (*d*) plasmodesma.

13. A researcher made an interesting observation about a protein made by the rough ER and eventually used to build a cell's plasma membrane. The protein in the membrane was actually slightly different from the protein made in the ER. The protein was probably changed in the
   (*a*) Golgi apparatus. (*b*) smooth ER.
   (*c*) mitochondrion. (*d*) nucleus.

14. When elongated, tube-shaped cells from the lining of the intestine are treated with a certain chemical, the cells sag and become round blobs. The internal structures disrupted by this chemical are probably
   (*a*) cell junctions. (*b*) microtubules.
   (*c*) rough ER. (*d*) dynein.

15. The electron microscope has been particularly useful in studying bacteria, because
   (*a*) electrons can penetrate tough bacterial cell walls.
   (*b*) bacteria are so small.
   (*c*) bacteria move so quickly they are hard to photograph.
   (*d*) with few organelles present, bacteria are distinguished by differences in individual macromolecules.

16. Cell fractionation is the most appropriate procedure for preparing ____ for study.
   (*a*) isolated cells which are normally found tightly attached to neighbouring cells
   (*b*) cells without a functional cytoskeleton
   (*c*) isolated organelles
   (*d*) the basic macromolecules

17. Which of the following clues would tell you whether a cell is prokaryotic or eukaryotic?
    (*a*) the presence or absence of a rigid cell wall
    (*b*) whether or not the cell is partitioned by internal membranes
    (*c*) the presence or absence of ribosomes
    (*d*) whether or not the cell carries out cellular metabolism

18. Seema would like to film the movement of chromosomes during cell division. Her best choice for a microscope would be a
    (*a*) transmission electron microscope, because of its magnifying power.
    (*b*) scanning electron microscope, because the specimen is alive.
    (*c*) transmission electron microscope, because of its great resolving power.
    (*d*) light microscope, because the specimen is alive.

19. A plant cell was grown in a test tube containing radioactive nucleotides, the parts from which DNA is built. Later examination of the cell showed the radioactivity to be concentrated in the
    (*a*) rough ER. (*b*) peroxisome.
    (*c*) nucleus. (*d*) central vacuole.

20. When isolated liver cells are combined with nonpolar toxins initial processing in the ___ increases the solubility of these compounds as an initial step in their excretion.
    (*a*) smooth ER (*b*) Golgi apparatus
    (*c*) mitochondrion (*d*) rough ER

21. Discontinuous segments of DNA are joined by:
    (*a*) telomerase (*b*) DNA ligase
    (*c*) exonuclease (*d*) DNA polymerase

22. The concentration of calcium in a cell is 0.3%. The concentration of calcium in the surrounding fluid is 0.1%. How could the cell obtain more calcium?
    (*a*) passive transport (*b*) diffusion
    (*c*) active transport (*d*) osmosis

23. Phospholipid molecules in a membrane are arranged with their ____ on the exterior and their ____ on the interior.
    (*a*) hydrophobic heads . . . hydrophilic tails
    (*b*) hydrophilic heads . . . hydrophobic tails
    (*c*) nonpolar heads . . . polar tails
    (*d*) hydrophobic tails . . . hydrophilic heads

24. Sister chromatids:
    (*a*) are created when DNA is replicated
    (*b*) are separated during mitosis
    (*c*) are attached at the centromere prior to division
    (*d*) all of the above

25. Which of the following correctly matches a phase of the cell cycle
    (*a*) S, immediately precedes cell division (*b*) M, duplication of DNA
    (*c*) G1, immediately follows cell division (*d*) G2, cell division

26. The kinetochores:
    (*a*) are the primary centromere structures that maintain the attachment
    (*b*) attach to the ring of actin along the cytoplasmic surface of the plasma membrane
    (*c*) move along spindle microtubules during anaphase, dragging
    (*d*) are located at the center of the centromere their function is to provide attachment site to spindle fibre

27. A biochemist measured the amount of DNA to be doubled during the cells in growing stages
    (*a*) between prophase and anaphase
    (*b*) between anaphase and telophase
    (*c*) during the M phase of the cell cycle
    (*d*) between the G1 and G2 phases

28. DNA damaged by sunlight:
    (*a*) has undergone depurination (*b*) has lost its phosphate groups
    (*c*) has formed pyrimidine dimers (*d*) has lost its hydrogen bonds

29. Which of the following functional processes results from the presence of protein within the plasma membrane?
    (*a*) enzymatic activity (*b*) signal transduction
    (*c*) intercellular joining (*d*) all of the above

30. Select the correct statement concerning membrane carbohydrate.
    (*a*) Carbohydrates are only found associated with the membranes of prokaryotic cells.
    (*b*) Glucose is the most abundant membrane carbohydrate.
    (*c*) Cell membranes consist of protein and phospholipid; carbohydrate is not a membrane component.
    (*d*) membrane carbohydrates function primarily in cell-cell recognition.

31. Imagine two solutions separated by a selectively permeable membrane which allows water to pass, but not sucrose or glucose. The membrane separates a 0.2 M sucrose solution from a 0.2 glucose solution. With time how will the solutions change?
    (*a*) Nothing happens because the two solutions are isotonic to one another.
    (*b*) Water enters the sucrose solution because the sucrose molecule is a disaccharide, and is larger than the monosaccharide glucose.
    (*c*) Water leaves the sucrose solution because the sucrose molecule is a disaccharide, and is larger than the monosaccharide glucose.
    (*d*) The sucrose solution is hypertonic and will gain water because the total mass of sucrose is greater than that of glucose.

32. During cytokinesis in plants:
    (*a*) a bundle of actin microfilaments called the contractile ring, pinch the cell in half
    (*b*) small vesicles, directed by the phragmoplast, move to the spindle
    (*c*) a cleavage furrow encircles the cell
    (*d*) cytoplasmic division is called cleavage

33. Progression through the eukaryotic cell cycle is regulated by:
    (*a*) microtubules (*b*) the p53 gene
    (*c*) cyclin-dependent kinases (*d*) DNA ligase

34. The result of the operation of an electrogenic pump would be
    (*a*) an electrochemical gradient on the cell membrane
    (*b*) a resting potential across the membrane
    (*c*) plasmolysis
    (*d*) a cell with a positively charged interior

35. A plant cell is placed in a solution whose solute concentration is twice as great as the concentration of the cell cytoplasm. The cell membrane is selectively permeable, allowing water but not the solutes to pass through. What will happen to the cell?
    (*a*) No change will occur because it is a plant cell.
    (*b*) The cell will shrivel because of osmosis.
    (*c*) The cell will swell because of osmosis.
    (*d*) The cell will shrivel because of active transport of water.

36. One consequence of the sidedness of the plasma membrane is that
    (*a*) molecules that begin on the inside face of the ER end up on the inside face of the plasma membrane
    (*b*) the asymmetrical distribution for membrane proteins, lipids, and carbohydrate must be determined when the membrane is first constructed
    (*c*) some proteins on the cytoplasmic side of the membrane are attached to the cytoskeleton
    (*d*) the inside of an ER vesicle is topographical equivalent to the extra cellular surface of the plasma membrane

37. The p53 gene:
    (*a*) is the most frequently mutated gene in human cancer
    (*b*) can lead to cell cycle arrest at the G1 checkpoint
    (*c*) can trigger apoptosis.
    (*d*) all of the above

38. During the Ras pathway:
    (*a*) cytoplasmic protein kinases are activated
    (*b*) the growth factor receptor is dephosphorylated
    (*c*) growth factors bind to receptors in the cytoplasm
    (*d*) leads to the production of translation factors

39. If a DNA molecule has a deaminated base, it will be repaired by:
    (*a*) by excision repair pathways
    (*b*) with the help of repair endonucleases
    (*c*) by base excision repair
    (*d*) with the help of DNA glycosylases

40. A benign tumor is one in which the cancerous cells:
    (*a*) have an unusual number of chromosomes
    (*b*) can divide indefinitely if an adequate supply of nutrients is available
    (*c*) migrate from the initial site of transformation to other organs or
    (*d*) remain confined to their original site

41. A DNA molecule is a polymer made of subunits called
    (*a*) bases. (*b*) amino acids.
    (*c*) nucleotides. (*d*) nucleic acids.

42. A human somatic cell contains _____ chromosomes.
    (*a*) 23 (*b*) 47
    (*c*) 2n (*d*) 46

43. Which of the following is a normal human female?
    (*a*) X Y (*b*) X X Y
    (*c*) X X (*d*) X

44. A karyotype would be least likely to show which of the following?
    (*a*) an extra chromosome
    (*b*) part of a chromosome duplicated
    (*d*) a missing chromosome
    (*d*) part of a chromosome turned around

45. The diploid stage of a plant that exhibits an alternation of generation is the
    (*a*) antheridium. (*b*) gametophyte.
    (*c*) spore. (*d*) sporophyte.

46. DNA replication occurs
    (*a*) whenever a cell makes protein.
    (*b*) to repair gene damage caused by mutation.
    (*c*) before a cell divides.
    (*d*) whenever a cell needs RNA.

47. Mitosis and cytokinesis result in the formation of ______; meiosis and cytokinesis result in the formation of ________.
    (*a*) 4 diploid cells; 4 haploid cells
    (*b*) 2 diploid cells; 2 haploid cells
    (*c*) 2 diploid cells; 4 haploid cells
    (*d*) 2 diploid cells; 2 diploid cells.

48. Which of the following occurs during meiosis but not during mitosis?
    (*a*) Chromosomes align at the metaphase plate.
    (*b*) Chromosomes condense.
    (*c*) Chromosomes migrate to opposite poles.
    (*d*) synapsis

49. At the end of telophase I and cytokinesis there are
    (*a*) 4 haploid cells.
    (*b*) 2 diploid cells.
    (*c*) 1 haploid ovum and 3 polar bodies.
    (*d*) 2 haploid cells.

50. Synapsis occurs during
    (*a*) anaphase I.
    (*b*) prophase I.
    (*c*) cytokinesis.
    (*d*) prophase II.

51. During anaphase II
    (*a*) homologues separate and migrate towards opposite poles.
    (*b*) sister chromatids separate and migrate towards opposite poles.
    (*c*) nuclei reform.
    (*d*) chromosomes line up in a single file.

52. During anaphase I
    (*a*) homologues separate and migrate towards opposite poles.
    (*b*) sister chromatids separate and migrate towards opposite poles.
    (*c*) nuclei reform.
    (*d*) chromosomes line up in a single file.

53. Cytokinesis is the
    (*a*) exchange of homologous regions of nonsister chromatids.
    (*b*) formation of tetrads.
    (*c*) independent assortment of chromosomes.
    (*d*) division of one cell into two

54. Centrioles separate during
    (*a*) cytokinesis.
    (*b*) prophase I and prophase II
    (*c*) metaphase I and metaphase II.
    (*d*) anaphase I and anaphase II.

55. Crossing over occurs during
    (*a*) cytokinesis.
    (*b*) metaphase I.
    (*c*) prophase II.
    (*d*) prophase I

56. Regions where nonsister chromatids cross are called
    (*a*) inversions.
    (*b*) homologues.
    (*c*) tetrads
    (*d*) chiasmata.

57. In humans, the haploid number of chromosomes is 23. Independent assortment has the possibility of producing _____ different gametes.
   (*a*) 23^2
   (*b*) 8 million
   (*c*) 22^3
   (*d*) 24

58. Crossing over is
   (*a*) the movement of genetic material from one chromosome to a nonhomologous chromosome.
   (*b*) independent assortment of chromosomes.
   (*c*) the formation of chiasmata.
   (*d*) the exchange of homologous portions of nonsister chromatids.

59. Variation occurs when chromosomes are shuffled in _____ and fertilization.
   (*a*) mitosis
   (*b*) genetic drift
   (*c*) meiosis
   (*d*) mutation

60. Heritable variation is required for
   (*a*) meiosis.
   (*b*) mitosis.
   (*c*) evolution.
   (*d*) asexual reproduction.

61. An antigen is
   (*a*) a protein molecule that helps defend the body against disease.
   (*b*) a type of white blood cell.
   (*c*) an invading virus or bacterium.
   (*d*) a foreign molecule that evokes a specific response by a lymphocyte.

62. How do memory cells differ from effector cells?
   (*a*) Memory cells are more numerous.
   (*b*) Memory cells are responsible for the primary immune response.
   (*c*) Memory cells attack invaders; effector cells do not.
   (*d*) Memory cells live longer.

63. Following tissue damage or the entry of microorganisms, an inflammatory response may be initiated by
   (*a*) the accumulation of phagocytes in an injured area.
   (*b*) the release of interferon by infected cells.
   (*c*) an increased blood flow in an infected or injured area.
   (*d*) the release of chemicals such as histamine by damaged cells.

64. Which of the following could be considered a nonspecific defense?
   (*a*) Intact skin creates a barrier that cannot normally be penetrated by bacteria or viruses.
   (*b*) Secretions from sebaceous and sweat glands give the skin an acidic pH that prevents bacterial colonization.
   (*c*) Tears, saliva, and mucous secretions contain lysozome, an enzyme that digests the bacterial cell wall.
   (*d*) all of the above

65. During a secondary immune response
   (*a*) selected B generate antibody-producing effector B cells called plasma cells.
   (*b*) the stricken individual may become ill.
   (*c*) about 10 to 17 days are required from exposure to maximum effector response.
   (*d*) the generation of effector cells begins with memory cells produced during the primary immune response.

66. Most individuals infected with HIV
   (*a*) can live for 15 to 20 years.
   (*b*) never develop AIDS.
   (*c*) die from autoimmune reactions.
   (*d*) die from other infections or cancer.

67. Tissues are typed before an organ transplant to make sure that the _____ of donor and recipient match as closely as possible.
   (*a*) T cells
   (*b*) antibodies
   (*c*) MHC (major histocompatibility complex) proteins
   (*d*) histamines

68. A vaccine contains
   (*a*) white blood cells that fight infection.
   (*b*) antibodies that recognize invading microbes.
   (*c*) inactivated disease-causing microbes.
   (*d*) a hormone that boosts immunity.

69. When you are immune to a disease,
   (*a*) antibodies against the disease are constantly circulating in your blood.
   (*b*) certain lymphocytes are able to make the proper antibodies quickly.
   (*c*) your nonspecific defenses are strengthened.
   (*d*) B cells are stimulated to quickly engulf invaders.

70. In a series of immune system experiments, the thymus glands were removed from baby mice. Which of the following would you predict as a likely result?
   (*a*) The mice suffered from numerous allergies.
   (*b*) The mice never developed cancerous tumors.
   (*c*) The mice suffered from autoimmune diseases.
   (*d*) The mice readily accepted tissue transplants.

71. The body produces antibodies complementary to foreign antigens. The process by which the body comes up with the correct antibodies to a given disease is most like
   (*a*) going to a tailor and having a suit made to fit you.
   (*b*) ordering the lunch special at a restaurant without looking at the menu.
   (*c*) going to a shoe store and trying on shoes until you find a pair that fits.
   (*d*) selecting a lottery prize-winner by means of a random drawing.

72. The antigen-binding sites of an antibody molecule are formed from the molecule's variable regions. Why are these regions called variable?
    (*a*) They can change their shapes on command to fit different antigens.
    (*b*) They change their shapes when they bind to an antigen.
    (*c*) They can be different shapes on different antibody molecules.
    (*d*) Their sizes vary considerably from one antibody to another.

73. The biggest difference between cell-mediated immunity and humoral immunity is
    (*a*) how long their protection lasts.
    (*b*) whether a subsequent secondary immune response can occur.
    (*c*) whether clonal selection occurs.
    (*d*) how they respond to and dispose of invaders.

74. Viruses and bacteria in body fluids are attacked by
    (*a*) antibodies from B cells.
    (*b*) cytotoxic T cells.
    (*c*) complement proteins.
    (*d*) helper T cells.

75. What do the antibodies secreted by plasma cells (the effector cells of humoral immunity) do to attack their targets?
    (*a*) activate complement to punch holes in them
    (*b*) clump cells together so that phagocytes can ingest them
    (*c*) cause antigen molecules to settle out of solution
    (*d*) all of the above

76. Tissue macrophages
    (*a*) begin their lives as neutrophils.
    (*b*) have short life spans because they self-destruct after engulfing foreign invaders.
    (*c*) originate from monocytes that leave the circulation and enter the tissues.
    (*d*) are most effective against parasites.

77. The idea behind vaccination is to induce _____ without the vaccinated individual having to get sick.
    (*a*) passive immunity
    (b) the primary immune response
    (*c*) anaphylactic shock
    (*d*) nonspecific defenses

78. A group of researchers have tested many chemicals and found several that have potential for use in modifying the action of the immune system. Which of the following would seem to have the most promise as a drug for inhibiting transplant rejection?
    (*a*) Compound A13: acts like histamine
    (*b*) Compound Q6: suppresses cytotoxic T cells
    (*c*) Compound N98: a potent allergen
    (*d*) Compound M31: stimulates helper T cells

79. Collagens:
    (*a*) are high in glycine, hydroxylysine and hydroxyproline
    (*b*) are the most abundant proteins in vertebrates
    (*c*) are the most abundant component of the extracellular matrix in animals
    (*d*) all of the above

80. The ECM of animals cells consists of what three classes of molecules?
    (*a*) protein-polysaccharides, structural proteins, microtubules
    (*b*) structural proteins, lipid bilayers, adhesive glycoproteins.
    (*c*) lipoproteins, polysaccharides, and adhesive glycoproteins.
    (*d*) structural proteins, protein-polysaccharides, adhesive glycoproteins

81. Procollagen consists of _______ and is formed in the lumen of the:
    (*a*) 2 β sheets, lysosomes
    (*b*) 3 β sheets, E R
    (*c*) 3 α chains, Golgi
    (*d*) 3 α chains, E R

82. The flexibility of the lungs is due mainly to:
    (*a*) laminins (*c*) elastins
    (*b*) collagens (*d*) fibronectins

83. A difference between collagen and elastin is that:
    (*a*) elastin has hydroxylysines and collagen does not
    (*b*) collagen does not have hydroxylated proline residues
    (*c*) there are over 15 types of elastins and less than 5 types of collagens
    (*d*) elastin molecules are crosslinked by covalent bonds between lysine residues, and collagen is not

84. Which is the correct order from least to most complex?
    (*a*) Glucuronate, hyaluronate, proteoglycans, GAG
    (*b*) Hyaluronate, glucuronate, GAG chains, proteoglycans
    (*c*) GAG chains, hyaluronate, glucuronate, proteoglycans
    (*d*) Glucuronate, hyaluronate, GAG chains, proteoglycans

85. Two of the most common adhesive glycoproteins in the ECM are:
    (*a*) laminins and elastins
    (*b*) collagens and elastins
    (*c*) fibronectins and laminins
    (*d*) collagens and fibronectins

86. Fibronectins have an effect on:
    (*a*) blood clotting (*b*) cell shape
    (*c*) cell movement (*d*) all of the above

87. The most abundant glycoproteins in the basal lamina are ______
(*a*) collagens
(*b*) entactin
(*c*) laminins
(*d*) fibronectins

88. The most abundant protein in human body is-
(*a*) Collagen
(*b*) Fibronectin
(*c*) Globin
(*d*) albumin

89. Roles of the glycocalyx include:
(*a*) cell adhesion
(*b*) cell recognition
(*c*) creation of permeability barriers
(*d*) all of the above

90. A red blood cell has just been targeted for destruction. This cell:
(*a*) has an increase in sialic acid groups.
(*b*) has a decrease in sialic acid groups
(*c*) has exposed galactose residues
(*d*) B and C

91. The three most common cell junctions in animals are:
(*a*) adhesive junctions, tight junctions, gap junctions
(*b*) adhesive junctions, tight junctions, plasmodesmata
(*c*) tight junctions, plasmodesmata, adhesive junctions
(*d*) gap junctions, tight junctions, plasmodesmata

92. The reason urine does not seep out of the bladder is due to the role of:
(*a*) adherens junctions
(*b*) hemidesmosomes
(*c*) gap junctions
(*d*) tight junctions

93. Desmosomes and hemidesmosomes are anchored in the cytoplasm by:
(*a*) desmocollins
(*c*) actin fibers
(*b*) collagen
(*d*) tonofilaments

94. Gap junctions consist of channels formed by:
(*a*) hydrophilic, connexons
(*b*) hydrophobic, cadherins
(*c*) hydrophobic, connexons
(*d*) hydrophilic, cadherins

95. A plant cell wall includes all of the following EXCEPT:
(*a*) hemicellulose
(*b*) extensins
(*c*) cellulose
(*d*) collagen

96. Which of the following would be most likely to lead to cancer?
(*a*) hyperactivity of both a proto-oncogene and a tumor-suppressor
(*b*) amplification of a proto-oncogene and the failure of a tumor-suppressor gene
(*c*) hyperactivity of bith a proto-oncogene and a tumor suppressor gene
(*d*) failure of a proto-oncogene to produce a protein and amplification of tumor suppressor gene

97. The characteristic strength of woody tissues is due to:
    (*a*) the secondary cell wall
    (*b*) hemicellulose
    (*c*) the middle lamina
    (*d*) the primary cell wall

98. The rule is derived from the ER and is continuous with the ER of two adjacent plant cells.
    (*a*) middle lamina
    (*b*) annulus
    (*c*) plasmodesma
    (*d*) desmotubule

99. One can estimate the length of M phase by knowing:
    (*a*) the S phase
    (*c*) the age of the cell
    (*b*) the mitotic index
    (*d*) the generation time

100. What is true of proto-oncogenes?
    (*a*) cells produce proto-oncogenes as a by-product of mitosis
    (*b*) proto-oncogenes are necessary for normal control of cell division
    (*c*) proto-oncogenes are genetic junk that has not yet been eliminated by natural selection
    (*d*) proto-oncogenes are unavoidable environmental carcinogens.

2

Biochemistry

BASIC CHEMISTRY

I. Properties of water

A. Water is polar

B. Effect on non-covalent bonds

1. electrostatic $A^+ \ldots\ldots\ldots B^-$
2. hydrogen bonds $-A-H\ldots\ldots B^-$ (A,B=N,O,S)
3. hydrophobic bonds (exclusion by water)
4. van der Waals forces optimal distance (Vanderwall contact distance)

C. Water ionization

1. $H_2O \Longleftrightarrow H^+ + OH^-$
2. $\text{Keq} = \dfrac{[H^+][OH^-]}{H_2O} = \dfrac{[H^+][OH^-]}{[55.5]}$

   $\text{Kw} = \text{Keq} \times 55.5 = [H^+]\,[OH^-] = 1 \times 10^{-14}$ at 25ºC
3. Pure water: $[H^+] = [OH^-] = 1 \times 10^{-7}$

II. Definition of pH and pOH

A. General: p"X" = log (1/"X") = –log"X"

B. $\text{pH} = -\log[H^+]$

C. $\text{pOH} = -\log[OH^-]$

D. $\text{pKw} = -\log \text{Kw} = \text{pH} + \text{pOH} = 14$

E. $\text{pKa} = -\log \text{Ka}$

F. A ten-fold change in $[H^+]$ alters the pH by 1.0 unit.

III. Buffers

1. A buffer is a mixture of a weak acid and the salt of that acid.
2. The practical buffer zone is pKa ñ 1 pH.
3. The Henderson-Hassalbalch equation is used for calculations involving buffers.

$$pH = pKa + \log\frac{[A^-]}{[HA]}$$

4. pH of a buffer is theoretically independent of dilution (depends only on the ration of A^-/HA and pKa).

IV. Solving pH problems

A. Strong acids (completely dissociated)

$[H^+]$ = normality of acid pH = $-\log[H^+]$

B. Strong bases (completely dissociated)

$[OH^-]$ = normality of base pOH = $-\log[OH^-]$ pH + pOH = 14

C. Weak acids: two kinds of problems

1. % ionization x molarity = $[H^+]$
2. $$Ka = \frac{[H^+][A^-]}{[HA]} = \frac{x^2}{[HA]^- x} \sim \frac{x^2}{[HA]}$$

$x = [H^+] = \{Ka \times [HA]\}^-$

V. Atoms

- Atoms are like a planetary system with negative electrons circling around a positively charged nucleus
  - In electricity opposite charges attract one another; like charges repel
    - All atoms are formed by the attraction of oppositely charged particles (electrons & protons)
  - Nucleus: has protons with (+) charge and neutrons with (0) charge
    - Almost all of mass of an atom is located in the protons and neutrons of the nucleus
    - The number of protons is called the atomic number
    - The type of atom is determined by the number of protons: carbon has 6 protons, nitrogen has 7, etc...
  - Orbits have electrons with (–) charge
    - Orbits are organized in a series of shells around the nucleus
    - Electrons have a very small mass
    - Chemical reactions involve the electrons, especially those in the outer shell
  - Charges in an uncharged atom must balance (electrons = protons)
- **Isotopes:** if you change the number of neutrons in the nucleus you produce different isotopes of an element
  - Some, but not all, isotopes are radioactive
  - Schematic diagram of 3 isotopes of carbon:

    - 6 electrons spin around nuclei in 2 shells (inner shell has 2 electrons; outer has 4)
    - Nuclei all have 6 protons: this makes them carbon atoms
    - Different numbers of neutrons produce different isotopes:
        - Carbon–12: 6 neutrons: this is the most common isotope of carbon (over 99%)
        - Carbon–13: 7 neutrons: a rare natural isotope
        - Carbon–14: 8 neutrons: a radioactive isotope produced in the atmosphere by cosmic rays; it is also produced in atom bomb tests
        - The isotope numbers are the sums of the protons and neutrons and they give the relative atomic masses
        - Carbon–14 has a higher mass and weighs more than carbon–12
- The chemical properties of the 3 isotopes will be almost identical, but some of the physical properties will be different
- Isotopes are frequently used as “tracers” in research and medicine

VI. Molecules and Chemical bonding

- All interactions between atoms are electrical attractions between charges
- Ionic and covalent bonds hold atoms together to form molecules
- Weak bonds (hydrogen, van der Waals and other types) hold molecules together
- Atoms make bonds by donating or sharing electrons
- **Ionic bonds**
    - Compounds with ionic bonds split into ions in water. Ions conduct electricity. Gives specialized cells (nerve, muscle) excitable properties.
    - Suppose Na gives one of its electrons to Cl; the Na now has a (+) charge and the Cl will have a (–) charge
        - These charged atoms are referred to as ions, and since they have opposite charges they attract each other and form a chemical bond (they form NaCl, common table salt)
        - Positively charged ions = cations (i.e, Na^+)
        - Negatively charged ions = anions (i.e., Cl^-)
- **Covalent bonds**
    - Each atom donates 1 or more electrons to the bond
    - The bonding electrons spend most of their time between the 2 atoms, attracting both nuclei and pulling them together
    - If each atom donates 2 electrons to a bond a double bond is formed
    - double bonds are stronger and more rigid than single bonds
    - A triple bond is formed when each atom donates 3 electrons to the bond
    - This type of bond holds together the long chains of macromolecules. These molecules do not split apart in water.

- **Hydrogen bonds**
  - Occur when a hydrogen ion is sandwiched between 2 atoms, usually nitrogen and oxygen
  - Much weaker (about 25 times) than covalent or ionic bonds
  - Occur between molecular groups with permanent dipoles
  - Water: makes water molecules stick together. Responsible for many of the strange properties of water.
  - Proteins: cause protein chains to spiral and bend, giving unique shapes. In DNA: hold together the 2 chains to form the double helix. Allow chains to "unzip" for replication and transcription.
- **Van der Waals & other weak bonds**
  - Weak forces that can bond like atoms together
  - Especially important between chains of carbon atoms
    - Although weak, numerous bonds between the chains can add up to produce significant cohesion
  - Determine physical state of compounds: gas, liquid or solid
  - Occur when one atom induces a temporary dipole in another atom
  - Important in holding like molecules together. Often determine the solid, liquid or gas state of a compound. Saturated fats are solid at room temperature because the have more van der Waals attractions than unsaturated fats, which are liquid.

Rates of and Equilibrium States of Chemical Reactions are Determined by Concentrations of the Reactants

- Consider a simple reaction in which 2 substances, A & B, react to form a third substance, C:
  - $A + B \leftrightarrow C$
  - The rate at which C is formed (in moles/second) will be proportional to the concentrations of A, B and C
    - Rate = Kf{A}{B} – Kb{C}
    - {A}, {B} and {C} = concentrations of A, B and C, respectively; Kf = rate constant of forward reaction, Kb = rate constant of backward reaction
      - Forward reaction rate = Kf{A}{B}
      - Backward reaction rate = Kb{C}
    - This relationship is a fundamental law of chemistry, called the Law of Mass Action
    - Note that if you double the concentration of either A or B, the rate of the forward reaction will double
    - Concentrations are the number of molecules or moles per unit of volume
    - Usually concentrations are given in moles/litre
    - Example: if you have 3 moles of NaCl dissolved in 6 liters of water the concentration is:
    - 3moles/6 litres = 0.5 moles/litre = 500 mM/litre
- Why are chemical reaction rates proportional to concentration?
    - Molecules must collide to react & number of collisions per second is proportional to the concentration

- Other factors affect reaction rates by changing the rate constants:
  - Temperature: affects rates in 2 ways:
  - High temperature causes molecules to move faster producing more collisions
  - At high temperature molecules have more energy and are more likely to react with other molecules
  - Catalysis: reaction rates can be greatly accelerated by certain types of molecules- this will be discussed in lecture 4 when we consider enzymes
- A chemical reaction proceeds until forward and backward reactions are equal
  - At this point the reaction is at equilibrium and concentrations do not change
  - At equilibrium:
    - Kf{A}{B} = Kb{C}
    - Ke = Kf/Kb = {A}{B}/{C}
    - The equilibrium constant (Ke) is the forward rate constant (Kf) divided by the backward rate constant (Kb)
  - Note: at equilibrium {C} = {B}/{C}/Ke; thus, both the rates of reaction and equilibrium concentrations are determined by concentrations of reactants

BIOENERGETICS

I. Energy producing and energy utilizing systems

A. Catabolic pathways – generation of energy by transformation (glycolysis) or oxidation (oxidative phosphorylation) of ingested or stored fuels.

B. Anabolic pathways – utilization of energy for biosynthetic purposes (DNA synthesis, protein synthesis, etc.)

C. ATP – the link between the two pathways

1. Phosphoanhydride bonds as high energy bonds
2. Other nucleotides
   (*a*) GTP: gluconeogenesis and protein synthesis
   (*b*) CTP: lipid synthesis
   (*c*) UTP: glycogen synthesis
   (*d*) All depend on ATP formation: nucleoside diphosphate kinase
3. Other bonds having a high free energy of hydrolysis (> 7 kcal/mole)
   (*a*) 1,3 bis-phosphoglycerate (mixed acid anhydrides)
   (*b*) Phosphoenolpyruvate (enol phosphates)
   (*c*) Creatine phosphate (phosphoguanidines)
   (*d*) Pyrophosphate (phosphoric acid anhydrides)
   (*e*) Acetyl CoA (thiol esters)

II. Thermodynamic relationships and energy rich compounds

A. Laws of thermodynamics

1. **First Law:** energy may be converted from one form to another, but the total in a system remains constant. (Glucose $\rightarrow$ lactate + ATP)

2. **Second Law:** Entropy (ΔS) is a measure of disorder or randomness of a system. All systems tend to progress towards maximum entropy. Entropy is unavailable to perform useful work.
3. **Free energy (ΔG):** available for useful work
   (*a*) $\Delta G = \Delta H - T\Delta S$ (ΔH =enthalpy, T = temperature in degrees K)
   (*b*) **Exergonic:**free energy lost, spontaneous reaction (ΔG less than 0)
   (*c*) **Endergonic:**requires energy for reaction to proceed (ΔG greater than 0)
   (*d*) **At $\Delta G = 0$, the reaction is at equilibrium**
   (*e*) The actual free energy change (ΔG for a reaction is equal to the standard free energy ($\Delta Go'$) plus a term tha depends on actual concentrations of products and reactants

$$\Delta G' = \Delta Go' + RT\ln\{[Products]/[Reactants]\}$$
$$\Delta G' = \Delta Go + 1.4 \log P/ \text{ (in kcal/mole)}$$
$$\text{Where } \Delta Go' = -Rt\ln(Keq = -1.4 \log(Keq) \text{ (inkcal/mole)}$$

   (*f*) **Free energy changes for coupled reactions are ADDITIVE**

$\Delta Go'$	$A + B \rightarrow C + D$	–5.0
	$D \rightarrow P + Q +$	4.5
Sum of coupled rx	$A + B \rightarrow C + P + Q$	– 0.5

B. Thermodynamics of membrane transport

1. Uncharged molecules: $\Delta Go' = RT \ln \{[C2]/[C1]\} = 1.4 \log\{[C2]/[C1]\}$
   where the direction of transport is from C1 to C2
2. Charged molecules: must also consider the membrane potential (inside -ve generally)

$$\Delta Go' = RT \ln \{[C2]/[C1]\} + Z(\Delta\psi) = 1.4 \log \{[C2]/[C1]\} + 23Z(\Delta\psi)$$

where F = Faraday constant = 23 kcal V–1mole–1
$\Delta\psi$ = the membrane potential (in volts)
and Z = the charge on the ion

ENZYMES

1. Enzymes were discovered by **Buchner** (1897-1903) but term enzyme was given by **Kuhne** (1878).
2. Almost all enzymes are proteins. However, **ribozyme, ribonuclease** P are non protein enzyme.
3. Every cell produces its own enzymes because they cannot move from cell to cell due to high molecular weight.
4. All components of cell including cell wall and cell membrane have enzymes.
5. Maximum enzymes in the cell are found in mitochondrion.
6. **Smallest enzyme** is **peroxidase** and **largest enzyme** being **catalase** found in peroxisomes.
7. Enzyme **urease** isolated from Jack bean *Canavalia* was crystallized by Summer in 1926, who proved protein nature of enzymes.

8. Enzymes show reversible reactions and act by lowering energy of activation by more than 50%.
9. Enzymes show three dimensional structures.
10. K_m (**Michaelis Mention Constant**) is the substrate concentration at which the chemical reaction attains half its maximum velocity. It is an inverse measure of the affinity of an enzyme for its substrate. Small the K_m, the greater the substrate affinity. Allosteric enzymes do not obey K_m constant.
11. Over 2000 enzymes have been recorded. Enzymes are synthesized by living cells. Most of the enzymes remain and function inside the cells. These are called **endoenzymes** (or **intracellular enzymes**). On the other hand, the enzymes which leave the cells and function outside them are called **exoenzymes** (or **extracellular enzymes**). These retain their catalytic ability even when extracted from cells. Rennet tablets (containing the enzyme rennin from the calf's stomach) have been in use for coagulating milk protein to obtain casein (cheese from milk).
12. A large number of enzymes require an additional non protein component called prosthetic group for their efficient activity. Prosthetic group may be divided rather loosely into two groups – (a) **Metal activators**; (b) **Cofactors** or **coenzymes**.
13. In **holoenzymes**, the **apoenzyme** (protein part) determines the specificity while **coenzyme** (prosthetic group) determines the catalytic functional activity of enzyme.
14. The proteinaceous part of enzyme is called **apoenzyme**. The apoenzyme plus non proteinaceous part is called **holoenzyme**. Some enzymes require a loose association with certain organic substances for their activity. These prosthetic groups are called **cofactors** or **coenzymes**. Examples of coenzymes are – **NAD** (nicotinamide adenine dinucleotide), **NADP** (nicotinamide adenine dinucleotide phosphate), **ATP** (adenosine triphosphate), **CoA** (coenzyme A), **FMN** (Flavin mononucleotide) and **FAD** (Flavin adenine dinucleotide). FAD and FMN contain **riboflavin** (vitamin B_2) as a component. **Riboflavin** is the hydrogen accepting part of FAD/FMN.
15. Enzymes are required in minute quantities which is sufficient to convert a large amount of substrates (starting materials of a reaction) to products (ending materials of a reaction).
16. Every enzyme has its own optimum pH. Any shift towards alkaline or acidic side results in a decrease in enzyme activity because it denatures the enzyme molecule (changes its shape). **Pepsin** of gastric juice has optimum activity at pH 2.0, while **trypsin** shows maximum acitivity at pH 8.0.
17. Every enzyme has a specific optimum temperature.
18. Over a range of **0–40°C**, the rate of enzyme controlled reaction almost doubles for every rise of 10°C. (Q_{10} = 2).
19. Most enzymes show maximum activity in a temperature range of **25–40°C**.
20. Enzymes are thermolabile i.e. are denatured at high temperatures. The loss of catalytic properties begins at 36°C and is almost complete as 60°C is reached. However, dried enzyme extracts can endure temperature of 100°C–120°C or even higher. That is why; dry seeds can endure high temperature than germinating seeds.
21. Enzymes are generally specific for the type of reactions they catalyse. This specificity is very strong for some enzymes.

22. Enzymes are colloidal in nature; and have high molecular weights raning from 10,000–50,000. However, the molecular weights of catalase and urease are 2,50,000 and 4,83,000 respectively.

23 **IUB** (1962) has divided enzymes into 6 classes (**oxidoreductases, transferases, hydrolases, lyases, isomerases** and **ligases**). Each class is divided into sub-classes and each sub-class into sub-sub classes depending upon the type of reaction and nature of substrate. Thus every enzyme has a four digit code called EC Number (Enzyme Commission Number).

24. **The enzymes are classified into 6 groups on the basis of type of reactions they catalyse**:
    (*a*) **Oxidoreductases**: Transfer of H and O atoms or electrons from one substance to another. Examples are dehydrogenase, oxidase.
    (*b*) **Transferases**: Transfer of a specific group (methyl, aceyl, amino or phosphate) from one substance to another. Examples: transaminase, kinase.
    (*c*) **Hydrolases**: Hydrolysis of a substrate. Examples are lipase, amylase, peptidase, esterase, phosphatase, carbohydrase, and protease.
    (*d*) **Lyases**: Non hydrolytic removal or addition of group from substrates, C–C, C–N, C–O, or C–S bonds may be split. Examples are decarboxylase, fumarase, and aldolase.
    (*e*) **Isomerases**: Change of a substrate into a related form by intramolecular rearrangement. Examples are phosphohexose isomerase.
    (*f*) **Ligases (synthetases)**: Joining of two molecules by synthesis of new C–O, C–S, C–N or C–C bonds with simultaneous breakdown of ATP. Examples are acetyl CoA synthetase (acting on fatty acids), pyruvate carboxylase.

25. The enzyme lowers the activation energy of a reaction. (The energy required for substrates to react in order to get converted into product is called energy of activation). An enzyme (E) combines with its substrates (S) to form a short-lived enzyme-substrate (ES) complex. Within this complex, the chances of occurring of reaction are greatly increased. Once a reaction has occurred, the complex breaks up into products and enzymes. Thus, the enzyme remains unchanged at the end of the reaction; and is free to interact again with more substrates.

26. Most enzymes are far larger molecules than substrates. Only a small portion of the enzyme (3-12 amino acids) comes into direct contact with the substrate. This region is called the active site of the enzyme. An enzyme may have more than one active site. The remaining amino acids maintain the correct globular shape of the molecule. It is important for proper functioning of the **active site**.

    Fischer (1890) proposed **lock and key hypothesis** to explain specificity. He proposed that enzymes have a particular shape into which the substrate or substrates fit exactly. For a lock to work, it must be provided with right key. Similar is the case with enzyme and substrates.

27. The best evidence for this lock and key hypothesis (or template theory) of enzyme action comes from the observation that compounds similar in structure to the substrate inhibit the reaction.

28. Evidence from protein chemistry suggested that a slight rearrangement of chemical groups occurs in both enzyme and substrate when as ES complex is formed. It means

that enzymes and their active sites are rather flexible structures. **Koshland** (1959), therefore, suggested induced-fit hypothesis. According to it, when a substrate combines with an enzyme, it induces change in the enzyme structure. The amino acids constituting the active site are moulded into a precise formation which enables the enzyme to perform its catalytic function more effectively.

29. **Enzyme action can be inhibited by** (*a*) denaturation of enzymes (*b*) competitive inhibition (*c*) non competitive inhibition (*d*) allosteric modification of feedback inhibition.

(*a*) **Denaturation**: Change in the spatial arrangement of polypeptide chain within the protein molecule so that its unique structure is changed. As a result, the physical or biological properties are changed.

(*b*) **Reversible Inhibition:**

1. **Competitive inhibition**: A substance which closely resembles actual substrate structure competes with the substrate for the active site. There is a decline in the number of actual substrate molecule binding the site, as many of these are occupied by closely resembling substance. As a result, enzyme action is inhibited. Can be reversed by increasing the substrate concentration. **Vmax unaffected & Apparent Km increased** by factor (1 + [I]) /KI). **Examples**:
   - Inhibition of activity of succinate dehydrogenase by malonate & oxaloacetate.
   - Sulpha drugs e.g. sulphanilamide inhibit the synthesis of folic acid in bacteria by competing with p-amino benzoic acid (PABA).
   - AZT and AIDS
   - Methotrexate and dihydrofolate reductase
2. **Non competitive inhibition**: The inhibitor has no structural similarity to the substrate and forms an enzyme-inhibitor complex at a point other than its active site so that the globular structure of the enzyme is changed. As a result, even if the substrate is able to bind with the enzyme, catalysis cannot take place. It is characteristic of allosteric and multisubstrate enzymes. **Km unaffected** in simplest case. **Vmax decreased** by factor (1 + [I])/KI) Cyanide inhibits the activity of cytochrome oxidase. Di isopropyl fluorophosphates (nerve gas) effects nerve impulse transfer by combining irreversibly with amino acid serine of acetylcholine esterase. It also poisons a number of other enzymes with trypsin, chymotrypsin, phsphoglucomutase, elastase etc. Iodo acetamide inhibits enzymes having sulphahydrol or imidazole group.
3. **Uncompetitive** (I binds to ES complex). **Km, Vmax both decrease**. Characteristic of multisubstrate enzymes

(*c*) **Irreversible inhibitors:** Generally achieved by Covalent modification. Similar to non-competitive kinetics **(Vmax lowered, Km unaffected)** Examples:

(*i*) PCMB and GAPDH

(*ii*) DFP and Serine hydrolases (trypsin, chymotrypsin, acetyl choline esterase, etc)

(*iii*) Suicide substrates: generation of reactive intermediate by enzyme (*d*) **Feedback inhibition**: The product of an enzyme catalysed reaction/chain of reactions accumulates and acts as inhibitor of the reaction. e.g. Inhibition of threonine deaminase by isoleucine. Proteases are added in detergents and amylase is used for dish washing.

- **Trypsin** is added to partially predigested food. Immobilisation of enzymes is done by attaching or trapping enzymes in inert supporting materials for better efficiency and recovering them after the reaction.
- **Alloenzymes** are enzymes which are produced by different genes.
- **Constitutive enzymes** are always present because they are always required for vital process e.g. glycolysis.
- **Repressible enzymes** – normally remain present but are repressed when a specific chemical or product is present e.g. glucokinase.
- **Inducible enzymes** – are formed in response to presence of its substrate e.g. lactose.
- **ELISA** – It is an enzyme linked immunosorbentassay when a protein, antibody or antigen is detected by means of a specific enzyme e.g. AIDS.
- **Restiction endonuclease** – These are enzymes which are used to break DNA ata specific site producing sticky ends. The enzymes are highly important for genetic engineering. Arber, Nathans and Smith were awarded Nobel Prize in 1978 for their discovery.

ENZYME KINETICS

A. Quantitation of enzymes

1. **activity = "how much"** (moles product formed per minute)
2. **specific activity = "how pure"** (moles product/min. per mg protein)
3. **Turnover number, kcat = "how efficient" = Vmax/[ET]** (moles product/min. per mole enzyme)

B. Initial velocity plots

1. v_o vs [Enzyme] assumed linear
2. v_o vs [Substrate] non-linear

C. Assumptions for derivation of Michaelis Menten equation

1. Mechanism E + S <——> ES —> E + P

**2. [ES] constant ("steady state")

3. [S] >> [Enzyme]
4. [P] ~ O (initial velocity) Not responsible for derivation of Michaelis-Menten equation

D. Meaning of Km, Vmax, kcat

1. Km is the concentration of substrate required to achieve 1/2 Vmax.
2. kcat, x [Enz] = Vmax

E. Determination of Km, Vmax Lineweaver-Burk plots: 1/vo vs 1/[S]

V. Multi-substrate enzyme mechanisms

A. Sequential: all substrates combine before any product release
B. Ping pong: product release before all substrates combine

ENZYMES: CONTROL OF ENZYME ACTIVITY

I. Overview of factors influencing enzyme activity

A. Environmental factors
   1. Temperature
   2. Ionic strength
   3. pH
   4. Concentrations of substrates (reactants), products, cofactors
B. Rate of synthesis and degradation of enzyme (minutes to hours)
C. **Isozymes:** multiple forms of an enzyme catalyzing the same reaction in the same organism
D. Covalent modification of enzyme (seconds to minutes)
E. Allosteric regulation (seconds)
F. Proteolytic cleavage:
   1. Activation: zymogens are inactive enzyme precursors that are activated by proteolytic cleavage (e.g. digestive enzymes trypsin, chymotrypsin, etc.)
   2. Inactivation by proteolysis: also digestive enzymes
G. Binding of a regulatory protein: e.g. trypsin and trypsin inhibitor
H. Compartmentation:
   1. Metabolic channeling: direct transfer of substrate to next enzyme (Pyruvate dehydrogenase complex)
   2. Separate subcellular location of catabolic, anabolic pathways (e.g. fatty acid oxidation in mitochodria, synthesis in cytosol)

II. Isozymes: different enzymes catalyzing the same reaction

A. Hexokinase and Glucokinase
   (The brain enzyme is normally saturated with substrate due to its low Km)
B. Lactic dehydrogenase (LDH)
   1. Five (5) isozymes possible (tetramer with 2 types of subunits, H & M)
   2. Isozyme pattern varies with tissue
   3. Tissue damage results in leakage into serum

Type	Composition	Location
LDH1	HHHH	Myocardium and RBC
LDH2	HHHM	RBC and myocardium
LDH3	HHMM	Brain and kidney
LDH4	HMMM	
LDH5	MMMM	Liver and skeletal muscle

C. Creatine (phospho) kinase (CPK or CK)
   1. A dimer of M and B subunits forms 3 separate isozymes (MM,MB,BB)
   2. Diagnosis of myocardial infarcts (MI)

III. Zymogens and Proenzymes: inactive precursors of enzymes

A. Nomenclature
   1. Trypsinogen – inactive precursor of trypsin
   2. Procarboxypeptidase – inactive precursor of carboxypeptidase

B. Activation by proteolysis (e.g., digestive enzymes from pancreas)

C. Role of Trypsin inhibitor: block premature activation

D. Specificity comparison T, CT, Elastase

IV. Regulation of enzyme activity by metabolic intermediates

A. Branch points in metabolism

$$\begin{array}{l} A \rightarrow B \leftrightarrow C \rightarrow D \leftrightarrow \\ \qquad\qquad\quad \downarrow \\ \qquad\qquad\quad E \rightarrow F \leftrightarrow G \end{array}$$

B. Committed step (first irreversible in specific path)

C. Feedback inhibition/cross regulation

D. Classic regulatory enzyme is ALLOSTERIC

V. Properties of allosteric enzymes

A. Unusual kinetics
   1. Classic example is "sigmoid" kinetics (S-shaped V_o v/s [S] curve) which is referred to as positive cooperativity between subunits
   2. Many other possibilities: atypical rate vs [substrate] curves.

B. Usually Multi-subunit, Separate binding site (allosteric site) for activators, inhibitors (positive or negative modulators or effectors)

C. Example: Protein kinase A
   1. cAMP binds to regulatory (R) subunits
   2. Catalytic subunits released, active
   3. Catalytic and Regulatory sites are on separate polypeptides

D. Example: aspartate transcarbamoylase
   1. ATP (substrate) a positive effector
   2. CTP (end product of pathway) a negative effector
   3. Catalytic and Regulatory sites on separate polypeptides

VI. Models for allosteric enzymes

A. The Concerted (Symmetry) model: R $\leftrightarrow$ T

B. The Sequential or induced fit model: block of 4 postage stamps

C. Both involve Tense and Relaxed subunit conformations

VII. Regulation by phosphorylation (covalent modification)

A. Serine, threonine, tyrosine hydroxyls

B. Example: Glycogen phosphorylase

ENZYMES: MECHANISMS OF ACTION

I. Introduction and terms

Nucleophile, electrophile,
carbonium ions, oxonium ions, carbanions,
transition state, intermediate,
activation energy

II. Active site: often polar and ionizable amino acids important

A. Catalytic center

B. Binding site

III. Theoretical explanations for enzyme catalysis

A. "Lock and Key"
   1. Proximity - "local concentration"
   2. Orientation effects - alignment of bonds to facilitate catalysis

B. Induced fit - Hexokinase (enzyme conforms to substrate)

C. Induced strain - Lysozyme (substrate conforms to enzyme)

D. Transition state stabilization (TSS)
   1. Transition state analogs are excellent enzyme inhibitors
   2. Drug design based on Transition State analogs
   3. **Abzymes:** antibodies against transition state analogs have enzymatic activity

IV. Enzymatic catalysis mechanisms

A. Acid-base catalysis

1. General model $\text{Enz–}\mathbf{H^+} + \text{R}'\text{– OR} \rightarrow \text{Enz} + \text{R}'\text{– }\mathbf{H} + \text{R}^+$

   $\text{R}^+ + \mathbf{H_2O} + \text{Enz} \rightarrow \text{Enz–}\mathbf{H} + \text{R} – \mathbf{O} \mathbf{–H}$

2. Specific examples: (*a*) Lysozyme (*b*) Ribonuclease

B. Covalent catalysis: intermediate with covalent bond between E and S

1. General model: $\text{Enz–O– }\mathbf{H} + \text{A–B} \rightarrow \text{Enz–}\mathbf{O}\text{–A} + \text{B– }\mathbf{H}$

   $\text{Enz–}\mathbf{O}\text{–A} + \mathbf{H_2O} \rightarrow \text{Enz} – \mathbf{O} – \mathbf{H} + \text{A} – \mathbf{O} \mathbf{–H}$

2. Specific examples:
   (*a*) Chymotrypsin
   (*b*) Subtilisin: convergent evolution

C. Metal ion catalysis

1. Function as Lewis acids
2. Function to stabilize intermediates (chelates)
3. Facilitate binding by neutralizing charges
4. Involved in many redox reactions

LIPIDS

Lipids are esters of fatty acids and polyhydric alcohol. The term 'lipid' was first used by **Bloor** (1943). These are the compounds of C, H, O but the ratio of H and O is more than 2:1 (i.e., the ratio of oxygen is lesses as compared to carbohydrates). These are water-insoluble organic substances which can be extracted from the cells by organic solvents such as ether, chloroform and benzene. Their general formula is $C_nH_{2n}O_2$. Some lipids have P, N and S also.

1. **Simple lipids** – esters of fatty acids with alcohol. Simplest alcohol in fats is glycerol (a trihydric alcohol) e.g., fats, oils and waxes. Triglycerides are common in nature.
2. **Compound lipids** – These lipids contain an additional group alongwith fatty acids and alcohols, e.g., phospholipids, glycolipids and lipoproteins.
3. **Derived lipids** – These are isoprenoid structures e.g., steroids, terpenes, carotenoids.

- **Fatty acids** are carboxylic acid with a chain of more than four carbon atoms ending with COOH group. Plants can synthesize all fatty acids. Animals can not synthesize **linoleic, linolenic** and **arachidonic acid**. These are called **essential fatty acids**. Their deficiency causes sterility, kidney failure and stunted growth.
- Saturated fatty acids have no double bond. Their melting point is high. Palmitic acid, stearic acid are saturated fatty acids.
- Unsaturated fatty acids are commonly present in vegetable oils, cod/shark oil. Their melting points are low. Oleic acid has one double bond, linoleic acid has two, linolenic acid has three and arachiodonic acid has 4 double bonds. Fatty acids with more than one double bond are called **polyunsaturated fatty acid (PUFA).**
  - **Drying oils** are unsaturated fatty acids which can be converted in hard fats on being exposed.
  - Edible oils can be converted into hard fats through **hydrogenation**.
- Waxes are esters of long chain monohydric alcohols like **cetyl, ceryl** or **mericyl.**
  - **Lanolin** forms a protective, water insoluble coating on animal fur.
  - **Bees wax** secreted from abdominal glands of honey bees has **palmitic acid** and **mericyl alcohol**.
  - **Paraffin wax** is a petroleum product.
  - **Cutin** is formed by cross esterification and polymerization of hydroxyl fatty acids and other fatty acids without esterification by alcohols other than glycerol. Cuticle has 50-90% cutin.
  - **Suberin** is condensation product of **glycerol** and **phellonic acid**. It makes the cell wall impermeable to water.

- **Phospholipids** are triglycerides in which one fatty acid is replaced by phosphoric acid which is often linked to additional nitrogenous groups like **choline** (in lecithin), **ethanolamine** (in cepalin), **serine** or **inositol**. These are amphipathic i.e. have both polar and non polar groups. These form cell membranes along with proteins.
- **Sphingolipids** have amino alcohol sphingosine. **Sphingomyelins** are present in myelin sheath of nerves. They have additional phosphate attached to choline, are present in nerve membrane. **Cerebrosides** are present in nerve membrane and have **galactose**.
- **Gangliosides** – have glucose, galactose, **sialic acid** and **acetyl glucosamine**, present in grey matter, receptors of viral particles, excess causes **Tay-Sachs** disease.
- **Sterols** or **steroids** contain 4 fused hydrocarbon rings called **cyclopentane perhydro phenanthrene** and a long side chain e.g. cholesterol, stigmasterol, campesterol, sitosterol, ergasterol.
  - Cholesterol helps in absorption of fatty acids, sex hormones, vitamin D and bile salts. Potato is rich in cholesterol. Excess of cholesterol causes **atheroscherosis**.
- **Prostagladins** are hormone modulators.
- Terpenes are lipid like carbohydrates formed of isoprene units e.g., menthol, camphor, carotenoids.
- Major function of lipids is to act as energy stores.
  - Plants usually store oil than fats. Seeds, fruits and choloroplasts are often rich in oils.
  - **Glycolipids** are important components of cell membranes, chloroplast membranes.
  - Fatty substance in the cell wall (Wax, cutin, suberin) helps reduce transpiration and provide mechanical protection from injury and parasites.
  - **Diosgenin** is a steroid obtained from the plant called *Dioscorea*. It is used for manufacturing antifertility pills.

MEMBRANE STRUCTURE AND TRANSPORT

I. Functions of membranes

Permeability barrier, transport, communication with the “outside”, cell-cell recognition, environment for non-aqueous reactions, cell volume regulation and locomotion.

II. Chemical composition of lipids

A. Fatty acid structures:
   1. Be able to identify structures of common fatty acids **palmitic, stearic, oleic, linoleic, linolenic and arachidonic.**
   2. Double bonds and shorter chains lower the melting point

B. Membrane lipids: amphipathic structures
   1. **Glycerophospholipids**
      (*a*) Phosphatidate + “X” (PC, PE, PS, PG, PI, and cardiolipin-)

(*b*) Plasmalogens (Glycerol ether phospholipids)
  (*i*) Platelet activating factor (PAF): acetyl at R2 and choline at R3
  (*ii*) Lowers blood pressure, causes platelets to aggregate
(*c*) Lysophosphoglycerides have R2 vacant; detergent action

2. **Sphingolipids**
   (*a*) Sphingosine as parental compound
   (*b*) **Ceramides:** N-fatty acyl sphingosine
   (*c*) **Cerebrosides:** ceramide + glu or gal
   (*d*) **Sulfatides:** gal-cerebroside that is sulfated
   (*e*) **Gangliosides:** ceramide + branched sugar, including N-Acetyl-Neuraminic Acid (NANA or sialic acid).
     (*i*) Ganglioside GM1 is the receptor for cholera toxin
     (*ii*) Variety of Sphingolipid storage diseases (Tay Sachs, etc.)
3. **Sphingomyelin:** a sphingo-phospho-lipid (Note structural similarity to glycerophospholipids)
4. **Cholesterol:** important component of membrane; makes membrane less fluid & precursor to steroid hormones

III. Properties of lipid aggregates

A. **Micelles**: spherical aggregates of single-tailed lipid

B. **Lipid bilayers**: aggregates of double-tailed phospholipids

1. **Liposomes:** proposed use as drug delivery agents
   properties:
   (*i*) impermeant to water solutes
   (*ii*) lateral diffusion rapid
   (*iii*) transverse (flip-flop) motion RARE
   (iv) fluidity decreases with chain length, saturation of FA
2. Planar Bilayers: similar properties

IV. Biological membranes

A. The Fluid Mosaic Model of Membranes by Sanger and Nicolson (two dimensional asymmetric lipid bilayer with proteins suspended within, carbohydrate only attached on outside of membrane).

B. Membrane proteins:

1. **Peripheral or extrinsic**
   (*a*) asymmetric in distribution
   (*b*) Variety of membrane anchors
     (*i*) ionic interactions (cytochrome c of mitochondria)
     (*ii*) hydrophobic amino acid sequence (cyto. b5 of E.R.)
     (*iii*) GPI anchors (glycosyl phosphatidylinositol)

(*iv*) Myristic (C–14) via amide to C-terminal glycine

(*v*) Palmitic (C–16) acid via thioester to cys

(*vi*) Prenylated or isoprenoid groups: farnesyl (C–15) or geranyl- geranyl (C–20) at C-terminal cys

2. **Integral or intrinsic**

(*a*) transmembrane helices (>20 hydrophobic amino acids)

(*b*) specific orientation (N, C termini)

(*c*) examples: glycophorin (one transmembrane helix); anion channel of RBC (12 transmembrane helices) (Cl^-/HCO_3^- exchanger)

(*d*) Porins – Transmembrane - pleated sheet mitochondria, bacteria) RARE: almost always alpha-helix across membrane

C. **Carbohydrate** – external side of plasma membrane

1. Attached to protein side chains

(*a*) **O-linked:** SER, THR (within polypeptide)

(*b*) **N-linked:** ASN (within polypeptide)

2. Carbohydrate is important for "targeting" proteins to subcellular compartments

D. Cholesterol with –OH at surface, rings within membrane (decreases fluidity)

V. Properties of biological membranes

A. Membrane fluidity

1. Lipids: lateral motion rapid, transverse rare; asymmetric location
2. Proteins: lateral motion variable (cytoskeleton interactions), transverse rare
3. General barrier to water-soluble molecules, but not to water

B. Erythrocyte (RBC) membrane as example

1. RBC a "dying cell"; no nucleus, no mitochondria (120 days lifetime)
2. Membrane rolls freely around cell yet cell maintains discoid shape
3. Membrane proteins

(*a*) Glycophorin A

(*b*) "Band 3" is HCO_3^-/Cl^- anion exchange protein

(*c*) Band 3 attached to Ankyrin, which in turn is attached to Spectrin, which are both part of cytoskeleton

(*d*) Cytoskeleton limits motion of certain attached membrane proteins

(*e*) Hereditary elliptocytosis – defective spectrin - malarial belt

VI. Membrane transport of small molecules (nutrients), ions

A. Characteristics of membrane transport: protein mediated, specific, inhibitable, exhibit saturation kinetics like enzymes.

B. Types of membrane transport

1. **Simple Passive Diffusion**

(*a*) not saturable, not specific, not inhibitable

(*b*) depends on solubility in membrane (non-polar preferred)

2. **Facilitated diffusion:** Protein mediated (transporters, translocases, porters, carriers, permeases)
   (*a*) saturation kinetics, specific, specific inhibitors
   (*b*) **ACTIVE TRANSPORT** – movement AGAINST the electrochemical gradient
      (*i*) primary – uses ATP as energy
      (*ii*) secondary – uses ion gradients for energy (which in turn require ATP)
   (*c*) **PASSIVE TRANSPORT** – movement DOWN the concentration gradient)
      (*i*) channels (specific) or pores (non-selective) – membrane hole, no binding of molecule; sometimes gated
      (*ii*) mediated transport – specific binding by protein involved
   (*d*) mode of transmembrane movement
      (*i*) Uniport – molecule moves by itself
      (*ii*) Symport – molecule moves along with another molecule
      (*iii*) Antiport – molecule moves opposite direction from another
      (*iv*) Electroneutral – no net change in transmembrane charge
      (*v*) Electrogenic – transport alters transmembrane charge

C. Thermodynamics of membrane transport

1. An electrical potential across membranes ("membrane potential") arises from differences in permeability and concentration for various ions across the membrane.
2. The energy required to move a molecule across a membrane depends on:
   (*a*) the transmembrane concentration gradient of that molecule, and
   (*b*) the membrane potential if the transport process is Electrogenic
   + Z(deltaPsi)F (in kcal/mole)
   where F = 23 kcal V–1 mol–1 (Faraday constant),
   Z is the net charge moved, and (deltaPsi) is the membrane potential in volts.

D. Specific examples of transport systems

1. **Passive mediated:** glucose transport into muscle, adipose tissue
   (*a*) glucose binds on one surface
   (*b*) conformational change occurs, exposing glucose to the opposite side of the membrane where it is released
   (*c*) no energy input, moves DOWN conc. gradient
   (*d*) Insulin stimulates movement of transporter protein from internal vesicle to membrane
2. **Active transport**
   (*a*) Primary: Na^+K^+ ATPase of plasma membrane
      (*i*) ATP hydrolysis is directly involved
      (*ii*) both Na^+ and K^+ move against the electrochemical gradient
      (*iii*) Phosphorylation of specific Asp triggers conformational change causing INTERNALLY bound Na^+ to be released OUTSIDE cell
      (*iv*) Dephosphorylation of Asp causes EXTERNALLY bound K^+ to be released INSIDE cell

(*b*) Secondary: Na^+ glucose symport into intestinal epithelium
(*i*) ATP only INDIRECTLY involved (to maintain Na^+ gradient)
(*ii*) Na^+ gradient supplies the energy for glucose entry
(*iii*) Glucose exits epithelial cell into the circulatory system via passive mediated symport
(*iv*) Amino acids transported similarly

E. **Ionophores:** bacterial poisons of ion transport systems
1. Mobile carriers: Valinomycin forms cage for K^+
2. Channel formers: Gramicidin for small inorganic ions; relatively non-specific

CARBOHYDRATES

Carbohydrates are mainly compounds of carbon, hydrogen and oxygen. Carbohydrates are so called because in most of them, the proportion of hydrogen and oxygen is the same as in water (H_2O) i.e., 2:1. Their general formula is $C_XH_{2X}O_X$. These are also knows as saccharides (compounds containing sugar). Carbohydrates are produced by green plants during photosynthesis. These constitute about 80% of the dry weight of plants. Carbohydrates are divided into 3 main classes – **monosaccharides**, **derived monosaccharides** and **oligosaccharides**.

1. Monosaccharides

- These have single saccharide units which cannot be hydrolysed further into still smaller carbohydrates; have general formula $C_NH_{2N}O_N$. These are composed of 3–7 carbon atoms, and are classified according to the number of C atoms as trioses (3C), tetroses (4C), pentoses (5C), hexoses (6C) and heptoses (7C). Of these, pentoses and hexoses are most common. Monosaccharides are important as energy source and as building blocks for the synthesis of large molecules.
- All monosaccharides are either aldoses or ketoses. The two simplest monosaccharides are trioses e.g., glyceraldehydes and dihydroxyacetone.
- Tetroses (e.g. erythrose) are quite rare. Erythrose takes part in the synthesis of lignin and anthocyanin pigments.
- Ribose, ribulose, xylulose and arabinoses are pentoses. Xyluloses and arabinoses polymerise to form xylans and arabans which are cell wall materials.
- Glucose, fructose, mannose, galactose are **hexoses**. These are white, sweet-tasting, crystalline and extremely, soluble in water.
- **Glucose** is the universal sugar. It is also known as **dextrose** or **grape sugar** or **corn sugar**.
- **Fructose** is the most common form of sugar in fruit. It is also known as **levulose**. **It is the sweetest among naturally occurring sugars**.
- Monosaccharides have 'free' aldehyde or ketone group which can reduce Cu^{++} to Cu^+. Hence, these are also called reducing sugars.

2. Derived monosaccharides

- **Deoxy sugar** – Loss of oxygen atom from ribose yields deoxyribose, a constituent of DNA.

- **Amino sugar** – Monosaccharides having an amino group e.g., glucosamine, galactosamine.
- **Sugar acid** – e.g., Ascorbic acid, glucuronic acid, galacturonic acid.
- **Sugar alcohol** – e.g. glycerol and mannitol (present in brown algae).

3. Oligosaccharides

The sugars with limited numbers (2–10) of monosaccharides are called **oligosaccharides**. These include trisaccharides, tetra saccharides, hexasaccharides, heptasaccharides, etc.

- **Disaccharides**: These are formed by condensation reactions between two monosaccharides (usually hexoses). The bond formed between two monosaccharides is called a **glycosidic bond**. It normally forms between C-atoms 1 and 4 of neighbouring units (1,4 bond). Once linked, the monosaccharide units are called residues.
  (*a*) **Maltose** (glucose + glucose), **lactose** (glucose + galactose), sucrose (glucose + fructose) are most common disaccharides. Sucrose is most abundant in plants and is known as **cane sugar** or **table sugar**. It is the sugar we buy from market.
  (*b*) On **hydrolysis**, disaccharides release their respective constituent monosaccharides (e.g., hydrolysis of sucrose yields one molecule each of glucose and fructose).
- **Trisaccharides**: Sugars composed of 3 monosaccharide units are called **trisaccharides (e.g., raffinose)**. Raffinose is a common saccharide found in plants. Upon hydrolysis, it yields one molecule each of glucose, fructose and galactose.
- **Larger oligosaccharides are attached to the cell membrane and cell recognition is due to their presence. They also take part in** antigen specificity**.**

Polymerisation of a large number of small molecules results in the formation of large molecules of high molecular weights, which may be branched or unbranched. These are called **macromolecules**. These include some polysaccharides, proteins and nucleic acids.

Polysaccharides

These are polymers of monosaccharides and are branced or unbranched linear molecular chains. These are insoluble carbohydrates and are considered to be non-sugars. Starch, glycogen, cellulose, pectin, hemicellulose, inulin and polysaccharides.

Polysaccharides are of two types –

- **Homopolysaccharides** – consists of only one type of monosaccharide monomer e.g. starch, glycogen and celluse, fructan, xylan, araban, galactan.
- **Heteropolysaccharide** – consists of more than one type of monosaccharide monomer e.g. chitin, agar, arabanogalactans, arabanoxylan etc.

Polysaccharides are of three main types – storage (e.g. starch and glycogen), **structural** (e.g. chitin, cellulose) and **mucopolysaccharides** (e.g. keratin sulphate, chondroitin sulphate, hyaluronic acid, agar, aliginic acid, carragenin & heparin).

1. Storage polysaccharide

(i) Starch, glycogen and **inulin** are reserve food materials. Starch turns blue with **Iodine**.

- Starch is a polymer of glucose. It is the major reserve food in plants. Starch has two components – amylase (an unbranched polymer) and amylopectin (a branched polymer).
- **Amylopectin** – consists of 2000 – 200,000 glucose molecules forming straight chain and branches (after 25 glucose units). Branching point has α, 1-6 glycosidic linkage.
- **Amylose** – consists of α, 1-4 glycosidic linkage between α-D glucose molecules. It is straight chain of 200-1000 glucose units. It is helical; each turn consists of 6 glucose units.

Starch molecules accumulate in the form of layers (stratifications) around a shifting organic centre (hilum) to form starch grains. In **eccentric** starch grains, hilum lies on one side. These are found in potatoes. In **concentric** starch grains, hilum is present in the centre. These are found in wheat, maize, and pea.

- **Dumb-bell shaped** starch grains are found in the latex of *Euphorbia*.
- Starch grains with single hilum are called simple (e.g. maize); but those with more than one hilum are called compound (e.g. potato, rice).

(ii) **Glycogen**: Glycogen is the animal equivalent of starch; many fungi also store it. Glycogen turns red-violet with iodine. It consists of 30,000 glucose units joined by α, 1-4 bonds, much more banched than starch. Branching point has α, 1-6 linkage, branching occurs after 10-14 glucose units.

(iii) **Inulin**: It is an unusual polysaccharide and polymer of fructose. It is used as a fructose, particularly in roots and tubers of the family Compositae (e.g. *Dahlia* tubers).

II. Structure of polysaccharide

(*a*) **Cellulose**: Cellulose is the main structural polysaccharide of plants. It is the most abundant molecule on earth. It is almost confined to plants, though it is found in primitive fungi and lower invertebrates also. It is structural component of all plant cell walls, constituting, on an average, about 20-40% of the wall. Cotton fibres contain the largest proportion (90%) of cellulose among natural materials.

Molecules are unbranched, consisting of 6000 – β – D glucose units joined by β, 1-4 linkages, and 2000 cellulose molecules from **microfibril**. Rayon and cellophane are similar to **cellulose xanthate**. Cellulose acetate is used to prepare tricot, double knit, wrinkle proof and mouth proof clothing, cigarette filters. Cellulose nitrate is used in propellent explosives. Carboxy methyl cellulose is used as emulsifier and smoothing reagent.

(*b*) **Chitin**: Chitin is a polymer of acetyglucosamine (β, 1-4 glycosidic linkage) forming bundles of long parallel chains like cellulose. It occurs in the cell walls of fungi (and forms exoskeleton in some animals especially arthropods).

(*c*) **Pectin and hemicellulose**: Pectin and hemicelluloses are structural polysaccharides. Pectins are made up of **arabinose, galactose** and **galacturonic acid**. Pectic acid is a homopolymer of the methyl ester of D-galacturonic acid.

Middle lamella which binds the cells together is composed of calcium pectate. Due to this substance, water absorption capacity of wall is increased.

Fruit walls contain high percentage of pectin. During ripening, the pectins break down into sugars resulting in the sweetning and loosening of fruits.

Hemicelluloses are homopolymers of D-xylose linked by β 1-4, Xylans, arabans, galactans are hemicelluloses. These are rarely used as food (e.g. dates – *Phoenix*).

III. Mucopolysaccharides

These are gelatinuous polysaccharides formed from galactose and mannose. Slimy substances of bhindi, agar agar, alginic acid and carrageenin obtained from seaweeds are mucopolysaccharides. Mycopolysaccharides are found in the cell walls of bacteria also.

(*a*) **Keratin sulphate** – consists of acetyl glucosamine, glaactose and sulphuric acid, provides strength and flexibility to skin and cornea.

(*b*) **Chondroitin sulphate** – consists of flycuronic acid and acetyl glucosamine, present in the vitreous humor of eye, synovial fluid and cerebrospinal fluid etc.

(*c*) **Heparin** is a polymer of α, 1-4 glucosamine and glucuronic acid. It is anticoagulant present in human blood. Husk of *Plantago ovata* and mucilage of *Aloe barbedense* are medicinally used. Agar, alginic acid carragenin are obtained from marine Brown algae (Phaeophyceae).

SUGARS

I. Sugar chemistry

A. Sugars are carbohydrates (Poly hydroxy aldehydes or Ketones)
   1. empirical chemical formula $(CH_2O)_n$
   2. polyalcohols
   3. hydrophilic, polar

B. Carbonyl classification of sugars
   1. Aldoses – aldehyde at the C-1 carbon
   2. Ketoses – carbonyl somewhere other than C-1 (usually C-2)

C. Stereochemistry of sugars
   1. all sugars have at least one chiral carbon (except DHA)
   2. naturally occuring sugars are in the D-form
   3. Fisher projection 2-D representation of sterochem.
   4. Epimer – sugars differing in config. at one chiral carbon

D. Intramolecular cyclization of sugars
   1. Sugars readily form ring structures
      (*a*) Condensation of a hydroxyl with a carbonyl
         (*i*) hemiacetal – cyclization between aldehyde and hydroxyl
         (*ii*) hemiketal – cyclization between ketone and hydroxyl
      (*b*) Different size cyclic structures may be formed
         (*i*) pyranose – six member ring
         (*ii*) furanose – five member ring

2. Anomeric carbon – new chiral center formed in the cyclization or form many esenzymes have specificity for the anomeric carbon
3. Haworth projection – 3-D representation of cyclic structure

E. Sugar chemistry
1. Reducing sugars
   (*a*) carbonyl group has reductive potential
   (*b*) anomeric carbon must be free (not polymerized)
   (*c*) can reduce Cu^{2+}(cupric) to Cu^{+}(cuprous)

GLYCOLYSIS

1. All life processes require energy. Much of the food obtained by autotrophic and heterotrophic nutrition is used as a source of this energy. The energy rich compounds are broken down to release energy by the process of respiration. **Respiration is a process by which the energy of the food is made available to the cells.**
2. Glucose is the most common respiratory substrate.
3. Photosynthesis is 10 times faster than respiration.
4. About 50% of sugar formed in photosynthesis is used in respiration.
5. Efficiency of respiration is 40-45%.
6. Cellular respiration is essentially (a) a catabolic process, (b) involves biological oxidation of organic molecules and (c) results in the release of the energy in the form of ATP. ATP is a derivative of AMP (Adenosine monophosphate) to which two additional phosphate groups are attached through an anhydride linkage. The two bonds are indicated by symbol (~). When last high energy phosphate bond is hydrolysed **8.9 kcal** energy is released. When second phosphate bond is broken, **6.5 k** calories of energy is released. However, if the third phosphate group (i.e., of AMP) is hydrolysed; only **3.4 kcal** of energy is liberated. The energy released by the breaking down of phosphate groups in ATP and ADP (Adenosine diphosphate) is much more than the energy released on the hydrolysis of most of the other covalent bonds.
7. ATP is an instant source of energy within the cell. It is mobile and transports chemical energy to energy requiring processes within the cell. The hydrolysis of ATP releases energy. Since ATP is found in all living cells, it is called **universal energy carrier or "energy currency" of cells.**
8. A respiratory substrate is a "substance which is oxidized to yield the energy necessary for cell maintenance and growth". These, include (i) carbohydrates, (ii) fats, (iii) proteins.
9. **Types of respiration**:
   (*a*) **Aerobic respiration**. It takes place in the presence of oxygen. Complete oxidation of the substrate results in the formation of CO_2 and water accompanied by the release of energy e.g.

   $$\underset{\text{(Glucose)}}{C_6H_{12}O_6} + 6O_2 \rightarrow 6CO_2 + 6H_2O + \underset{\text{(686 kcal)}}{\text{energy}}$$

   In most forms of life, respiration occurs aerobically.

   (*b*) **Anaerobic respiration**. It takes place in the absence of oxygen and results in incomplete degradation of the substrate. CO_2 and organic compounds like ethyl alcohol, lactic acid etc., are produced accompanied by the release of some energy, water is not a product of this reaction.

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ + energy

Usually, anaerobic respiration occurs in the deep seated tissues of plants and animals, in germinating seeds, in fruits and among many microorganisms e.g. yeasts and bacteria.

10. A large variety of organisms (anaerobic) employ anaerobic respiration as their major energy yielding process. In fact, some bacteria are even killed if exposed to substantial amount of oxygen. These are termed as obligate anaerobes. The organisms which can respire both in the presence and the absence of the oxygen are called facultative anaerobes.
11. **Mechanism of respiration**: In aerobic as well as anaerobic respiration, initial sequence of events is the same; collectively termed as glycolysis. Glycolysis (splitting of sugar) results in the breakdown of one molecule of glucose into two molecules of **pyruvic acid**. It is completed in the cytoplasm of the living cell not in the mitochondria and does not require the presence of oxygen. It is also known as **Embden-Meyerhof-Parnas** pathway after the names of three German scientists who discovered it.
12. **The process of glycolysis maybe sub-divided into three steps**: (*a*) Phosphorylation, (*b*) Splitting of fructose-1, 6-diphosphate, (*c*) Formation of pyruvic acid.
13. **Fate of pyruvic acid in aerobic respiration**: In aerobic respiration, each pyruvic acid molecules enters a mitochondrion where its oxidation is completed. It is carried out in the following phases: (*a*) Formation of acetyl coenzyme A and (*b*) Krebs cycle.
14. Acetyl CoA is produced not only from pyruvic acid, but also produced as a result of â-oxidation of fatty acids undergoes TCA cycle. Enzymes required for Kreb's cycle are found in the matrix of mitochondria except succinate dehydrogenase which is bound to inner membrane.
15. **TCA: An amphibolic pathway**: The TCA cycle is a central metabolic pathway playing an important role in both: catabolism and anabolism. It serves as a pathway for oxidation of not only carbohydrates, but fat and proteins also, serving as a common oxidative pathway (catabolism). On the other hand, the intermediates of the TCA cycle are used in the synthesis of macromolecules (anabolism).
    - The term amphibolic (dual purpose) is preferred for such pathways.
16. One molecule of ATP (via GTP), four NADH, 1 $FADH_2$ and two molecules of CO_2 are released per molecule of pyruvic acid oxidized. However, as two molecules of pyruvic acid are formed from one glucose molecule, TCA cycle must occur twice for each molecule of glucose respired. Therefore, 2 ATP, 8 NADH and 2 $FADH_2$ are formed from 2 molecules of pyruvic acid (coming from one molecule of glucose).
17. The hydrogen ions and electrons removed from respiratory intermediates by dehydrogenation during glycolysis and TCA cycle are ultimately oxidized to water by molecular oxygen. They reduce acceptor molecules such as NAD^+ and FAD to NADH and $FADH_2$ respectively. From NADH or $FADH_2$, these are passed along a chain of intermediate substances (a chain of electron acceptors and transfer molecules). The enzymes necessary for the transfer of electrons are present in the inner mitochondrial

membrane in an ordered manner and also function in a specific sequence. This assembly of electron transporting enzymes is called **mitochondrial respiratory chain** or the **electron transport chain**.

Such mitochondrial membrane is impermeable to protons; these can not diffuse back into the matrix across the membrane. However, these can enter the membrane via a proton channel established by the membrane bound adenosine triphosphatase (ATPase). ATPase is a multienzyme complex containing two parts F_0 and F_1. F_1 component sits on the surface of the membrane while F_0 component is embedded in it forming a channel across the membrane. Through this channel, the protons flow to F_1. The back of protons down the proton gradient provides energy for the synthesis of ATP molecules. F_1 (acting as ATP synthesis) catalyses the synthesis of ATP from ADP. **For each pair of protons flowing back into the matrix, one molecule of ATP is synthesized**. Thus, the three pairs of protons, thre molecules of ATP are generated.

Since $FADH_2$ denotes its electrons to CoQ and not to FMN, only 4 protons are transported outside the membrane. Therefore, the backflow of these 4 protons through F_0-F_1 complex results in the formation of only 2 ATP molecules.

18. Not yield of ATP in aerobic respiration of glucose:
    (*a*) In glycolysis, 4 molecules of ATP are produced while two are consumed. Thus, there is a direct gain of 2 ATP molecules in glycolysis.
    (*b*) In TCA cycle, one molecule of ATP is produced (via GTP) per molecule of pyruvic acid. Since 2 molecules of pyruvic acid are produced from one molecule of glucose, 2 molecules of ATP per glucose molecules are obtained in TCA cycle.
    - Thus, by direct phosphorylation there is a gain of 4 ATP molecules in respiration.

    (*c*) 10 NADH molecules are also produced (2 in glycolysis and 8 from pyruvic acid. Each NADH molecule, through electron transfer releases energy for the synthesis of 3 ATP molecules. Thus, 30 more molecules of ATP are obtained.
    (*d*) Also, 2 molecules of $FADH_2$ are produced in TCA cycle which yield 2 x 2 i.e. 4 ATP molecules.
    (*e*) Thus, 4 + 30 + 4 = 38, i.e. a total of 38 ATP molecules are yielded during aerobic respiration of glucose.
    (*f*) In most eukaryotic cells, 2 ATP molecules are used up in transporting 2 NADH molecules produced in glycolysis to the mitochondrion, in such cells, there in a net gain of 36 ATP molecules instead of 38.
19. Though glycolysis and Krebs cycles constitute a major respiratory pathway, other respiratory pathways also exist.
    (*a*) **Pentose phosphate pathway** (Hexose mono-phosphate shunt) occurring in cytoplasm, **requires oxygen and is a major source of 5-C sugars. It produced 36 ATP molecules and may operate simultaneously along with normal glycolytic pathway. Net yield is 35 ATP molecules**.
    (*b*) Another cycle, Glyoxylate cycle occurs in seeds that possess tissues rich in fat and enable stored fat to be converted into carbohydrates. Enzymes for the cycle are present in glyoxysomes.

20. The accumulation of lactic acid in the muscle causes fatigue. However, durng rest, the lactic acid is again converted into pyruvic acid and undergoes aerobic respiration.
21. **Remember**
    (*a*) 264 Gms of CO_2 is liberated during complete oxidation of 180 gms of glucose.
    (*b*) α-ketoglutaric acid is **first dicarboxylic acid** formed during Kreb's cycle.
    (*c*) Number of ATP molecules formed by complete oxidation of pyruvic acid is 15.
    (*d*) **Mercury is used in anaerobic respiration experiments because it does not react with CO_2**.
    (*e*) Rate of respiration is measured by **respirometer**.
    (*f*) **Fermentation** was discovered by **Gay Lussac**.
    (*g*) Enzyme extracted from yeasts which brings about the fermentation is zymase.
    (*h*) Fruits and seeds are stored at low temperature to reduce the rate of respiration.
    (*i*) If a leaf is kept in sugar solution, the rate of respiration increases.
    (*j*) **Dinitrophenol** inhibits ATP synthesis (uncoupler of oxidative phosphorylation).
    (*k*) **Oligomycin** inhibits oxidative phosphorylation (energy transfer inhibitor).
    (*l*) Abnormal rise in respiratory rate of ripening fruits is called **climactric e.g. banana.**
22. **Fermentation differs from anaerobic respiration by following features**
    (*a*) Fermentation is an extracellular process.
    (*b*) It usually occurs in the presence of microbes.
    (*c*) Enzymes extracted from cell can perform fermentation.
    (*d*) A small quantity of oxygen rather stimulates fermentation, while anaerobic respiration occurs in the absence of oxygen.
23. Higher concentration of CO_2 and absence of O_2 adversely affect the rate of respiration (except in anaerobic respiration).
24. 1 molecule of glucose or fructose produces a total of 38 ATP molecules out of which two are used and therefore, net gain of ATP is 36. Out of this 38 ATP, 4 ATP are formed by direct (substrate) phosphorylation and 32 ATP by oxidative phosphorylation through ETS and 2 by through GTP.
25. 1 molecule of $NADH_2$ forms 3 ATP and 1 FADH2 forms 2 ATP through ETS located on inner membrane of mitochondrion.
26. One turn of Krebs cycle produces 12 ATP, 11 ATP through ETS and 1 ATP by substrate phosphorylation.
27. ATP formation is an endergonic process and occurs in chloroplast and mitochondria.
28. RBC and muscles get energy by glycolysis.
29. Ratio of CO_2 formation in aerobic and anaerobic respiration is 3:1.
30. Ratio of ATP in aerobic and anaerobic respiration is 18:1.
31. Kreb's cycle is basically a catabolic cycle but also functions as anabolic cycle and hence called **amphibolic cycle**. Its starting product is citric acid which is a tricarboxylic acid. **It undergoes 4 oxidations and 2 decarboxylations** to produce CO_2 and H_2O. It occurs in matrix of mitochondria.
32. ETS, is located on inner membrane of mitochondria, is responsible for ATP synthesis (oxidative phosphorylation).

33. ETS involves hydrogen and electron carriers and oxysomes ($F_0 - F_1$ particles) located on inner membrane of mitochondrion. The sequence of these carriers is:
$NADH_2 \rightarrow FMN \rightarrow CoQ \rightarrow$ Cyt b $\rightarrow$ Cyt $c_1 \rightarrow$ Cyt c $\rightarrow$ Cyt a $\rightarrow$ Cyt a_3.
34. Flow of electron in ETC is $Fe^{+3} \rightarrow Fe^{+2} \rightarrow Fe^{+3}$.
35. Cytochromes are Fe^{+2} rich intrinsic proteins. Cyt a_3 has both Cu^{+2} and Fe^{+2} and acts as cytochrome oxidase.
36. Ratio of the volume of CO_2 liberated to the volume of O_2 absorbed during respiration is called Respiratory Quotient, the RQ.
   (*a*) RQ is an index of type of substrate being respired. Different substrates (carbohydrates/fats/proteins/organic acids) yield different values of RQ on oxidation.
   (*b*) When carbohydrates are completely oxidized, RQ = 1.
   (*c*) When fats and proteins are respired, RQ is less than one.
   (*d*) For organic acids (malic/oxalic acids etc.), RQ is greater than one.
   (*e*) In succulents (e.g., *Opuntia*, *Bryophyllum*) RQ = zero as no CO_2 is released (is fixed into organic acids).
   (*f*) During anaerobic respiration, RQ is infinity (O_2 is not absorbed)
   $C_6H_{12}O_6 \rightarrow 6C_2H_5OH + 2CO_2$
   $$(RQ = 2 / 0 = \infty)$$
37. Overall reaction
   1. 2 pyruvates, 2 NADH and 2 ATP produced per glucose
   2. 2 stages (hexose and triose stages)
      (*a*) hexose stage
         (*i*) glucose phosphorylated and cleaved to form two glyceraldehyde-3-P
         (*ii*) uses 2 ATPs per glucose
      (*b*) triose stage
         (*i*) converts two glyceraldehyde-3-P to two pyruvates
         (*ii*) generates 4 ATPs and 2 NADH
   3. Oxygen supply determines end product of pathway
      (*a*) Aerobic conditions
         (*i*) NADH is reoxidized by ET/Ox Phos
         (*ii*) pyruvate is used for acetyl CoA synthesis
      (*b*) Anaerobic conditions
         (*i*) NADH is reoxidized by reducing pyruvate to lactate
         (*ii*) lactic acid is produced
38. Pyruvate has multiple fates
   1. Anaerobic glycolysis (higher organisms)
      (*a*) Allows glycolysis to continue without O_2
         (*i*) NAD^+ needs to be regenerated from NADH
         (*ii*) electron transport is inoperable
         (*iii*) LDH reoxidizes NADH

(*b*) Lactate dehydrogenase (LDH)
  (*i*) Reversible & requires NAD^+ (NADH)
  (*ii*) lactic acid produced
(*c*) Physiology:
  (*i*) skeletal muscle becomes anaerobic during exercise
  (*ii*) lactic acid is produced so glycolysis can continue
  (*iii*) during recovery lactate transports to the liver for reconversion to pyruvate or glucose

2. Anaerobic glycolysis (yeast)
  (*a*) yeast generates ethanol in absence of O_2
    (*i*) NAD^+ needs to be regenerated from NADH; since electron transport is inoperable
    (*iii*) alcohol dehydrogenase reoxidizes NADH
  (*b*) pyruvate decarboxylated to acetaldehyde
    (*i*) requires thiamine pyrophosphate (TPP)
    (*ii*) CO_2 causes bubbles in champagne and dough to rise
  (*c*) thiamine pyrophosphate
    (*i*) derived from the vitamin thiamine (B1)
    (*ii*) involved in decarboxylation reactions
  (*d*) acetaldehyde converted to ethanol
    (*i*) catalyzed by alcohol dehydrogenase
    (*ii*) NADH reoxidized to NAD^+
3. Aerobic oxidation
  (*a*) pyruvate is oxidatively decarboxylated to form acetyl CoA
  (*b*) Acetyl CoA has many fates including the TCA cycle

39. Thermodynamic of glycolysis
  A. Overall reaction: Free energy change (G) is highly negative
  B. Individual reactions
    1. Reactions with positive Go'
      (*a*) Free energy changes (G) is 0 or negative
      (*b*) increase substrates and/or decrease products
      (*c*) examples (*i*) aldolase
    2. Highly exergonic reactions are irreversible
      (*a*) hexokinase (*b*) phosphofructokinase (*c*) pyruvate kinase

40. Regulation of glycolysis
  A. Hexose transport
    1. Glucose transported into cell by GLUT
      - passive transport; insulin causes more GLUT to move to membrane
      - insulin increases glucose uptake by cells
    2. GLUT is a family of glucose transporters
      (*a*) GLUT1: most tissues (not in liver or muscle)
      (*b*) GLUT2: pancreatic – cells; regulate insulin release (?)
      (*c*) GLUT4: heart, skeletal muscle, and adipose tissue

3. No GLUT in liver: uptake of glucose by liver is not regulated by insulin

B. Hexokinase, Glucokinase

1. Isozymes with different properties

	Tissue	*Km*	*Inhibition by Glucose-6-P*
Hexokinase	all	0.1 mM	yes
Glucokinase	liver, pancreas	10 mM	no

C. Pyruvate kinase

1. 4 pyruvate kinase isozymes

(*a*) liver, kidney, and RBC isozymes are allosteric; activated by Fructose–1,6–BP & inhibited by ATP

(*b*) liver and intestinal isozymes can be phosphorylated

- phosphorylation by protein kinase A; glucagon stimulates protein kinase A
- phosphorylated pyruvate kinase is less active; glucagon decrease pyruvate kinase activity

D Phosphofructokinase-1

1. PFK-1 is allosterically regulated by several effectors
2. ATP allosterically increases Km for fructose-6–P
   - decreases PFK activity; AMP relieves ATP effect
   - ATP varies little (<10%), ADP and AMP vary greatly
3. ADP activates PFK-1 in mammals
4. Citrate inhibits PFK-1
5. Fructose 2,6-bisphosphate (F-2,6-BP) is a potent activator of PFK-

(*a*) One enzyme controls synthesis and degradation of F-2,6-BP

(*i*) two enzymatic functions on one protein

(*ii*) activities on separate domains

(*iii*) phosphorylation of enzyme controls activity

- dephosphoenzyme synthesizes F-2,6-BP
- phosphoenzyme converts F-2,6-BP to F-6-P
- phosphorylation regulated by a cAMP-dependant kinase
- dephosphorylation regulated by a phosphatase

(*b*) Phosphofructokinase-2 (PFK-2)

(*i*) synthesizes F-2,6-BP from fructose-6-P and ATP

(*ii*) inhibited by citrate & activated by Pi and indirectly by glucagon (cAMP)

(*c*) Fructose-2,6-bisphosphatase

- hydrolyzes F-2,6-BP to produce fructose-6-P

41. **Pasteur effect** – **Pasteur Effect** is a sudden change from anaerobic to aerobic respiration due to availability of oxygen. The rate of glucose consumption is greatest anaerobically

1. aerobic metabolism of glucose produces more ATP/glucose than anaerobic metabolism

2. ATP/ADP ratio controls glycolysis; glycolysis metabolizes more glucose to generate equivalent word only ATP levels

AMINO ACIDS

I. Function of amino acids

A. Building blocks of polypeptides
   1. polymerized to form polypeptides
      (*a*) linked by a peptide bond
      (*b*) synthesized during translation of messenger RNA
   2. primary structure of a protein is the sequence of amino acids
   3. both peptides and polypeptides can be functional
      Structure $^{-}OOC–CH_2–CH_2–NH_3^{+}$ GABA
      Structure $^{+}H_3N–CH_2–CH_2–SO_3^{-}$ TAURINE

B. Amino acids may be functional
   1. neurotransmitters
      - glutamate and aspartate (excitory)
      - glycine, taurine, and aminobutyric acid (GABA) (inhibitory)

C. Precursors to other molecules
   1. metabolic intermediates
      - citrulline and ornithine in urea cycle
      - can be metabolized to form glucose or acetyl CoA
   2. neurotransmitters – serotonin, dopamine, epinephrine, etc.
   3. tyrosine (thyroid hormone)
   4. porphyrins
   5. creatine (energy storage)
   6. histamine (mediator of immune response)
   7. nucleotide synthesis – S-adenosylmethionine

II. Structure of amino acids

A. 20 standard alpha-amino acids
   1. Structure.
      - alpha-carbon
      - alpha-amino group
      - alpha-carboxyl group
      - side chain (R group)
   2. “Standard” amino acids are encoded by messenger RNA
   3. Amino acids are abbreviated by a 3-letter and 1-letter code

B. Some amino acids are not incorporated into proteins during translation
   1. Modified amino acids

(*a*) Hydroxyproline and hydroxylysine
 (*i*) hydroxylated enzymatically after translation
 (*ii*) important in collagen structure (Structures of phosphoserine, 4-OH-proline, 5-OH-lysine)

(*b*) phosphoamino acids
 (*i*) Tyr, Ser, Thr hydroxyl groups can be phosphorylated
 (*ii*) important in activation and inhibition of enzymatic or signalling activity

2. Other important amino acids
 (*a*) Urea cycle intermediates – ornithine, citrulline, arginosuccinate
 (*b*) Thyroid hormone (tyrosine $\rightarrow$ thyroxine)

Abbreviations for the 20 "standard" amino acids

alanine	Ala	A	leucine	Leu	L
arganine	Arg	R	lysine	Lys	K
asparagines	Asn	N	methioneine	Met	M
aspartic acid	Asp	D	phenylalanine	Phe	F
cysteine	Cys	C	proline	Pro	P
glycine	Gly	G	serine	Ser	S
glutamine	Gln	Q	threonine	Thr	T
glutamic acid	Glu	E	tryptophan	Trp	W
histidine	His	H	tyrosine	Tyr	Y
isoleucine	Ile	I	valine	Val	V

III. Chemical Properties of Amino Acids

A. Physical characteristics

1. Charge
 (*a*) Amino acids are dipolar ions (zwitterions) at neutral pH
  (*i*) zwitterion is a dipolar molecule with pos. and neg. charges spatially separated
  (*ii*) definition of zwitterion in book is incorrect
 (*b*) Ionic states of amino acids depend on pH
  (*i*) amino acids have two or three dissociable protons
  (*ii*) pKa of the dissociable proton and the pH determine its degree of dissociation
  H–H equation: $pH = pKa + \log\{[A^-]/[HA]\}$

2. Titration curve of an amino acid
 (*a*) calculated using the H-H equation
 (*b*) Isoelectric point (pI) – pH at which the molecule has a net charge = 0 (average of the two appropriate pKa values)

3. Polarity
   (*a*) nine nonpolar amino acids
      (*i*) tend to orient to the inside of proteins
      (*ii*) Gly, Ala, Val, Leu, Ile, Met, Pro, Phe, Trp
   (*b*) eleven polar amino acids
      (*i*) tend to orient to the outside of proteins
      (*ii*) Ser, Thr, Tyr, Asp, Glu, Asn, Gln, Cys, Arg, Lys, His

4. Hydropathicity – index of solubility characteristics in H_2O
   (*a*) combines hydrophobic and hydrophilic tendencies
   (*b*) can be used to predict protein structure
   Hydrophobic Ile>Val>Leu>Phe>Met (listed from most hydrophobic)
   Less Hydrophobic Ala>Gly>Cys>Trp>Tyr>Pro>Thr>Ser
   Hydrophilic His>Glu>Asn>Gln>Asp>Lys>Arg (arg is most hydrophilic)

5. UV absorbance
   (*a*) aromatic a.a.s (Trp, Tyr, Phe) absorb UV light
   (*b*) absorbs UV light between 260-280 nm

B. Stereochemistry

1. Most amino acids have optical activity
   (*a*) chiral centers are asymmetric centers (usually carbons)
   (*b*) α-carbon of amino acids is chiral
   (*c*) chirality yields stereospecificity
   (*d*) Gly is not chiral (has no α-carbon)

2. L and D enantiomers (stereoisomers)
   (*a*) enantiomers are nonsuperimposable mirror images of the same molecule
      (*i*) L is levorotatory, D is dextrarotatory
   (*b*) L and D nomenclature from L and D-glyceraldehyde (Fisher convention)
      (*i*) not equivalent to R and S
      (*ii*) most natural a.a.s are L
      (*iii*) some a.a.s are R, some are S
   (*c*) L and D forms are chemically and physically distinguishable
      (*i*) different activity, melting points, and spectra

C. Cysteine can form disulfide bonds

1. cysteine is the reduced form (sulfhydryl)
2. cystine is the oxidized form (disulfide)
3. disulfide bridges formed between cysteines are important in protein structure

PROTEIN STRUCTURE AND PROTEIN FOLDING

I. Peptide bond – amide bond between alpha-amino and alpha-carboxyl groups of 2 amino acids

A. Chemical properties

1. Peptide bond is polar and planar
   (*a*) electron resonance structure
   (*b*) has partial (40%) double bond character
   (*c*) amide group is planar, usually trans
2. Synthesis
   (*a*) condensation produces water
   (*b*) energy required (ATP hydrolysis)
3. Peptide bond is hydrolyzable
   (*a*) acid hydrolysis generates free amino acids
      (*i*) 6N Hydrochloric acid heated at 110°C for 24 hr in a vacuum
   (*b*) base hydrolysis generates free amino acids
      (*i*) 4N Sodium hydroxide heated at 100°C for 4 hr
   (*c*) cyanogen bromide cleaves at the COOH-terminal side of Met
   (*d*) enzymatic hydrolysis of peptide bonds by proteases
      (*i*) peptidases are specific for certain amino acids
4. Polypeptides are polyampholytes
   (*a*) ampholyte has both acidic and basic pKa values
   (*b*) **isoelectric point** – pH at which the net charge is zero
   For example: H_3N^+–Ala–Lys–Ala–Ala–COO–
   pKa of the Alpha-carboxyl group = 3.6 pKa of the Alpha-amino group = 8.0
   pKa of the delta-amino of the Lysine = 10.6
   at pH = 1 the net charge is +2 at pH = 6 the net charge is +1
   at pH = 14 the net charge is –1
   the isoelectric point pI = (pKa2 + pKa3)/2 = (8 +10.6)/2 = 9.3

B. Nomenclature

1. Size
   (*a*) dipeptide (2 aminoacids & 1 peptide bond), tripeptide (3 aminoacids & 2 peptide bonds)
   (*b*) oligopeptide – several amino acids (up to 20)
   (*c*) polypeptides (more than 20 amino acids). All proteins are polypeptides

II. Physical Forces Governing Protein Conformation

A. Physical forces govern 3-D structure of proteins (Pauling and Corey)

1. bond lengths and angles should be distorted as little as possible
2. structures must follow Van der Waal's rules for atomic radii
3. peptide bond is planar and trans
4. noncovalent bonding stabilizes structure
5. conformation can change without breaking bonds (flexibility)

B. Types of non-covalent forces important to protein conformation

1. Hydrophobic forces
   (*a*) hydrophobic residues orient to inside
   (*b*) hydrophilic residues orient out
2. Van der Waal's potential:
   includes electron shell repulsion, dispersion forces, and electrostatic interactions
3. Salt bridges, electrostatic forces
4. Hydrogen bonds

C. Angles of rotation of the polypeptide chain determine structure

1. angles of rotation around alpha-carbon are [ψ (psi) and φ (phi)]
   (*a*) ψ (psi) is the angle of the alpha-carbon bond to the carbonyl-carbon
   (*b*) φ (phi) is the angle of the alpha-carbon bond to the amide-nitrogen
2. primary sequence and angles of rotation for each alpha-carbon completely define protein conformation
3. only a small number of psi and phi angles are allowed
4. statistical analysis of all proteins yields groups of prefered angles
   (*a*) areas of repeating (psi) and (phi) angles are secondary structures

III. Levels of Protein Structure

A. Primary Structure – amino acid sequence of a polypeptide

1. primary structure determines 3-dimensional structure (Anfinsen)
2. always represented NH_2-terminus to COOH-terminus

B. Secondary structure – regular local conformation of linear segments of the polypeptide chain

1. Secondary structure are stabilized by hydrogen bonds between amide and carbonyl groups
2. Several types of secondary structure
   (*a*) alpha-helix
      1. right handed helix

2. 3.6 amino acids per turn, rise per helix 5.4 Å, rise per aminoacid 1.5 Å
3. carbonyl oxygen hydrogen bonded to 4th amide hydrogen ($n \rightarrow n+4$)
4. amino acid R-groups orient out
5. proline breaks the helix

(*b*) beta-pleated sheet

(*i*) polypeptide chains side by side
(*ii*) polypeptide chains can be parallel or antiparallel
(*iii*) carbonyl oxygen hydrogen bonded to amide hydrogen
(*iv*) beta-strand is a single pass of the polypeptide

(*c*) reverse turn, beta-bend

(*i*) allows a sharp turn in polypeptide chain
(*ii*) carbonyl oxygen hydrogen bonded to 3rd amide hydrogen ($n \rightarrow n+3$)
(*iii*) Glycine is required

3. Fibrous proteins demonstrate secondary structure

(*a*) Fibroin
(*i*) silk is fibroin
(*ii*) antiparallel-beta-pleated sheet

(*b*) alpha-Keratin and tropomyosin
(*i*) alpha-keratins in wool and hair and epidermal layer
(*ii*) tropomyosin is a thin filament in muscle
(*iii*) alpha-helix allows elasticity
(*iv*) alpha-keratin converts to beta-pleated sheet with heat or stretching
- disulfides are important to maintenance of keratin secondary structure
- alpha-keratins are beta-pleated sheets; feathers and claws

(*c*) Collagen
(*i*) structural protein; skin, bones
(*ii*) triple helix (not alpha-helix)
(*iii*) sequence (Gly-Xaa-Pro) ‘ x or (Gly-Xaa-HyPro) x
(*iv*) glycine required for triple helix to form, contains many modified amino acids
(*v*) hydroxyproline stabilizes the structure, vitamin C required for hydroxylation; scurvy

C. Tertiary structure – overall folded conformation of the polypeptide

1. Physical forces affect tertiary structure

(*a*) Hydrophobic forces - hydrophobic residues orient to inside & hydrophilic orient out
(*b*) salt bridges, electrostatic forces
(*c*) Van der Waals radii
(*d*) Hydrogen bonds
(*e*) Disulfide bridges

D. Quaternary structure – subunit structure

1. aggregation of 2 or more subunits
   (*a*) hetero- or homo- polymers
2. same forces drive tertiary and quaternary structure

E. Structural elements

1. Sequence motif – small functional linear polypeptide sequence (may not be 3-D)
   (*a*) signal peptide
   (*b*) ER-retention signal
   (*c*) mitochondrial and nuclear targeting signals
   (*d*) RGD cell adhesion motif
2. Supersecondary structure (structural motif)
   (*a*) smallest conformational unit (may be functional)
   (*b*) examples àà (helix-loop-helix), hairpin, beta-barrels
      - Rossman fold, a nucleotide binding site
      - leucine zipper mediates transcription factor dimerization
      - zinc finger is a DNA binding motif
3. Domain
   (*a*) the part of a polypeptide chain that can independently fold into a tertiary structure
   (*b*) often domains have units of function
   (*c*) proteins may contain one or many domains

IV. Protein folding

A. Folding occurs step-wise with several intermediates unfolded/secondary structure/ domains/molten globule/native tertiary structure

1. a collapsed structure (molten globule) occurs very quickly
2. steps between molten globule and native tertiary structure usually occur slowly
   (*a*) intermediates are isolatable
   (*b*) multiple pathways are possible

B. Folding is driven by hydrophobic forces

C. Proteins can self assemble but in vivo folding is facilitated by proteins

1. **Chaperones** are binding proteins which assist folding
   (*a*) chaperones cause misfolded protein to unfold rather than aggregate
   (*b*) many chaperones require ATP hydrolysis for activity
   (*c*) more than one chaperone may act simultaneously and sequentially in the folding of a single protein
   (*d*) chaperones are specific for specific protein synthesis pathways (cytosolic vs. mito. vs. endoplasmic reticulum)

2. Enzymes catalyze kinetically slow steps infolding
   - (*a*) cis-trans prolyl isomerase
     - (*i*) both cis and trans peptide bonds to proline naturally occur
     - (*ii*) the isomerization of peptidyl-proline bonds may be slow
   - (*b*) protein disulfide isomerase
     - (*i*) catalyzes disulfide bond formation and isomerization

D. Denaturation is unfolding

1. Requires some input to overcome hydrophobic forces
   - (*a*) heat
   - (*b*) denaturant (urea or guanidinium)
2. Requires reductant to reduce disulfide bridges to sulfhydryls

V. Analytical Techniques in Protein Biochemistry

A. Determination of Amino Acid Composition

1. Amino acid analysis provides % of each amino acid in protein
   - (*a*) Hydrolysis of polypeptide with 6N HCl
   - (*b*) Derivitization of amino acids with dansyl chloride PITC, or O-phthalaldehyde (OPA)
   - (*c*) Liquid chromatographic separation of the tagged amino acids
   - (*d*) Quantitation
2. Composition of a protein can be used to identify a protein

B. Determination of primary sequence of a polypeptide

1. Preparation of peptides for sequencing
   - (*a*) Removal of disulfide bridges
     - (*i*) reducing agent (-mercaptoethanol or dithiothreitol)
     - (*ii*) derivatize sulfhydryls to block disulfides from reoxidizing
   - (*b*) Digestion with cyanogen bromide
     - (*i*) CNBr cleaves at the carboxyl side of methionine residues
   - (*c*) Digestion with proteolytic enzymes
     - (*i*) use at least two different enzymes
     - (*ii*) overlapping enzymes allows determination of peptide sequence
   - (*d*) Separation of peptides
     - (*i*) peptides separated by chromatography
     - (*ii*) based on differences in ionic, polar, and/or hydrophobic characteristics
2. **Edman degradation** is used to sequentially determine aminoacid sequence
   - (*a*) PITC reacts with the N-terminal amino acid
   - (*b*) Strong acid cleaves the peptide bond between the 1st and 2nd amino acids
   - (*c*) Product is a PTH derivative of amino acid #1

(*d*) Determine identity of amino acid-PTH using HPLC chromatography
(*e*). Repeat steps a-d

Note: Edman degradation has limited success with very long polypeptides

C. Determination of Molecular Mass

1. Gel Filtration (Molecular exclusion chromatography)
   (*a*) protein is loaded on a column of porous beads
   (b) small molecules can enter the beads, large ones cannot
   (*c*) an aqueous buffer moves the protein through the beads
2. SDS-polyacrylamide gel electrophoresis (SDS-PAGE)
   (*a*) protein is unfolded and coated with sodium dodecyl sulfate (SDS) detergent
   (*b*) proteins are loaded on an acrylamide gel matrix
   (*c*) electricity moves the proteins through the matrix
   (*d*) low molecular weight proteins move faster (farther)
   (*e*) large molecules migrate faster because they bypass beads

D. X-ray Crystallography and NMR

1. Physical techniques to identify 3-D structure of a pure protein
2. Requires tremendous time, effort, and analytical resources
   1. To understand the major structural features of immunoglobulins
   2. To understand the interaction of immunoglobulins with antigens
   3. To learn the major classes of immunoglobulins
   4. To understand the analytical uses of immunoglobulins

DNA STRUCTURE

A. DNA is a polymer of deoxyribonucleotide monophosphates

1. bases are adenine, guanine, cytosine, and thymine
2. linkage is through phosphodiester bonds; 5' and 3' ends
3. every DNA has a specific sequence of nucleotides—its primary structure—genetic information is stored in the primary structure of DNA

B. Most DNA in a cell exists as the Watson-Crick double helix which is known as B form DNA

Major features: right handed helix; bases on inside and sugar phosphate backbone on outside; base pairs are formed through hydrogen bonding; A pairs with T; G pairs with C; bases are perpendicular to the helical axis stacked on top of each other and interacting through hydrophobic interactions and van der Waals interactions; 3.4 A per base pair; ~10 base pairs per helical turn; strands are antiparallel; strands are complementary

- **A form** – having 11 base pairs (instead of 10 base pairs per turn), the base pairs are not perpendicular to the axis, but are tilted.

- **C form** – like B form, but having 9 base pairs per turn.
- **D form** – like B form, but have 8 base pairs per turn.
- **Z-DNA**–DNA with left handed coiling is called **Z-DNA**.

C. DNA supercoiling

1. a supercoil is when the double-helix twists around itself
2. supercoils can be positive or negative but natural DNAs exist in the negative supercoiled form
3. DNA can be supercoiled if it is circular or if is linear and has fixed ends
4. supercoiled DNA is more compact than relaxed DNA
5. negatively supercoiled DNA molecules are easier to unwind than relaxed molecules
   - DNA unwinding is required for replication and transcription

Topoisomerases are enzymes that catalyze changes in DNA supercoiling

1. ***Type I topoisomerases*** function by breaking a phosphodiester bond of one strand, passing the other strand through the break and resealing the break—they can only remove supercoils
2. ***Type II topoisomerases*** function by breaking both strands and passing a double strand region through the break before resealing the break—require ATP
3. Topoisomerases are targets of numerous chemotherapeutic drugs: adriamycin, VP16 (tenoposide), VM26 (etoposide), camptothecin

D. Nucleases

Enzymes that catalyze hydrolysis of phosphodiester bonds in nucleic acids

1. exonucleases cleave terminal nucleotides from either the 5′ or 3′ end of a polynucleotide
2. endonucleases cleave in the interior of nucleic acid molecule—restriction enzymes are endonucleases that cleave at specific sequences of DNA

E. Denaturation and renaturation of DNA

1. denaturation is the conversion of the double stranded form of DNA into single stranded form
   (*a*) DNA can be denatured by heat or alkaline treatment
   (*b*) The temperature at which half the DNA is unwound is defined as the melting temperature **(Tm)**
   –Tm is dependent on the GC content of the DNA, on the solvent, and on the ionic strength
   (*c*) **Hyperchromic effect:** On denaturation of dsDNA into SS DNA UV absorption at 260 nm increases.
2. renaturation—under proper conditions, complementary single-stranded nucleic acids can renature into a double-stranded form
3. denaturation/renaturation is the basis of hybridization experiments—this type of analysis is central to recombinant DNA technology and gene manipulation

F. Packaging of DNA in eukaryotes

1. DNA is packaged in the nucleus as a nucleoprotein complex called chromatin
2. Levels of chromatin packaging:
   (*a*) **Nucleosomes:** ~200 bp DNA and histones
      (*i*) nucleosome core particles consist of ~140 bp of DNA wrapped around a protein octamer consisting of 2 subunits each of histones H2A, H2B, H3, and H4
      (*ii*) linker DNA is the DNA between two core particles; histone H1 binds to the linker DNA and the core particle
   (*b*) **30 nm fiber (Solenoid):** nucleosomes are wound into a solenoid-like structure—requires histone H1 binding to every linker DNA
3. chromatin is the template for replication and transcription and the substrate for DNA repair and recombination

DNA REPLICATION

A. DNA replication is semiconservative

B. DNA replication is (usually) bidirectional

C. Chain growth occurs by addition of deoxynucleotidyl monomers to the end of a DNA chain
   1. DNA is always synthesized in the 5' to 3' direction
   2. This reaction is carried out by DNA polymerases
      (*a*) general requirements of DNA polymerases
         (*i*) deoxynucleotide triphosphates (dATP, dGTP, dCTP, TTP)
         (*ii*) DNA template
         (*iii*) a primer chain with a free 3'-OH—note that DNA polymerases cannot start with a single nucleotide

D. At a replication fork one of the new strands is synthesized in a continuous manner (the leading strand) and the other is synthesized in a discontinuous manner (the lagging strand)

E. Molecular events of DNA replication (E. coli chromosomal replication)
   1. **Initiation**
      (*a*) an initiator protein (dnaA protein in E. coli) binds to an origin of replication and “melts” a short DNA sequence —an origin is a unique site on the chromosome where replication begins, it consists of binding sites for the initiator protein and a flanking AT-rich sequence
      (*b*) helicase (dnaB/dnaC complex) binds to melted region and further unwinds parental strands
      (*c*) SSB (single-strand binding protein) binds to unwound region to prevent reannealing and stabilize the single-stranded form at the replication fork
      (*d*) an RNA primer is synthesized by primase (primase is part of a multi-protein complex called the primosome)
      (*e*) DNA polymerase III (holoenzyme) is assembled

2. **Elongation**
   (*a*) DNA polymerase III extends RNA primers
   (*b*) helicase continues to unwind parental DNA strands ahead of polymerase
      (*i*) the leading strand continues uninterrupted (DNA pol III has high processivity)
      (*ii*) on the lagging strand, approximately 1000 bp are replicated before primase must synthesize a new RNA primer to be elongated by DNA pol III. —Okazaki fragments
3. **DNA polymerase I (in E. coli)**
   Klenov fragment have 5'→3' polymerase (fills in the gap) and 3'→5' Exonuclease activity (Proofreading activity). Another unit removes RNA primer (5'-3' exonuclease activity) and
4. **DNA ligase**
   Seals the nicks—E. coli DNA ligase requires NAD^+ and Bacteriophage λ requires ATP
5. **Termination** of replication takes place within a region of the circular E. coli chromosome called ter

F. The replisome is a large multiprotein "machine" that is thought to replicate both the leading and lagging strand simultaneously

G. Proofreading: Pol III (and Pol I) has 3′—5′ exonuclease activity —if incorrect base is inserted it can back up 1 nucleotide and then continue polymerization

H. DNA replication in eukaryotes
1. enzymatically the mechanism is basically the same as in prokaryotes
2. each chromosome has multiple origins
3. DNA is replicated only during S phase of the cell cycle and only once during each cell cycle
4. the substrate (template) for replication is chromatin
5. a special enzyme called telomerase is necessary for replicating the ends of linear chromosomes
   (*a*) the ends of eukaryotic chromosomes are called telomeres and are made up of short repetitive sequences
   (*b*) telomerase is an enzyme that contains both protein and RNA components
   (*c*) the RNA component is used as a template to synthesize new telomere repeats
   (*d*) telomerase and cancer

DNA REPAIR

A. DNA damage caused by ultraviolet light

1. cyclobutane-type pyrimidine dimer is the major photoproduct formed
2. a second product, the 6-4 photoproduct, is formed in about 10 % of UV induced pyrimidine dimers
3. the cyclobutane type dimer can be reversed by a process called photoreactivation

   (*a*) this is carried out by an enzyme called DNA photolyase (photoreactivating enzyme)
   (*b*) importance of the photolyase enzyme in humans is questionable
4. DNA photoproducts can also be repaired by excision repair

B. Spontaneous deamination of cytosine

1. deamination of cytosine is common and results in the conversion of cytosine to uracil
2. can be repaired by excision repair process
   (*i*) uracil-DNA glycosylase hydrolyzes N-glycosidic bond to remove uracil base
   (*ii*) AP endonuclease removes deoxyribose-phosphate
   (*iii*) gap is extended by exonuclease
   (*iv*) gap is filled by DNA polymerase I and nick is sealed by DNA ligase

C. Depurination

Pathway is similar to that above except that excision repair begins with AP endonuclease

D. DNA damaged by alkylating agents

1. Some simple alkylating agents:
2. examples of products of alkylating agents:
3. many of these products can be repaired by excision repair that is initiated by specific glycosylases
4. some damage resulting from methylation can be reversed by methyltransferases
   (*a*) O6-methylguanine-DNA methyltransferase

E. Mismatch repair

1. mismatches can occur when DNA polymerase inserts the wrong nucleotide during replication
2. mismatch repair is "coupled" to replication
3. How do the mismatch repair enzymes distinguish which base is incorrect?
   (*a*) parental DNA is methylated—in E. coli an enzyme called Dam methylase methylates the C in both strands at the sequence GATC
   (*b*) immediately after replication only the parental strands are methylated (the DNA is hemimethylated)
4. the defective gene in one form of hereditary colon cancer was recently found to be the human homologue of mutS

F. Recombinational repair

1. occurs during DNA replication
2. major steps:
   (*a*) DNA polymerase skips over damaged DNA leaving a gap opposite the lesion
   (*b*) the undamaged parental strand recombines into the gap (this is facilitated by recA protein in E. coli)
   (*c*) the new gap in the parental strand is filled by DNA polymerase and ligase

G. Genetic Defects in DNA repair and human disease

1. Xeroderma pigmentosum is an inherited disease that is characterized by severe photosensitivity and a very high incidence of skin cancers. It is due to defective excision repair.
2. Bloom's syndrome.
3. Cockayne's syndrome
4. Fanconi's anemia
5. Ataxia telangiectasia

RNA STRUCTURE, TRANSCRIPTION, RNA PROCESSING

I. Structure of RNA

A. RNA is a polymer of ribonucleotide monophosphates
   1. purine bases are adenine and guanine; pyrimidine bases are cytosine and uracil
   2. RNA molecules can have extensive secondary structure
      (*a*) intramolecular base pairing
      (*b*) regions of base pairing in RNA form an A-type double helix
      (*c*) many secondary structures of RNA have defined functional roles

II. Classes of RNA molecules

A. Messenger RNA (mRNA): transcribed by RNA polymerase II in eukaryotes; encode proteins
B. Ribosomal RNA (rRNA)
   1. 18 S, 28 S, and 5.8 S rRNAs are transcribed by RNA polymerase I in eukaryotes
   2. 5 S RNA is another type of RNA associated with ribosomes but is transcribed by RNA polymerase III in eukaryotes
   3. rRNA serve structural and catalytic roles in ribosomes
C. Transfer RNA (tRNA): transcribed by RNA polymerase III in eukaryotes.

Note: all three types of RNA's above are transcribed by the same RNA polymerase in prokaryotes

D. Numerous other small RNA's are also found in cells—in eukaryotic cells these can be put into two general classes: snRNA = small nuclear RNA & scRNA = small cytoplasmic RNA
   1. snRNA's and scRNA's are found complexed with proteins and carried a variety of cellular functions (snRNP and scRNP)

III. Transcription

A. RNA molecules are transcribed from a DNA template by RNA polymerases
B. requirements for RNA polymerases: DNA template, ATP, GTP, CTP, UTP, Mg^{++} (no primer is necessary for RNA polymerase)

C. chain growth is from 5′ to 3′

D. General mechanism of transcription

IV. RNA synthesis in bacteria

A. Steps of transcription

1. Initiation

(*a*) RNA polymerase binds to DNA and migrates to the promoter

(*i*) a promoter is a specific DNA sequence that contains a site for transcriptional initiation—E. coli promoter contain a -10 region and a -35 region that are important in binding polymerase

(*ii*) specific interaction between the promoter and RNA polymerase requires sigma factor

(*iii*) initial complex between polymerase and promoter is called the closed complex

(*b*) RNA polymerase unwinds ~18 bp forming an open complex

(*c*) first nucleotide, which is almost always a purine, interacts with the open complex by binding to polymerase and base pairing with the complementary nucleotide in the template strand

2. Elongation

(*a*) the second nucleotide binds to the polymerase-template complex and a phosphodiester bond is formed

(*b*) sigma factor is released and polymerase moves down the template, unwinding the template and catalyzing the addition of each successive nucleotide

(*c*) approximately 12 nucleotides of the growing RNA chain are base paired with the DNA template during the elongation phase

3. Termination

(*a*) Termination requires special termination signals

(*i*) rho-independent termination

(*ii*) rho-dependent termination

B. Inhibitors of bacterial RNA synthesis

1. actinomycin D—binds to DNA by intercalating between base pairs
2. rifampicin (rifamycin)—binds to the beta subunit of bacterial RNA polymerase
   - also inhibits mitochondrial RNA polymerase
   - used to treat tuberculosis which is resistant to most other antibiotics

V. DNA synthesis in eukaryotes

A. transcription and processing of mRNA

1. most transcription units have exons and introns
2. Initiation of transcription by RNA polymerase II

(*a*) polymerase II does not recognize a specific sequence in the promoter; it is positioned at the correct site by interaction with transcription factors (*b*) many genes contain a sequence called the TATA box approximately 30 bp upstream from the transcriptional start site; a transcription factor named TFIID specifically binds to the TATA box to help position the polymerase at the initiation site. Some genes lack a TATA box but also utilize a sequence-specific transcription factor to target polymerase to the initiation site.

3. Capping of the 5' end of the transcript
   (*a*) very soon after the transcript is initiated a 7-methylguanosine "cap" is added to the 5' end of the transcript by guanosyl transferase
   (*b*) 7mG cap is an important signal for the translation process and may also help protect the message from degradation
4. Polyadenylation by Poly (A) polymerase
   (*a*) the 3' end of (most) transcripts is modified by polyadenylation
   (*b*) the poly A tail is usually about 200-250 nucleotides
   (*c*) the poly A tail is not encoded by the gene but is added post-transcriptionally
   (*d*) polyadenylation requires a specific sequence (AAUAAA) in the mRNA
   (*e*) no specific termination signal is known for eukaryotic genes and transcription proceeds past the polyadenylation signal
5. mRNA splicing
   (*a*) intron sequences are removed from primary transcripts by a process called splicing
   (*b*) splicing requires consensus splicing signals at the 5' and 3' ends of the intron, a consensus branch point 10-40 bases upstream of the 3' end of the intron
   (*c*) splicing is carried out by a large complex called the spliceosome—the spliceosome is assembled from small nuclear ribonucleoprotein (snRNP's)

B. Synthesis and processing of rRNA in eukaryotes

1. rRNA is synthesized in the nucleolus by RNA polymerase I
2. genes for rRNA's are found in multiple copies in tandem arrays on the chromosome
3. all three major ribosomal RNA's (28S, 18S, 5.8S) are synthesized as part of the same precursor transcript which is processed by a series of cleavage steps to produce the mature rRNA's
4. assembly of rRNA's and ribosomal proteins into large and small ribosomal subunits also takes place in the nucleolus

C. Synthesis and processing of tRNA

1. synthesized by RNA polymerase III in eukaryotes
2. primary transcript is a precursor that generally has extra nucleotides on both the 5' and 3' ends; some tRNA genes also have introns but splicing is by a completely different mechanism than with mRNA
3. the extra nucleotides are removed from the ends and then 3 nucleotides (CCA, these are not encoded by the gene) are added to the 3' end post-transcriptionally
4. the bases of tRNAs undergo extensive post-transcriptional modification, up to 10 % of the nucleotides can be modified
5. mature tRNAs have extensive secondary and tertiary structure that is important for their function

PROTEIN SYNTHESIS

I. Overview of Translation

A. Translation is the process by which a polypeptide chain is synthesized by ribosomes using the sequence of codons in an mRNA to direct the sequence of amino acids.

B. Translation is the ultimate step in gene expression.

C. The energy cost for protein synthesis is very high.

1. Only a small fraction of the energy input of translation is needed to form the peptide bond.
2. The majority of energy is invested to assure that the sequence of the polypeptide is correct.
3. If incorrect polypeptides (e.g. enzymes) are made by the cell, it could have devastating effects on cell function.

D. The mRNA is always read from 5' to 3'.

E. The polypeptide is always synthesized in the direction of amino-terminus to carboxyl-terminus.

II. Components of Translation

A. mRNA

The mRNA serves at the template that will determine the sequence of amino acids in the new polypeptide.

1. Structure of mRNA

(*a*) 5' untranslated region (5' UTR).

(*i*) This is the sequence of the mRNA extending from the 5' end of the mRNA to the initiation codon.

(*ii*) It is not translated into polypeptide sequence.

(*iii*) It has a function analogous to the function of a promoter on a gene. It will direct the binding of the ribosome to the initiation codon.

(*b*) Initiation codon

(*i*) This is the triplet codon at which polypeptide synthesis begins.

(*ii*) It is always AUG and codes for a methionine.

(*iii*) As a result, all polypeptides are synthsized with an amino-terminal methionine.

(*c*) Coding region

(*i*) This is the sequence of mRNA that contains the consecutive triplet codons that direct polypeptide synthesis.

(*ii*) This region spans from the start codon to the stop codon.

(*iii*) The coding region is often referred to as the **open reading frame or ORF**.

(*d*) Stop codon

(*i*) This is the triplet codon that signals the termination of translation.

(*ii*) There are three possible stop codon sequences: UAA, UAG, UGA.

(*iii*) Stop codons have no corresponding tRNA or amino acid.

(*e*) 3' untranslated region (3' UTR)

(*i*) This is the nucleotide sequence downstream from the stop codon.

(*ii*) It extends from the stop codon to the 3' end of the mRNA

(*iii*) It does not code for amino acid sequence.

(*iv*) It may function in stabilizing the mRNA.

B. tRNA

1. The function of tRNA is deliver the correct amino acid to the ribosome as directed by the codon on the mRNA for incorporation into the polypeptide.
2. The tRNA has two important functional features

(*a*) A tRNA is covalently bound to an amino acid at its 3' end.

(*i*) This form of tRNA is called an **amino acyl tRNA**.

(*ii*) Each tRNA will be bound to only one of the twenty possible amino acids. However, there can be multiple tRNAs for each amino acid.

(*b*) The tRNA contains a triplet sequence of nucleotides that are complementary to the triplet codons of the mRNA. This sequence is called the **anti-codon**.

(*i*) The covalently bound amino acid and the anti-codon strictly correspond to one another.

(*ii*) As a result, the pairing of codon of the mRNA and the anti-codon of the amino acyl-tRNA during translation will deliver the correct amino acid to the growing polypeptide chain.

3. Structure of tRNA

(*a*) Cloverleaf structure

(*i*) 73-93 bases in length

(*ii*) Many unusual bases (Psuedo Uracil, Thymine, Dihdroxy Uracil etc.)

(*iii*) The nucleotides form many **intra-chain base pairs**, resulting in a **secondary structure** that resembles a cloverleaf.

(*b*) Acceptor Stem

(*i*) This is a region of the tRNA that is the site of attachment for the appropriate amino acid.

(*ii*) It is formed by seven regular Watson & Crick base pairs between the 5' and 3' ends of the tRNA.

(*iii*) The 3' terminal end of all tRNAs is always CCA-OH.

(*a*) It is not base paired and is the site of attachment of the amino acid.

(*b*) The amino acid is covalently bound through an **ester linkage** between the carboxyl group of the amino acid and the 3' hydroxyl group of the ribose of the tRNA.

(*c*) Anticodon Loop

(*i*) The anti-codon loop contains the three nucleotide sequence that is the reverse complement of the codon of mRNA to which it corresponds.

(*ii*) It consists of a total of seven unpaired bases; three of which are the anti-codon.

4. Wobble Hypothesis

(*a*) Four common bases in mRNA can be arranged in 43 or 64 different combinations

(*b*) How does this relate to the 20 aa’s available for translation?

(*i*) Genetic code is redundant

(*a*) 3 codons used as stops UAA, UAG, UGA.

(*b*) 61 available as codons

(*c*) 1965, Francis Crick proposed the Wobble Hypothesis to account for this inconsistency

(*i*) Codons in mRNA and anti-codons interact in an anti-parallel manner at the ribosome so that positions 1 and 2 of the codon form normal Watson-Crick base pairs.

(*ii*) The third position allows non-standard base pairing or **wobble**.

(*d*) Consequences: Different anti-codons can pair with one codon.

C. Ribosome

1. Performs 3 essential functions

(*a*) Selection of mRNA initiation site.

(*b*) Ensures correct pairing of codons and anticodons.

(*c*) Catalyzes formation of peptide bonds.

2. Ribosomes are large protein-RNA complexes that are divided into a large and small subunit.

(*a*) Large subunit.

(*i*) In prokaryotes this subunit is called the 50S subunit.

(*ii*) In eukaryotes this subunit is called the 60S subunit.

(*iii*) It contains the active site for catalyzing polypeptide bond formation. This enzyme within the ribosome is called the **peptidyl transferase**.

(*b*) Small subunit

(*i*) In prokaryotes this subunit is called the 30S subunit.

(*ii*) In eukaryotes this subunit is called the 40S subunit.

(*iii*) It is primarily responsible for positioning the ribosome at the intitiation codon and pairing codon and anti-codon during synthesis.

III. Mechanism of Translation

A. Three steps in translation process

1. **Initiation–** The small and large subunits of the ribosome bind at the initiation codon and the methionine-tRNA anticodon pairs with the start codon.
2. **Elongation–** The ribosome proceeds down the mRNA one triplet codon at a time, positioning the correct amino acyl-tRNA with the codon, and catalyzing polypeptide synthesis.
3. **Termination–** The ribosome encounters a stop codon. The polypeptide, tRNA, and mRNA are released. The small and large subunits dissociate from one another.

B. Prokaryotic translation

1. Initiation– three steps to initiation

(*a*) mRNA binds to 30S.

(*i*) Ribosome aligned by base pairing of a region of 16S rRNA of the 30S ribosomal subunit to a region on the mRNA 6-10 bases upstream of the initiation codon.

(*ii*) The region is called the **Shine/Dalgarno sequence**.

(*b*) Methionyl-tRNA binds to 30S-mRNA complex.

(*i*) First aa-tRNA is positioned complementary to the first codon by the 30S ribosomal subunit.

(*ii*) In prokaryotes the first amino acyl-tRNA is always formyl methionyl tRNA (fMet-tRNAfMet)

(*iii*) Therefore, all proteins in prokaryotes are synthesized with formyl methionine as their first amino acid.

(*iv*) This complex is called the 30S pre-initiation complex.

(*c*) 50S subunit binds to 30S-tRNA-mRNA complex.

(*i*) This complex is called the **initiation complex**.

(*ii*) Two sites for amino acyl-tRNA binding on 50S subunit.

(*a*) The **peptidyl site** or **P-site**. This is the site where the growing polypeptide will be anchored to the ribosome. The polypeptide is held in place by covalent attachment of its carboxyl-terminal amino acid to its corresponding tRNA. This is called the **peptidyl-tRNA**.

(*b*) The **amino acyl site** or **A-site**. This is the site adjacent to the P-site where the next amino acyl-tRNA will bind at the ribosome. It is positioned directly over the triplet codon to allow codon-anticodon pairing.

(*iii*) At initiation, fMet-tRNA is in the P-site and the 2nd codon is positioned at the A-site.

2. Elongation

(*a*) Three reactions

(*i*) **Binding** of aa-tRNA to A-site

(*a*) Specificity determined by codon, anticodon pairing.

(*b*) GTP is hydrolyzed at the ribosome is pairing is correct.

(*c*) GTP hydrolysis is part of **proofreading**.

(*d*) If anti-codon and codon are completely non-complementary, amino acyl-tRNA will not bind to ribosome.

(*e*) If complement is sufficient, binding and GTP hydrolysis occur.

(*f*) If complement is not perfect, the ribosome will reject the amino acyl-tRNA.

(*g*) Hydrolysis of GTP must occur before the next step in translation can occur.

(*ii*) **Transpeptidation**

(*a*) Transfer of the growing polypeptide from peptidyl tRNA at the P-site to the amino acyl-tRNA at the A-site.

(*b*) The ester bond between the peptide and tRNA of the peptidyl-tRNA is broken and the carboxyl-terminus of the peptide reacts with the amino group of the amino acid of the amino acyl-tRNA to form a peptide bond at the A-site. The hydrolysis of the ester bond provides sufficient energy to drive peptide bond formation.

(*c*) Catalyzed by **peptidyl transferase**.

(*iii*) **Translocation**

(*a*) Movement of peptidyl-tRNA from A-site to the P-site and release of **deacylated** tRNA from the P-site.

(*b*) Also requires GTP hydrolysis.

(*iv*) Steps in elongation are repeated until a stop codon is reached.

(*v*) Many ribosomes at various stages of translation can be bound to a single mRNA.

(*a*) This structure is called a polysome.

(*b*) As a result many polypeptides are synthesized simultaneously from a single mRNA.

3. Termination

(*a*) When the ribosome encounters a UGA, UAG or UAA codon, no amino acid is added to the polypeptide. These codons are called **termination codons**.

(*b*) Termination also requires **release factors**.

(*c*) Function of release factors

(*i*) Catalyze hydrolysis of peptidyl tRNA

(*ii*) Promote dissociation of 50S subunit

(*d*) 30S dissociates or moves to the next start codon on the polycistronic mRNA.

C. Eukaryotic translation

1. Several differences from prokaryotes in the initiation stage.

(*a*) Initiation takes place at 1st AUG on the mRNA within Kozak Sequence (CCRCCAUGG).

(*b*) Methionyl-tRNAmet is used to initiate translation.

(*c*) There is no Shine/Dalgarno sequence in eukaryotes. The 40S Rb binds to the 5' cap structure of the mRNA and scans to kozak sequence.

(*d*) Initiation complete with association of 60S subunit.

2. Elongation and termination are very similar in prokaryotes and eukaryotes.

IV. Energetics of Translation

A. High energy bonds for synthesis of polypeptide chain of (N) amino acid residues

N ATP to charge tRNA

1 GTP for initiation

N-1 GTP for binding of aa-tRNA to A-site

N-1 GTP for translocation step

1 GTP for termination

Sum: 3N

300 aa protein requires 900 high energy bonds; Each bond is 7.5 kcal/mol

900 bonds × 7.5 kcal/bond = 6,750 kcal/mol polypeptide

22.5 kcal/bond

Free energy of peptide bond hydrolysis is –0.5 kcal/mol

At 10% energy conversion, –5 kcal would be sufficient to form a peptide bond.

B. High price paid for synthesizing a defined sequence.
   1. Random polymerization is cheaper
   2. Only one high energy bond is involved in peptide bond formation
   3. Cells need to proofread to insure defined sequence.
   4. The ultimate step in gene expression must be correct.

METABOLIC INTERRELATIONSHIPS

I. Review of digestion

A. Carbohydrates, Proteins hydrolyzed and circulated as monomers
   1. Na^+ dependent uptake into intestinal cells
   2. Intestinal cells → blood → liver →
   3. Insulin stimulates uptake

B. Fat digestion different from CHO, Protein
   1. requires bile salts; Vit. A, E, and K fat soluble
   2. breakdown, resynthesis of triglycerides in mucosal cells
   3. chylomicrons → LYMPH, by-passing liver
   4. Medium Chain Fatty Acids enter blood directly as free fatty acids
   5. Liver takes up VLDL remnants, LDL, resynthesizes VLDL
   6. Role of specific apolipoproteins
      (*a*) A-I activates HDL-LCAT (Lecithin-Cholest. Acyl transferase)
      (*b*) B-48, B100, E for CM, VLDL, LDL receptors
      (*c*) C-II activates Lipo Protein Lipase (LPL)
   7. Effects of intracellular cholesterol
      (*a*) directly inhibits and decreases synthesis rate of HMG-CoA Reductase
      (*b*) decreases rate of synthesis of LDL receptors
      (*c*) stimulates Acyl-CoA Cholesterol Acyl Transferase (ACAT)

II. Review of Metabolism, Regulation

A. Glycolysis, Gluconeogenesis
   1. PFK-2 regulation:
      (*a*) cAMP-dependent PK inhibits it in liver
      (*b*) cAMP-dependent PK activates it in heart
      (*c*) cAMP-dependent PK has no effect in skeletal muscle
   2. Futile cycles and regulation

B. Glycogenesis, Glycogenolysis: Ca^{++}, cAMP-dependent phosphorylations

C. Fatty acid oxidation, fatty acid synthesis
   1. cAMP →→ Hormone Sensitive Lipase, Acetyl CoA Carboxylase
   2. Malonyl CoA blocks CAT transporter of FA into mitochondrion

D. Citric Acid Cycle
   1. $NADH/NAD^+$ ratio

2. Ca^{++} activates ICDH, α-KGDH, PDH
3. [Oxaloacetate] often limiting

E. Oxidative Phosphorylation
1. ATP/ADP,Pi "Mass action ratio" controls (DGATP)
2. ATP synthesis in equilibrium with Proton Motive Force (PMF)

F. Pentose Phosphate Pathway
1. Important source of NADPH, pentoses
2. [NADPH]/[$NADP^+$] ratio controls oxidative steps
3. Pentose-P / Hexose-P ratio controls reversible steps

G. Amino acid synthesis, degradation
1. Both require aminotransferases, glutamic dehydrogenase
2. Ala, Gln major amino acids for N transport in blood
3. Gln, Asp major Nitrogen sources for biosynthesis of other compounds (urea, purines, pyrimidines, Asn, etc.)

III. Metabolic Division of Labor among Major Organs

A. Liver

1. Major producer of fuel for other tissues: glucose, ketone bodies, VLDL
2. Uses glucose (fed), fatty acids (fasted), and amino acids as fuel (either)
   (*a*) Essential amino acids catabolized only when in excess (high Km enz.)
   (*b*) BCAA $\rightarrow$ muscle catabolism
   (*c*) gluconeogenesis from amino acids requires urea synthesis
   (*d*) gluconeogenesis driven by energy from fatty acid oxidation

B. Adipose

1. The major triacylglycerol (and calories) store
2. One of the major fates for excess dietary fats
3. Synthesis and breakdown of triglycerides under hormonal control
4. Synthesis requires glucose (NADPH via PPP; glycerol phosphate)
5. Hormone sensitive lipase (cAMP) releases FA, glycerol

C. Skeletal muscle

1. Fuel preference: Fatty acids > ketone bodies > glucose; BCAA
2. Glucose and glycogen primary fuel during exertion
3. Early starvation (first few days): muscle protein is broken down for energy throughout body and for gluconeogenesis (liver)
4. Muscle releases amino groups as ALA, GLN
5. As ketone bodies from liver rise, muscle proteolysis shut off

D. Heart

1. Heart has more mitochondria per gm of tissue than muscle, liver

2. Fuel preference: Fatty acids > ketone bodies > glucose
3. Negligible stores of glycogen or triglycerides: requires continual supply of fuels from blood (glucose, fatty acids, lactate, ketone bodies)

E. Brain

1. Glucose preferred substrate (60% of total glucose consumption at rest)
2. Long term fasting: adapts to ketone bodies as fuel (rate depends on conc.)

F. Other tissues

1. Intestinal cells:
   (*a*) Metabolize ASP, ASN, GLU, GLN for energy
   (*b*) Release citrulline, proline, NH_3, and ala
2. Kidney
   (*a*) Citrulline from intestinal cells used to make ARG
   (*b*) Long term fasting – significant gluconeogenesis
   (*c*) In acidosis, GLN $\rightarrow$ ALA + NH_4^+ (excreted) + HCO_3^- (retained)
3. Red blood cells: GLUCOSE, GLUCOSE, GLUCOSE

Some Commonly Used Inhibitors of Protein Synthesis

Inhibitor	Subunit or Factor Affected	Step(s) Blocked	Reaction Affected	Cell Type Affected
Aurintricarboxylic acid	30S/40S	Initiation	Binding of m-RNA	Prokaryotes/ Eukaryotes
Chloramphenicol	50 S	Elongation	Peptide bond Formation	Prokaryotes
Colcicin E3	30S	Initiation Elongation	Binding of m-RNA Binding of aminoacyl t-RNA	Prokaryotes
Cyclohexamide	60S	Initiation Elongation	Binding of Initiator t-RNA Translocation (t-RNA release from P Site)	Eukaryotes
Diptheria Toxin	eEF-2	Elongation	Translation	Eukaryotes
Erthromycin	50 S	Initiation	Formation of Initiation complex	Prokaryotes
Fusidic Acid	EF-G/eEF-2	Elongation	Translocation	Prokaryotes/ Eukaryotes
Kasugamycin	30 S	Initiation	Binding of initiator t-RNA	Prokaryotes
Puromycin	50S/60S	Elongation	Peptide bond formation (Trigger immature chain release)	Prokaryotes/ Eukaryotes
Spectinomycin	30 S	Elongation	Translocation	Prokaryotes
Streptomycin Elongation	30 S	Initiation	Binding if Initiator t-RNA Binding of aminoacyl t-RNA (Induced Misreading)	Prokaryotes
Tetracycline	30 S	Elongation Termination	Binding of aminoacyl t-RNA Binding of RF-1 and RF-2	Prokaryotes

Practice Test Paper-I

1. The pH of the blood is maintained by
   (*a*) mineral salts
   (*b*) globulins
   (*c*) albumins
   (*d*) haemoglobin

2. A protein having both structural and enzymatic traits is
   (*a*) actin
   (*b*) haemoglobin
   (*c*) myosin
   (*d*) myoglobin

3. Potassium cyanide stops cell activity by
   (*a*) preventing diffusion of O_2
   (*b*) blocking trachea
   (*c*) preventing transfer of electrons from cytochrome a3 to O_2
   (*d*) coagulating protein carriers

4. Successful Replication of chromosomes does not require the presence of
   (*a*) Ribosomes
   (*b*) DNA Template
   (*c*) Nuclear enzymes
   (*d*) ATP

5. In a diluted starch solution, α-salivary amylase is added at pH 1.6 and kept at 35°C for half an hour and then Iodine solution is added. What would be the result?
   (*a*) no black colour will appear
   (*b*) black colour will appear
   (*c*) solution will be clear and colourless
   (*d*) solution will be sweet

6. An amino acid devoid of a free-COOH group can be an
   (*a*) Amine
   (*b*) Amide
   (*c*) Imine
   (*d*) Purine

7. The most striking example of an unique point mutation is found in a disease called
   (*a*) Night blindness
   (*b*) Thalassemia
   (*c*) Down syndrome
   (*d*) Sickle cell anaemia

8. For the formation of one molecule of hexose sugar, how many turns of Calvin cycle are needed ?
   (*a*) Six
   (*b*) One
   (*c*) Thirty-six
   (*d*) One-sixth

9. The hormone that controls pulse rate and blood pressure is
   (*a*) vasopressin
   (*b*) oxytocin
   (*c*) adrenalin
   (*d*) thyroxine

10. The maximum number of Hydrogen bonds in which water molecule can participate is?
    (*a*) 1 (*b*) 2
    (*c*) 3 (*d*) 4

11. Denaturation of proteins leads to loss of biological activity by
    (*a*) formation of amino acid
    (*b*) loss of primary structure
    (*c*) loss of both primary and secondary structure
    (*d*) loss of secondary and tertiary structure

12. The pKa of acetic acid is 4.76. What is the pH of 0.1 M solution of acetic acid?
    (*a*) 5.76 (*b*) 2.88
    (*c*) 2.43 (*d*) 1.88

13. 40 g of ice at 0 °C and 80 g water at 40 ºC are mixed thoroughly, the temperature of the mixture will be
    (*a*) 0° C (*b*) 10 °C
    (*c*) 20 °C (*d*) 30 °C

14. Galactose and Mannose are two isomeric monosaccharides, which are
    (*a*) Enantiomers (*b*) Epimers
    (*c*) Anomers (*d*) Diastereoisorners

15. Proteins absorbs maximally UV radiation at 280 nm due to the presence of
    (*a*) Tryptophan (*b*) Tyrosine
    (*c*) Phenyl alanine (*d*) All of the above

16. Which one of the following solutions will have the least Osmotic Pressure?
    (*a*) 0.5 M glucose (*b*) 0.5 M NaCl
    (*c*) 0.5 M Na_2SO_4 (*d*) 0.499 M Starch

17. The free energy change (ΔG)at the midpoint of helix-coil transition in DNA melting curve is equal to
    (*a*) zero (*b*) 1.0
    (*c*) –1.0 (*d*) indeterminate

18. DNA is usually dissolved in TRIS-EDTA buffer, EDTA is added to ensure that
    (*a*) DNA is not degraded by nucleases
    (*b*) Divalent metal ions are chelated
    (*c*) Both of the above
    (*d*) pH is kept alkaline

19. Two proteins have same molecular weight and same isoelectric point. The best way to resolve them will be by
    (*a*) Ion Exchange Chromatography
    (*b*) Gel Filtration Chromatography
    (*c*) Reverse Phase Chromatography
    (*d*) Chromatofocussing

20. Mark the incorrect statement: Ribozyme and Abzyme are
    (*a*) both enzymes
    (*b*) both proteins
    (*c*) RNA and protein respectively
    (*d*) able to hydrolyse phosphodiester and peptide bonds respectively

21. DNA sequencing is done on a sequencing gel, which is
    (*a*) SDS-PAGE
    (*b*) Urea-PAGE
    (*c*) Native PAGE
    (*d*) Agarose

22. The digestion of lipid takes place in small intestine by lipases, However, it does not occur till bile fluid mixes with the food. This mixing up of food with bile juice is essential for digestion of lipids because
    (*a*) lipases present in the intestine require another coenzyme present in the bile juice for its functioning
    (*b*) Emulsification is must for fats to be digested and for lipases to act upon lipids
    (*c*) lipase can only act at alkaline pH
    (*d*) None of the above

23. Mark the Incorrect statement:
    (*a*) Endocrine signaling is relatively slow because it depends on diffusion and blood flow
    (*b*) If the same hormone has different effects on different target organs, the receptor are usually different
    (*c*) Water soluble hormones interact with cell surface receptors, whereas lipid soluble hormones usually bind to intracellular receptors
    (*d*) The specificity of hormone signaling depends on responsive cells possessing receptors that bond the hormone tightly by means of multiple weak bonds.

24. Silencers are located to upstream of transcription start site and function-
    (*a*) in both the orientation
    (*b*) in forward orientation
    (*c*) in reverse orientation
    (*d*) None of the above

25. The renaturation of the genome is a random collision of complementary sequences and follows
    (*a*) first order kinetics
    (*b*) second order kinetics
    (*c*) third order kinetics
    (*d*) None of the above

26. Which one of the following electrophoresis dependents least on the charge of the protein?
    (*a*) Free zone capillary electrophoresis
    (*b*) Gel electrophoresis
    (*c*) SDS-polycrylamide gel electrophoresis
    (*d*) Isoelectric focussing

27. Which one of the following compound has the highest group transfer potential for phosphate ?
    (*a*) Glucose-6-phosphate
    (*b*) Fructose-1, 6-diphosphate
    (*c*) 2-phosphoenolpyruvate
    (*d*) Adenosine triphosphate

28. Which one of the following sets of glycolytic enzymes is allosterically regulated?
    (*a*) Glucokinase, phosphofructokinase and pyruvate kinase
    (*b*) Hexokinase, aldolase and pyruvate kinase
    (*c*) Phosphofructokinase, enolase and pyruvate kinase
    (*d*) Hexokinase, phosphofructokinase and pyruvate kinase

29. Which one of the following compounds is required for acetyl coenzyme A (acetyl CoA)to enter the citric acid cycle?
    (*a*) Isocitrate
    (*b*) Malate
    (*c*) Oxaloacetate
    (*d*) Pyruvate

30. Which one of the following DNA polymerase is essential for both the replication and repair of DNA?
    (*a*) DNA polymerase I
    (*b*) DNA polymerase II
    (*c*) DNA polymerase III
    (*d*) DNA polymerase δ

31. The factor required only for accurate initiations of transcription in prokaryotes is
    (*a*) alpha (α)
    (*b*) beta (β)
    (*c*) rho (ρ)
    (*d*) sigma (σ)

32. A post-transcriptional processing event that occurs in the formation of both messenger RNA (mRNA)and transfer RNA (t-RNA) in eukaryotes is
    (*a*) the addition of the sequence CCA to 3' ends
    (*b*) the removal of introns by splicing
    (*c*) the modification of some of their bases
    (*d*) cleavage event before polyadenylation

33. Eukaryotic mRNAs differ from Prokaryotic mRNAs in that
    (*a*) they do not have a 5′ untranslated region
    (*b*) their coding regions are separated by spacers
    (*c*) they do not have 3′ UTR
    (*d*) they have a free 3′ hydroxy group on each of their ends

34. Degeneracy of the genetic code means that
    (*a*) a given base triplet can code for more than one amino acid
    (*b*) there is no punctuation in the code sequence
    (*c*) the third base in a codon is net important for coding
    (*d*) a given amino acid can be coded for by more than one base triplet

35. Which one of the following sequences is most likely to be a restriction enzyme recognition site?
    (*a*) CGGC
    (*b*) CGC
    (*c*) GTAATG
    (*d*) GTCGAC

36. Which step is the first in the formation of a double stranded complementary DNA (c DNA) target for cloning?
    (*a*) blunt end ligation
    (*b*) DNA dependent DNA synthesis
    (*c*) Restriction enzyme cleavage
    (*d*) Primer annealing

37. Cyclic AMP regulates the lactose (lac)operon by
    (*a*) binding to the operator to turn on transcription
    (*b*) binding to the lac repressor to prevent transcription
    (*c*) combining with the catabolitic activator protein (CAP) to form a complex that enhances transcriptions upon binding to the promotor .
    (*d*) combining with the CAP to remove CAP's inhibition of transcription

38. A 4 Kb covalently closed circular (ccc) plasmid has 2 (two) sites for a restriction enzyme 1 kb apart. It is partially digested by the enzyme. The maximum number of bands that could be seen on a gel will be
    (*a*) 1 (*b*) 2
    (*c*) 3 (*d*) 4

39. In an enzyme reaction the reaction velocity becomes more than double when the substrate concentration is doubled. This is possible when the equation governing the kinetics is
    (*a*) Michelis-Menton Kinetics
    (*b*) Micheils-Menton Kinetics with substrate inhibition
    (*c*) Michelis-Menton Kinetics with product inhibition
    (*d*) Hill Equation

40. A mixture separated on HPLC gives clearly defined peaks whereas in a manually run column the peaks tend to blend into each other. This is primarily because
    (*a*) the small size of the packing material used in the HPLC column
    (*b*) the better control of flow in HPLC
    (*c*) the use of high pressure in HPLC
    (*d*) the use of better detection systems in HPLC

41. Which is true about enzymes,
    (*a*) they always increase rate of reaction
    (*b*) they always decrease rate of reaction
    (*c*) they do not disturb the equilibrium
    (*d*) Always carry irreversible reactions

42. Linkage present in cellulose molecule is
    (*a*) $\beta (1 \rightarrow 4)$ (*b*) $\alpha (1 \rightarrow 4)$
    (*c*) $\alpha (1 \rightarrow 6)$ (*d*) both (*b*)and (*c*)

43. Blocking action of enzyme through blocking its active site is
(*a*) Allosteric inhibition (*b*) Feedback inhibition
(*c*) Competitive inhibition (*d*) Non-competitive inhibition

44. Which one of the following is without coenzyme activity ?
(*a*) Vitamin E (*b*) Thiamine
(*c*) Biotin (*d*) Riboflavin

45. Active transport
(*a*) Releases energy (*b*) Require energy
(*c*) Produces energy (*d*) Produces toxic material

46. A short length of double stranded DNA molecule contains 120 adenine and 120 cytosine bases. The total number of nucleotides in this DNA fragment is
(*a*) 60 (*b*) 120
(*c*) 240 (*d*) 480

47. Which of the following element plays an important role in nitrogen fixation?
(*a*) Manganese (*b*) Molybdenum
(*c*) Zinc (*d*) Copper

48. Specificity of an enzyme depends upon
(*a*) Active site (*b*) Linear sequence
(*c*) Km (*d*) Turn over number

49. Sodium Dodecyl Sulphate (SDS) is used while separating proteins by polyacrylanide gel electrophoresis because
(*a*) It helps in solubilization of proteins thereby making it easier to separate
(*b*) It binds to proteins and confers uniform negative charge density thereby making them move during electrophoresis
(*c*) Decreases the surface tension of the buffer used for electrophoresis
(*d*) Stabilizes the proteins

50. In a substitution nucleophilic first order reaction (SN1)the stereochemical outcome is
(*a*) Raemisation (*b*) Inversion of configuration
(*c*) Retention of configuration (*d*) Difficult to predict

51. Which of the following chemotherapeutic agents works by impairing de novo purinesynthesis?
(*a*) acyclovir (acycloguanosine) (*b*) 5-fluorouracil (antimetabolite)
(*c*) methotrexate (anti folate) (*d*) hydroxyurea

52. The largest energy reserve (in terms of kilocalories) in humans is:
(*a*) liver glycogen (*b*) muscle glycogen
(*c*) adipose tissue triacylglycerol. (*d*) muscle protein.

53. In the interaction of a hormone with its receptor all of the following are true EXCEPT:
    (*a*) more than one polypeptide chain of the hormone may be necessary.
    (*b*) more than one second messenger may be generated.
    (*c*) an array of transmembrane helices may form the binding site for the hormone.
    (*d*) hormones released from their receptor after endocytosis could theoretically interact with a nuclear receptor.

54. Some hormone-receptor complexes are internalized by endocytosis. This process may involve:
    (*a*) binding of hormone-receptor complex to a clathrin coated pit.
    (*b*) recycling of receptor to cell surface.
    (*c*) formation of a receptosome.
    (*d*) all of the above

55. In hypopituitarism it is necessary to maintain the ovarian cycle in female patients. In the ovarian cycle:
    (*a*) GnRH enters the vascular system via transport by a specific membrane carrier.
    (*b*) corpus luteum rapidly involutes only if fertilization does not occur.
    (*c*) inhibin works by inhibiting synthesis of a subunit of FSH.
    (*d*) LH is taken up by corpus luteum and binds to cytoplasmic receptors.

56. All of the following statements about actin and myosin are true EXCEPT:
    (*a*) the globular head section of myosin has domains for binding ATP and actin.
    (*b*) actin is the major protein of the thick filament.
    (*c*) the binding of ATP to the actin-myosin complex promotes dissociation of actin and myosin.
    (*d*) F-actin, formed by aggregation of G-actin-ATP-MgH complex, is stabilized when tropomyosin is bound to it.

57. Starch digestion is more efficient after heating the starch with water because heating:
    (*a*) hydrates the starch granules, making them more susceptible to pancreatic amylase.
    (*b*) partly hydrolyses α-1, 6 links.
    (*c*) converts the linear amylose to branched amylopectin, which resembles glycogen.
    (*d*) inactivates amylase inhibitors, which are common in the tissues of starchy plants.

58. Micelles:
    (*a*) are the same as emulsion droplets.
    (*b*) form from bile acids at all bile acid concentrations.
    (*c*) although they are formed during lipid digestion, do not significantly enhance utilization of dietary lipid.
    (*d*) always consist of only a single lipid species.

59. Certain tissues effect Cl^- secretion via a Cl^- channel (CFTR protein-cystic fibrosis transmembrane regulatory protein). Cholera toxin abnormally opens the channel leading to a loss of NaCl. Treatment for cholera and sports drinks for electrolyte replacement are fluids high in Na^+ and glucose. The presence of glucose enhances NaCl replenishment because:
   (*a*) absorbing any nutrient causes Na^+ uptake.
   (*b*) glucose prevents Na^+ excretion.
   (*c*) Na^+ and glucose are transported in opposite directions.
   (*d*) glucose is absorbed across intestinal epithelial cells via a Na^+ -dependent cotransporter.

60. Of two people with approximately the same weight, the one with the higher basal energy requirement would most likely be:
   (*a*) taller
   (*b*) female if the other were male.
   (*c*) older
   (*d*) under less stress.

61. Basal metabolic rate:
   (*a*) is not influenced by energy intake.
   (*b*) may decrease up to 50% during periods of starvation.
   (*c*) increases in direct proportion to daily energy expenditure.
   (*d*) is not responsive to changes in hormone levels.

62. The primary effect of the consumption of excess protein beyond the body's immediate needs will be:
   (*a*) excretion of the excess as protein in the urine.
   (*b*) an increase in the "storage pool" of protein.
   (*c*) an increased synthesis of muscle protein.
   (*d*) an enhancement in the amount of circulating plasma proteins.

63. Kwashiorkor is:
   (*a*) the most common form of protein-calorie malnutrition in the INDIA.
   (*b*) characterized by a thin, wasted appearance.
   (*c*) an adequate intake of total calories but a specific deficiency of protein.
   (*d*) an adequate intake of total protein but a deficiency of the essential amino acids.

64. A complete replacement of animal protein in the diet by vegetable protein:
   (*a*) would be expected to have no effect at all on the overall diet.
   (*b*) would reduce the total amount of food consumed for the same number of calories.
   (*c*) might reduce the total amount of iron and vitamin B12 available.
   (*d*) would be satisfactory regardless of the nature of the vegetable protein used.

65. Dietary fat:
   (*a*) is usually present, although there is no specific need for it.
   (*b*) if present in excess, can be stored as either glycogen or adipose tissue triacylglycerol.
   (*c*) should include linoleic and linolenic acids.
   (*d*) should increase on an endurance training program in order to increase the body's energy stores.

66. For diabetics:
(*a*) the only carbohydrate that must be eliminated in the diet is sucrose.
(*b*) not all carbohydrate foods raise blood glucose levels at the same rate because the glycemic index of all foods is not the same.
(*c*) who are normally in good control, stress will have no effect on their blood sugar levels.
(*d*) a vegetarian diet is the only appropriate choice.

67. The effects of vitamin A may include all of the following EXCEPT:
(*a*) prevention of anemia.
(*b*) serving as an antioxidant.
(*c*) cell differentiation.
(*d*) the visual cycle.

68. Ascorbic acid may be associated with all of the following EXCEPT:
(*a*) iron absorption.
(*b*) bone formation.
(*c*) wound healing.
(*d*) participation in hydroxylation reactions.

69. The transmembrane portion of a protein spanning the membrane is most likely to be composed of aminoacids that are-
(*a*) basic
(*b*) acidic
(*c*) glycosylated
(*d*) hydrophobic

70. All the following compounds are Intermediate of the citric acid cycle except
(*a*) Isocitrate
(*b*) Malate
(*c*) Pyruvate
(*d*) Succinate

71. Cellulose is a _____ made of many _____.
(*a*) polypeptide . . . monomers
(*b*) carbohydrate . . . fatty acids
(*c*) polymer . . . glucose molecules
(*d*) protein . . . amino acids

72. The four main categories of macromolecules in a cell are
(*a*) proteins, DNA, RNA, and steroids.
(*b*) monosaccharides, lipids, polysaccharides, and proteins.
(*c*) proteins, nucleic acids, carbohydrates, and lipids.
(*d*) nucleic acids, carbohydrates, monosaccharides, and proteins.

73. The characteristic that all lipids have in common is
(*a*) they are all made of fatty acids and glycerol.
(*b*) none of them is very high in energy content.
(*c*) they are all acidic when mixed with water.
(*d*) none of them dissolves in water.

74. How you cellulose and starch are different
   (*a*) Cellulose molecules are much too large.
   (*b*) Starch is made of glucose; cellulose is made of other sugars.
   (*c*) The bonds between sugars in cellulose are much stronger.
   (*d*) The sugars in cellulose bond together differently than in starch, giving cellulose a different shape.

75. In some places a protein molecule may twist or fold back on itself. This is called _____ and the coils or folds are held in place by _____.
   (*a*) tertiary structure . . . hydrogen bonds
   (*b*) primary structure . . . covalent bonds
   (*c*) secondary structure . . . peptide bonds
   (*d*) tertiary structure . . . covalent bonds

76. A hydrophobic amino acid R group would be found where in a protein?
   (*a*) forming a peptide bond with the next amino acid in the chain
   (*b*) on the outside of the folded chain, in the water
   (*c*) on the inside of the folded chain, away from water
   (*d*) forming hydrogen bonds with other R group

77. The overall three-dimensional shape of a polypeptide is called the
   (*a*) double helix. (*b*) primary structure.
   (*c*) secondary structure. (*d*) tertiary structure.

78. How many different kinds of protein molecules are there in a typical cell?
   (*a*) Twenty (*b*) about a hundred
   (*c*) Thousands (*d*) billions

79. The building blocks of nucleic acid molecules are called
   (*a*) polysaccharides. (*b*) amino acids.
   (*c*) fatty acids. (*d*) nucleotides.

80. Which of the following do nucleic acids and proteins have in common?
   (*a*) They are both made of amino acids.
   (*b*) Their structures contain sugars.
   (*c*) They are hydrophobic.
   (*d*) They are large polymers.

81. Which of the following would probably not be affected when a protein is denatured?
   (*a*) primary structure (*b*) secondary structure
   (*c*) hydrogen bonds (*d*) tertiary structure

82. A glucose molecule is to starch as
   (*a*) a steroid is to a lipid. (*b*) a protein is to an amino acid.
   (*c*) a nucleic acid is to a polypeptide. (*d*) a nucleotide is to a nucleic acid.

83. Palm oil and coconut oil are more like animal fats than other plant oils. Because they ____ than other plant oils, they can contribute to cardiovascular disease.
(*a*) contain fewer double bonds (*b*) are less saturated
(*c*) contain more sodium (*d*) are less soluble in water

84. A shortage of phosphorus in the soil would make it especially difficult for a plant to manufacture
(*a*) DNA (*b*) proteins.
(*c*) cellulose. (*d*) fatty acids.

85. How does DNA differ from RNA?
(*a*) DNA is larger.
(*b*) One of their nitrogenous bases is different.
(*c*) They contain different sugars.
(*d*) DNA consists of two strands in a double helix.

86. Which of the following ranks the molecules in the correct order by size?
(*a*) water . . . sucrose . . . glucose . . . protein
(*b*) protein . . . water . . . glucose . . . sucrose
(*c*) water . . . protein . . . sucrose . . . glucose
(*d*) protein . . . sucrose . . . glucose . . . water

87. On the basis of the principle of complementary base pairing you would expect the percentage of ___ to be equal the percentage of ____.
(*a*) A ... T (*b*) A ... G
(*c*) T ... G (*d*) A ... C

88. Lipids differ from other large biological molecules in that they
(*a*) are much larger. (*b*) are not truly polymers.
(*c*) do not have specific shapes. (*d*) do not contain carbon.

89. Water is a polar molecule. This means that
(*a*) the opposite ends of the molecule have opposite charges.
(*b*) water molecules are linear, like a pole.
(*c*) water is one of the many hydrophobic molecules.
(*d*) the atoms in water have electronegativites which are equal.

90. Cellular respiration is an example of
(*a*) an anabolic pathway. (*b*) a catabolic pathway.
(*c*) bioenergetics. (*d*) thermodynamics.

91. Organisms are described as thermodynamically open systems. This means that
(*a*) the metabolism of an organism is isolated from its surroundings
(*b*) organisms can reverse the increase in entropy.
(*c*) organisms acquire energy from their surroundings.
(*d*) organisms are capable of circumventing the second law of thermodynamics.

92. From the equation delta G = delta H -T delta S it is clear that
   (*a*) a decrease in the system's total energy will increase the probability of spontaneous change.
   (*b*) spontaneous change is most probable when the system experiences an increase in entropy.
   (*c*) increasing the temperature of a system will increase the probability of spontaneous change.
   (*d*) the capacity of a system to perform work is related to the total energy of the system.

93. An endergonic reaction is characterized by
   (*a*) its tendency to occur spontaneously.
   (*b*) the net release of free energy.
   (*c*) a value for delta G which is positive.
   (*d*) reactants that are more complex than products.

94. Cells continue to function only when a metabolic disequilibrium is in effect; cells avoid reaching metabolic equilibrium
   (*a*) because cellular metabolism utilizes only those reactions that are nonreversible.
   (*b*) because the products of one reaction become the reactants for a different reaction and are unable to accumulate.
   (*c*) because the majority of important metabolic reactions have delta Gs of zero.
   (*d*) by limiting the entry of high free energy molecules once they have been catabolized.

95. What must be true if the reaction AB plus CD to AC plus BD occurs spontaneously?
   (*a*) The delta G of the reaction must be negative.
   (*b*) the reaction must be exergonic.
   (*c*) the environments has adequate thermal energy to meet the EA requirement.
   (*d*) all of the above

96. What best characterizes the role of ATP in cellular metabolism?
   (*a*) The release of free energy during the hydrolysis of ATP heats the surrounding environment.
   (*b*) Its free energy is coupled to an endergonic process via the formation of a phosphorylated intermediate.
   (*c*) It is catabolized to carbon dioxide and water.
   (*d*) The delta G associated with its hydrolysis is positive.

97. Enzymes are described as catalysts, which means that they
   (*a*) provide activation energy for the reactions they facilitate.
   (*b*) change the rate of a reaction without being consumed by the reaction
   (*c*) stabilize molecules in the transition state.
   (*d*) elevate the EA barrier so the molecules will not spontaneously degrade.

98. What best explains the observation of substrate specificity?
    (*a*) There is a precise compatibility between an enzyme's active site and the substrate molecule
    (*b*) Molecules and active sites vary in size; only properly sized molecules can fit.
    (*c*) Reaction-specific enzymes, such as hydrolases, assume a fit by folding around the most numerous substrate molecules.
    (*d*) Polarity compatibilities; active sites contain electronegative atoms while substrates tend to carry slight positive charges.

99. Sucrase normally catalyses the catabolism of sucrose to glucose and fructose. What, if any, changes could be made to the system so that sucrase could synthesize sucrose from the two products?
    (*a*) increase the temperature of the system
    (*b*) alter the concentration of molecules so that sucrase is low and glucose and fructose are very high
    (*c*) selectively denature the enzyme by varying the pH
    (*d*) phosphorylate either the glucose or the fructose

100. A plot of enzyme velocity against temperature for an enzyme indicates little activity at 0 degrees celsius and 45 degrees celsius, with peak activity at 35 degrees celsius. The most reasonable explanation for the low velocity at 0 degrees celsius is that at this temperature
    (*a*) the hydrogen bonds that define the enzyme's active site are unstable.
    (*b*) at low temperatures the substrate becomes an allosteric regulator.
    (*c*) the enzyme was denatured.
    (*d*) there is too little activation energy available.

Practice Test Paper-II

1. Prokaryotic cells, but not eukaryotic cells, have:
   (*a*) endoplasmic reticulum.
   (*b*) histones.
   (*c*) nucleoid.
   (*d*) a nucleus.

2. Factors responsible for a water molecule being a dipole include:
   (*a*) the tetrahedral structure of liquid water.
   (*b*) the magnitude of the H-O-H bond angle.
   (*c*) the ability of water to hydrogen bond to various chemical structures.
   (*d*) the difference in bond strength between hydrogen bonds and covalent bonds.

3. Hydrogen bonds can be expected to form only between electronegative atoms such as oxygen or nitrogen and a hydrogen atom bonded to:
   (*a*) carbon.
   (*b*) an electronegative atom.
   (*c*) hydrogen.
   (*d*) iodine.

4. The ion product of water:
   (*a*) is independent of temperature.
   (*b*) has a numerical value of 1×10^{-14} at 25°C.
   (*c*) is the equilibrium constant for the reaction H_3O^+ and OH^-.
   (*d*) requires that $[H^+]$ and $[OH^-]$ always be identical.

5. Lysosomal enzymes:
   (*a*) are hydrolases.
   (*b*) usually operate at acidic pH.
   (*c*) are normally isolated from their substrates by the impermeable lysosomal membrane.
   (*d*) All of the above are correct.

6. In a DNA double helix:
   (*a*) the individual strands are not helical.
   (*b*) hydrogen bonds form between a purine and a pyrimidine base on the same strand.
   (*c*) adenine on one strand is hydrogen bonded to thymine on the opposite strand.
   (*d*) phospho diester bonds are oriented toward the interior of the helix.

7. The A helix of DNA differs from the B helix in all of the following EXCEPT:
   (*a*) appearance of the major and minor grooves.
   (*b*) pitch of the base pairs relative to the helix axis.
   (*c*) thickness of the helix.
   (*d*) polarity of the strands.

8. The Z-DNA helix:
   (*a*) has fewer base pairs per turn than the B-DNA.
   (*b*) is favored by an alternating GC sequence.

(*c*) tends to be found at the 3'-end of genes.
(*d*) is inhibited by methylation of the bases.

9. RNA:
(*a*) incorporates both modified and unmodified purine and pyrimidine bases during transcription.
(*b*) does not exhibit any double-helical structure.
(*c*) structures exhibit base stacking and hydrogen-bonded base pairing.
(*d*) usually contains about 65-100 nucleotides.

10. Bent DNA:
(*a*) occurs only in the presence of external agents like the antitumor drugs.
(*b*) may be a fundamental element in the interaction between DNA sequences and proteins for such processes as transcription and site-specific recombination.
(*c*) occurs primarily in the presence of triple-stranded DNA.
(*d*) requires the presence of inverted repeats.

11. Chaperone proteins:
(*a*) all require ATP to exert their effect.
(*b*) cleave incorrect disulfide bonds, allowing correct ones to subsequently form.
(*c*) guide the folding of polypeptide chains into patterns that would be thermodynamically unstable without the presence of chaperones.
(*d*) of the hsp70 class are involved in transport of proteins across mitochondrial and endoplasmic reticulum membranes.

12. Proteins may be separated according to size by:
(*a*) isoelectric focusing.
(*b*) polyacrylamide gel electrophoresis.
(*c*) ion-exchange chromatography
(*d*) molecular exclusion chromatography.

13. Changes in protein conformation can be detected rapidly by:
(*a*) ultraviolet absorbance spectroscopy.
(*b*) fluorescence emission spectroscopy
(*c*) optical rotatory dispersion.
(*d*) all of above.

14. Which of the following statements about E. coli DNA polymerases is correct?
(*a*) All polymerases have both 3' to 5' and 5' to 3' exonuclease activity.
(*b*) The primary role of polymerase III is in DNA repair.
(*c*) Polymerases I and III require both a primer and a template.
(*d*) Polymerase I tends to remain bound to the template until a large number of nucleotides have been added.

15. Both strands of DNA serve as templates concurrently in:
(*a*) replication. (*b*) excision repair.
(*c*) mismatch repair. (*d*) transcription-coupled repair.

16. All of the following statements about telomerase are correct EXCEPT:
    (*a*) the RNA component acts as a template for the synthesis of a segment of DNA.
    (*b*) it adds telomeres to the 5' ends of the DNA strands.
    (*c*) it provides a mechanism for replicating the ends of linear chromosomes in most eukaryotes.
    (*d*) it is a reverse transcriptase.

17. A transition mutation:
    (*a*) occurs when a purine is substituted for a pyrimidine, or vice versa.
    (*b*) results from the insertion of one or two bases or base analogs into the DNA chain.
    (*c*) decreases in frequency in the presence of base analogs such as 2-amino purine.
    (*d*) results from the substitution of one purine for another or of one pyrimidine for another.

18. Homologous recombination:
    (*a*) occurs only between two segments from the same DNA molecule.
    (*b*) requires that a specific DNA sequence be present.
    (*c*) requires that one of the duplexes undergoing recombination be nicked in both strands.
    (*d*) may result in strand exchange by branch migration.

19. Of the following are true about transpositions EXCEPT:
    (*a*) transposons move from one location to a different one within a chromosome.
    (*b*) both the donor and target sites must be homologous.
    (*c*) transposons have insertion sequences that are recognized by transposases.
    (*d*) the transposon may either be excised and moved or be replicated with the replicated piece moving.

20. All of the following are true about nucleotide excision repair EXCEPT:
    (*a*) removal of the damaged bases occurs on only one strand of the DNA.
    (*b*) it removes thymine dimers generated by UV light.
    (*c*) it involves the activity of an excision nuclease, which is an endonuclease.
    (*d*) only the damaged nucleotides are removed.

21. During the elongation stage of eukaryotic protein synthesis:
    (*a*) the incoming aminoacyl-tRNA binds to the P site.
    (*b*) a new peptide bond is synthesized by peptidyl transferase site of the large ribosomal subunit in a GTP-requiring reaction.
    (*c*) the peptide, still bound to a tRNA molecule, is translocated to a different site on the ribosome.
    (*d*) streptomycin can cause premature release of the incomplete peptide.

22. Termination of protein synthesis:
    (*a*) requires a stop codon to be located at the P site of the large ribosomal subunit.
    (*b*) occurs when a non-ribosomal protein release factor binds to the ribosome.

(*c*) requires the action of a non-ribosomal hydrolase to release the peptide.
(*d*) does not require energy.

23. 4-Hydroxylation of specific prolyl residues during collagen synthesis requires all of the following EXCEPT:
(*a*) $Fe2^+$
(*b*) a specific amino acid sequence.
(*c*) ascorbic acid
(*d*) succinate.

24. Diphtheria toxin:
(*a*) releases incomplete polypeptide chains from the ribosome.
(*b*) activates translocase.
(*c*) prevents release factor from recognizing termination signals.
(*d*) attacks the RNA of the large subunit.

25. Targeting a protein to be degraded within proteasomes usually requires ubiquitin. In the functions of ubiquitin all of the following are true EXCEPT:
(*a*) ATP is required for activation of ubiquitin.
(*b*) linkage of a protein to ubiquitin does not always mark it for degradation.
(*c*) the identity of the N-terminal amino acid is one determinant of selection for degradation.
(*d*) ATP is required by the enzyme that transfers the ubiquitin to the protein to be degraded.

26. In all enzymes the active site:
(*a*) contains the substrate-binding site.
(*b*) is contiguous with the substrate-binding site in the primary sequence.
(*c*) contains a metal ion as a prosthetic group.
(*d*) contains the amino acid side chains involved in catalyzing the reaction.

27. Enzymes may be specific with respect to all of the EXCEPT:
(*a*) chemical identity of the substrate.
(*b*) the atomic mass of the elements in the reactive group (e.g., 12 C but not 14 C).
(*c*) Optical activity of product formed from a symmetrical substrate.
(*d*) which of a pair of optical isomers will react.

28. The transport system that maintains the Na^+ and K^+ gradients across the plasma membrane of cells:
(*a*) involves an enzyme that is an ATPase.
(*b*) moves Na^+ either into or out of the cell.
(*c*) is an electrically neutral system.
(*d*) in the membrane, hydrolyzes ATP independently of the movement of Na^+ and K^+.

29. A mediated transport system would be expected to:
(*a*) show a continuously increasing initial rate of transport with in increasing substrate concentration.
(*b*) exhibit structural and/or stereospecificity for the substance transported.

(*c*) be slower than that of a simple diffusion system.
(*d*) establish a concentration gradient across the membrane.

30. The group translocation type of transport system:
(*a*) does not require metabolic energy.
(*b*) involves the transport of two different solute molecules simultaneously.
(*c*) has been demonstrated for fatty acids.
(*d*) results in the alteration of the substrate molecule during the transport process.

31. AIP-binding cassette (ABC) transporters:
(*a*) all have both a membrane-spanning domain that recombine substrate and an ATP-binding domain.
(*b*) all effect translocation by forming channels.
(*c*) all have two functions-forming a channel and con regulation.
(*d*) are all P-glycoproteins.

32. The mitochondrial membrane contains a transporter for:
(*a*) NADH. (*b*) acetyl CoA.
(*c*) GTP. (*d*) ATP.

33. If rotenone is added to the mitochondrial electron transport chain:
(*a*) the P/O ratio of NADH is reduced from 3: 1 to 2: 1
(*b*) the rate of NADH oxidation is diminished to two-thirds of its initial value.
(*c*) succinate oxidation remains normal.
(*d*) electron flow is inhibited at site II.

34. If cyanide is added to tightly coupled mitochondria that are actively oxidizing succinate:
(*a*) subsequent addition of 2,4-dinitrophenol will cause ATP hydrolysis.
(*b*) subsequent addition of 2,4-dinitrophenol will restore succinate oxidation.
(*c*) electron flow will cease, but ATP synthesis will continue.
(*d*) subsequent addition of 2,4-dinitrophenol and the phosphorylation inhibitor, oligomycin, will cause ATP hydrolysis.

35. The chemiosmotic hypothesis involves all of the following EXCEPT:
(*a*) a membrane impermeable to protons.
(*b*) electron transport by the respiratory chain pumps protons out of the mitochondrion.
(*c*) proton flow into the mitochondria depends on the presence of ADP and Pi'
(*d*) only proton transport is strictly regulated; other positively charged ions can diffuse freely across the mitochondrial membrane.

36. Suppose the specific defect were a mutant pyruvate dehydrogenase (the first catalytic subunit) with poor binding of its prosthetic group. In this type of defect, sometimes greatly increasing the dietary precursor of the prosthetic group is helpful. In this case increasing which of the following might be helpful?
(*a*) thiamine(TPP) (*b*) niacin (for NAD)
(*c*) pantothenic acid (for CoA) (*d*) riboflavin (for FAD)

37. In glycolysis ATP synthesis is catalyzed by:
    (*a*) hexokinase.
    (*b*) 6-phosphofructo-I-kinase.
    (*c*) glyceraldehyde 3-phosphate dehydrogenase.
    (*d*) phosphoglycerate kinase.

38. The irreversible reactions of glycolysis include that catalyzed by:
    (*a*) phosphoglucose isomerase.
    (*b*) 6-phosphofructo-l-kinase.
    (*c*) fructose bisphosphate aldolase.
    (*d*) glyceraldehyde 3-phosphate dehydrogenase.

39. Glucokinase:
    (*a*) has a Km considerably greater than the normal blood glucose concentration.
    (*b*) is inhibited by glucose 6-phosphate.
    (*c*) is also known as the GLUT-2 protein.
    (*d*) has glucose 6-phosphatase activity as well as kinase activity.

40. In the Cori cycle:
    (*a*) only tissues with aerobic metabolism (i.e., mitochondrial O_2) are involved.
    (*b*) a three-carbon compound arising from glycolysis is converted to glucose at the expense of energy from fatty acid oxidation.
    (*c*) glucose is converted to pyruvate in anaerobic tissues this pyruvate returns to the liver, where it is converted into glucose.
    (*d*) the same amount of ATP is used in the liver to synthesis glucose as it is released during glycolysis, leading to no net loss on whole-body energy balance.

41. Gluconeogenic enzymes include all of the following EXCEPT
    (*a*) glucose 6-phosphatase.
    (*b*) phosphoenolpyruvate carboxykinase.
    (*c*) phosphoglucomutase.
    (*d*) pyruvate carboxylase.

42. Glycosaminoglycans:
    (*a*) are the carbohydrate portion of glycoproteins,
    (*b*) contain large segments of a repeating unit typically consisting of a hexosamine and a uronic acid.
    (*c*) always contain sulfate.
    (*d*) exist in only two forms.

43. All of the following statements about acetyl-CoA carboxylase are correct EXCEPT:
    (*a*) it undergoes protomer-polymer interconversion during its physiological regulation.
    (*b*) it is inhibited by cAMP-mediated phosphorylation.
    (*c*) it is activated by both palmitoyl CoA and citrate.
    (*d*) its content in a cell responds to changes in fat content in the diet.

44. Primary bile acids:
    (*a*) are any bile acids that are found in the intestinal tract.
    (*b*) are any bile acids reabsorbed from the intestinal tract.
    (*c*) are synthesized in hepatocytes directly from cholesterol.
    (*d*) are converted to secondary bile acids by conjugation with glycine or taurine.

45. Structural features that are common to all prostaglandins include:
    (*a*) 20-carbon atoms.
    (*b*) an oxygen-containing internal heterocyclic ring.
    (*c*) a peroxide group at C-15.
    (*d*) two double bonds.

46. Amino acids considered nonessential for humans are:
    (*a*) those not incorporated into protein.
    (*b*) not necessary in the diet if sufficient amounts of precursors are present.
    (*c*) the same for adults as for children.
    (*d*) generally not provided by the ordinary diet.

47. Aminotransferases:
    (*a*) usually require α-ketoglutaramate or glutamine as one of the reacting pair.
    (*b*) catalyze reactions that result in a net use or production of amino acids.
    (*c*) catalyze irreversible reactions.
    (*d*) require pyridoxal phosphate as an essential cofactor for the reaction.

48. The amide nitrogen of glutamine:
    (*a*) represents a nontoxic transport form of ammonia.
    (*b*) is a major source of ammonia for urinary excretion.
    (*c*) is used in the synthesis of asparagine. purines. and pyrimidines.
    (*d*) can be recovered as ammonia by the action of glutaminase.

49. S-Adenosylmethionine:
    (*a*) contains a positively charged sulfur (sulfonium) that facilitates the transfer of substituents to suitable acceptors.
    (*b*) yields α-ketobutyrate in the reaction in which the methyl is transferred.
    (*c*) donates a methyl group in a freely reversible reaction.
    (*d*) generates H_2S by transsulfuration.

50. In humans, sulfur of cysteine may participate in all of the following EXCEPT:
    (*a*) the conversion of cyanide to less toxic thiocyanate.
    (*b*) the formation of thiosulfate.
    (*c*) the formation of taurine.
    (*d*) the donation of the sulfur for methionine formation.

51. More free energy is released during the citric acid cycle than during glycolysis, but only 1 mole of ATP is produced for each mole of acetyl CoA that enters the cycle. What happens to most of tile remaining free energy that is produced duril1g the citric acid cycle?
   (*a*) It is used to synthesize GTP
   (*b*) It is used to reduce electron carriers
   (*c*) It is lost as heat
   (*d*) It is used to reduce pyruvate

52. The reduction of pyruvate to lactic acid during fermentation allows glycolysis to continue in the absence of oxygen. Why?
   (*a*) Water is formed during this reaction
   (*b*) This reaction is a kinase reaction
   (*c*) This reaction is coupled to the oxidation of NADH to NAD^+
   (*d*) This reaction is coupled to the reduction of NAD^+ to NADH

53. Assume that eukaryotic cell has abundant glucose and O_2 but needs ATP. The proton gradient in mitochondria of the cell will be generated by_____________ and used primarily for ——————————.
   (*a*) the electron transport chain; ATP synthesis
   (*b*) the electron transport chain; substrate-level phosphorylation
   (*c*) glycolysis; production of H_2O
   (*d*) fermentation; NAD reduction

54. The general name for an enzyme that transfers phosphate groups from ATP to a Protein is
   (*a*) Protein kinase (*b*) Phosphorylase
   (*c*) Phosphatase (*d*) ATPase

55. All of the following arc potential control mechanisms for regulation of gene expression in eukaryotic organisms EXCEPT
   (*a*) Gene amplification (*b*) The degradation of mRNA
   (*c*) The lactose operon (*d*) Transcription

56. It is theoretically possible for a gene from any organism to function in any other organism. Why is this possible?
   (*a*) All organisms have similar nuclei
   (*b*) All organisms have the same genetic code
   (*c*) All organisms are made up of cells
   (*d*) All organisms have transfer RNA

57. DNA fragments from a gel are transferred to a membrane via a procedure called Southern blotting. The purpose of Southern blotting is to
   (*a*) Analyze the RFLPs in the DNA
   (*b*) Separate out the PCRs'
   (*c*) Permanently attach the DNA fragments to a substrate
   (*d*) Separate the two complementary DNA strands

58. 5'-phosphoribosyl-1-pyrophosphate'(PAPP) is an intermediate in
    (*a*) the de nevo synthesis of purine nucleotides
    (*b*) the de novo synthesis of pyrimidine nueleotides
    (*c*) the salvage pathway for the synthesis of purine nucleotides
    (*d*) All of the above

59. In Lesch-Nyhan Syndrome lack of activity of the defective enzyme (HGPRTase) should result in higher than normal tissue concentrations of all of the following EXCEPT
    (*a*) adenine
    (*b*) guanine
    (*c*) uric acid
    (*d*) hypoxanthine

60. A complete lack of adenosine deaminase causes SCID (Severe combined immunodeficiency). Which of the following is LEAST true
    (*a*) Loss of the enzyme causes increased levels of dATP because there is less turnover of adenosine nucleosides in general
    (*b*) Increased dATP decreases the concentration of all rNTPs, blocking RNA synthesis
    (*c*) Increased dATP inhibits ribonucleotide reductase, such that de novo production of all rNDPs is inhibited
    (*d*) Adenosine deaminase loss causes SCID because T cells are particularly sensitive to DNA replication inhibition

61. DNA and RNA synthesis polymerization [of deoxynucleotides] which takes place
    (*a*) In a 3' to 5' direction
    (*b*) In a 5' to 3' direction
    (*c*) In either (or both)directions
    (*d*) DNA in 5' to 3' and RNA in 3' to 5'

62. TATA boxes and Pribnow boxes are components of
    (*a*) Operators
    (*b*) Promoters
    (*c*) Enhancers
    (*d*) Activators

63. The RNA in the cell with the greatest sequence diversity is
    (*a*) Messenger RNA
    (*b*) Ribosomal RNA
    (*c*) Transfer RNA
    (*d*) (*a*) and (*c*)

64. During the overall process of protein synthesis, amino acids become covalently attached to
    (*a*) Messenger RNA
    (*b*) Ribosomal RNA
    (*c*) Transfer RNA
    (*d*) More than one of the above

65. Proteins whose binding to DNA acts to prevent transcription are known as
    (*a*) Activators
    (*b*) Operators
    (*c*) Repressors
    (*d*) Transcription factors

66. A common target for antibiotics in bacteria is
    (*a*) Microsomes
    (*b*) Mesosomes
    (*c*) Ribosomes
    (*d*) None of the above

67. A piece of DNA of length 10 KB obtained using EcoRI digestion is being inserted in a pBR322 plasmid (approximately 4 KB) vector which was first digested by the restriction enzyme EcoRI. The optimum vector: insert ratio (μg/μg) should be approximately
(*a*) 0.1 (*b*) 0.5
(*c*) 1 (*d*) 5

68. Dried fish treated with salt and nitrates has been found to contain the mutagen 2-chloro-4-methylthiobutanoic acid (CMBA). From what amino acid is CMBA derived?
(*a*) Lysine (*b*) Cysteine
(*c*) Methionine (*d*) Valine

69. In experiments designed to explore whether there is protein transverse asymmetry in membranes, it was shown that when trypsin was used to treat intact erythrocytes, the carbohydrate groups of the transmembrane protein glycophorin was released from the N-terminus of the protein (as glycopeptides). This was taken as evidence that the N-terminus of the glycophorin must be on the exterior side of the membrane because
(*a*) trypsin is too large to get inside the cell to attack interior parts of glycophorin.
(*b*) trypsin only attacks carbohydrate residues, not proteins
(*c*) trypsin always attacks near the N-terminus of a protein and never near the C-terminus
(*d*) trypsin specifically cleaves proteins at lysine or arginine residues

70. When a muscle contracts, what is happening to the Ca^{++} levels inside and outside the cell?
(*a*) High amounts of cytosolic Ca^{++} are released to the extracellular space
(*b*) Ion channels open to allow extracellular Ca^{++} to flow into the cell
(*c*) Ca^{++} from the nucleus is released to the cytoplasm and this triggers contraction.
(*d*) Ca^{++} ions attach stoma and this causes muscle contraction

71. Acetyl CoA enters the TCA cycle by combining with:
(*a*) oxaloacetate. (*b*) succinate.
(*c*) citrate. (*d*) alpha-ketogluterate.

72. Cytochrome c is a moveable peripheral proteins that is oxidized by complex:
(*a*) I . (*b*) II .
(*c*) III . (*d*) IV.

73. Which of these complexes work by rotational catalysis?
(*a*) NADH dehydrogenase (complex I)
(*b*) Cytochrome c oxidase (complex IV)
(*c*) Glycerol phosphate dehydrogenase (glycerol phosphate shuttle)
(*d*) ATP synthase

74. In which of the following ways are peroxisomes NOT similar to mitochondria?
(*a*) Engages in oxidative metabolism.
(*b*) Has DNA that encodes a few of its genes.

(*c*) Generated by splitting from pre-existing organelles.
(*d*) Imports preformed proteins from the cytosol.

75. Complex III (cytochrome bc_1) receives electrons directly from __________, which is a lipid soluble membrane molecule.
(*a*) ubiquinone (*b*) cytochrome c
(*c*) $NADH^+$ (*d*) $FADH_2$

76. Where are ATP synthase complexes found in the mitochondrion?
(*a*) On the outer membrane. (*b*) In the intermembrane space.
(*c*) Attached to the cristae. (*d*) Floating in the matrix.

77. ATP synthase is powed by a (n):
(*a*) proton motive force. (*b*) electron gradient.
(*c*) K^+ gradient. (*d*) ATP.

78. Both the mitochondrion and the chloroplast have all of the following EXCEPT
(*a*) an inner and an outer membrane. (*b*) ATP synthase.
(*c*) cristae. (*d*) electron transport.

79. Which of these molecules or complexes has a greater oxidizing potential than oxygen?
(*a*) Photosystem I ($P700^+$) (*b*) Photosystem II ($P680^+$)
(*c*) $NADP^+$ (*d*) plastiquinone

80. In the Calvin cycle, CO_2 is fixed to ribulose bisphosphate catalyzed by an enzyme familiarly known as
(*a*) Ribozyme (*b*) LHCII
(*c*) Rubisco (*d*) P680

81. GLUT4 is an example of
(*a*) simple diffusion. (*b*) facilitated transporter.
(*c*) active transporter. (*d*) cotransporter.

82. A hydropathy plot identifies potential membrane spanning regions of a protein by analyzing the
(*a*) primary
(*b*) secondary
(*c*) tertiary
(*d*) quaternary structure of the protein.

83. ABO blood types are determined by a saccharide attached to what?
(*a*) Phosphoglyceride (*b*) Sphingolipid
(*c*) Cholesterol (*d*) Ion channel

84. Cholesterol does what to membranes?
(*a*) Lowers the transition temperature.
(*b*) Accumulates on the outer leaf.
(*c*) Makes the membrane more hydrophilic.
(*d*) Blurs the transition between gel state and fluid state.

85. Which of these integral proteins is an active transporter?
(*a*) Kv channel (*b*) GLUT4
(*c*) Na/K ATPase (*d*) aquaporin

86. Acetocholine and norepinephrine are examples of:
(*a*) glycoproteins. (*b*) integral proteins.
(*c*) ion channels. (*d*) neurotransmitter.

87. Epithelial cells within the intestine can absorb glucose against a concentration gradient by linking glucose transport with sodium transport, since sodium is much more concentrated outside the cell. What term best describes this strategy?
(*a*) Antiport (*b*) Active transport
(*c*) Cotransport (*d*) Importation

88. This most abundant ECM protein is formed of alpha-helix trimers that are bundled to form rigid cable-like fibrils.
(*a*) Collagen (*b*) Proteoglycans
(*c*) Fibronectin (*d*) Laminins

89. Which of these molecules definitely indicates the presence of secondary cell walls?
(*a*) Cellulose (*b*) Hemicellulose
(*c*) Pectin (*d*) Lignin

90. The concept that proteins possess amino acids that act as an address code is called the
(*a*) signal hypothesis. (*b*) cell theory.
(*c*) peptide transferase proposal. (*d*) protein address concept.

91. Which of the following does NOT happen in cyclic photophosphorylation?
(*a*) ATP is produced
(*b*) Photosystem I reaction center is active
(*c*) Electron transport occurs in the photosynthetic membranes
(*d*) NADPH is formed

92. The conversion of light energy to chemical energy during photosynthesis begins when an excited pigment molecule:
(*a*) undergoes fluorescence (*b*) loses energy as heat
(*c*) undergoes an oxidation reaction (*d*) increases its molecular motion

93. An overall result of photosynthesis in plants is the use of electrons from water to reduce:
(*a*) glucose (*b*) carbon dioxide
(*c*) oxygen (*d*) NADPH

94. Which of the following is NOT true of photosystem II?
(*a*) It is located in thylakoid membranes.
(*b*) It is involved in the oxidation of water.
(*c*) It has a special oxidizable chlorophyll, P680.
(*d*) It is required for cyclic photophosphorylation.

95. The electron transport chain is located predominantly in the:
(*a*) Outer membrane of the mitochondria
(*b*) Intermembrane space of the mitochondria
(*c*) Inner membrane of the mitochondria
(*d*) Matrix of the mitochondria

96. What cellular compartment becomes acidic (high concentration of hydrogen ions) during mitochondrial electron transport?
(*a*) Mitochondrial stroma
(*b*) Cytoplasm
(*c*) Endoplasmic reticulum
(*d*) Space between inner and outer mitochondrial membranes

97. In the absence of oxygen, the primary purpose of fermentation is to:
(*a*) produce amino acids for protein synthesis
(*b*) oxidize glucose to generate reduce electron carriers
(*c*) generate alcohol for beverages
(*d*) regenerate NAD^+ from NADH allowing glycolysis to continue

98. Which statement about enzyme catalyzed reactions is NOT true?
(*a*) enzymes form complexes with their substrates.
(*b*) enzymes lower the activation energy for chemical reactions.
(*c*) enzymes change the K eq for chemical reactions.
(*d*) many enzymes change shape slightly when substrate binds.

99. Activation energy is
(*a*) energy that must be added to get a reaction started, which is recovered as the reaction proceeds
(*b*) difference in energy between reactants and products
(*c*) energy that is lost as heat
(*d*) free energy

100. Energy-requiring reactions can occur in biological systems because enzymes allow their coupling to other reactions with:
(*a*) an increase in entropy
(*b*) a low activation energy
(*c*) no inhibitors
(*d*) products of lower free energy than the reactants

3

Physiology

RESPONSE TO STRESS

Stress: Stress can be defined as any environmental factor that can have an adverse effect on a Plant's growth, reproduction, and survival. Plants can respond to stress in several ways they can escape the effects of stress by completing their growth during less stressful periods or they may suffer injury if the stress is present and they cannot cope. Plants can cope with environmental stress through a combination of development and physiological responses.

Response to water stress

On bright, warm, dry day, a plant may be stressed by a water deficiency because it is losing water by transpiration faster than the water can be restored by uptake from the soil. This continuous drought can stress plants for weeks or month. Severe water deficit, may kill a plant. But plants have control systems that enable them to cope with less extreme water deficts. Many of a plants responses to water defict help the plant conserve water by reducing the rate of transpiration. Water defict can stimulates increased synthesis and release of abscisic acid from mesophyll cells in the leaf, and this hormone helps keep stomata closed by acting on guard cell membranes and causes guard cell to loose turgor. Leaves respond to water defict in several other ways, because cell expansion is a turgor- dependent process, a water defict will inhibit the growth (expansion) of yong leaves. This response minimizes the transcriptional loss of water by slowing the increase in leaf surface. When the leaves of many grasses and other plants wilt from a water deficit, they roll into a shape that reduces transcription by exposing less leaf surface to the sun. While all of these responses of leaves help the plant conserve water, they also reduces photosynthesis. This is one reason a drought diminished crop yield.

Response To Oxygen Stress

An overwatered house plant may suffocate because the soil lacks the air spaces that provide oxygen for cellular respiration in the roots. Some plants are structurally adapted to very wet habitats. For example, the submerged roots of trees called mangroves, which inhabit coastal marshes, are continuous with aerial roots that provide access to oxygen. Experimentally it was shown that oxygen deprivation stimulates the production of hormone ethylene, which causes some of the cells in the roots cortex to age and die. Enzymatic destruction of the cell walls creates air tubes that function as ‘snorkes’ providing oxygen to the submerged roots.

Response To Salt Stress

An excess of sodium chloride or other salts in the soil threatens plants for two reasons. First, by lowering the water potential of the soil solution, salt can cause a water defict in plants even though the soil has plenty of water. This is because in an environment with a water potential more negative than that of the root tissue, roots will lose water rather than absorb it. The second problem with saline soil is that sodium and certain other ions are toxic to plants when their concentration is relatively high. The selectively permeable membranes of root cells impede the uptake of most harmful ions, but this only aggravates the problem of acquiring water from soil that is rich in solutes. Many plants can respond to moderate soil salanity by producing compatible solutes, organic compounds that keeps the water potential of cells more negative than that of the soil solution without admitting toxic quantities of salt. However, most plants cannot survive salt stress for very long. The exception are halophytes, salt tolerant plants with special adaptations such as salt glands, which pump salts out of the plant across the leaf epidermis.

Response to Heat Stress

Exccesive heat can harm and eventually kill a plant by denaturing its enzymes and damaging its metabolism in other ways. One function of transpiration is evaporative cooling. On a warm day, for example, the temperature of a leaf is below air temperature which favours transpiration and causes water deficiency in many plants; the closing of stomata in response to this stress conserves water but sacrifices evaporative cooling. This dilemma is one of the reasons that very hot, dry days take such a toll on most plants. Many plants response to this stress by synthesizing relatively large quantities of special proteins called **heat shock proteins**. Some heat shock proteins are identical to chaperon proteins, which function in unstressed cells as temporary scaffolds that other proteins fold into their functional conformations.

Response to Cold Stress

One problem plants face when the temperature of the environment falls is a change in the fluidity of cell membranes. When a membrane cools below a critical point, it loses its fluidity as the lipids become locked into crystalline structures. This alters solute transport across the membrane and also adversely affects the functions of membrane proteins. Plants respond to cold stress by altering the lipid composition of their membranes. For example, membrane lipids increase in their proportion of unsaturated fatty acids, which have shapes that help keep membranes fluid at lower temperature by impeding crystal formation. Freezing is a more severe version of cold stress. At freezing temperatures, ice crystals begin to form in most plants. If ice crystals are confined to cell walls and Intercellular spaces, the plant will probably survive. However, if ice crystals begin to form within protoplasts, the sharp crystal perforate membranes and organelles, killing the cells. However, plants like oaks, maple, rhododendrons native to regions where winters are cold have special adaptations that enable to cope with freezing stress. For example, changes in the solute composition of live cells allow the cytosol to cool below 0 degree Celsius without crystal formation Although ice crystals may form in the cell walls.

TRANSPORT ACROSS MEMBRANES

1. **Movement of Small Molecules Across Membranes can involve simple diffusion or protein-mediated transport. Cell membranes are selectively permeable.**
   (*a*) **Passive Diffusion**. Lipophilic solutes cross the membrane freely by dissolving in the lipid bilayer. This is passive diffusion. **Examples**: **ethanol** (alcohol, contains both polar and non-polar regions); also **fatty acids**, **glycerol**, **steroids**, etc. Also nonpolar gases like O=O (O_2)
   (*b*) **Selective transport by protein carriers = "permeases". Polar** or **ionic** small solutes may be transported across membranes if specific protein carriers are in the membrane. **Examples**: sugars, amino acids, ions.
   (*c*) **Many substances cannot cross the membrane. Examples**: large molecules such as proteins, nucleic acids. Also small polar molecules or ions for which there is no protein carrier.
2. **Some protein transporters require energy; others do not. There are 2 possible situations:**
   (*a*) **facilitated diffusion**. Membrane has specific protein carrier, will bind to molecule and bring it across cell membrane. No energy required. No preferential direction. If molecule is more concentrated outside than inside cell, net movement will be out of cell. Examples include-
   - Glucose transporters- 5 different GLUT proteins and 2 types that cotransport Na and glucose (these are used for secondary active transport)
   - Water channels- 8 different types of aquaporins

   (*b*) **active transport**. Membrane has specific protein carrier, also a requirement for energy (ATP or other form of energy). Will move solute against a concentration gradient, so can concentrate material even if diffusion would favor opposite direction of flow.

   Example: **Na^+- K^+ ATPase** in nerve cells. Pumps Na^+ to outside, K^+ in, maintains electrical potential against diffusion. When nerve cell "fires", momentary gates open to let diffusion occur. Then pumps are turned back on to restore potential.
3. **Active transport can involve ATP pumps, symport, or antiport**
   (*a*) **ATP pumps**.
   - ATP-powered pumps (ATPases) couple the splitting, or hydrolysis, of ATP with the movement of ions across a membrane against a concentration gradient.
   - ATP is hydrolyzed directly to ADP and inorganic phosphate, and the energy released is used to move one or more ions across the cell membrane.
   - As much as 25% of a cell's ATP reserves may be spent in such ion transport.
   - Examples include:
     1. The Na^+-K^+ ATPase pumps Na^+ out of the cell while it pumps K^+ in. Because the pump moves three Na^+ to the outside for every two K^+ that are moved to the inside, it creates an overall charge separation known as polarization. This electrical potential is required for nervous

system activity, and supplies energy needed for other types of transport such as symport and antiport.

2. Ca^{++} ATPases are responsible for keeping intracellular Ca^{++} at low levels, a necessary precondition for muscle contraction.

(*b*) **Symport**

- To transport some substances against a concentration gradient, cells use energy already stored in ion gradients, such as proton (H^+) or sodium (Na^+) gradients, to power membrane proteins called transporters.
- When the transported molecule and the co-transported ion move in the same direction, the process is known as symport.
- Example: transport of amino acids across the intestinal lining in the human gut.

(*c*) **Antiport**

Cell uses movement of an ion across a membrane and down its concentration gradient to power the transport of a second substance "uphill" against its gradient.

- In this process, the two substances move across the membrane in opposite directions.
- Example: transport of Ca^{2+} ions out of cardiac muscle cells. Muscle cells are triggered to contract by a rise in intracellular Ca^{2+} concentration, so it is imperative that Ca^{2+} be removed from the cytoplasm so that the muscle can relax before contracting again. This antiport system is so effective that it can maintain the cellular concentration of Ca^{2+} at levels 10,000 times lower than the external concentration.

4. Movement of Large Molecules: Exocytosis & Endocytosis

(*a*) Large molecules (proteins, nucleic acids, polypeptides larger than a few amino acids, polysaccharides larger than a few sugars) are not carried by transport proteins.

(*b*) There are mechanisms for moving larger molecules, but they don't enter into cytoplasm.

(*i*) **Exocytosis**: membrane vesicle fuses with cell membrane, releases enclosed material to extracellular space. Ex: release of digestive enzymes from pancreatic cells; mucus, milk, hormones, etc.

(*ii*) **Endocytosis**: cell membrane invaginates, pinches in, creates vesicle enclosing contents. Three common situations:

1. **Phagocytosis**: Typically works on debris, bacteria, other particulate matter. Contents of the "phagosome" are usually fused with lysosome to create "phagolysosome", where material is broken down. Especially common in white blood cells such as macrophages and other leukocytes.
2. **Pinocytosis**: similar to phagocytosis, but ingests fluid rather than particulate matter. "Cell drinking". Ex. cells lining blood capillaries take fluid from blood (but not red cells), move fluid across their cytoplasm, release into extracellular space surrounding cells outside the capillary.

3. **Carrier-mediated endocytosis (CME)/ receptor-mediated endocytosis**: very specialized system. Certain important molecules or ions are not brought into cell by transport processes, but by CME. The body uses hormones to regulate membrane transport in this way
Eg. 1. iron is carried through blood tightly bound to transferrin protein carrier. To get iron into cells, cell membrane contains special receptor proteins that bind transferrin, move towards special regions of membrane under which lie **clathrin** proteins. Endocytosis occurs inside clathrin "cage", moves inside cell. Cage eventually recycles back to cell surface, returning transferrin proteins to cell exterior. However, iron is released inside cell, exits from vesicles, becomes bound to ferritin.

5. **Cells Regulate Permeability by Adding & Removing Membrane Transport Proteins**
   (*a*) Insulin is transported by transporter GLUT4. Insulin causes glucose transport molecules to be inserted into muscle and adipose tissue cells. Glucose is then taken up into those tissues, lowering the blood concentration.
   (*b*) Antidiuretic Hormone (ADH) is transported via aquaporin. ADH causes aquaporin 2 proteins to be added to the kidney collecting duct membranes. The result is water conservation.
   (*c*) Aldosterone is transported by Na Pump. Aldosterone causes cells in the distal tubules and collecting duct of the kidney to make more Na pump molecules. The final result is that the body retains more Na and secretes more K into the urine.

PLANT HORMONES

In all plants, there occur in minute quantities of certain substances (plant growth regulators or phytohormones) which regulate growth and differentiation. Five major types of growth substances are recognized: auxins and gibberellins (both concerned with cell enlargement and differentiation); cytokinins (concerned with cell division); abscisic acid (with resting states like lateral buds); and ethylene (with senescence-ageing),

1. Auxins

The auxins are weak organic acids with the acidic group positioned at the end of the side chain attached to an unsaturated ring(s) system. Presently, indole acetic acid (IAA) and other natural or synthetic growth-regulating substances having structures and functions similar to IAA, are termed auxins.

(*i*) Charles Darwin conducted his experiments concerning growth on canary grass (*Phalaris canariensis*).

(*ii*) Went is credited with the discovery of auxin.

(*iii*) Auxins are synthesized mainly in apices and exhibit polar transport.

(*iv*) Using Avena curvature test, Kogl and Haagen Smit (1931) found that human urine contained a growth substance, which was isolated and given the name auxin a (auxentriolic acid). In 1934, Kogl and coworkers isolated another compound auxin-b (auxenolinic acid) from corn germ oil and heteroauxin (now known as IAA or indole 3-acetic acid) from human urine. The auxins a and b could not be isolated again and their existence is doubtful but IAA has been isolated in crystalline form from different sources by different investigators at different times.

(*v*) Plants having excurrent habit (palms, conifers, polyathia) have greater apical dominance.

Functions of auxins

(*i*) Cell elongation
(*ii*) Cell divisions
(*iii*) Phototropism
(*iv*) Geotropism
(*v*) Apical dominance
(*vi*) Root initiation
(*vii*) Abscission
(*viii*) Feminising effect
(*ix*) Parthenocarpy
(*x*) Weedicide
(*xi*) Prevention of lodging

Applications of synthetic auxins

1. **Rooting:** IBA, IBA-alanine and NAA are used.
2. **Parthenocarpy:** IAA, IBA.
3. **Weedicide:** 2,4-D, 2,4, 5- T.
4. **Flowering:** NAA and 2,4-D for litchi and pineapple.
5. **Storage:** Methyl ester of NAA for storage of potato.
6. **Pre harvest fruit drop:** 2,4-D for citrus fruits, NAA for tomato.
7. **Prevention of lodging:** Naphthalene acetamide.
8. **Vegetable crops:** Chlorophenoxypropionic acid is used to improve quality of vegetable crops.
9. **Dwarf shoots:** NAA for increasing dwarf shoots and number of fruits in apple.

2. Gibberellins

Gibberellins are synthesized in the apices of young leaves and roots and are transported through xylem. Anti-giberellins are synthetic compounds which interfere with the synthesis of gibberellins in the plant body, hence called growth retardants e.g. maleic hydrazide, phosphon D, chlorocholine chloride (CCC).

Japanese farmer noticed 'bakanae' or 'foolish seedling disease of rice'. As a result of the disease, certain rice seed lings grew excessively tall and rapidly; and toppled over before forming seeds. Crop losses as high as 40% were reported. In the beginning of twentieth century, it became known that the disease is caused by a fungus *Gibberella fujikuroi* (perfect state of *Fuasarium moniliforme*).

Kurosowa (1926) showed that the sterile filtrates of the fungus are capable of causing the symptoms of bakanae disease in otherwise normal seedlings. Yabuta and Hayashi (1910) isolated the growth inducing principle and called it Gibberellin. In 1938, Yabuta and Sumiki were able to isolate the crystalline form of gibberellin from the culture of the fungus. This and other similar compounds isolated were called gibberellins (after the name of the fungus Gibberella) and were numbered GA_1, GA_2, GA_3.

Chemically all gibberellins arc terpenes a complex group of plant chemicals related to lipids. All are weak acids. Gibberellins are found in abundance in young expanding organs being synthesized especially in embryos, young apical leaves, buds, seeds and root tips. After synthesis, these are translocated up or down the plants from the leaves.

Applications of gibberellins

(*i*) **Internodal elongation:** Like auxins, the main effect of gibberellins is on stem elongation mainly by affecting cell elongation. Gibberellins stimulate stem elongation and leaf expansion, but do not affect roots. Thus, gibberellins restore normal size and growth to genetically dwarf varieties of pear and maize. Though stem growth of normal plants is also promoted, but here these do not induce marked elongation. It is believed that certain specific types of dwarfness in plants are due to deficiency of gibberellin.

(*ii*) **Bolting:** In many plants, leaf development is profuse, while internode growth is retarded. This form of growth is called “rosette” e.g., cabbage. Just before the reproductive phase, the internodes elongate enormously causing a marked increase in height. The stem sometimes elongates from 5-6 times the original height of the plant. This is called bolting. Bolting requires either long days or cold nights. So if a cabbage head is kept under warm nights, it returns to its rosette habit. However, application of gibberellins to these plants can induce bolting even under the conditions that would normally favor rosette form. The gibberellins thus appear to have a role in bolting or not bolting of a plant. Some gibberellin-like substances found in greater amounts in bolted plants than in the non-bolted form.

(*iii*) **Germination of seeds:** especially in cereals, is triggered by soaking the seed in water. After imbibition of water, the embryo secretes gibberellin which diffuses to the aleurone layer, stimulating the synthesis of several enzymes, including amylase, proteases, lipases. These enzymes catalyse the breakdown of food reserves in the endosperm and the products liberated diffuse to the embryo, where they are used in growth.

(*v*) **Control of flowering:** Gibberellins promote flowering in long day plants and inhibit it in short day plants. These also control sex-expression in certain species. In general, the application of gibberellins promotes the production of male flowers in female plants of Callilabis.

(*vi*) **Control of fruit growth:** Along with gibberellins, the auxins control fruit growth and development. Gibberellins cause parthenocarpy in pome fruits (apple, pear etc.) and are now-a-days used extensively to increase the fruit size and bunch length in grape.

(*vii*) **Vernalization:** Gibberellins can substitute vernalization.

(*viii*) **Dormancy:** Gibberellins overcome natural dormancy of buds, tubers, seeds etc.

Commercial application

1. **Fruit growth** – increase number and size of grapes, tomato.
2. **Parthenocarpy** – in pomes.
3. **Malt -** Increase yield of mall from barley.
4. **Delayed ripening** – in citrus.
5. **Overcoming dormancy** – in photoblaslic seeds of tobacco and lettuce.
6. **Flowering** – in long day plants in non-inductive period.

3. Cytokinins

Cytokinins are substances which act primarily on cell division and have little or no effect on extension growth. A number of compounds capable of promoting cell division are found in plants.

During the period 1954-1956, Skoog found that coconut milk contained it substance that stimulated cell division in tobacco pith cultures. In 1955, Miller et. al. separated from yeast DNA an active stimulant of cell division which they called kinetin (because of its involvement in cell division i.e. cytokinesis). Later on, the substance was identified as 6-furfuryl aminopurine. Subsequently, the term cytokinin was adopted.The first naturally occurring cytokinin to be chemically identified was from young maize (*Zea mays*) grains in 1963 and was called zeatin.

Applications of cytokinins

(*i*) **Cell-division:** Cytokinins are quite abundant wherever, rapid cell division occurs, especially in growing tissues such as embryos, developing fruits and roots. In mature plants, these are frequently synthesized in the roots and move to the shoots through xylem.

(*ii*) **Morphogenesis:** Cytokinins promote cell division. However, these never act alone. In the presence of auxins, cytokinins promote cell division even in non-meristematic tissues. In tissue cultures of parenchyma, mitotic divisions are accelerated when both auxin and cytokinin are present. However, no response occurs with auxin or cytokinin alone. Also, the ratio of cytokinins to auxins also controls cell differentiation. When both of these are present in relatively equal quantities the cells do divide but -fail to differentiate. If there is more cytokinin than auxin, shoot buds develop. Relatively more auxin than cytokinins leads to the developments of roots.

(*iii*) **Apical Dominance:** Cytokinin and auxin can act antagonistically in the control of apical dominance. While auxins promote the growth of apical buds, the cytokinin stimulate the growth of lateral buds.

(*iv*) **Delay in senescence:** Cytokinins delay the senescence of plant organs by controlling protein synthesis and mobilization of resources. This is evidenced by the fact the cut leaves dipped in cytokinins stay green longer than the control leaves. This is called Richmond Lang effect.

(*v*) **Flowering:** Cytokinins also induce flowering in certain species of plants and are also responsible for breaking the dormancy of seeds of some plants

(*vi*) **Phloem transport and Accumulation of salts in the cells.**

(*vii*) **Sex-expression** – promote femaleness

Commercial application

1. Tissue culture.
2. Shelf life of vegetables, flowers is increased.
3. Overcoming senescence.

4. Ethylene

Ethylene is the only gaseous natural plant growth regulator. Some of the inhibitory effects which were earlier thought to be due to auxins are now known to be the effect of ethylene.

A ripe or injured fruit in a container hastens the ripening of other fruits. 'This is very common observation and belief. Merchants have been using kerosene lamps and hay for hastening the development of color in fruits. These effects are due to ethylene. In 1930's it became known that ethylene gas hastened the ripening of citrus fruits and affected plants growth in different ways. Later on, it was found that certain ripe fruits e.g., bananas produced a gas with similar effects. In 1934, maturing apple was shown to emit ethylene. Later on, it was found that ethylene is emitted by a wide variety of ripening fruits, and from wounded organs.

Ethylene is produced by most or all plant organs. High concentrations of auxin induce the formation of ethylene. Though it is a gas, it does not genenrally move through the air spaces in the plants. Rather, it escapes from the plants surface.

Applications of ethylene

(*i*) **Growth:** It inhibits stem elongation and stimulates its transverse expansion. As a result, the stem looks swollen.

(*ii*) **Abscission**: It accelerates abscission of leaves, flowers and fruits.

(*ii*) **Fruit ripening**: Its chief effects are on the ripening of fruits accompanied by a rise in the rate of respiration (climacteric).

(*iv*) **Flowering:** Application of ethylene induces flowering in pineapp.12 and stimulates the ripening of citrus fruits and tomatoes. Its application increases the number of female flowers and fruits in cucumber plants.

A commercial compounds '**ethephon**' breaks down to release ethylene in plants. It is particularly applied to rubber plants to stimulate the flow of latex.

5. Abscisic Acid

For a long time it has been suspected that dormancy is caused by inhibitors. A group of scientists led by Wareing initiated studies to find them. In 1964, pure crystals of a substance were called dormin. It was found to be similar to another compound isolated from young cotton fruits in 1963 by another group of scientists. This substance accelerated abscission and was called abscission II. In 1967 it was decided to call it abscisic acid.(ABA)

Since then, it has been found in all groups of Plants (from mosses to higher plants). In liverworts and algae a compound lunularic acid had been found having activities similar to ABA. Chemically, ABA is a terperioid. It is the only growth substance in its class.

ABA is synthesized in the leaves, stems, fruits and seeds. Isolated chloroplast can synthesize it. It is distributed through the vascular system, especially phloem. ABA is a major inhibitor of growth in plants and is antagonistic to all the three growth promoters.

APPLICATIONS OF ABA

(*i*) **Stoppage of cambial activity** – It inhibits mitosis in vascular cambium.

(*ii*) **Bud dormancy** – It induces axillary buds to become dormant as the winter approaches.

(*iii*) **Seed dormancy** – It induces dormancy in seeds.

(*iv*) **Transpiration** – It is a 'stress hormone' and helps the plant to cope with adverse environmental conditions especially drought. In wilting tomato leaves, ABA brings about the closure of stomata.

Commercial uses

1. It may be sprayed on tree crops to regulate fruit drop at the end of the season.
2. Application of ABA to green oranges turns them yellow by inducing synthesis of caretenoids.
3. Anti-transpirant.

ANIMAL HORMONES

1. **Exocrine glands** are those which drain out their secretion through a **duct**, **e.g. liver, intestinal glands, gastric glands.**
2. **Endocrine glands**. The glands, which lack duct and discharge, their secretions into the blood stream are called as Endocrine glands. They are also called as **ductless glands**. The chemical secretions of endocrine glands are called **hormones** and are popularly called the **chemical messengers** of the body. They affect definite part of the body and prepare it for a specific function. The part of the body where a hormone produces its effect is called the target.
   - **Endocrine secretion.** Target organs lies at a distance or is far removed from the site of origin of hormone.
   - **Paracrine secretion**. Acting on cells in near vicinity.
   - **Autocrine secretion.** Acting on same cells, which secrete it.
3. **Mechanism of action of hormones**:

   Protein hormones act on the target receptors present on plasma membrane. These receptors in turn excite second messengers inside the nucleus for action on DNA for differential transcription second messenger can be.
   - **cAMP** (3′5′ cyclic adenosine mono phosphate) e.g. TSH, LH, ACTH, FSH, vasopressin, parathyroid hormone, glucagons, secretin, catecholamines.
   - Ca^{++} ions and calmodulin (calcium binding protein) e.g. ?
   - Inositol phosphate and diacylglycerol
4. The name **hormone** was first used by the English physiologists. **M. Bayliss and E.H. Starling** in 1909. A hormone (Gr. Hormao = to excite) may be defined as a specific organic product of an endocrine gland secreted into the blood which carries it to some part of the body (target organ) where it regulates a definite physiological effect.

5. **Heterocrine glands** are those glands which are exocrine as well as endocrine in functions e.g. testes, ovaries.
6. Hormones are required in specific amount. Their **hyposecretion** (secretion in lesser amount than normal), as well as **hypersecretion** (secretion in larger amount than normal) produces serious physiological disturbances in the body.
7. **Properties of hormones:**

   The hormones have the following properties:
   (*a*) They have low molecular weight.
   (*b*) They are soluble in water and blood.
   (*c*) They have no cumulative effect.
   (*d*) They can act in very low concentration.
   (*e*) They are non-antigenic.
   (*f*) They are organic catalysts.
8. **Kinds of hormones**: Based on their influence on physiological activities and control, the hormones may be divided into following 5 categories.
   (*i*) Hormones concerned with metabolism e.g. Insulin etc.
   (*ii*) Hormones for growth and development e.g. Somatotropin etc.
   (*iii*) Horomones of digestion e.g. Gastrin, Secretin etc.
   (*iv*) Hormones for reproduction e.g. Gonadotropic and Sex hormones.
   (*v*) Hormones that control other endocrine glands e.g. Thyrotropin etc.
9. **Biochemical Classifaction of hormones**: All hormones, depending upon their chemical structure, may be classified under the following categories.
   (*i*) **Amines:** Hormones of pineal gland (melatonin) and adrenal medulla (catecholmines, viz., adrenaline, nonadrenaline).
   (*ii*) **Modified Amino Acids:** Hormones of thyroid are iodinated tyrosine, *e.g.*, thyroxine.
   (*iii*) **Peptides:** Hormones of hypothalamus (ARH, TRH, GRH, GIH), intermediate (MSH) and posterior lobes of pituitary (ADH, oxytocin). ACTH of anterior pituitary and calcitonin of thyroid belong to this category. They may further be differentiated into short peptides (*e.g.*, oxytocin, ADH) and long peptides (*e.g.*, calcitonin, ACTH).
   (*iv*) **Proteins:** Hormones of pancreas (*e.g.*, insulin, glucagon), gastrointestinal tract, some female hormones (*e.g.*, relaxin of ovary and hCG of placenta), parathormone (PTH) and most hormones of anterior pituitary except ACTH (*e.g.*, TSH, FSH, LA, LTH, GH) are proteinaceous.
   (*v*) **Steroids:** Hormones are derived from cholesterol and other steroids, *e.g.*, aldosterone, cortisol, sex corticoids (adrenal cortex), testosterone, estradiol, progesterone (gonads except relaxin, placenta except hCG).
10. **RIA** – Radioimmunoassay technique to measure the hormones, their precursor and their metabolic end products quantitatively in a living body.
11. **Endocrine glands in human beings**: In man the following major endocrine glands are present.
   (*i*) Pituitary gland or Hypophysis

(*ii*) Pineal Gland
(*iii*) Thyroid gland
(*iv*) Parathyroid gland
(*v*) Adrenal gland
(*vi*) Gonads
(*vii*) Islets of Langerhands in Pancreas
(*viii*) Placenta
(*ix*) Thymus gland
(*x*) Hypothalamus
(*xi*) Gastro-Intestinal lining

SUMMARY OF ENDOCRINE GLANDS AND THEIR HORMONES

I. Pituitary Gland

It consists of three lobes, anterior, middle and posterior.

Location: Floor of diencephalons and attached to the hypothalamus by a stalk to form hypothalamic – pituitary system.

(*a*) Anterior lobs of Pituitary: It possesses acidophils (α- cells), basophils (β-cells) and chromophobes (precursors of other two). Acidophils produce two hormones (GH and LTH) while basophils secrete five hormones (TSH, Lipotropin, ACTH, FSH, LH).

(*i*) **Somatotropin or Growth Stimulating Hormone (GH)**

Functions: Stimulates growth by accelerating the protein synthesis and retention of calcium.

Effect of hyposecretion: Less secretion of GSH leads to **dwarfism** and **acromicria** in adults.

Effect of Hypersecretion: 1. Gigantism. Due to excess secretion of GSH during childhood.

2. Acromeagly in adults.

(*ii*) ***Prolactin/ Lactogenic or Luteotrophic Hormone (LTH)–*** Proteinaceous hormone (often included under gonadotrophins) that stimulates development of mammary glands during pregnancy and lactation after childbirth. It is also called maternity hormone.

(*iii*) ***Lipotropin or Adipokinetic Hormone–*** The hormone stimulates liberation of fatty acids from stored fats.

(*iv*) ***Gonadotropins:*** The hormones, which regulate the sexual activity of gonads, and other structures of the body. They include:

1. Follicle Stimulating Hormone (FSH)

Functions: Stimulation of testes in male to form the sperms from the seminiferous tubules: In females, the FSH stimulates ovary for the maturation of ovation follicle. Here, it also stimulates the follicular cells to secrete estrogen. The latter is responsible for the secondary sexual characters in female.

Effect of hyposecretion: Failure of gamete formation from the gonads.

2. **Intestinal Cells Stimulating Hormone (ICSH) in males.**

   Functions: Stimulates the interstitial or Leydig's cells or testis to produce testosterone. The latter brings about secondary sexual characters of male.

   Effect of hyposecretion: Impaired development of the external genitalia.

3. **Leutinizing hormone in females (LH) (or Lutropin).**

   Functions: Release of ovum from ovary (ovulation); formation of corpus luteum and the secretion of progesterone from corpus luteum.

   Effect of hyposecretion: Sterility in females.

(*v*) Thyroid Stimulating Hormone (TSH)

Function: Production of thyroid hormones from thyroid gland

(*vi*) Adrenocortiocotropin Hormone (ACTH):

Function: Brings about the production and release of hormones from adrenal cortex.

(*b*) Intermediate lobs of pituitary

Hormone: *Melanocytes stimulating hormone (MSH)*

Function: May be connected with pigment maintenance in hair, pregnancy related skin pigmentation.

(*c*) Posterior lobs of pituitary

Hormones

(*i*) ***Oxytocin (Pitocin):*** Stimulation of uterine contraction during child birth. Stimulation of milk flow by mammary glands under the control of Prolactin or LTH.

(*ii*) ***Vasopressin (Pitressin, ADH):*** Influences water balance by reducing output of urine by reabsorption of water from nephric filtrate in DCH and CT. Also, causes arteriole constriction, raise blood pressure and causes contraction of several smooth muscles like those of intestine, gall bladder, urinary bladder etc.

Hyper secretion

Causes Diabetes insipidus (Drinker's disease) It is hormonal abnormality of **polyuria** (excessive urine) or micturating dilute urine (hypotonic, sugar-free) several times a day.

II. Pineal Gland

It is a stalked small rounded gland found behind the anterior choroid plexus on the epithalamus. Calcification occurs in middle age. It has pineal and glial cells.

Hormones

The gland secretes two biogenic amine hormones

(*i*) ***Serotonin:*** Also by disintegrating blood cells. Constricts (Vasoconstriction) blood vessel at site of injury and gives burning sensation.

(*ii*) ***Melatonin:***. The hormone develops pale skin color in amphibians. It shows a marked diurnal rhythm with maximum concentration at midnight and minimum during noon. The hormone controls sleep, mood, ovarian cycle, delays puberty, opposes FSH and LH hormones (hence anti-gonadotrophic).

III. Thyroid

Location: Base of larynx

Hormones:

(*i*) **Thyroxine**

(*ii*) ***Triodothronine*** (Both are iodinated amino acids)

Functions: Regulate cellular oxidation of food and basal metabolism, growth and differentiation.

Effect of hyposecretion:

(*i*) **Cretinism** in children, and **Myxodema** in adult.

(*ii*) Iodine deficiency goiter.

(*iii*) **Hashimoto Disease:** It occurs in middle aged females due to sensitization of their own thyroid protein called thyroglobulin. There is mild hypothyroidism. The thyroid gland is enlarged.

Effect of Hypersecretion: Exophthalamic goiter/ Grave disease indicated by protruding eyes, loss of weight, nervous- ness and fast heart beat.

(*iv*) ***Calcitonin (Protein):*** Regulates calcium and phosphorus

IV. Parathyroids

Location: Behind thyroid

Hormones: Parathormone (protein)

Functions: Regulates calcium and phosphorus balance in the blood.

Effect of hyposecretion: Reduces Ca in blood and results in severe cramps Parathyroid tetany.

Effect of Hypersecretion: High Ca level in blood by releasing it from bones and leading to ostestis fibrosa cystica.

V. Adrenals

Each adrenal has two parts, an outer cortex and inner medulla.

Location: Over the superior end of kidneys.

(*a*) Adrenal Cortex. The outer part of adrenals which further consists of three zones

(*i*) Zona glomerulosa:

Hormones: ***Mineralocorticoids (mainly aldosterone)***

Functions: Regulation of Na^+ and K^+ in blood. Increases Na^+ level, and lowers that of K^+

(*ii*) Zona Fasciculata

Hormone: ***Glucocorticoids (Mainly cortisol)***

Function: Increase glucose level in body by changing proteins and fast to carbohydrates.

Hypersecretion: Cushing's syndrome due to high glucose level, and high Na^+ level caused by excess of glucocorticoids. High B.P. and rise in blood volume.

(iii) Zona reticulosa

Hormone: ***Androgens (Male sex hormones)***

Function: Development of male secondary sexual characters.

Hypersecretion: Adrenal virilism due to excess of androgens secreted in female who develops certain masculine features.

(*b*) Adrenal medulla (The inner portion of adrenals)

The adrenals are commonly called the glands of emergency because of the role of their hormones.

Hormone:

(*i*) ***Noradrenaline (= Norepinephrine)*** Secreted under normal conditions.

Function: Regulate blood pressure under normal condition by constricting small arteries.

(*ii*) ***Adrenaline (= Epinephrine)*** secreted under conditions of physical and mental stress such as grief, pain, injury, anger, fall in blood pressure and blood sugar, cold fear, etc. In man, adrenalin is produced in much more amount than nonadrenaline.

Function: Increase of heart beat rate, breathing rate and blood sugar. Dilation of small arteries of heart, brain and skeletal muscles. Constriction of small arteries of skin: constriction of small arteries of skin; contraction of spleen to squeeze out the reserve, dilation of pupil, contraction of arrector pili muscles (goose flesh condition).

VI. Gonads

(*a*) Testes. A heterocrine gland. The endocrine portion is represented by the Leydig's cells (Interstitial cells) present between the seminiferous tubules.

Location: Situated in Scrotum

Hormones: ***Testosterone and other androgens.***

Functions:

1. Growth of the reproductive system to full size and to functional state.
2. Stimulates sperm formation.
3. Formation of sexual characters of female.

Hyposecretion: Eunuchoidism (Inadequate formation of reproductive system, incapability of sperm formation).

(*b*) Ovaries

Location: In the abdominal cavity.

Hormones:

(*i*) Oestrogen from follicular cells.

Function: Growth of female reproductive system to full size, formation of secondary sexual characters of female.

(*ii*) Progesterone (secreted by corpus luteum).

Function:

(*a*) Suspends the ovulation.

(*b*) Formation of placenta.

(*iii*) ***Relaxin*** (produced by corpus luteum at the end of pregnancy)

Function: Controls the development of foetus, Relaxation of cervix, and ligaments of pelvic girdle to facilitate the birth.

VII. Pancreas

A myxocrine gland. Its endocrine part is represented by Islets of Langerhans which have two type of cells the α (alpha) cells, and β (beta) cells.

Location: In the duodenal loop.

(*a*) Beta cells

Hormone: *Insulin* (an anabolic hormone)

Function:

(*i*) Conversion of glucose to glycogen in liver and muscles.
(*ii*) Promotes protein synthesis in tissues.
(*iii*) Promotes synthesis of fats from fatty acids
(*iv*) Inhibits breakdown of proteins and fats.

Hyposecretion: Diabetes mellitus indicated by the rise of glucose level in blood, and higher level of cholesterol, excretion of sugar by the kidneys in urine; excessive thirst; delayed wound healing of proteins in tissues, and gangrene.

(*b*) Alpha cells

Hormone: *Glucagon*

Function:

(*i*) Converts glycogen to blood glucose in liver
(*ii*) Formation of glucose from amino acids.

VIII. Placenta

Location: A living connection between the foetus and uterine wall.

Hormones:

(*i*) Human chorionic gonadotropin (HCG)

Function: Produced in large amount in first few months of pregnancy. It stimulates the enlargement of corpus luteum to secrete progesterone. Presence of hCG in urine is indication of pregnancy, used for pregnancy test

(*ii*) ***Progesterone:*** Functionally same as the one produced by corpus luteum.

(*iii*) ***Estrogen:*** : Similar role as that produced by the follicular cells of ovary

IX. Thymus

Location: Near the heart. Gets reduced in adults.

Hormone: *Thymosin (Protein)*

Function: Proliferation of lymphocytes, and also regulates growth; important for immune system.

Hyposecretion: Poor development of immunity. Retarded development of sex organs.

X. Hypothalamus

(Composed of neurosecretory cells of the floor of diencephalons secrete neurohormones).

Location: Floor of diencephalons of brain; connected to the anterior lobe of pituitary by hypophyseal blood vessel, and with posterior lobe of pituitary through the axons of its neurons. Some hormones are poured into adenohypophysis (anterior, and intermediate pituitary), through hypophysial portal system while two hormones (***oxytocin and ADH***) are directly taken by nerve cells in neurohypophysis (posterior pituitary). Hormones poured in adenohypophysis function as releasing or inhibiting hormones. They are peptide in nature.

Hormones:

(*i*) ***Thyrotropin Releasing Hormone (T-RH):*** Release of TSH from anterior pituitary.

(*ii*) ***Adrenocorticotropin- Releasing Hormone (A-RH):*** Release of ACTH from anterior pituitary.

(*iii*) ***Somatotropin Releasing hormone (S-RH):*** Release of SH from anterior pituitary.

(*iv*) ***Gonadotropin- Releasing hormone (G-RH):*** Release of goandotropins from the anterior pituitary.

(*v*) ***Growth inhibiting hormone (GIH) or somatostatin:*** Inhibits the hormone from pituitary.

XI. Gastrointestinal lining

Location: Inner layer of wall of gut.

(*a*) **Stomach**

Hormone: ***Gastrin***

Function: Stimulation of gastric glands to release gastric juice. Also stimulates stomach movements.

(*b*) **Intestine**

(i) ***Secretin***

(1) Stimulates pancreas to release enzymes.

(2) Stimulates gall bladder to release bile.

(*ii*) ***Cholecystokinin Pancreozymin (CCK – PZ):*** Stops the secretion of gastric juice and slows down gastric movements.

(*iii*) ***Enterogastrone*:** Stops the secretion of gastric juice and slows down gastric movements.

(*iv*) ***Enterocrininn*:** Release the intestinal juice from crypts of Liberkuhn.

(*v*) ***Duocrinin*:** Release of mucus from Brunner's Glands

(*vi*) ***Villikrinin:*** Accelerates the movement of villi.

Local Hormones (Tissue Hormones)

(*i*) Local hormones are those hormones which do not pass into blood but diffuse to the target as the same is nearby. They are also called paracrines or parahormones

(*ii*) The important ones are acetylcholine (from nerve endings), kinins (bradykinins) and prostaglandins. Prostaglandins are fatty acid derivatives, which have diverse functions including blood flow regulation, uterine contractions, antithrombotic, relaxation of arterial smooth muscles, etc. Kinins or bradykinins are polypeptides that cause contraction of smooth muscles and dilation of blood vessels.

(*iii*) The gaseous hormone, nitric oxide (also an air pollutant), is also a local hormone. Molecule of the year 1994, it has been used in rescuing end stage patients in respiratory distress. It is a signalling molecule of cardiovascular system that regulates blood pressure and blood flow besides relaxing smooth muscle cells. It is currently used in male potency drug viagra.

Pheromones

(*i*) They are chemicals used for communication amongst individuals of the same species. Pheromones are produced by exocrine glands and are transmitted to other members through air or excrements *(e.g.,* urine in dogs).

(*ii*) Pheromones invoke a specific response in other members like recognition, attraction, warning, etc. Bombykol is sex attractant pheromone produced by female silkworm moth, which is received by male antenna several kilometers away.

(*iii*) Ant trail is due to pheromone. Queen Bee is recognized by workers due to release of 9-oxydecenoic acid by it. Dormitory effect is also believed to be due to pheromones.

REPRODUCTION

Reproduction is the formation of new similar young living organisms by the grown up individuals of a species or race. It is meant for perpetuation of the race/species because individuals are bound to die after a life span. Reproduction provides group immortality. Four processes are basic to reproduction – DNA replication, cell division, formation of reproductive units and development of a new individual. Animal reproduction is of two types, asexual and sexual.

Asexual Reproduction

It is a mode of reproduction or formation of new young individuals from a specialized or unspecialized part of single parent without the formation and fusion of gametes. Besides being uniparental and absence of gametes, asexual reproduction is characterized by divisions through mitosis only, genetic similarity between parent and young ones, rapidity and absence of haploid-diploid alteration. Asexual reproductive propagule is called blastos. It contains totipotent cells like **archaeocytes** (sponges), **interstitial cells** (cnidaria), **parenchyma** (platyhelminthes) and **neoblasts** (annelids), etc. An individual produced through asexual reproduction is ramet. Clone is group of all genetically similar individuals formed through asexual reproduction.

1. **Fission:** It is a type of asexual reproduction in which the body of an individual undergoes division to produce two or more equal sized daughters.

   (*i*) ***Binary Fission***. The mature individual divides into two equal sized daughter individuals. Binary fission is irregular (can occur in any plane) in *Amoeba*, longitudinal in *Euglena*, oblique in dinoflagellates and transverse in *Paramecium* and *Planaria.* In unicellular forms, binary fission is accomplished through mitotic nuclear division followed by cytokinesis. In multicellular individuals like *Planaria* the posterior part is fixed firmly to substratum while anterior part extends forward and exerts a pull causing the middle part to break.

   (*ii*) ***Multiple Fission:*** It is formation of a number of small daughters by division of a parent. In unicellular forms, the nucleus divides a few times followed by collection of cytoplasm around each daughter nucleus forming a number of daughter cells, *e.g., Amoeba, Plasmodium, Monocystis.*

(*iii*) ***Plasmotomy:*** Cleavage of plasmodium or multinucleate body into multinucleate parts, *e.g., Opalina, Pelomyxa.*

(*iv*) ***Strobilisation:*** A modification of multiple fission is strobilisation in multicellular animals (body segmentation for reproduction as forming zooids in coelenterates like *Aurelia* and proglottides in Tapeworm).

2. **Cysts and Spores:** They are minute propagules, which function as dissemules as well as perennating structures. Each cyst or spore gives rise to a new individual.
3. **Budding:** It is a mode of asexual reproduction in which new organisms develop as outgrowth or buds from a parent.

   (*i*) ***Exogenous/ External Budding.*** The bud develops externally on the parent. In the young condition the two are internally connected to provide nourishment to the bud. Later on, the bud enlarges and becomes nutritionally independent. It then separates as a new individual, *e.g.,* Yeast, *Hydra.* However, in some cases, the new individual remains joined to the parent to form colony, *e.g., Scypha.*

   (*ii*) ***Endogenous/ Internal Budding.*** Internal buds or gemmules/ statoblasts occur in sponges/bryozoans to help in dispersal as well as perennation.
4. **Fragmentation:** It is breaking of an individual into two or more parts due to external (*e.g.,* Star fish) or internal forces (*e.g.,* Tunicates). Each fragment grows into a new individual.

Sexual Reproduction

It is mode of multiplication in which the new individuals or young ones are formed through the process of formation and fusion of gametes. Haploid (gametes)- diploid (individual) alternation occurs. Gametogenesis involves meiosis. Fusion of gametes or fertilization restores the chromosome number. The offspring is produced by the growth of the fusion product of gametes called zygote. Sexual reproduction is commonly biparental. A number or variations appear in the offspring.

Parthenogenesis (Apomixis)

It is the development of a new individual from a single gamete (generally the egg/ovum) without involving fertilization. On the basis of chromosome sets, parthenogenesis is of two types:

(*i*) ***Arrhenotoky*** (Haploid Parthenogenesis). Haploid eggs grow to form haploid males, *e.g.,* arachnids, some insects.

(*ii*) ***Thelotoky*** (Diploid Parthenogenesis). Diploid eggs grow without fertilization into diploid individuals, generally females, *e.g.,* Gall Fly

Parthenogenesis can be natural or artificial. Natural parthenogenesis may be obligatory or cyclic.

Natural Parthenogenesis

1. **Obligatory/Complete Parthenogenesis:** Males are absent. Females develop parthenogenetically, *e.g.* rotifers, *Typhlina brahmina* (small lizard), *Lacerta saxicola-armeniaca* (Caucasian Rock Lizard), *Cnemidophorus* (Whiptail lizard of America)
2. **Cyclic/Incomplete Parthenogenesis:** Both sexual and parthenogenetic individuals occur. In aphids, several generations of parthenogenetic females develop followed by

formation of both males and females to perform sexual reproduction. In Turkey, 40% of the males develop parthenogenetically. In Honey Bee, male or drone develops parthenogenetically (no meiosis at the time of spermatogenesis) while queen and workers develop from fertilized eggs. Also in wasps and ants. In Gall Fly, larvae may lay eggs that develop parthenogenetically (paedogenesis).

Artificial/Induced Parthenogenesis

Sugar, salt, alkaloids and other chemicals, heat, cold, pricking and other stimuli can stimulate eggs to undergo cleavage and form parthenogenetic embryos. Being haploid, they generally do not survive.

GAMETOGENESIS

The process of formation off gametes in the gonads is called gametogenesis. Gametes are produced by way of meiotic division resulting in the reduction of number of chromosomes to one half. The production of sperms in the seminiferous tubules of testis is called spermatogenesis and production of ova in ovaries is called oogenesis.

1. **Spermatogenesis**

   Spermatogenesis is the process of formation of haploid functional spermatozoa from diploid germinal cells of seminiferous tubules. Lining layer of seminiferous tubules possesses primary germ cells and indifferent cells that mature into nurse cells or Sertoli cells.

   (*i*) ***Multiplication Phase:*** Diploid primary germ cells undergo repeated mitosis to form a number of diploid spermatogonia.

   (*ii*) ***Spermatocytogenesis:*** Each spermatogonia divided mitotically to from two interconnected primary spermatocyte

   (*iii*) ***Growth Phase:*** Primary spermatocytes grow in size.

   (*iv*) ***Maturation Phase:*** Each diploid primary spermatocyte undergoes meiosis I to form two haploid secondary spermatocytes. All the secondary spermatocytes derived from a single spermatogonium remain attached to one another. Secondary spermatocytes- divides by meiosis II, each giving rise to two haploid spermatids. The spermatids become partially embedded in Sertoli cells for nourishment and support.

   (*v*) ***Spermiogenesis:*** Spermiogenesis is differentiation of a spermatozoon from a spermatid. Golgi apparatus forms acrosome. Centriole divides into two. Distal centriole forms axial filament. Mitochondria collect around upper part of axial filament. Nucleus undergoes condensation. A spermatozoon now separates while the unused cytoplasm degenerates. Heads of spermatozoa remain embedded for some time in Sertoli cells but ultimately the spermatozoa are released into lumen of seminiferous tubule for onward passage.

Sperm

Human sperm is dart-like flagellate structure of 60 µm length. It has four parts—

(*i*) **Head.** Knob-like terminal part has two components, acrosome and nucleus. Acrosome contains sperm lysins. Nucleus is compact mass of DNA having some **protamines**. On the outside is present a double membrane head cap.

(*ii*) **Neck.** It is short narrow part between head and middle piece, which contains two centrioles, unconnected proximal centriole and distal centriole attached to axial filament (that passes into middle piece).

(*iii*) **Middle Piece.** It is cylindrical part. It has axial filament surrounded by 10-14 spiral turns of mitochondria and bearing towards the end a ring centriole or annulus. Mitochondria provide energy for swimming but food is limited.

(iv) Tail. It is narrow vibratile long part, with two regions, main and end piece. Main piece of tail is 0.5 mm in diameter near the beginning but gradually narrows behind. It has an axial filament, small amount of cytoplasm and plasma membrane. In the end piece, cytoplasm and membrane are absent.

2. Oogenesis

It is the process of formation, development and maturation of haploid ova from diploid germinal cells of ovary. Oogenesis occurs in three phases

(*i*) **Multiplication Phase.** Diploid primary germ cells from germinal epithelium of ovary multiply mitotically and form oogonia. The latter produce ovigerous cords or egg tubes of Pfluger in mammals.

(*ii*) **Growth Phase.** It is prolonged and slow. Oogonia form rounded masses or egg nests at the tips of egg tubes of Pfluger. An egg nest forms ovarian follicle. One central oogonium grows and functions as primary oocyte. The others form the covering follicular cells. The latter provide nourishment to primary oocyte. Some nourishment also comes from outside. Enlarged primary oocyte secretes mucoprotein membrane or zona pellucida outside its own plasma membrane or vitelline membrane. There is increase in reserve food, size of nucleus, number of mitochondria, functioning of Golgi apparatus and complexity of endoplasmic reticulum.

(*iii*) **Maturation Phase.** Meiosis occurs. Nucleus shifts towards animal pole and undergoes meiosis I. A daughter nucleus alongwith small quantity of cytoplasm is extruded as primary polar body or polocyte below zona pellucida. Simultaneously primary oocyte is changed into haploid secondary oocyte. Ovum is generally shed in secondary oocyte stage. Meiosis II is completed in fallopian tube at the time of fertilization. It then produces a small secondary polar body and a large ovum. The primary polar body may also divide.

Ovum

Human egg or ovum is noncleidoic and alecithal (nearly microlecithal), rounded female gamete having a diameter of about 100 mm. The ovum possesses three coverings – inner thickened plasma membrane or vitelline membrane, middle mucoprotein zona pellucida and outer cellular corona radiata with radially elongated scattered cells held in mucopolysaccharide (hyaluronic acid). In between plasma membrane (= vitelline membrane) and zona pellucida is peri-vitelline space in which are present 1- 3 polar bodies towards animal pole. The opposite end is vegetal pole. Cytoplasm of ovum is called ooplasm. It has a large nucleus or germinal vesicle. Ectoplasm possesses

FERTILIZATION IN HUMANS

Only a single ovum is released in human females from one of the two ovaries towards the middle of ovarian/menstrual cycle. It passes into fallopian tube and rests inside ampulla for some time. Human male produces 300 - 400 million sperms per ejaculation. They are deposited in vagina during coitus. The process of deposition of sperms in the female genital tract is called insemination. A number of them are demobilised or eaten.

Fertilization involves the following steps:

(*i*) **Approximation of Sperm and Ovum.** Sperms can remain motile for 24-48 hours. They swim at the rate of 1. 5 - 3.0 mm/min. They are able to reach the ampulla part of female genital tract partly by their own swimming and partly by contraction of uterus and fallopian tubes. One sperm comes to lie against the ovum and undergo fertilizin (from ovum) and antifertilizin (from sperm) compatibility reaction (Lillie, 1919) in the region of animal pole.

(*ii*) **Acrosome Reaction.** It prepares the sperm to fertilize ovum. The phenomenon is called capacitation. In contact with corona radiata, the acrosome covering lyses to release acrosome. With the help of sperm lysins (chiefly hyaluronidase), acrosome dissolves corona radiata and zona pellucida in front of it.

(*iii*) **Egg Reaction.** A small protuberance or fertilization cone (cone of reception), develops from the surface of ovum in the region of animal pole.

(*iv*) **Penetration of Sperm.** Sperm head establishes contact with lateral surface of fertilization cone. Plasma membranes of the two dissolve. Contents of head (nucleus), neck and middle piece of sperm enter ooplasm. Tail is left outside. Fertilization cone subsides. Depolarisation of egg membrane kills other sperms. Plasma membrane of the egg is now modilled with the help of mucopolysaccharide cortical granules into fertilization membrane. A perivitelline space is created between it and zona pellucida.

(*v*) **Activation of Ovum.** Ovum (previously in secondary oocyte stage) undergoes meiosis II and extrudes a secondary polar body. It is now the actual ovum or female gamete.

(*vi*) **Fusion of Sperm and Egg Nuclei.** The envelopes of the sperm and egg nuclei degenerate and their chromosomes intermingle to form ‘synkaryon’. The act is called karyogamy or syngamy. The proximal centriole brought by sperm help~ form the spindle for the division of synkaryon (cleavage nucleus). Fertilized egg is also called zygote

Practice Test Paper-I

1. Mineral nutrients
   (*a*) are not essential to plant growth, since all a plant needs is water and CO_2.
   (*b*) contribute little to the weight of a plant.
   (*c*) enter plants via the stomata.
   (*d*) are organic nutrients.

2. Professor Arun claims to have discovered a new macronutrient required for plant growth. Most of Professor Arun's colleagues are skeptical of this claim. Why might they consider it unlikely?
   (*a*) All the nutrients required for plant growth have already been found.
   (*b*) It is very difficult to prove that a plant needs a certain nutrient.
   (*c*) Plants need thousands of nutrients; a new one is not significant.
   (*d*) Any nutrient needed in large amounts has probably been found already.

3. Soil could be deficient in any of the following nutrients. If you had to supply one of them, which would be needed in the smallest amount?
   (*a*) iron (*b*) phosphorus
   (*c*) nitrogen (*d*) potassium

4. Which of the following is a symptom of magnesium deficiency?
   (*a*) yellowing of younger leaves' prior to yellowing of older leaves.
   (*b*) enhanced plant growth, since magnesium is toxic to plants.
   (*c*) chlorosis
   (*d*) decreased transpiration

5. Topsoil
   (*a*) is the relatively inert upper layer of soil.
   (*b*) does not retain water.
   (*c*) is a mixture of rock fragments, living organisms, and humus.
   (*d*) is uniform in texture.

6. The roots of many aquatic plants have special structures that project above the surface of the water. For example, cypress trees (which grow in swamps) have knees that extend upward above water level. Which of the following is the most logical function of these structures?
   (*a*) obtaining carbon dioxide for photosynthesis
   (*b*) nitrogen fixation
   (*c*) obtaining oxygen for the roots
   (*d*) transpiration

7. The clay particles in soil are important because they
   (*a*) are composed of nitrogen needed by plants.
   (*b*) eliminate spaces for air and facilitate drainage.

(*c*) fill spaces and keep oxygen out of the soil.
(*d*) are charged and hold ions needed by plants.

8. Soil can easily become deficient in _____, because these ions are negatively charged and do not stick to negatively charged clay particles.
(*a*) potassium. (*b*) calcium.
(*c*) magnesium. (*d*) nitrate.

9. Fertilizers are usually enriched in
(*a*) iron, manganese, and zinc.
(*b*) calcium, boron, and carbon.
(*c*) nitrogen, phosphorus, and potassium.
(*d*) molybdenum, copper, and magnesium.

10. Nitrogen-fixing bacteria in the soil
(*a*) convert nitrates to N_2.
(*b*) convert ammonia into ammonium.
(*c*) convert atmospheric nitrogen into ammonia.
(*d*) use nitrates to make amino acids that plants can use.

11. Nitrogen fixation is
(*a*) using nitrogen to build molecules such as proteins and nucleic acids.
(*b*) converting nitrogen in the air into a form usable by plants.
(*c*) recycling nitrogen from organic matter in the soil.
(*d*) absorbing N_2 from the soil.

12. The enzyme that catalyzes the conversion of atmospheric nitrogen into ammonia is
(*a*) catalase. (*b*) nitrogenase.
(*c*) reductase. (*d*) rubisco.

13. The relationship between legumes and Rhizobium is
(*a*) mutualistic. (*b*) parasitic.
(*c*) competitive. (*d*) commensalism

14. Mycorrhizae are
(*a*) nutrients required by plants in relatively small amounts.
(*b*) plants such as mistletoe that parasitize other plants.
(*c*) cells that control evaporation of water from leaves.
(*d*) associations of roots with beneficial fungi.

15. The term alternation of generations refers to a plant’s life cycle alternating between
(*a*) the production of haploid gametes by meiosis with the production of diploid spores by mitosis.
(*b*) a haploid gametophyte generation and a haploid sporophyte generation.
(*c*) a haploid gametophyte generation and a diploid sporophyte generation.
(*d*) a flower producing generation and a leaf-producing generation.

16. Self-incompatibility
    (*a*) works the same way in all plants.
    (*b*) are all based on the same mechanism of transplant rejection seen in animals.
    (*c*) maintains variation.
    (*d*) is the rejection of a graft by a plant.

17. In angiosperms, each pollen grain produces two sperm. What do these sperm do?
    (*a*) Each one fertilizes a separate egg cell.
    (*b*) One fertilizes an egg and the other fertilizes the fruit.
    (*c*) One fertilizes an egg and the other is kept in reserve.
    (*d*) One fertilizes an egg and the other fertilizes a cell that develops into stored food.

18. What is endosperm?
    (*a*) male reproductive cells in plants
    (*b*) stored food in a seed
    (*c*) cells that make up the bulk of a pollen grain
    (*d*) the fleshy part of a fruit such as an apple or strawberry

19. The correct arrangement of the meristematic tissue of an embryo is
    (*a*) a ring of lateral meristem surrounding apical meristem.
    (*b*) a ring of procambium surrounding a ring of meristem surrounding a ring of protoderm.
    (*c*) a ring of hypocotyl surrounding a ring of radicle surrounding a ring of epicotyl.
    (*d*) a ring of protoderm surrounding a ring of ground meristem surrounding procambium.

20. The scutellum
    (*a*) is a specialized cotyledon found in certain monocots.
    (*b*) develops into the seed coat.
    (*c*) presents a barrier to self-fertilization.
    (*d*) is a specialized cotyledon found in dicots.

21. After fertilization, the _____ develops into a seed and the _____ develops into a fruit.
    (*a*) ovule . . . ovary
    (*b*) pollen grain . . . ovule
    (*c*) ovary . . . ovule
    (*d*) egg . . . ovule

22. Plants growing in harsh environments such as deserts, sand dunes, and arctic tundra often reproduce vegetatively. This is because
    (*a*) there are few animals available to pollinate them.
    (*b*) they are members of plant families that only reproduce asexually.
    (*c*) fruits would freeze or dry out in these environments.
    (*d*) vegetative reproduction is not as risky as making seeds.

23. In contrast to animals, plants exhibit ______ and _____.
   (*a*) determinate growth . . . persistent morphogenesis
   (*b*) indeterminate growth . . . are not capable of morphogenesis throughout their lifespan
   (*c*) indeterminate growth . . . persistent morphogenesis
   (*d*) growth . . . morphogenesis

24. Which of the following seedlings will probably bend toward the light?
   (*a*) tip covered with a cap made of black plastic
   (*b*) tip separated from base by a gelatin block
   (*c*) tip separated from base by aluminum foil
   (*d*) tip cut off and place a block of agar over half of the cut portion; the side with the agar block will bend towards the light

25. In shoots, branching is inhibited by _____ from the tip of a growing shoot, but this effect is countered by _____ from the roots.
   (*a*) cytokinins . . . auxins
   (*b*) gibberellins . . . ethylene
   (*c*) auxins . . . cytokinins
   (*d*) gibberellins . . . abscisic acid

26. As leaf lettuce matures, the basal edible leaves suddenly send up a tall flowering shoot. After the plant bolts like this, it no longer produces broad, tasty leaves. Suppose you wanted to prevent bolting so that you could harvest lettuce longer. You might look for some way to interfere with the effects of
   (*a*) abscisic acid. (*b*) gibberellins.
   (*c*) cytokinins. (*d*) ethylene.

27. Seeds of many desert plants will not germinate until a heavy rain washes away their
   (*a*) phytochrome. (*b*) abscisic acid.
   (*c*) gibberellins. (*d*) auxins.

28. The abscission layer
   (*a*) causes a shoot to bend toward light.
   (*b*) secretes cytokinin.
   (*c*) is the location of the biological clock in a plant.
   (*d*) is where a leaf separates from a stem.

29. When a plant structure such as a leaf is injured, it produces ______, which may cause the part to age and drop off.
   (*a*) cytokinins (*b*) ethylene
   (*c*) auxins (*d*) abscisic acid

30. Once a flower is pollinated, changes occur that make it less attractive to insects. Its petals, for example, shrivel and fall off. Pollination must
   (*a*) increase the output of cytokinins in the flower.
   (*b*) block the flow of auxins from the roots.

(*c*) trigger the release of ethylene in the flower.
(*d*) increase the formation of phytochrome, which sets the biological clock.

31. In the autumn, the amount of ____ increases and the amount of ____ decreases in fruit and leaf stalks, causing a plant to drop fruit and leaves.
(*a*) ethylene . . . auxin
(*b*) gibberellin . . . abscisic acid
(*c*) cytokinin . . . abscisic acid
(*d*) auxin . . . ethylene

32. Plant hormones act by affecting the activities of
(*a*) genes.
(*b*) genes and enzymes.
(*c*) enzymes.
(*d*) genes, membranes, and enzymes.

33. _______ appear to be responsible for gravitropism.
(*a*) Statoliths
(*b*) phytochromes
(*c*) Gibberellins
(*d*) Cytokinins

34. A rapid loss of water in specialized cells in the sensitive plant Mimosa pudica causes
(*a*) the plant to bend toward light.
(*b*) stomatal opening so photosynthesis can begin.
(*c*) stress that results in the production of PR proteins.
(*d*) leaves to droop.

35. A biological cycle with a period of about 24 hours is called
(*a*) thigmotropism.
(*b*) a circadian rhythm.
(*c*) photoperiod.
(*d*) abscission.

36. An Rajasthani hunter was worried about being attacked by grizzly tigers, so he left the lights in his cabin on all the time. Plants near the cabin flowered a month early. Which of the following best explains this?
(*a*) They must have been long-night plants.
(*b*) The lights must have emitted far-red light.
(*c*) They must have been long-day plants.
(*d*) They must have been short-day plants.

37. Most plants flower when
(*a*) the soil reaches a certain temperature.
(*b*) the days are of right length.
(*c*) a certain number of days have passed since they last flowered.
(*d*) the nights are of right length.

38. A certain short-day plant flowers when days are less than 12 hours long. Which of the following would cause it to flower?
(*a*) a 9-hour night and 15-hour day with 1 minute of darkness after 7 hour.
(*b*) an 8-hr day and 16-hour night with a flash of white light after 8 hr.
(*c*) a 13-hour night and 11-hour day with 1 minute of darkness after 6 hr.
(*d*) a 12-hour day and 12-hour night with a flash of red light after 6 hr.

39. A chemical change in a substance called phytochrome
(*a*) causes a plant to bend toward light.
(*b*) triggers fruit drop.
(*c*) enables a plant to respond to the presence of light.
(*d*) is responsible for gravitropism.

40. Which of the following tissues produces voluntary body movements?
(*a*) smooth muscle (*b*) simple cuboidal epithelium
(*c*) cardiac muscle (*d*) skeletal muscle

41. Which of the following best illustrates homeostasis?
(*a*) All the cells in the body have much the same chemical composition.
(*b*) Cells of the skin are constantly worn off and replaced.
(*c*) When blood CO_2 increases, you breathe faster and get rid of CO_2.
(*d*) All organs are composed of the same four kinds of tissues.

42. How does a gastrovascular cavity differ from an alimentary canal? The gastrovascular cavity
(*a*) stores food but does not digest it.
(*b*) absorbs food molecules but does not produce hydrolytic enzymes.
(*c*) has only a single opening.
(*d*) functions in digestion but not absorption.

43. In humans, most nutrient molecules are absorbed by the
(*a*) stomach. (*b*) liver.
(*c*) small intestine. (*d*) large intestine.

44. The largest variety of digestive enzymes function in the
(*a*) large intestine. (*b*) oral cavity.
(*c*) stomach. (*d*) small intestine.

45. Which of the following is not an essential nutrient for a human?
(*a*) linoleic acid, a fatty acid (*b*) glucose, a monosaccharide
(*c*) methionine, an amino acid (*d*) ascorbic acid, a vitamin

46. Individuals lacking adequate levels of enterogastrone would have the greatest difficulty digesting
(*a*) fats. (*b*) proteins.
(*c*) carbohydrate (*d*) nucleic acids.

47. It is important to get some vitamin B-1 every day, but it is all right if intake of vitamin A varies a bit. Why?
(*a*) Vitamin B-1 is an essential nutrient, and vitamin A is not.
(*b*) Vitamin A can be stored by the body, but vitamin B-1 cannot.
(*c*) The body needs much larger amounts of vitamin B-1 than vitamin A.
(*d*) The body requires vitamin B-1, but vitamin A is just an "extra."

48. How would you expect the digestive system of a hawk, a carnivore, to compare with that of a sparrow, a seed-eater?
   (*a*) The hawk would have a larger gastrovascular cavity.
   (*b*) The sparrow's digestive system would be longer.
   (*c*) The hawk would have a gizzard, but the sparrow would not.
   (*d*) The hawk digestive system would be longer.

49. Gallstone surgery sometimes requires that the gallbladder be remove. Patients are then advised to avoid ingesting large amount of fat because
   (*a*) the gallbladder makes bile, which is necessary for fat emulsification.
   (*b*) without the bile produced by the gallbladder, fats cannot be enzymatically hydrolyzed.
   (*c*) the gallbladder produces the hormone enterogastrone.
   (*d*) the gallbladder stores large quantities of bile, releasing it when necessary.

50. Researchers provided radioactively labeled food to a dog, and traced the movement of absorbed molecules. Which type of molecule would move along a different path than all the others?
   (*a*) carbohydrates (*b*) proteins
   (*c*) nucleic acids (*d*) fats

51. The cardiac sphincter surrounds the cardiac orifice. If this sphincter failed to properly constrict, there might be a problem with
   (*a*) regurgitation of food into the esophagus.
   (*b*) movement of the bolus into the trachea rather than the esophagus.
   (*c*) rapid emptying from the stomach to the small intestine.
   (*d*) rapid emptying from the small intestine to the large intestine.

52. Which of the following might make the most effective antiulcer medication? A chemical that
   (*a*) stimulates parietal cells of the gastric glands.
   (*b*) kills bacteria in the stomach.
   (*c*) inhibits mucous cells of the gastric glands.
   (*d*) stimulates chief cells of the gastric pits.

53. The lungs consist of many small air sacs and blood vessels, which greatly increase surface area and improve the transfer of substances through their walls. The structures in the digestive system similar in function to these air sacs and capillaries are the
   (*a*) villi. (*b*) colon and rectum.
   (*c*) gastric glands. (*d*) high-density lipoproteins.

54. During some types of antibiotic treatments, patients often experience diarrhoea because
   (*a*) antibiotics are toxic to the colon's epithelium as well as to bacteria.
   (*b*) the bacterial flora of the large intestine digest fiber, which otherwise would create osmotic pressure and result in decreased water reabsorption.

(*c*) antibiotics interfere with the vitamin absorption process normally occurring within the large intestine.
(*d*) after intestinal bacteria have been killed, an unusually large amount of water is reabsorbed.

55. Imagine that you have eaten a meal containing the following nutrients. Which would not have to be digested before being absorbed?
(*a*) protein (*b*) polysaccharide
(*c*) disaccharide (*d*) amino acid

56. Which of the following best describes an artery?
(*a*) carries blood away from the heart
(*b*) carries oxygenated blood
(*c*) contains valves
(*d*) has thin walls

57. In a fish, blood circulates through ____, while in a mammal, it circulates through ____.
(*a*) two circuits . . . four circuits (*b*) one circuit . . . two circuits
(*c*) four circuits . . . two circuits (*d*) one circuit . . . four circuits

58. A recording of the electrical activity of a patient's heart shows that the atria are contracting regularly and normally, but every few beats the ventricles fail to contract. Which of the following is probably functioning improperly?
(*a*) AV node (*b*) semilunar valve
(*c*) coronary artery (*d*) pacemaker

59. Stroke occurs when
(*a*) the pacemaker becomes defective, producing an irregular heartbeat.
(*b*) a blood clot enters and blocks one of the coronary arteries.
(*c*) a blood clot dislodges from a vein and moves into the lung, where it blocks a pulmonary artery.
(*d*) a blood clot enters the cerebral circulation, blocking an artery and causing the death of brain tissue.

60. An advantage of gas exchange in water, compared with gas exchange in air, is that
(*a*) water usually contains a higher concentration of oxygen than air.
(*b*) water is easier to move over the respiratory surface.
(*c*) the respiratory surface does not dry out in water.
(*d*) ventilation requires less energy in water.

61. In the blood, bicarbonate ions
(*a*) help transport oxygen.
(*b*) act as buffers to guard against pH changes.
(*c*) are transported by hemoglobin.
(*d*) attach to numerous carbon dioxide molecules, keeping them from solution.

62. Most oxygen is carried by the blood __. Most carbon dioxide is carried by the blood__.
    (*a*) attached to hemoglobin . . . in the form of bicarbonate ions
    (*b*) dissolved in the plasma . . . dissolved in the plasma
    (*c*) in the form of H+ ions . . . in the form of bicarbonate ions
    (*d*) attached to hemoglobin . . . attached to hemoglobin

63. Which of the following is an endotherm?
    (*a*) mouse (*b*) iguana
    (*c*) frog (*d*) trout

64. As filtrate passes through the long loop of Henle, salt is removed and concentrated in the interstitial fluid of the kidney medulla. (a)Because of this high salt concentration, the nephron is able to
    (*a*) excrete the maximum amount of salt.
    (*b*) neutralize toxins that might accumulate in the kidney.
    (*c*) control the pH of the interstitial fluid.
    (*d*) establish a hypertonic interstitial medullary concentration.

65. Uric acid is the nitrogenous waste excreted by birds, insects, and many reptiles. An advantage of excreting uric acid is that it ____ , but a disadvantage is that it _____ .
    (*a*) saves water . . . costs energy
    (*b*) saves energy . . . is highly toxic
    (*c*) is not very toxic . . . wastes a lot of water
    (*d*) is much more soluble in water than other wastes . . . costs energy

66. On a cold day, blood vessels in the skin
    (*a*) dilate, allowing blood to keep the skin warm.
    (*b*) constrict, forcing blood to flow through vessels in the skin.
    (*c*) constrict, reducing heat loss from blood at the surface.
    (*d*) dilate, causing blood to pass through the cold skin more quickly.

67. The animals in which of these pairs have similar problems regulating water balance?
    (*a*) freshwater fish and saltwater fish
    (*b*) land animal and freshwater fish
    (*c*) osmoconformer and freshwater fish
    (*d*) saltwater fish and land animal

68. Which would have the toughest time surviving over the long term in the environment given?
    (*a*) an osmoconformer in seawater
    (*b*) an endotherm in a warm environment
    (*c*) an ectotherm in a cold environment
    (*d*) an ectotherm in a warm environment

69. Most aquatic animals excrete ammonia, while land animals excrete urea or uric acid. What is the most likely explanation for this difference?
   (*a*) They have different diets.
   (*b*) Land animals can get the energy needed to make urea or uric acid.
   (*c*) Ammonia is very toxic, and it takes lots of water to dilute it.
   (*d*) Land animals cannot afford the energy needed to make ammonia.

70. Which of the following hormones has the broadest range of targets?
   (*a*) ADH (*b*) TSH
   (*c*) epinephrine (*d*) ACTH

71. Every time you eat a cookie or candy bar, your blood sugar increases. This triggers an increase in the hormone
   (*a*) insulin (*b*) epinephrine.
   (c) adrenocorticotropin(ACTH). (*d*) glucagon.

72. Every hormone
   (*a*) is a protein.
   (*b*) is produced in response to stress.
   (*c*) is under the control of the pituitary gland.
   (*d*) enters a cell and interacts with DNA.

73. Since most chemical signals are unable to pass through the plasma membrane, the cellular action they initiate results from
   (*a*) ligand binding.
   (*b*) the activation of a signal transduction pathway.
   (*c*) direct stimulation of the cell's DNA.
   (*d*) the enzymatic behaviour of the signal molecule.

74. Which of the following hormones have antagonistic (opposing) effects?
   (*a*) thyroxin and calcitonin
   (*b*) insulin and glucagon
   (*c*) growth hormone and epinephrine
   (*d*) ACTH and glucocorticoids

75. What is the role of a second messenger in hormone action?
   (*a*) It signals a cell to secrete a hormone.
   (*b*) It informs a gland as to whether its hormones are having an effect.
   (*c*) It relays a hormone's message inside a target cell.
   (*d*) It stops hormone action when it is no longer needed.

76. When the levels of juvenile hormone (JH) are maintained at artificially high levels, insects will
   (*a*) be unable to molt.
   (*b*) bypass some larval stages and pupate prematurely.
   (*c*) molt more frequently.
   (*d*) be unable to advance to a pupal stage.

77. The action of a local regulator is illustrated when
    (*a*) prostaglandins released from the placenta alter the excitability of the muscle of the uterus.
    (*b*) histamine promotes the secretion of hydrochloric acid by stomach cells.
    (*c*) the relaxation of arterial smooth muscle caused by nitric oxide.
    (*d*) all of the above.

78. Some glands produce hormones that stimulate other endocrine glands. Which of the following hormones specifically acts to trigger secretion of hormones by another endocrine gland?
    (*a*) thyroid hormone (T3 and T4)
    (*b*) progesterone
    (*c*) adrenocorticotropin (ACTH)
    (*d*) antidiuretic hormone (ADH)

79. How is the level of thyroxin in the blood regulated?
    (*a*) Thyroxin stimulates the pituitary to secrete thyroid-stimulating hormone (TSH).
    (*b*) TSH inhibits secretion of thyroxin from the thyroid gland.
    (*c*) Thyroxin stimulates the hypothalamus to secrete TRH.
    (*d*) Thyroxin and TSH inhibit secretion of TRH.

80. The endocrine and nervous systems share which of the following in common?
    (*a*) Both utilize feedback.
    (*b*) Several chemicals serve as both hormones and neurotransmitters.
    (*c*) Nerve impulses can cause endocrine glands to release hormone.
    (*d*) all of the above.

81. It takes much longer for sex hormones and other steroids to produce their effects than it takes nonsteroid hormones. Why?
    (*a*) Steroids are bigger, slower molecules.
    (*b*) Steroids usually must be carried longer distances by the blood.
    (*c*) Steroids cause target cells to make new proteins, which takes time.
    (*d*) Steroids must relay their message via a second messenger.

82. Which disorder is correctly matched with its cause?
    (*a*) pituitary dwarfism and hyposecretion of growth hormone
    (*b*) infant cretinism and hypersecretion of thyroxin
    (*c*) low blood calcium and hypersecretion of parathyroid hormone (PTH)
    (*d*) acromegaly and hyposecretion of growth hormone

83. Injections of a hormone are sometimes given to strengthen contractions of the uterus during childbirth. What hormone might this be?
    (*a*) adrenocorticotropin (ACTH)
    (*b*) thyroxin
    (*c*) oxytocin
    (*d*) follicle-stimulating hormone (FSH)

84. Type I diabetes mellitus
   (*a*) an autoimmune disease that develops following immune attack on pancreatic cells.
   (*b*) a commonly seen in overweight individuals older than forty.
   (*c*) is treated by improving insulin receptor efficiency rather than by giving insulin.
   (*d*) is the most common form of the disease; more than 90% of all diabetics have type I.

85. Jet lag occurs when a person moves rapidly from one time zone to another, causing conflict between the body's biological rhythm and the new cycle of light and dark. Some scientists suspect that jet lag may result from disruption of a daily hormone cycle. Which of the following hormones do you think is the most likely suspect?
   (*a*) epinephrine (*b*) insulin
   (*c*) melatonin (*d*) estrogen

86. As a young girl, Sunita suffered a head injury that damaged her pituitary. An injury to the pituitary is particularly serious because of all the functions controlled by this gland As Sunita got older, she and her doctors found that all of the following except _____ were affected.
   (*a*) metabolic rate (*b*) blood sugar level
   (*c*) her menstrual cycle (*d*) milk production

87. A hormone from the parathyroid gland works in opposition to a hormone from the _____ to regulate _____ .
   (*a*) posterior pituitary . . . metabolic rate
   (*b*) thyroid gland . . . blood calcium
   (*c*) pancreas . . . water reabsorption
   (*d*) adrenal medulla . . . blood calcium

88. Diabetes insipidus is an inherited endocrine malfunction (unrelated to diabetes mellitus) in which the kidneys fail to reabsorb normal amounts of water. Victims of this disease produce gallons of urine each day, and their kidneys soon wear out. Treatment of this disease involves replacing a missing hormone. Which of the following do you think it is?
   (*a*) glucagon (*b*) epinephrine
   (*c*) glucocorticoids (*d*) antidiuretic hormone (ADH)

89. Because only the _____________ gland uses iodine to make its hormones, radioactive iodine is often used as a treatment for tumors of this gland.
   (*a*) pituitary (*b*) pancreatic
   (*c*) thyroid (*d*) adrenal

90. Which of the following is a form of sexual reproduction?
   (*a*) budding (*b*) fission
   (*c*) fragmentation (*d*) hermaphroditism

91. A peak in ______ triggers ovulation on about the ______ day of the monthly cycle.
   (*a*) LH . . . seventh
   (*b*) FSH . . . second
   (*c*) LH . . . fourteenth
   (*d*) estrogen . . . twentieth

92. External fertilization occurs mostly in
   (*a*) land animals.
   (*b*) insects.
   (*c*) aquatic animals.
   (*d*) animals that reproduce asexually.

93. On its way to fertilize a human egg, a sperm cell does not have to pass through which of the following?
   (*a*) oviduct (*b*) vagina
   (*c*) ovary (*d*) vas deferens

94. Which of the following hormones is the first to increase significantly every 28 days or so and initiates the ovarian cycle?
   (*a*) progesterone
   (*b*) follicle-stimulating hormone (FSH)
   (*c*) estrogen
   (*d*) lutenizing hormone (LH)

95. After ovulation occurs, the empty follicle
   (*a*) can be recycled to produce more eggs.
   (*b*) changes into the corpus luteum and makes hormones.
   (*c*) quickly degenerates.
   (*d*) immediately initiates menstruation.

96. Oogenesis in comparison to spermatogenesis is somewhat unusual in humans in that
   (*a*) cytokinesis is unequal during the meiotic divisions.
   (*b*) the sequence from primary oocyte to ovum is interrupted by a relatively long resting period.
   (*c*) the first meiotic division is not completed unless reactivated by a hormone.
   (*d*) all of the above

97. Birth control pills contain synthetic estrogen and progesterone. How might these hormones prevent pregnancy?
   (*a*) They trigger premature ovulation, before an egg is mature.
   (*b*) They cause the lining of the uterus to be sloughed off.
   (*c*) They cause the corpus luteum to degenerate.
   (*d*) They keep the pituitary from secreting FSH and LH, so ovulation does not occur.

98. Pregnancy tests detect a hormone hCG in a woman's urine that is present only when an embryo is developing in her uterus. This hormone is secreted by
    (*a*) the ovary.
    (*b*) the embryo.
    (*c*) a follicle.
    (*d*) the endometrium.

99. In many mammals the testes are located outside the abdominal cavity within the scrotum because
    (*a*) the elevated pressure within the abdominal cavity would collapse the small passage ways within the testes.
    (*b*) this location allows for a shorter pathway to the urethra.
    (*c*) blood flow to the scrotum is not interrupted during erection.
    (*d*) sperm are unable to properly mature at the higher temperatures found within the abdominal cavity.

100. Because the genetic composition of the foetus is not identical to that of the mother, it is somewhat surprising that the foetus is not rejected as a foreign body. It appears that this is because
    (*a*) the embryo does not expresses paternal antigens on its cells until after birth.
    (*b*) the embryo produces signal molecules that turn off the mother's immune system for the 9 months of pregnancy.
    (*c*) a protective layer, the trophoblast, surrounds the embryo and prevents direct contact with maternal tissue.
    (*d*) special maternal immune cells produce antigenic modifier proteins (AMPs), which mask the foreign antigens.

Practice Test Paper-II

1. One early, and inexpensive, approach to infertility is to test a woman's urine for a hormone that would indicate a high probability of ovulation. What hormone is this test kit designed to detect?
   (*a*) oxytocin
   (*b*) follicle-stimulating hormone (FSH)
   (*c*) testosterone
   (*d*) lutenizing hormone (LH)
2. A sperm has several components; the function of the acrosome is
   (*a*) produce base to neutralize the acidic environment of the female reproductive system.
   (*b*) metabolize the sugars provided for energy by the semen.
   (*c*) release an enzyme that breaks down the membrane of the ovum.
   (*d*) propel the sperm as they swim through the fluid of the female reproductive tract.
3. The drug RU486 was developed in France and is widely used in Europe as a method of birth control. Its introduction to the United States has been controversial, however, the drug is taken after sexual intercourse. It blocks the implantation of the developing blastocyst. Opponents of the drug say it is an abortion pill. Its defenders point out that it works the same way as
   (*a*) the familiar birth control pill used for the last 30 years.
   (*b*) spermicidal foam.
   (*c*) an intrauterine device (IUD).
   (*d*) tubal ligation.
4. Acetylcholinesterase is the enzyme that degrades acetylcholine. What effect on nerve transmission would occur following the administration of a chemical that inhibited acetylcholinesterase?
   (*a*) no effect
   (*b*) Synaptic transmission would be prevented; muscle paralysis would occur.
   (*c*) It would be identical to giving an anesthetic, but would last permanently.
   (*d*) The pre-synaptic neuron would be inactivated.
5. Anesthetics block pain by blocking the transmission of nerve signals. Which of these three chemicals might work as anesthetics?
   (*a*) a chemical that prevents the opening of sodium channels in membranes;
   (*b*) a chemical that inhibits the enzymes that degrade neurotransmitters;
   (*c*) a chemical that blocks neurotransmitter receptors.
   (*d*) a and c both
6. What is the difference between a neuron and a nerve?
   (*a*) One is sensory in function, the other motor.
   (*b*) Nerves are found only in the central nervous system.

(*c*) They consist of different numbers of cells.
(*d*) Neurons are made of white matter, nerves of gray matter.

7. The first stage of embryonic development is ______. This process produces _______.
(*a*) gastrulation . . . a three-layered embryo
(*b*) gestation . . . a gastrula
(*c*) ovulation . . . a zygote
(*d*) cleavage . . . a hollow ball of cells

8. The function of the amnion in birds, reptiles, and mammals is
(*a*) to digest yolk and form a network of blood vessels to distribute nutrients to the embryo.
(*b*) to collect uric acid.
(*c*) to create an aqueous environment in which development can occur.
(*d*) to transport oxygen to the embryo.

9. Up to the eight-cell stage, the blastomeres of a mouse embryo can each form a complete embryo if isolated. This indicates that
(*a*) differentiation does not depend on cytoplasmic determinants.
(*b*) the mouse embryo is strongly polarized.
(*c*) only the zygote is totipotent.
(*d*) cytoplasmic determinants are equally distributed during the early cleavage divisions.

10. One difference between the blastula and gastrula stages of development is that
(*a*) blastula cells are more differentiated than gastrula cells.
(*b*) there are many more cells in a blastula.
(*c*) the blastula consists of more cell layers.
(*d*) there is an opening from the cavity inside the gastrula to the outside.

11. Among the following which disease is not related to vitamin deficiency:
(*a*) Osteomalacia (*b*) Xerophthalmia
(*c*) Marasmus (*d*) Pellagra

12. A protein deficiency disorder characterized by match stick legs, protruded belly, oedema of certain parts is:
(*a*) Marasmus (*b*) Kwashiorkor
(*c*) Rickets (*d*) Osteomalacia

13. Vitamin which cause Pernicious anaemia, glossitis, loss of peripheral sensation due to its deficiency and also called as Erythrocyte Maturing Factor is-
(*a*) Vit B2 (*b*) Vit B6
(*c*) Cobaltamine (*d*) Folic Acid

14. The type of anemia caused by deficiency of folic acid is-
(*a*) Megablastic (*b*) Macrocytic
(*c*) Pernicious (*d*) Thalassemia

15. Among the following the fat soluble vitamin is
    (*a*) Folic Acid (*b*) Calciferol
    (*c*) Ascorbic Acid (*d*) Biotin

16. Vitamin which is anti-sterility factor, anti-oxidative for membrane lipids, skin and hair reduces atherosclerosis is:
    (*a*) Tocopherol (*b*) Calciferol
    (*d*) Phylloquinone (*d*) Pyridoxine

17. Among the following essential aminoacids is:
    (*a*) Arginine (*b*) Histidine
    (*c*) Tyrosine (*d*) Glutamine

18. Which mineral is required for blood clotting, muscle contraction, ATPase, nerve impulse transmission, heart functioning etc:
    (*a*) Mg (*b*) Ca
    (*c*) K (*d*) Fe

19. Mineral engaged in maintaining enamel and checking dental decay is:
    (*a*) Selenium (*b*) Potassium
    (*c*) Calcium (*d*) Fluorine

20. Among the following, which are not peptide hormone:
    (*a*) ARH, MSH (*b*) Oxytocin, ACTH
    (*c*) Calcitonin, , ADH (*d*) TSH, LTH, FSH

21. Relaxin is secreted by:
    (*a*) Anterior Pituitary (*b*) Posterior pituitary
    (*c*) Corpus Luteum (*d*) Grafian follicle

22. Which among the following is not a function of parathormone for maintaining optimum level of Ca
    (*a*) By mobilization from bone
    (*b*) Reduced urinary excretion
    (*c*) Increased absorption from intestine
    (*d*) By mobilization from muscles

23. Which among the following is gastro-intestinal hormone:
    (*a*) Insulin (*b*) Glucagons
    (*c*) Serotonin (*d*) Secretin

24. Dormitory effect (synchronization of menstrual cycle of women living together) in females is believed to be due to-
    (*a*) Estrogen (*b*) Progesterone
    (*c*) Pheromone (*d*) Oxytocin

25. Female contraceptive pills such as Mala-D generally contains :
    (*a*) Progesterone (*b*) Estrogen
    (*c*) Both a & b (*d*) hCG

26. Complete (Obligate) Parthenogenesis (males completely absent) is present in:
    (*a*) Lacerta saxicola armeniaca (Caucasian rock lizard)
    (*b*) Typhilina brahmina (Small lizard)
    (*c*) Cnemidophorus (Whiptail lizard of America)
    (*d*) All the above

27. The cells which functions as nurse cells for differentiating spermatozoa:
    (*a*) Leydig cells (*b*) Interstitial cells
    (*c*) Sertoli cells (*d*) Copus Epididymus

28. The type of egg/ovum of higher mammals on basis of amount of yolk is-
    (*a*) Alecithal (*b*) Microlecithal
    (*c*) Macrolecithal (*d*) Mesolecithal

29. Glands of male reproductive system are:
    (*a*) Prostrate, seminal vesicle , mammary
    (*b*) Prostrate, Bertholin's, seminal vesicle
    (*c*) Seminal vesicle, Bertholin's gland
    (*d*) Prostrate, seminal vesicle, Cowper's

30. Temperature in Scortum necessary for sperm formation should be:
    (*a*) 2 °C Above body temperature
    (*b*) 2 °C Below body temperature
    (*c*) 4 °C Above body temperature
    (*d*) 4 °C Below body temperature

31. The Process of differentiation of a spermatozoa from a spermatid is known as:
    (*a*) Spermiogenesis (*b*) Spermatogenesis
    (*c*) Spermatocytogeneis (*d*) Spermatoneogenesis

32. During fertilization compatabilty reaction takes place between:
    (*a*) Fertilizin (from ovum)& antifertilizin (Sperm)
    (*b*) Fertilizin (from sperm)& antifertilizin (ovum)
    (*c*) Fertilizin (sperm head)& antifertilizin (Sperm tail)
    (*d*) Fertilizin (sperm tail)& antifertilizin (Sperm head)

33. Zygote formation by sperm and egg is result of phenomenon called-
    (*a*) Fusion (*b*) Endocytosis
    (*c*) Phagocytosis (*d*) En-nucleation

34. Which hormone is called as stress hormone:
    (*a*) Auxin (*b*) Epinephrine
    (*c*) Ethylene (*d*) Nitrous oxide

35. Which disease is not related to thyroid gland:
    (*a*) Grave's disease (*b*) Hashimoto disease
    (*c*) Addison disease (*d*) Cretinism

36. Among the following which is not correctly matched-
   (*a*) cAMP-Protein Kinase A Pathway
   (*b*) IP_3/DAG-Protein Kinase C Pathway
   (*c*) cGMP-Protein Kinase G Pathway
   (*d*) None of these

37. Among the following which pair of hormone is secreted by posterior pituitary
   (*a*) FSH & LH (*b*) ADH & Oxytocin
   (*c*) GH and PRL (*d*) ACTH and TSH

38. Among the following shortest peptide hormone is-
   (*a*) Thyrotropin releasing hormone
   (*b*) Gonadotropin releasing hormone
   (*c*) ACTH
   (*d*) Insulin

39. Among the following, which hormone acts on sertoli cells of seminiferous tubules to increase protein in sperm and other proteins; acts on ovarian follicle to stimulate the maturation of ovum and production of estradiol-
   (*a*) FSH (*b*) LH
   (*c*) hCG (*d*) Progestrone

40. Which hormone stimulates pancreatic acinar cells to release bicarbonate and water in duodenum at pH values below 4.5 to elevate duodenal pH
   (*a*) cholecystokinin (CCK) (*b*) Gastrin
   (*c*) Secretin (*d*) Erythropoeitin

41. Among the following which is not secreted by ovarian corpus luteum-
   (*a*) Relaxin (*b*) estrogen
   (*c*) Human placental lactogen (hPL) (*d*) Progestrone

42. Which hormone stimulates bone resorption; stimulates phosphate excretion by kidney and raises serum calcium level-
   (*a*) Calcitonin (*b*) Serotonin
   (*c*) Parathormone (*d*) Endothelin

43. Epinephrine is synthesized from amino acids-
   (*a*) Phenyl allanine/Tyrosine (*b*) Methionine/cysteine
   (*c*) Leucine/Isoleucine (*d*) Glycine/Proline

44. With anterior pituitary hormones TSH, LH and FSH-
   (*a*) α-subunits are all different
   (*b*) β-subunits are specifically recognized by receptors
   (*c*) β-unit alone can bind to receptor
   (*d*) intracellular receptors recognize these hormones

45. Steroid hormones are synthesized from-
(*a*) Fatty acids (*b*) Sterols
(*c*) Amino acids (*d*) Alcohols

46. The C-21 steroid hormone include-
(*a*) aldosterone (*b*) estradiol
(*c*) testosterone (*d*) Vitamin D_3

47. Among the following which hormone binds to the membrane receptors-
(*a*) Thyroxin (*b*) Estrogen
(*c*) insulin (*d*) testosterone

48. Among the following which protein is not involved in photo transduction cascade during reception of light by rod cells
(*a*) Rhodopsin (*b*) Tranducin
(*c*) Phosphodiestrase (*d*) Adenylate cyclase

49. Among the following which is not an type of excitatory neurotransmitter in nervous tissue-
(*a*) Acetyl choline (*b*) Dopamine
(*c*) Histamine (*d*) g-aminobutyric acid (GABA)

50. Thick filament of muscle is-
(*a*) Actin (*b*) Myosin
(*c*) Tropomyosin (*d*) Troponin

51. Classic hemophelia is due to deficiency of –
(*a*) Factor IV (*b*) Factor VIII
(*c*) Factor IX (*d*) Factor XI

52. The Effect of Vitamin A may include all of the following except-
(*a*) Prevention of anemia (*b*) Serving as antioxidant
(*c*) The visual cycle (*d*) Induction of certain cancers

53. In the propagation of nerve impulse by an electrical signal-
(*a*) the electrical potential across the membrane is maintained by ATP driven Na^+-K^+ pump becomes more negative
(*b*) local depolarization of membrane causes protein conformational changes in ion channels that allow Na^+ and K^+ to move down concentration gradient
(*c*) Charge propagation is bidirectional along axons
(*d*) "Voltage gated" ion channels have finite recovery time so the amplitude of the impulse changes as it moves along the axon.

54. ATP concentration is maintained relatively constant during muscle contraction by-
(*a*) increasing the metabolic activity
(*b*) the action of adenylate cyclase
(*c*) the action of creatine phosphokinase
(*d*) All the above

55. An excessive intake of calories-
(*a*) usually doesn't have adverse metabolic consequences
(*b*) leads to metabolic changes that are usually irreversible
(*c*) frequently leads to elevated serum level of free fatty acid, cholesterol and tri acyl glycerol
(*d*) is only component o obesity

56. A complete replacement of animal protein in diet by vegetable protein
(*a*) would reduce the total amount of food consumed for the same number of calories
(*b*) might reduce total amount of Iron and cobaltmaine available
(*c*) Would be satisfactory regardless of nature of vegetable protein used
(*d*) Could not satisfy protein requirements

57. Among the following, which is NOT a function of tocopherol (Vitamin-E)
(*a*) Antioxidant (*b*) enhance heme synthesis
(*c*) Prevent oxidation of LDL (*d*) carboxilation of prothrombin

58. Ascorbic acid (Vitamin C) may be associated with all of the following EXCEPT-
(*a*) iron absorption
(*b*) bone formation
(*c*) acute renal disease when taken in high dose
(*d*) wound healing

59. Stomata opens when guard cells-
(*a*) sense an increase in CO_2 in the air spaces of leaf
(*b*) flap open because decrease in turgor pressure
(*c*) become more turgid because of an influx of K^+, followed by entry of water
(*d*) close aquaporins, preventing water uptake.

60. The movement of sap from a sugar source to sugar sink
(*a*) occurs through apoplast of sieve tube members
(*b*) may translocate sugars from the breakdown of stored starch in a root tip to developing shoots
(*c*) is similar to flow of xylem sap in depending on tension or negative pressure
(*d*) All of the above

61. The productivity of crop declines when leaves begin to wilt mainly because-
(*a*) the chloroplast of wilting leaves decomposes
(*b*) flaccid mesophyll cells are incapable of photosynthesis
(*c*) stomata close, preventing CO_2 from entering the leaf
(*d*) Photolysis of water cannot occur

62. Micronutrients are needed in very small amount because-
(*a*) most of them are mobile in plants
(*b*) most function as cofactor for enzymes
(*c*) most are supplied in large quantities in seed
(*d*) only the growing region of plant require them

63. Mycorrhyzae enhance plant nutrition mainly by
   (*a*) absorbing water and minerals through fungal hyphae
   (*b*) converting atmospheric nitrogen to ammonia
   (*c*) enabling the roots to parasitize neighboring plants stimulating the development of root hairs
   (*d*) stimulating the development of root hairs

64. Carnivorous plant mainly compensate for soil that has relatively low content of-
   (*a*) K^+ (*b*) Nitrogen
   (*c*) PO_4^- (*d*) Ca^{++}

65. A mineral deficiency is likely to affect older leaves more then younger leaves if
   (*a*) the mineral is micronutrient
   (*b*) mineral is mobile within plant
   (*c*) mineral is required for chlorophyll synthesis
   (*d*) Deficiency persists for longer time

66. The Thompson seedless grape is triploid, with three copies of each chromosome. Which phase of the cell cycle would you expect triploid cells to be unable to complete.
   (*a*) meiosis 1 (*b*) S
   (*c*) meiosis 2 (*d*) G2

67. Some organisms are capable of asexual or sexual reproduction. Under favorable conditions, reproduction proceeds asexually. When conditions become more stressful reproduction switches to a sexual mode. Why?
   (*a*) Sexual reproduction is simple and more rapid allowing larger numbers of offspring to be produced.
   (*b*) Sexual reproduction requires two separate individuals, who can mutually provide nutrient support during stress.
   (*c*) Asexual reproduction requires more energy.
   (*d*) Sexual reproduction produces individuals with new combinations of recombined chromosomes increasing diversity.

68. The stage of meiosis where cells become haploi(d)
   (*a*) prophase I (*b*) prophase II
   (*c*) anaphase I (*d*) anaphase II

69. One of the earliest events that distinguishes meiosis occurs in prophase I and involves:
   (*a*) Condensation of chromosomes
   (*b*) Loss of the nuclear membrane
   (*c*) Movement of chromosomes towards the metaphase plate
   (*d*) Pairing of homologous chromosomes

70. Coral in the ocean grows by budding, where the new organism grows out of the old one by mitosis. This form of replication is an example of:
   (*a*) meiosis to produce a zygote (*b*) asexual reproduction
   (*c*) sexual reproduction (*d*) gamete formation

71. ________ most closely resembles events of mitosis except that the cells are ________.
    (*a*) interphase, diploid (*b*) meiosis II, diploid
    (*c*) interphase, haploid (*d*) meiosis II, haploid

72. Which of the following is not alive, but requires life to be able to reproduce?
    (*a*) Eubacteria (*b*) Fungae
    (*c*) Protozoa (*d*) Viruses

73. In plants IAA causes cell elongation due to-
    (*a*) Increase in pH of Apoplast (*b*) Increase in pH of cytoplasm
    (*c*) Decrease in pH of Apoplast (*d*) Increase in pH of cytoplasm

74. A hormone that controls closure of stomata in response to water stress is-
    (*a*) Abscissic acid (*b*) Gibberellins
    (*c*) Proline (*d*) Ethylene

75. Which of the following plays the important role in the maturation of spermatocyte outside the seminal vesicle of testis-
    (*a*) Leydig Cells (*b*) Sertoli Cells
    (*c*) Sperms (*d*) Spermatocytes

76. Among the following which phytohormone increases the femaleness tendency in plants-
    (*a*) GA (*b*) IBA
    (*c*) Ethylene (*d*) Kinetin

77. Which hormone is related with á-amylase activity in germinating seeds-
    (*a*) GA (*b*) Kinetin
    (*c*) Auxin (*d*) ABA

78. The amino acid which help in osmo regulation during stress condition is-
    (*a*) Proline (*b*) Alanine
    (*c*) β-glycine (*d*) Both a&c

79. The plants are termed as halophytes if they are growing in soil having salt concentration above-
    (*a*) 0.1 % (*b*) 0.2 %
    (*c*) 0.4 % (*d*) 0.5 %

80. CAM mechanism is observed in plants having-
    (*a*) water stress (*b*) Salt stress
    (*c*) No stress (*d*) Oxygen stress

81. Which among the following is not an endocrine gland?
    (*a*) Pineal (*b*) Pituitary
    (*c*) Adrenals (*d*) Gonads

82. The excreta of lizards is rich in
    (*a*) urea (*b*) uric acid
    (*c*) guanidine (*d*) alantoin

83. Which one of the following supports glycogen synthesis
(*a*) High cyclic adenosine monophosphate (cAMP) levels
(*b*) Inactive adenyl cyclase
(*c*) Active phosphorylase-a
(*d*) Epinephrine

84. Which of the following vitamins, if taken in excess is least likely to cause problems in a healthy person?
(*a*) Vitamin A (*b*) Vitamin B
(*c*) Vitamin C (*d*) Vitamin D

85. When a muscle contracts, what is happening to the Ca^{++} levels inside and outside the cell?
(*a*) High amounts of cytosolic Ca^{++} are released to the extracellular space
(*b*) Ion channels open to allow extracellular Ca^{++} to flow into the cell
(*c*) Ca^{++} from the nucleus is released to the cytoplasm and this triggers contraction
(*d*) Ca^{++} ions attach stoma and this causes muscle contraction

86. Na^+-K^+ pump is-
(*a*) Symport system (*b*) Antiport system
(*c*) ABC transporter (*d*) Diffusion pump

87. Consider the following statements. Which is correct?
(*a*) Intracellular concentration of Na^+ is always high
(*b*) Intracellular concentration of K^+ ion is low
(*c*) Extra cellular concentration of K^+ and Na^+ ion is isotonic to intracellular concentration
(*d*) Extra cellular concentration of Na^+ and intracellular concentration of K^+ is always high in normal cell.

88. The nutritional medium was supplied to growing bacteria. If whole nutrient get depleted in 20 cycles, then stage at which the amount of nutrient was half used-
(*a*) At end of 10 cycle (*b*) At beginning of 19 cycle
(*c*) At end of 19 cycle (*d*) At end of 11 cycle

89. Phytohormone responsible for conversion of stored proteins into glucose in germinating cereals is-
(*a*) Cytokinin (*b*) Auxin
(*c*) Gibberellin (*d*) Abscissic Acid

90. Direct oxidation of peroxides in plants is carried our by-
(*a*) Superoxide Dismutase (*b*) Glutathione Synthase
(*c*) Catalase (*d*) Peroxidase

91. A strong peptide bond is present in arginine and aspartic acid. This Bond will be weak if arginine is being replaced by-
(*a*) Glutamic Acid (*b*) Lysine
(*c*) Histidine (*d*) Proline

92. Mainly absorption of glucose by intestine is by-
(*a*) Na-K Pumps (*b*) Diffusion
(*c*) Na-glucose Symporters (*d*) Uniporters

93. Pepsin which digest protein donot digest the cells of intestine because-
(*a*) Intestine cells do not have proteins
(*b*) Half life of pepsin is very low
(*c*) Pepsin acts only in acidic pH
(*d*) Pepsin do not digest intestine proteins

94. During nerve impulse when acetyl choline binds receptors, there is-
(*a*) In flow of Na & K ions
(*b*) In flow of Na and outflow of K ions
(*c*) In flow of K ions and outflow of Na ions
(*d*) In flow of K and H ions

95. Cellulose digester digest cellulose of fermentation. Fore gut fermentors such as rabit and elephant ferment before intestine while hind gut digestor like deer ferment in large intestine. It suggest that-
(*a*) Hind gut fermentor are effective digestor of Cellulose
(*b*) Fore gut fermentor are effective digestor of Cellulose
(*c*) Both hind gut & fore gut fermentor are effective digestor of Cellulose
(*d*) Cellulose digestion do not depend on gut position

96. Addison disease and Cushing syndrome are due to malfunctioning of –
(*a*) Adrenal medulla (*b*) Adrenal cortex
(*c*) Thyroid (*d*) Pituitary

97. Which hormone is present in high amount during pregnancy in urine and used for pregnancy test-
(*a*) hCG (*b*) Progestrone
(*c*) Estrogen (*d*) Relaxin

98. Osmotic potential in plant cell is maintained by-
(*a*) Proline & beta Glycine (*b*) Histidine
(*c*) Lysine (*d*) Glycine

99. Sperms are morphologically fit but are unable to swim due to defect in-
(*a*) Spermatogenesis (*b*) Spermiogenesis
(*c*) Prostrate glands (*d*) Epidydimis

100. Which hormone play important role in water stress
(*a*) Absiccic acid (*b*) Ethylene
(*c*) Gibberlic acid (*d*) Auxin

4

GENETICS

THE FOUNDATION OF GENETICS

- Five thousand years ago or earlier, people were using applied genetics in the form of plant and animal breeding. The foundation for the science of genetics was laid in 1866, when Gregor Mendel used varieties of peas to conduct experiments on inheritance. Mendel's research was ignored until the turn of the twentieth century.

Plant breeders showed that both parents contribute equally to inheritance

- Plants have some desirable characteristics for genetic studies.
- Plants can be grown in large quantities. They produce large numbers of offspring. Many have both male and female reproductive organs in the same plant, which allows self-fertilization. The generation time is relatively short. It is easy to control which individuals mate.
- Josef Gottlieb Kölreuter made a few observations that Mendel later found useful.
- Kölreuter's research focused on the relative contribution of males and females to the genetics of plants. Reciprocal crosses helped prove that both male and female parents contribute equally to the characteristics inherited by offspring. An example is a cross of a male white plant with a female pink plant, and the reciprocal cross of a male pink with a female white plant. The resulting progeny have the same appearance.
- Before the acceptance of Mendel's research, the concept of blending was favored. An example of this form of inheritance would be purple progeny resulting from red and blue parents. As a consequence of blending, the purple color would be forever blended and could not be separated.

Mendel's discoveries were overlooked for decades

- Gregor Mendel was a monk with scientific training in mathematics, physics, and biology. Mendel presented his nine-year-long project orally in 1865 and in writing in

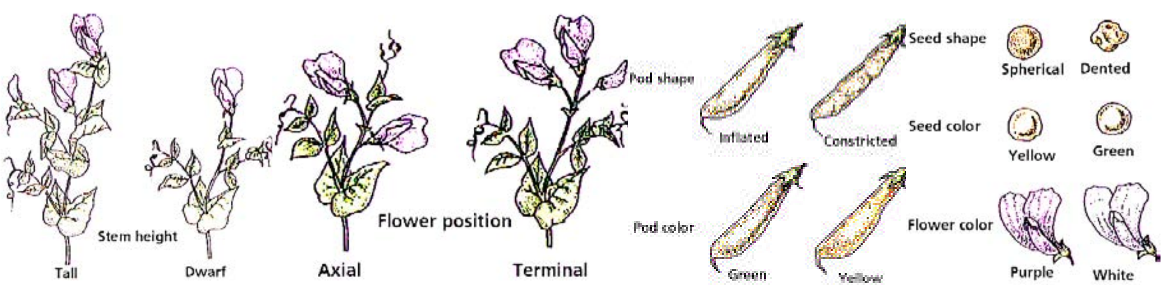
1866. His data challenged the blending concept, but he was ahead of his time. His theory was ignored, perhaps because his biological peers were not accustomed to reviewing mathematical data. Even Darwin, whose evolutionary theory rests on genetic variation among individuals, failed to understand Mendel's point and relied on the blending concept.

- In 1900, Hugo de Vries, Karl Correns, and Erich von Tschermak each independently published papers on the quantitative outcomes from crosses. Each cited Mendel's then rediscovered 1866 paper. By 1900, meiosis had been described and Mendel's ideas were finally accepted.

MENDEL'S EXPERIMENTS AND THE LAWS OF INHERITANCE

Mendel devised a careful research plan

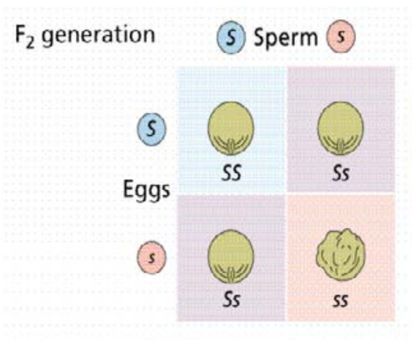
- Mendel chose garden peas as his subjects as they are easily grown and their pollination is easily controlled. He controlled pollination by manually moving pollen between plants. He could also allow the plants to self-pollinate (using emasculation and bagging). Mendel examined varieties of peas for heritable characters and traits for his study. A character is a feature, such as flower color. A trait is a particular form of a character, such as white flowers. "Heritable" means the trait can be passed from parent to progeny.
- Mendel looked for characters that had well-defined alternative traits and that were true breeding. A trait is true breeding when it is the only trait that occurs through many generations of breeding individuals that share that trait. A true-breeding white-flowered plant would have only white-flowered progeny when crossed with others in its strain.

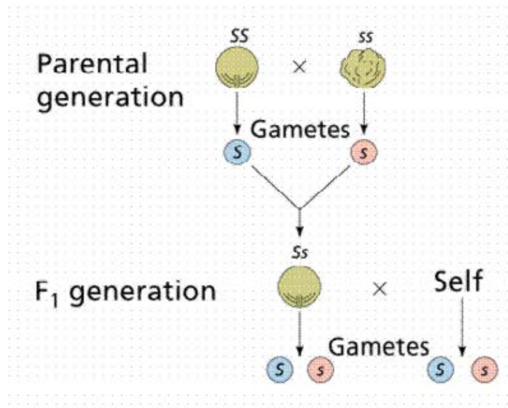


- True-breeding plants, when used for crossing with other plants that have an alternative trait, are called the parental generation, designated P. The progeny from the cross of the P parents are called the first filial generation, designated F_1. When F_1 individuals are crossed to each other or self-fertilized, their progeny are designated F_2.
- Mendel's well-organized plan allowed him to observe and record the traits of each generation in sufficient quantity to explain through analysis the relative proportions of the kinds of progeny. His paper is recognized today as a model of clarity.

Mendel's Experiment 1 examined a monohybrid cross

- Mendel crossed true-breeding plants that differed for a given character. A monohybrid cross involves one (mono) character and different (hybrid) traits. Pollen from true-breeding pea plants with wrinkled seeds (one trait) was placed on stigmas of true-breeding plants with spherical seeds (another trait).



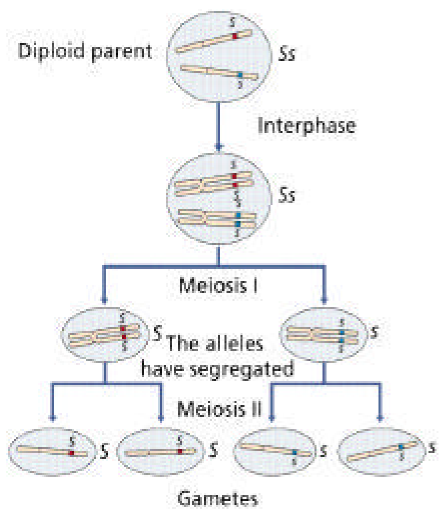


- The F_1 seeds were all spherical; the wrinkled trait failed to appear at all. Because the spherical trait completely masks the wrinkled trait when true-breeding plants are crossed, the spherical trait is called *dominant*, and the wrinkled trait is called *recessive.*
- The F_1 plants were allowed to self-pollinate. This step was the monohybrid cross. *This is also called an F_1 cross. Self-pollination is sometimes called* ***selfing.***
- The progeny, called F_2, were examined: 5,474 were spherical and 1,850 were wrinkled in ratio 3:1
- Mendel proposed that the units responsible for inheritance were discrete particles. They existed within an organism in pairs, separated during gamete formation, and retained their integrity. This is called the **particulate theory**, which is in sharp contrast to the blending theory. Each pea has two units of inheritance for each character. During production of gametes, only one of the pair members for a given character passes to the gamete. When fertilization occurs, the zygote gets one from each parent, restoring the pair.
- Mendel's units of inheritance are now called **genes.** Different forms of a gene are called alleles. Each allele is given a symbol. In the case of wrinkled seeds, *S* might represent smooth and *s* wrinkled. By convention, uppercase *S* represents the dominant; lowercase *s* represents the recessive.
- True-breeding individuals would have two copies of the same allele. Wrinkled would be *ss* (two copies of same allele = *homozygous*). Smooth true-breeding would be *SS* (two copies of same allele = *homozygous*). Some smooth-seeded plants could be *Ss*, although they would *not* be true-breeding. Individuals that are smooth, but had a wrinkled parent, are *heterozygous*: *Ss.*
- When an organism is studied for three different genes and has the alleles *AABbCC*, it is homozygous for *A* and *C* genes but heterozygous for the *B* gene.

- The physical appearance of an organism is its *phenotype*. Wrinkled-seed would be a phenotype. The actual composition of the organism's alleles for a gene is its *genotype*: *Ss* is a genotype.
- *Organisms have many different genes—some have thousands, and complex organisms have 10 times that number. Most of these genes are yet to be described in terms of the DNA sequence or the amino acid sequence of the gene product.*

Mendel's first law says that alleles segregate

- When an individual produces gametes, alleles separate, so each gamete receives one member of the pair of alleles. **This is Mendel's first law, the law of segregation.**



- When fertilization occurs, pairs are reestablished by receiving one copy from each parent.
- The Punnett square is a simple box-like device that helps us to consider all genetic combinations and can provide clarity by showing the expected frequencies of genotypes. The *S* and *s* symbols represent the single allele each gamete receives. Fertilization provides the two alleles for the new individual, one from the male (sperm) and one from the female (egg).
- The Punnett square shows that the genotypes and associated ratios for a monohybrid cross are **1 *SS*: 2 *Ss* :1 *ss*.**
- Any progeny with an *S* would have the dominant (smooth) phenotype, so the phenotypic ratio is 3 smooth to 1 wrinkled.
- Now it is known that a gene is a portion of the chromosomal DNA that resides at a particular site, called a *locus* (plural is *loci*). The gene codes for a particular function. Mendel arrived at the law of segregation with no knowledge of meiosis or chromosomes. The mechanism of chromosome separation in **meiosis I** today explains his law of segregation.

Mendel verified his hypothesis by performing a test cross

- **A test cross** can determine the genotype (*heterozygous* or *homozygous*) of an individual with a dominant trait. It involves crossing the individual to a true-breeding recessive (homozygous recessive).
- If the unknown is heterozygous, approximately half the progeny will have the dominant trait and half the recessive trait (**Ratio 1:1**).
- If the unknown is homozygous dominant, all the progeny will have the dominant trait.
- **Back cross** is cross of F1 with any one of the parent. Generally, back cross with homozygous recessive parents is made in plant breeding application to ensure maximum homozygosity in order to obtain pure line variety.

Deviation from Mendelian Monohybrid cross:

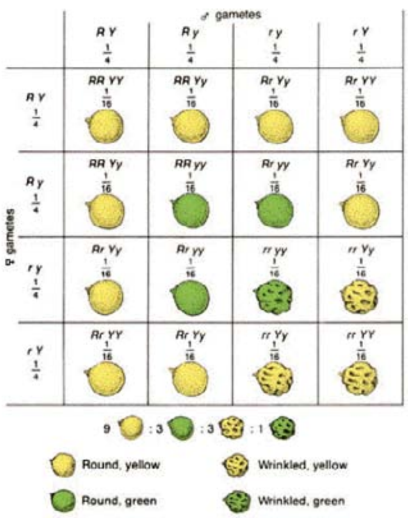
- While Mendel discussed traits, we now know that genes are segments of the DNA that code for specific proteins. These proteins are responsible for the expression of the phenotype. The basic principles of segregation and independent assortment as worked out by Mendel are applicable even for sex-linked traits.
- **Codominant alleles:** Codominant alleles occur when rather than expressing an intermediate phenotype, the heterozygotes express both homozygous phenotypes. An example is in human ABO blood types, the heterozygote AB type manufactures antibodies to both A and B types. Blood Type A people manufacture only anti-B antibodies, while type B people make only anti-A antibodies. Codominant alleles are both expressed. Heterozygotes for codominant alleles fully express both alleles. Blood type AB individuals produce both A and B antigens. Since neither A nor B is dominant over the other and they are both dominant over O they are said to be codominant.
- **Incomplete dominance:** Incomplete dominance is a condition when neither allele is dominant over the other. The condition is recognized by the heterozygotes expressing an intermediate phenotype relative to the parental phenotypes. If a red flowered plant is crossed with a white flowered one, the progeny will all be pink. When pink is crossed with pink, the progeny are 1 red, 2 pink, and 1 white.
- Flower color in snapdragons is an example of this pattern. Cross a true-breeding red strain with a true-breeding white strain and the F1 are all pink (heterozygotes). Self-fertilize the F1 and you get an F2 ratio of 1 red: 2 pink: 1 white. This would not happen if true blending had occurred (blending cannot explain traits such as red or white skipping a generation and pink flowers crossed with pink flowers should produce ONLY pink flowers).

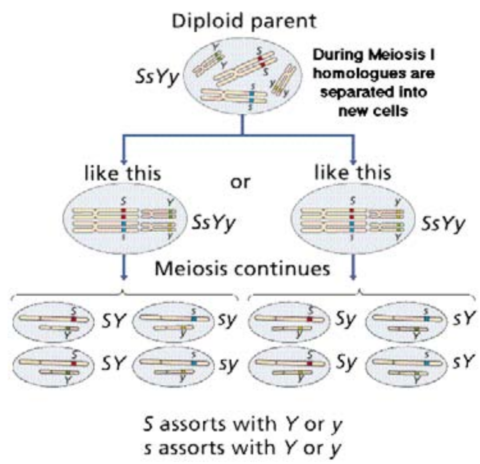
Mendel's second law says that alleles of different genes assort independently

- The second law describes the outcome of **dihybrid** (two character) crosses, or hybrid crosses involving additional characters. A dihybrid is an individual that is a double heterozygote (e.g., with the genotype *SsYy*).
- Mendel's second law states that the *Ss* alleles assort into gametes independently of the *Yy* alleles. The dihybrid, *SsYy*, produces gametes that have one allele of each gene. Four different gametes are possible and will be produced in equal proportions:

SY, *Sy*, *sY*, and *sy*. Random fertilization of gametes yields the outcome visible in the Punnett square. Note its 4 × 4 table construction to accommodate 16 possible phenotypes. Filling in the table and adding the like cells reveals a **9:3:3:1** ratio of the four possible phenotypes (smooth yellow, smooth green, wrinkled yellow, and wrinkled green). **The law of independent assortment** states that alleles of different genes assort independently of one another during gamete formation.

- In fact, this law is not always true. The law of independent assortment is accurate for genes that are on separate chromosomes, but not necessarily for genes that are on the same chromosome (**due to Linkage**).
- *Genes that are close to each other on the same chromosome tend to stay together, but crossing over during meiosis may separate them. The closer together on the same chromosome genes are, the more they tend to stay together.*





Punnett squares or probability calculations: A choice of methods

- **Multiplying probabilities:** If two coins, a penny and a dime, are tossed, each acts independently of the other. The probability of both landing on heads would be 1/2 × 1/2 = 1/4. To find the probability that independent events will *both* happen, the general rule is to multiply the probabilities of the individual events.
- **Monohybrid cross probabilities:** In the example of smooth and wrinkled seeds, heterozygotes produce *S* and *s* gametes. The probability of a gamete being *S* is 1/2. The probability of that an F_2 plant will be *SS* is 1/2 × 1/2 = 1/4.
- **Adding probabilities:** The probability of an event that can occur in two or more ways is the sum of the probabilities for each way in which the event can occur. For example, the genotype *Ss* can result from *s* in the egg and *S* in the sperm, or from *S* in the egg and *s* in the sperm. Thus, the probability of heterozygotes in the F_2 generation of a monohybrid cross is 1/4 + 1/4 = 1/2.
- **The dihybrid cross:** To calculate the probabilities of the outcomes of dihybrid crosses, simply multiply the outcomes from each of the individual monohybrid components. For example, the probability of the *SSYy* genotype can be calculated as follows: An F_1

(dihybrid) cross of *SsYy* generates 1/4 *SS*, 1/2 *Ss*, 1/4*ss*, and 1/4 *YY*, 1/2 *Yy*, 1/4 *yy*. The probability of the *SSYy* genotype is the probability of the *SS* genotype, which is 1/4, times the probability of the *Yy* genotype, which is 1/2. This would be 1/8 (1/4 × 1/2).

Mendel's laws can be observed in human pedigrees

- Patterns for over 2,500 inherited human characteristics have so far been determined. Humans cannot be studied using planned crosses, so human geneticists rely on pedigrees, which show phenotype segregation in several generations of related individuals. Since humans have such small numbers of offspring, human pedigrees do not show clear proportions. The actual number of affected versus unaffected offspring is impossible to predict for a certain couple because outcomes for small samples fail to follow closely the expected outcomes.
- If neither parent has a given phenotype, but it shows up in progeny, the trait is recessive and the parents are heterozygous. The chance of other children getting the trait is 1/4. Half of the children from such a cross will be carriers (heterozygous for the trait). The probability of a carrier (heterozygote) for a rare allele unknowingly marrying another unrelated carrier is quite low.
- **For a dominant allele**, e*very* affected person has an affected parent. About half of the offspring of an affected person are also affected (assuming only one parent is affected). The phenotype occurs equally in both sexes.
- **For a rare recessive trait,** Affected people usually have parents who are both not affected. One-quarter of the children, on average, of unaffected parents would be affected. The phenotype occurs equally in both sexes.
- Marriage between close relatives results in a higher likelihood that both parents will be carriers of a rare allele and produce affected children. The major use of pedigree analysis is in clinical evaluation and counseling of patients with inherited abnormalities.

SOME EXCEPTIONS TO MENDEL'S LAWS

I. Linkage

If two different genes are located relatively close to each other on the same chromosome they can not segregate independently. Term **centimorgan (cM)** is used in **eukaryotic genetics** and **map unit/Morgan** in **microbial genetics**. The numbers of linkage groups are equal to number of haploid sets of chromosomes. But in XX-XY type of organisms, number of linkage groups will be one more in male than in the female as in male X and Y both are different chromosomes.

- *Cis – tans* **arrangement of genes:** If the dominant alleles A, B of two linked genes are present on the same chromosome and their recessive alleles are present on the homologous chromosomes, the arrangement of genes is called **cis-arrangement**. On the other hand, if one dominant gene and other recessive gene are present on the same chromosome (A,b) and their alleles type (a,B) on the homologous chromosome, this type of arrangement is called trans-arrangement.

- Recombination Frequency = $\frac{\text{Number of recombinats}}{\text{Total progeny}} \times 100$
- Several ascomycetes fungi (e.g., Neurospora) produce asci, which hold the haploid ascospores produced after meiosis in a specific linear order, an ordered tetrad. This order reflects the organization and chromatids involved in recombination (crossover) at meiosis.
- Maximum recombination frequency possible is 50 %.
- Crossing over is absent in case of male *Drosophilla* and female *Bombyx mori* (silkworm)

Interference

Crossing over take place at chaismata. These are physical structures involving two chromatids. Not surprisingly the presence of one chaismata in a particular chromosome region can reduce the frequency of others forming close to it. This is termed as interference.

- The extent of interference is calculated as **coefficient of coincidence (S),** which is equal to observed number of double crossover divided by the expected number of double crossover.
- **Coefficient of Interference** is 1 minus coff of coincidence (1 – S). If it comes to be positive values interference is termed as positive while if the value is negative it is termed as negative interference.

II. Dominance

Mendel actually investigated complete dominance, i.e. dominant gene totally masks the recessive.

A. Incomplete dominance

A blending of the effects of two alleles which creates an intermediate form. E.g. RR – red, rr – white, Rr – pink. At first this appears to be blending inheritance – but use a Punnett square to predict the colors obtained from crossing two pinks (Rr).

B. Codominance

Both genes are expressed, e.g. human AB blood types.

III. Multiple alleles

Three or more alleles for same gene, e.g. three alleles for human blood groups A, B, O with O the recessive and A and B codominants. Human blood types exhibit both codominance and multiple alleles. B. There are about 100 alleles for hair color in mammals.

IV. Polygenic Inheritance

Traits are determined by more than one pair of genes. E.g. human eye color and height. Therefore generally get continuous variation in characteristics and a bell shaped curve.

V. Pleiotropy

One allele can affect two or more traits. E.g. sickle cell anemia is caused by a single mutation in the hemoglobin gene. It produces a number of effects.

VI. Environment may affect the expression of genes. Examples

Eg.1. Siamese cats have dark ears, nose and paws because they are colder than rest of the body. The enzyme responsible for the dark color only functions at lower temperatures (recall effect of temperature on enzymes).

Eg.2. Above water versus submerged leaves on some plants are markedly different.

Eg.3. Identical twins have identical genes but exercise, diet and a number of other factors may cause them to have different phenotypes.

VII. Cytoplasmic inheritance

Recall that plastids and mitochondria have their own DNA. Therefore some characteristics may be under the control of genes in the cytoplasm.

Eg.1. In plants cytoplasm ic inheritance from **plastids** produces the variegated leaves of some leaves, e.g. Coleus.

Eg.2. Male sterility in some cultivated plants is due to a **mitochondrial gene**. This is useful for producing artificial hybrids because the stamens do not have to be removed to prevent self-pollination.

VIII. Sex chromosomes

In many organisms, particularly animals, the males and females may have one pair of chromosomes that are different and they determine the sex of the individual. These are called sex chromosomes.

A. Humans have 22 pairs of autosomes and one pair of sex chromosomes. In humans the male, Y chromosome, carries a master gene called SRY (Sex determining Region of the Y chromosome) which causes the development of male hormones and reproductive organs.

ALLELES AND THEIR INTERACTIONS

- Differences in alleles of genes are slight differences in the DNA sequence at the same locus, which result in slightly different protein products. Some alleles are not simply dominant or recessive. There may be many alleles for a single character or a single allele may have multiple phenotypic effects.

New alleles arise by mutation

- Different alleles exist because any gene is subject to *mutation*, or change, to a stable, heritable new form. Alleles can randomly mutate to become a different allele depending on DNA sequence changes. *Wild type* is a term used for the most common allele in the population. Other alleles, often called mutant alleles, may produce a phenotype different from that of the wild-type allele. A genetic locus is called *polymorphic* if the wild-type allele has a frequency less than 99% in a population (that is, if more than 1% of the alleles at that locus are mutant alleles).

Many genes have multiple alleles

- A population might have more than two alleles for a given gene. *The ABO blood types are an example of multiple alleles.* In rabbits, coat color is determined by one gene with four different alleles. Five different colors result from the combinations of these alleles. Even if more than two alleles exist in a population, any given individual can have no more than two of them: one from the mother and one from the father.

Incomplete Dominance-Dominance is usually not complete

- Heterozygotes may show an intermediate phenotype. For example, red-flowered snapdragons (Mirabalis jalapa; 4 O" Clock plant) when crossed with white will generate pink-flowered plants. This phenotype might seem to support the **blending theory** (The blending theory predicts pink F_1 progeny). The F_2 progeny, however, demonstrate Mendelian genetics. When the F_1 pink individuals self-fertilize, the F_2 progeny have a phenotypic ratio of 1 red: 2 pink: 1 white (The blending theory predicts all pink F_2 progeny). This mode of inheritance is called incomplete dominance.
- The phenotypic outcomes for snapdragon flower color and incomplete dominance in general can be explained biochemically. One allele of the gene codes for an enzyme that functions in the production of the red color. The enzyme coded by the other allele is not functional in pigment production. The red-flowered plants have two functional copies of the gene and produce enough enzyme to make red flowers. The pink-flowered plants have one functional allele, just enough to create a pink color. Neither allele in white-flowered plants is capable of making the functional enzyme, so the resulting flowers are white.

In co-dominance, both alleles are expressed

- In codominance, two different alleles for a gene produce two different phenotypes in the heterozygotes. The AB of the human ABO blood group system is an example. The alleles for blood type are I^A, I^B and I^O. They all occupy one locus. These alleles determine which antigens (proteins) are present on the surface of red blood cells.
- These antigens react with proteins called antibodies in the serum of certain individuals. The result is red blood cell agglutination, or clumping, which may be fatal for those individuals.
- Individuals with two I^A, or with I^A and I^O, are type A. Individuals with two I^B, or with I^B and I^O, are type B.
- Individuals with I^A and I^B are type AB.
- Individuals with I^O and I^O are type O.
- Both I^A and I^B are expressed when present, and both produce an antigen.
- This is why they are called codominant.
- *I^O is a recessive trait and is the absence of either the A or B antigen.*

Pleiotropy–Some alleles have multiple phenotypic effects

- Pleiotropy is the effect of a single gene on more than one characteristic (phenotype). An example is the "frizzle-trait" in chickens. The primary result of this gene is the production of defective feathers. Secondary results are both good and bad; good include increased adaptation to warm temperatures, bad include increased metabolic rate, decreased egg-laying, changes in heart, kidney and spleen. Cats that are white with blue eyes are often deaf, white cats with a blue and an yellow-orange eye are deaf on the side with the blue eye. Sickle-cell anemia is a human disease originating in warm low land tropical areas where malaria is common. Sickle-celled individuals suffer from a number of problems, all of which are pleiotropic effects of the sickle-cell allele. Another example is the coloration pattern and crossed eyes of Siamese cats, which are both caused by the same allele. These unrelated characters are caused by the same protein produced by the same allele.

GENE INTERACTIONS

Some genes (Epistatic) alter the effects of other (Hypostatic) genes

- Epistasis occurs when the alleles of one gene cover up or alter the expression of alleles of another gene.
- **Recessive Epistasis (**An example is coat color in mice.) **Ratio 9:3:4.**
- The *B* allele determines a banded pattern, called agouti. The recessive *b* allele results in unbanded hairs. The genotypes *BB* or *Bb* are agouti. The genotype *bb* is solid colored (black). Another locus determines if any coloration occurs. The genotypes *AA* and *Aa* have color and *aa* are albino. The *aa* genotype blocks *all* pigment production. The mice heterozygous for both genes are agouti. The F_2 phenotypic ratio is **9 agouti:3 black:4 white**. The corresponding genotypes are 9 agouti (1 *BBAA* + 2 *BbAA* + 4 *BbAa*):3 black (1 *bbAA* + 2 *bbAa*):4 albino (1 *BBaa* + 2 *Bbaa* + 1 *bbaa*).
- **Complementation (9:7)**: As another example of epistasis, imagine that when a true-breeding white-flowered plant is crossed to a true-breeding purple-flowered plant, the F_1 are all purple. When the purple F_1 plants are self-crossed, 9 purple for every 7 white are observed in the F_2 progeny. This ratio is different from what would be expected if purple were simply dominant to white. The ratio provides a clue to the relationship of two different genes (A and B) necessary to create the purple pigment in this plant. Suppose the gene at locus A has two alleles: A, which is dominant and codes for enzyme A, and a, which is recessive and codes for a nonfunctional enzyme. Suppose also that the gene at locus B has two alleles that follow the same pattern: B is dominant and codes for enzyme B, and b is recessive and codes for a nonfunctional enzyme. The following biochemical pathway for production of purple pigment could explain the ratio in the dihybrid cross:

colorless	*enzyme A*	*colorless*	*enzyme B*	*purple*
precursor	→	*intermediate*	→	*pigment*

- Dominant alleles are necessary at both the A and B loci to produce purple pigment. Both enzyme reactions, A and B, must take place. Such genes are called complementary genes. *A Punnett square for the dihybrid cross, with Xs drawn through the boxes of offspring that cannot produce pigment, shows clearly the* ***9 purple:7 white ratio.***

Some other ratios of Gene Interactions

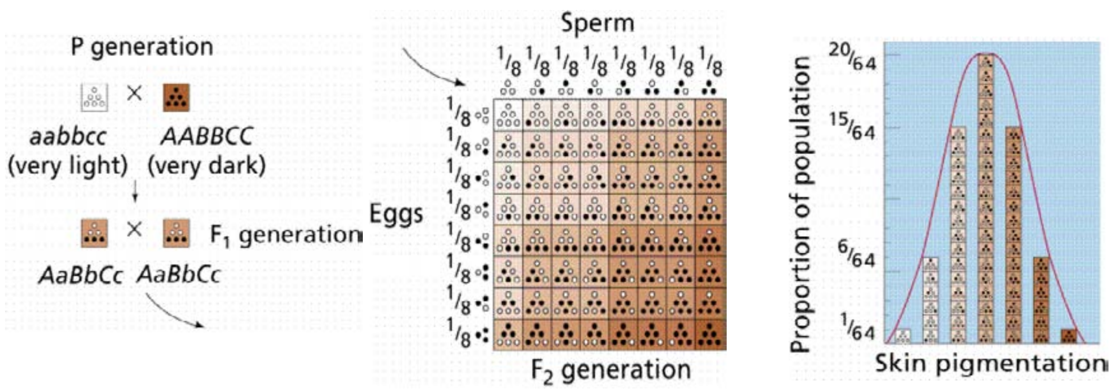
- **Supplementary gene and Recessive epitasis: 9:3:4**
- **Dominant epitasis: 12:3:1**
- **Duplicate Gene: 15:1**
- **Inhibitory gene: 13:3**
- **Collaborator gene: 9:3:3:1**

Hybrid vigor results from new gene combinations and interactions

- For centuries, it has been known that when two homozygous strains of plants or animals are crossed, the offspring are phenotypically stronger, larger, and more vigorous than either parent. In the early twentieth century, G. H. Shull crossed two varieties of corn, and the yield went from 20 to 80 bushels per acre. This is called either **hybrid vigor or heterosis**. Hybridization is now a common agricultural practice to increase production in plants. A hypothesis called **overdominance** proposes that the heterozygous condition in certain important genes is superior to either homozygote.

POLYGENIC INHERITANCE

- Polygenic inheritance is a pattern responsible for many features that seem simple on the surface. Many traits such as height, shape, weight, color, and metabolic rate are governed by the cumulative effects of many genes. Polygenic traits are not expressed as absolute or discrete characters, as was the case with Mendel's pea plant traits. Instead, polygenic traits are recognizable by their expression as a gradation of small differences (a continuous variation). The results form a bell shaped curve, with a mean value and extremes in either direction.



- Height in humans is a polygenic trait, as is color in wheat kernels. Height in humans is not discontinuous. If you line up the entire class a continuum of variation is evident, with an average height and extremes in variation (very short [vertically challenged?] and very tall [vertically enhanced]). Traits showing continuous variation are usually controlled by the additive effects of two or more separate gene pairs. This is an example of polygenic inheritance. The inheritance of each gene follows Mendelian rules.
- Usually polygenic traits are distinguished by
  1. Traits are usually quantified by measurement rather than counting.
  2. Two or more gene pairs contribute to the phenotype.
  3. Phenotypic expression of polygenic traits varies over a wide range.
- Human polygenic traits include: Height, Weight, Eye Color, Intelligence, Skin Color, Many forms of behaviour.

- Individual heritable characters are often found to be controlled by groups of several genes, called polygenes. Each allele intensifies or diminishes the phenotype. Variation is continuous or quantitative (“adding up”). Examples of continuous characters are height, skin color, and possibly intelligence.

THE ENVIRONMENT AFFECTS GENE ACTION

- Genotype and environment interact to determine the phenotype of an organism. Variables such as light, temperature, and nutrition can affect the translation of genotype into phenotype. For example, the darkness of the fur on extremities of a Siamese cat is affected by the temperature of that region. Darkened extremities normally have a lower temperature than the rest of the body. The coloration can be manipulated experimentally. The proportion of individuals in a group with a given genotype that express the corresponding phenotype can sometimes be measured, and the measure is called **penetrance.**
- The **expressivity** of the genotype is the degree to which it is expressed in an individual.
- *An example is hereditary hemochromatosis. This disease causes abnormally high levels of iron to accumulate in the liver and other organs of affected people. Some people with the disease accumulate toxic levels of iron, and others accumulate levels just above normal.*
- The influence of environment on genotype or phenotype can be studied with identical twins, especially when they are separated from birth and reared apart in substantially different environments.

GENES AND CHROMOSOMES

- How do we determine the order and distance between the genes that are located on the same chromosome? A system was first developed in Thomas Hunt Morgan’s fly lab in 1909. The biological model used was the fruit fly, *Drosophila melanogaster*, which is still used today in chromosomal studies.

Linked genes are on the same chromosome

- Mendel’s second law, independent assortment, failed to be universal. One early exception was found in *Drosophila* when crossing flies that were hybrids for two particular alleles (body color and wing size) with flies that were recessive for both alleles (a test cross). The results were not the expected 1:1:1:1, but instead, two of the genotypes occurred at a frequency higher than the other two. These results make sense if the two loci are on the same chromosome, and thus their inheritance is linked. All the loci on a given chromosome make up a linkage group. Absolute or total linkage of all loci is however, extremely rare.
- Drosophila *have just 3 pairs of autosomal chromosomes and one pair of sex chromosomes. The normal fly is diploid and has 8 chromosomes.* The fruit fly has thousands of genes on just 4 pairs of chromosomes. Therefore, many exist together on the same chromosome.

Genes can be exchanged between chromatids

- When two homologous chromosomes physically exchange corresponding segments during prophase I of meiosis, geneticists call it crossing over.
- Recombinations occur at **chiasmata during pachytene of meiosis-I**. If just a few exchanges occur, genes that are closer together tend to stay together. The farther apart on the same chromosome genes are, the more likely they will separate during recombination. The two extremes are independent assortment and complete or absolute linkage.
- The progeny resulting from crossing over appear in repeatable proportions, called **the recombinant frequency.** Greater recombination frequencies are observed for genes that are farther apart on the chromosomes because a chiasma is more likely to cut between genes that are far apart than genes that are closer together.

Geneticists make maps of eukaryotic chromosomes

- Alfred Sturtevant, an undergraduate student working in Morgan's fly room, resolved the puzzling question of the deviation of results from the expected ratios by suggesting that as the distance between two genes on a chromosome increases, so does the likelihood that they will separate and recombine. The closer loci are on a chromosome, the less likely they will separate and recombine in meiosis.
- A map unit is a recombination frequency of 0.01 (or a 1% recombination). It is referred to as a **centimorgan (cM)**.

EUKARYOTIC CHROMOSOMES

- Apart from gametes, most human cells contain two full sets of genetic information, one from the mother and the other from the father. Eukaryotes have more than one chromosome, and the number varies from organism to organism; for example, humans have 46 and horses have 64. Each eukaryotic chromosome consists of a single, double-stranded molecule of DNA; the molecule is extremely long relative to the size of the cell. Many proteins associate with the DNA molecule. After the DNA of a chromosome replicates during S phase, each chromosome consists of two joined chromatids. The two chromatids are joined at a region called the centromere.

Chromatin consists of DNA and proteins

- The complex of the DNA and proteins is called chromatin. The DNA carries the genetic information. The proteins organize the DNA physically and regulate the activities of the DNA. By mass, chromatin consists of about equal parts DNA and protein. Chromatin condenses, becoming highly coiled and compacted during mitosis or meiosis. This makes it possible to get copies of the DNA into separate cells. Without condensation of the chromatin, the strands, which are much longer than the cell, would fail to properly partition into the two sister cells.

Chromatin proteins organize the DNA in chromosomes

- DNA of a human cell has a total length of 2 meters. The nucleus is just 5 mm in diameter. During interphase, the DNA is decondensed or "unwound," although proteins still package it. Interphase chromosomes are wrapped around proteins called histones. These wraps of DNA and histone proteins are called **nucleosomes** (11nm diameter) and resemble beads on a string.

- There are five classes of histones. The core of a nucleosome contains eight histone molecules, two each from four of the histone classes. There are 146 base pairs of DNA wrapped around the core, or 1.65 turns of DNA. One molecule from the remaining histone class, histone H1, clamps the DNA to the core, and helps form the next level of packaging.
- During mitosis and meiosis, the chromatin becomes even more coiled and condensed.

Telomerase, Aging and Cancer

- The ends of chromosomes are called telomeres. When DNA is replicated the telomeres are often not duplicated properly and the chromosome becomes a little shorter after each replication.
- Some scientists believe that the gradual shortening of the chromosomes causes cell aging and eventual death (most cells in the body can duplicate only 50-100 times before they die). Cells which divide often (germ cells, stem cells and cancer cells) have high levels of an enzyme called telomerase which allows the telomeres to be duplicated properly.
- Telomerase may make the cells potentially immortal. Inhibitors of telomerase may someday be useful in cancer therapy.
- Methotrexate, aminopterin and aminopthrin are anticancerous drug which are nucleotide analog and inhibit the activity of enyme involved in salvage pathway of nucleotide biosynthesis.

GENE EXPRESSION

- Two steps are used to express a gene:
- Transcription makes a single-stranded RNA copy of a segment of the DNA.
- Translation uses information encoded in a portion of the RNA to make a polypeptide.
- *In eukaryotes, these two steps are physically separated in time and space.*

RNA differs from DNA

- RNA is single-stranded. The sugar in RNA is ribose, not deoxyribose since 2'OH in ribose was acting as nucleophile and was involved in Auto-catalytic activity to make genetic material stable 2' Oxygen was removed to yield deoxyribose. Wherever thymine is found in DNA, it is replaced by uracil in RNA. During evolution uracil of RNA was changed into Thymine of DNA so as to help repair machinery to recognize deaminated cytosine. RNA can fold over and base-pair with itself.

Information flows in one direction when genes are expressed

- Francis Crick's central dogma stated that DNA codes for RNA, and RNA codes for protein; that is, once information passes into protein, it cannot get out again. Messenger RNA (mRNA) moves from the nucleus of eukaryotic cells into the cytoplasm where it serves as a template for protein synthesis. Transfer RNA (tRNA) is the link between the code of the mRNA and the amino acids of the polypeptide. The tRNA molecules specify the correct amino acid.

RNA viruses modify the central dogma

- RNA viruses are viruses that use RNA as their information molecule during transmission. Examples are the influenza virus and poliovirus. HIV and certain tumor viruses (**Reteroviruses)** have RNA as their infectious information molecule, but convert it to a DNA copy inside the host cell, then use it to make more RNA with the help of reverse transcriptase (**RNA dependent DNA polymerase**) by process known as reverse transcription.

Transcription: DNA-Directed RNA Synthesis

- RNA polymerase is the enzyme that uses DNA as a template to make RNA in direction 5'→3'. Just one of the strands of a gene's DNA is used to make the RNA. This strand is called the *template strand* (3'→5') and is used for transcription. The other untranscribed strand is called the *complementary strand (sense strand/non-coding strand)*. For different genes in the same DNA molecule, however, the roles of these strands may be reversed.
- The continuous double helix of DNA has many regions that are read by RNA polymerase. The DNA double helix partly unwinds to serve as template. As the RNA transcript forms, it peels away, allowing the already transcribed DNA to be rewound into the double helix.

Initiation of transcription requires a promoter and an RNA polymerase

- Transcription of a gene begins at a promoter, which is a certain sequence of DNA. There is at least one promoter for each gene to be transcribed into mRNA. The RNA polymerase binds to the promoter region when conditions allow. The promoter sequence directs the RNA polymerase as to which of the double strands is the template and in what direction the RNA polymerase should move. In effect, the promoters serve as punctuation marks for the transcription process. *RNA is synthesized in the 5'-to-3' direction*, moving along the ***template DNA in the 3'-to-5' direction.***
- In prokaryotes promoters are centered at –10 (TATAAT pribnow box) and –35 (TTGACA). In eukaryotes 80% of genes have a TATA box centered at –25. Further upstream, within 100-200 are boxes or elements—The CAAT box, GC box and eight base pair octamer box. Not all promoters are identical.
- Some bind RNA polymerase more effectively; this causes them to be transcribed more frequently, when other conditions allow. For correct initiation (σ) factor is required which is released after initiation. Prokaryotes have one type of RNA polymerase that transcribes mRNA, tRNA, and rRNA.
- In *E. Coli* the RNA core enzyme has four subunit α_2(160 KD each) β(150 KD) β'(155KD) and σ (70 KD)factor attach for initiation to form holoenzyme. β -subunit is involved in phosphodiester bond formation (**catalytic site**), both β and β' subunits participate in DNA binding and α subunit have several activities including recognition of UP elements in promoter.

- Antibiotic **rifamycin** inhibits prokaryotic RNA polymerase by acting at the catalytic site (β **subunit**). Another antibiotic known as **streptolydigin**, blocks the *RNA chain elongation*.
- Eukaryotes have three different RNA polymerases which can be separated by **ion exchange chromatography**: RNA polymerase I (found in nucleolus, transcribes rRNA), II (mRNA), and III (t-RNA; both II and III present in nucleoplasm).
- RNA polymerase II makes all mRNA in eukaryotes and is highly sensitive to **α-amanitin** obtained from mushrooms of genus ***Amanita***. RNA polymerase I is insensitive while RNA pol III shows sensitivity at high dose.
- rRNA synthesis can be inhibited by **actinomycin D** as it selectively inserts (intercalcates) in between GC-rich region of DNA and since rRNA genes are rich in GC sequences.

RNA polymerase elongates the transcript

- After binding, RNA polymerase unwinds the DNA about 20 base pairs at a time and reads the template in the 3′-to-5′ direction. The RNA transcript is antiparallel to the DNA template strand. Energy for synthesis comes from the removal and breakdown of the pyrophosphate group from each nucleoside added. Transcription errors for RNA polymerases are high relative to DNA polymerases; a mistake occurs for every 10^4 to 10^5 bases incorporated. These are errors in the copies, however, not the original DNA master, so they are less likely to be harmful.
- Transcription factors are required for RNA polymerase to recognize promoters. **TFIID** is the basal transcription factor in eukaryotes which interact directly with TATA box with help of Tata Binding Protein (TBP) and eight or more other TAFs (TBP associated factors).
- The most common motif for proteins interacting promoters in prokaryotes is **Helix turn helix** while in eukaryotes are **leucine Zipper and Zinc finger** (**eg. TFII D, TFIIIA)** proteins. **Homeodomains** proteins coded by Homeotic genes are highly conserved being similar in structures in insect Drosophila and in vertebrates, including humans.

Transcription terminates at particular base sequences

- Particular base sequences in the DNA specify termination (Generally GC rich, forms hair pin loop in mRNA followed by A rich sequence). Gene mechanisms for termination vary. For some genes, the newly formed transcript simply falls away from the DNA template and the RNA polymerase. For other genes, a helper protein (**Rho factor**) pulls the transcript away by its unwinding (**helicase**) activity.
- In prokaryotes, translation of the mRNA often begins before transcription is complete.
- In eukaryotes, the process is more complicated and involves a spatial separation as well as further processing.

THE GENETIC CODE

- DNA codes for RNA by the transcription process. mRNA is read in three-base contiguous segments called *codons.*

- The number of different codons possible is 64, because each position in the codon can be occupied by one of four different bases. Four possibilities for the first base, times four for the second, times four for the third yields 64 possibilities. The 64 possible codons code for only 20 amino acids and the start and stop signals found in all mRNA molecules. AUG, which codes for methionine, is called the *start* codon. The start codon initiates translation. Three of the possible codons are *stop* codons (UAA, UAG, and UGA). Stop codons direct the ribosome to stop reading the mRNA since there is no t-RNA for them; that is, they end translation.

The genetic code is redundant but not ambiguous

- After subtracting start (codes for methionine) and stop codons, the remaining 60 codons code for 19 different amino acids. This means that many amino acids have more than one codon. Thus the code is redundant. But the code is *not* ambiguous. Each codon is assigned only one amino acid, not two or three possible amino acids.
- *The tRNA molecules that have the correct amino acids attached determine the assignment of amino acids to the mRNA codons.* The genetic code is nearly universal, applying to all species on our planet. Minor variations are found within mitochondria and chloroplasts; other exceptions are few and slight. This common genetic code has great implications in genetic engineering.
- In mitochondria of Drosophila, yeast, higher plants UGA is codon for tryptophan rather then stop. In mammalian mitochondria including human, AGG and AGA, they are stop codon instead of arginine.

Biologists broke the genetic code by using artificial messengers

- Decoding breakthroughs started in 1961. Early on, the likelihood of a three-letter codon was postulated. Nirenberg prepared an artificial mRNA in which all bases were uracil. Incubated with required additional components, the poly U mRNA led to synthesis of a polypeptide chain consisting only of phenylalanine amino acids. UUU appeared to be the codon for phenylalanine. Other codons were deciphered from this starting point.
- An additional technique finished the deciphering. Simple synthetic mRNA's, three nucleotides long, could bind to ribosomes. This complex then caused the tRNA-amino acid to bind according to the three-letter codon. Using this technique, the code was fully deciphered.
- *Radioactive labeling was also used to decipher the code.*

Preparation for Translation: Linking RNA's, Amino Acids, and Ribosomes

- Translation occurs at ribosomes, which are molecular protein synthesizing machines that hold mRNA and tRNA in place. In prokaryotes, ribosomes bind to mRNA as it is being synthesized. In eukaryotes, mRNA is made in the nucleus, and translation occurs at the ribosomes in the cytoplasm.
- To assure protein specificity: The tRNA's must read mRNA correctly & it must carry the correct amino acids.

Transfer RNA's carry specific amino acids and bind to specific codons

- Specific tRNA molecules function as adapters. Each carries an amino acid, associates with mRNA molecules, and interacts with ribosomes. A tRNA molecule has 75 to 80 nucleotides. It has a three-dimensional shape maintained by complementary base pairing and hydrogen bonding. At the 3′ end of every tRNA molecule is a site to which its specific amino acid binds covalently. Midpoint in the sequence are three bases called the *anticodon*.

- The anticodon is the contact point between the tRNA and the mRNA. The anticodon is complementary (and antiparallel) to the mRNA codon. The codon and anticodon unite by complementary base pairing.There are fewer anticodon codes than mRNA codons. This is possible because some codon-anticodon interactions tolerate a mismatch at the 3′ base of the mRNA. This is called **wobble**, but does not allow the genetic code to be ambiguous.
- The three-dimensional shape of the tRNA's allows them to combine with the binding sites of the ribosome.

Activating enzymes link the right tRNA's and amino acids

- The correct amino acids are attached to the correct tRNA's by a family of activating enzymes called aminoacyl-tRNA synthetases. Each activating enzyme is specific for one amino acid and its tRNA. The enzyme has a three-part active site that binds a specific amino acid, ATP, and a specific tRNA, which is charged with a high-energy bond. This bond provides the energy for making the peptide band that will join adjacent amino acids.
- The reactions have two steps: Enzyme + ATP + AA → enzyme—AMP—AA + PP_i

  Enzyme—AMP—AA + tRNA → enzyme + AMP + tRNA—AA

The ribosome is the staging area for translation

- Each ribosome has two subunits, a larger one and a smaller one. The large one in eukaryotes has three different associated rRNA molecules and 45 different proteins. The smaller subunit has one rRNA and 33 different protein molecules. When they are not translating, the two subunits are separate. Ribosomes of prokaryotes are somewhat smaller, and their ribosomal proteins and rRNA's are different. The different proteins and rRNA's are held together by ionic bonds and hydrophobic forces, not covalent bonds. The structure can self-assemble if disassembled by detergents.
- Ribosomes are simply molecular factories and are nonspecific. They combine with any mRNA and all tRNA's. The large subunit has four sites where tRNA molecules bind. The **T site** is where the tRNA first lands. It is brought to the site by a special protein, the T, or transfer factor. **The A site** is where the tRNA anticodon binds to the mRNA codon. **The P site** is where the tRNA adds its amino acid to the growing polypeptide chain. The **E (exit) site** is where the tRNA, less its amino acid, goes before leaving the ribosome.

TRANSLATION: RNA-Directed Polypeptide Synthesis

Translation begins with an initiation complex

- At the beginning of translation, m-RNA attaches itself to small subunit of ribosome (by **shine dalgarno sequence** complementary to 16 S rRNA of ribosome in prokaryotes or at 5′ cap in eukaryotes) to form an initiation complex. The initiation complex includes the first tRNA and its amino acid, a small subunit of the ribosome, and an mRNA molecule. This complex is bound to a region upstream (toward the 5′ end) of where the actual reading of the mRNA begins. The start codon (AUG) for methionine (formyl methionine in prokaryotes) designates the first amino acid in all proteins. (However, some proteins are trimmed after synthesis, and the methionine is thereby removed). In eukaryotes initiator codon AUG lies within consensus sequence known as Kozak sequence. The large subunit then joins the complex. The process is directed by proteins called *initiation factors*, which use GTP as an energy source.

The polypeptide elongates from the N terminus

- Ribosomes move in the 5′-to-3′ direction on the mRNA. *They synthesize the peptide in the N terminus-to-C terminus direction*. The large subunit catalyzes two reactions: Breakage of the bond between the tRNA in the P site and its amino acid (on the polypeptide) and Peptide bond formation between this (tRNA-attached) amino acid and the tRNA in the A site. This is called **peptidyl transferase** activity (by 23 S rRNA in prokaryotes). One of the rRNA's in the large subunits appears to participate in the catalysis of this reaction. Here we see rRNA acting as the catalyst, or ***ribozyme.***

Elongation continues and the polypeptide grows

- The first tRNA releases methionine, dissociates from the ribosome, and returns to the cytosol. The second tRNA then moves to the P site. The next charged tRNA enters the open A site. The peptide chain is then transferred to the P site. These steps are assisted by proteins called elongation factors.

A release factor terminates translation

- When a stop codon—UAA, UAG, or UGA—enters the A site, a release factor and a water molecule enter the A site, instead of an amino acid. The newly completed protein then separates from the ribosome.

REGULATION OF GENE EXPRESSION

- **Histone acetylation** occurs both in cytoplasm and nucleus. Cytoplasmic acetylation is carried out by **HAT-B** (Histone acetyl transferase) and prepares histone for incorporation into nucleosomes. The acetyl groups are later removed in nucleus. Nuclear acetylation of is catalyzed by **HAT-A** and correlates with transcription activation. A variety of co-activators have HAT-A activity, which may allow then to loosen the association of nucleosides with a genes control region, thereby ***enhancing transcription***.
- The transcript of approximately 1 in 20 genes are subject to alternate splicing. This can have profound effect on the protein product of gene. For eg., it can make difference between secreted and membrane bound protein.
- **5′ Cap** of m-RNA are made in steps: First a **phosphohydrolase** removes the terminal phosphate; next a **guanyl transferase** adds the capping GMP (from GTP). Next, two methyl transferase methylates N^7 of guanosine and 2′-O-methyl group of the penultimate nucleotide. These events occur early in transcription process, before the chain length reaches 30 nt. The cap provides protection of the mRNA from degradation,

enhancement of the mRNA's stability; transport of mRNA to nucleus and proper splicing of m-RNA.

- **Polyadenylation:** Most eukaryotic mRNA and their precursors have a chan of AMP residues about 250 nt long at their 3′ ends. This poly(A) is added post-transcriptionally by **poly(A) Polymerase.** Poly(A) enhances both life time and translation ability of mRNA; by helping to recruit mRNA to polysomes. An efficient mammalian **polyadenylation signal** consist of **AAUAAA** motif about 20 nt upstream of polyadenylation site in pre-mRNA.
- **Group I introns** such as *Tetrahymena* 23 S rRNA precursor, can be removed without proteins (**Ribozyme**).
- **Group II (GU-AG)** introns of eukaryotes self splice using an A-branched lariat and spliceosome.

Some antibiotics work by inhibiting translation

- Antibiotics are defense molecules. They are produced by some fungi and bacteria. They have been used to combat human bacterial infectious disease. Antibiotics must specifically destroy microbial invaders, but not harm the human host. Some antibiotics work by blocking the synthesis of the bacterial cell walls, others by inhibiting protein synthesis.
- *In prokaryotes,* **streptomycin** *affects initiation,* **kirromycin** *prevents EF-Tu release, and* **erythromycin** *and* **chloramphenicol** *inhibits translocase and peptidyl transferase respectively (This is true for mitochondrial ribosomes too).* **Fusidic acid** *inhibits translocation by blocking EF-G-GDP release.* Because of differences between prokaryotic and eukaryotic ribosomes, the human ribosomes are unaffected.
- **Puromycin** resembles an amino acyl t-RNA and so bind to A site, couple with the peptide in the P site, and cause premature termination of protein synthesis by releasing peptidyl puromycin.
- **Diptheria toxin** *inhibits EF2 the eukaryote translocase (Equals EF-G in bacteria).* **Ricin,** *the toxin of castor bean, is an N-glycosidase that removes a single adenine base from one of the eukaryote ribosomal RNA and inactivates large subunit. One molecule of ricin can destroy a cell containing tens of thousands of ribosomes.*

Polysome formation increases the rate of protein synthesis

- Polysomes are mRNA molecules with more than one ribosome attached (generally around 5). These make protein more rapidly, producing multiple copies of protein simultaneously. They are more common in prokaryotes.

Posttranslational Events

- Some proteins require additional modification after synthesis before they become functional. New chemical groups might be added to the protein, it might be folded (with the assistance of other proteins), or it might get trimmed. Most of such mechanism occurs in golgi complex and to some extent in lumen of ER.

Chemical signals in proteins direct them to their cellular destinations

- As the polypeptide chain forms, it spontaneously folds into its three-dimensional shape. The amino acid sequence also contains an "address label" indicating where in the cell the polypeptide belongs. All protein synthesis begins on free ribosomes in the cytoplasm. In eukaryotes, as the peptide chain is made, information on the nascent portion gives one of two sets of instructions: 1. Finish translation and be released to the cytoplasm and 2. Stall translation, go to the endoplasmic reticulum, and finish synthesis at the ER surface.
- Those destined to finish synthesis in the cytoplasm may contain information in their amino acid sequence that specifies where they belong: the nucleus, mitochondria, or peroxisomes. Some of the proteins that are transported to a destination require chaperonin proteins and docking proteins at the membrane that the protein must cross to its organelle destination.
- Those destined for the ER generate an approximately 25-amino-acid-long hydrophobic leader sequence that signals to a signal recognition particle, which is composed of protein and RNA. The association of the signal to the signal receptor particle stalls any additional translation. This stall continues until the ribosome attaches to a specific receptor protein on the surface of the ER. Translation continues with the protein moving through a pore in the ER membrane. Some proteins have signals that direct the embedding of the protein into the ER membrane. This is when membrane proteins of the ER, Golgi apparatus, lysosomes, and plasma membrane get positioned. Other signals direct the protein to the Golgi apparatus, lysosomes, or to the outside of the cell. Proteins with no signals from the ER go through the Golgi apparatus and are secreted from the cell.

Many proteins are modified after translation

- It is the exception, not the rule, that the finished protein is identical to the translation from the mRNA code. Modifications are often essential to the final functioning of the protein.
- Proteolysis is the cleavage of the protein to make a shortened finished protein. *Insulin is an example of a protein that gets trimmed.* The signal to go to the ER is often cleaved after the protein gets there. The virus HIV needs a protease to cleave a protein. One treatment for HIV inhibits this enzyme.
- Glycosylation involves the addition of sugars to the protein. Signals in the amino acid sequence of the protein direct the addition of the sugars (**N-linked)** in the ER by resident enzymes. Additional modifications occur in both the Golgi apparatus **(O-linked)** and the ER.
- Phosphorylation is the addition of phosphate groups to certain proteins. These additions may be temporary and affect the activity of the protein by changing the three-dimensional shape.

Degradation of proteins

- Selective destruction of proteins involves **ubiquitin**, a small protein found universally in eukaryotes (but not in prokaryotes). By an ATP dependent reaction its –COOH terminal group becomes linked ε-NH_2 of the side chain of lysine residues of its target protein and once attached, that protein is marked for destruction. **Proteasome** present in cytosol degrades the ubiquitin tagged protein. **Chaperons** also appears to play a role in targeting protein in destruction.

- **Lysosomes** may participate in the destruction of longer lived structural protein. They are also responsible for the autolytic destruction of cell during the development. The disappearance of tadpole's tail is example of this.

SEX DETERMINATION AND SEX-LINKED INHERITANCE

- Sometimes parental origin of a chromosome does matter. Reciprocal crosses give identical results when organisms are diploid. *Many organisms have homologous pairs of all chromosomes except for those that determine sex. The homologous pairs are called autosomes; the unpaired X and Y chromosomes are called sex chromosomes.*

Dosage Compensation by X-inactivation in female mammals

How does an organism compensate for the fact that some individuals have a double dosage of sex-linked genes while others have only one? In female mammals, most diploid cells have only one fully functional X chromosome.

- The explanation for this process is known as the Lyon hypothesis, proposed by the British geneticist Mary F. Lyon. In females, each of the embryonic cells inactivates one of the two X chromosomes. The inactive X chromosome contracts into a dense object called a Barr body.

Barr body

Located inside the nuclear envelope, it is a densely staining object that is an inactivated X chromosome in female mammalian cells. Most Barr body genes are not expressed. They are reactivated in gonadal cells that undergo meiosis to form gametes. Female mammals are a mosaic of two types of cells, those with an active maternal X and those with an active paternal X. Which of the two Xs will be inactivated is determined randomly in embryonic cells. After an X is inactivated, all mitotic descendants will have the same inactive X. As a consequence, if a female is heterozygous for a sex-linked trait, about half of her cells will express one allele and the other cells well express the alternate allele. Examples of this type of mosaicism are coloration in calico cats and normal sweat gland development in humans. A woman who is heterozygous for this trait has patches of normal skin and patches of skin lacking sweat glands.

- X chromosome inactivation is associated with **DNA methylation**. **Methyl groups (-CH_3) attach to cytosine**, one of DNA's nitrogenous bases. Barr bodies are highly methylated compared to actively transcribed DNA. What determines which of the two X chromosomes will be methylated? A recently discovered gene, **XIST** is active only on the Barr body. The product of the XIST gene, X-inactive specific transcript, is an RNA; multiple copies of XIST attach to the X chromosome inactivating it.

Sex is determined in different ways in different species

- In corn, every diploid adult has both male and female reproductive structures. The same is true for peas. This type of organism is called **monoecious** ("one house"). Other plants and animals, which have individuals that are one or the other sex, are called **dioecious** ("two houses").

- In most dioecious organisms, sex is determined by differences in the chromosomes. In honeybees, eggs either are fertilized with a sperm and become diploid females, or they are not fertilized and become haploid males, called *drones*.
- Female grasshoppers have two X chromosomes, and males have just one. The sperm determines the sex of the zygote. If a sperm without an X fertilizes an egg, the zygote becomes a male grasshopper.
- Humans have different sex chromosomes, X and Y. Males have X and Y; females have X and X.
- Sex of the offspring is determined by the sperm.
- Females do not have a Y chromosome, so all normal female gametes (eggs) have one X chromosome. Males have one X chromosome and one Y chromosome, so half of the male gametes (sperm) have an X chromosome and the other half have a Y chromosome. If a sperm with an X chromosome reaches the egg, the resulting offspring will be female (XX). If a sperm with a Y chromosome reaches the egg, the resulting offspring will be male (XY).
- In humans, maleness is determined by the presence of the Y chromosome.

The X and Y chromosomes have different functions

- The gene that determines maleness was identified by studying people with chromosomal abnormalities.
- Some XY females were found. Some XX males were found. The XY females had a piece missing from the Y, and the XX males had a piece of a Y on one X. The fragment missing from the Y chromosome in XY females or present on the X chromosome in XX males contained the maleness-determining gene. The gene was named *SRY* (for *s*ex-determining *r*egion on the *Y* chromosome). The *SRY* gene codes for a functional protein involved in primary sex determination. If this protein is present, testes develop; if not, ovaries develop. A gene on the X chromosome called *DAX1* produces an anti-testis factor. The *SRY* gene product in a male inhibits the gene *DAX1*, and no maleness inhibitor is made.
- Secondary sex traits like breast development, body hair, and voice are influenced by hormones such as testosterone and estrogen.
- *Drosophila* chromosomes follow the same pattern as humans, but the mechanism is different. The males are XY, and females XX. **The ratio of X chromosomes to the autosomal sets determines sex**. Two X chromosomes for each diploid set yield females. One X for each diploid set yields males. (XO is sterile; XY is fertile).
- Birds, moths, and butterflies have XX males and XY females. These are called ZZ males and ZW females to help prevent confusion. In these organisms, the egg rather than the sperm determines the sex of the offspring.

Genes on sex chromosomes are inherited in special ways

- The Y carries very few genes (about 20 are known), but the X carries a great variety of characters. Females with XX are diploid for X-linked genes; males with XY are haploid. This partial haploid condition of sex chromosomes for males is called hemizygous. This generates a special type of inheritance called sex-linked inheritance.

Human beings display many sex-linked characters

- The human X chromosome carries thousands of genes. *The probability for a male of having an X-linked genetic disease caused by a mutant recessive allele is much higher than it is for a female. Barring inbreeding, the probability of a woman having a recessive X-linked genetic disease is the square of frequency of the disease-causing allele. (That is the probability that she would inherit the gene from her mother times the probability that she would inherit it from her father.) Because men have only one X chromosome, and they express what they get whether it is dominant or recessive, the probability for a man of having an X-linked recessive genetic disease is simply the frequency of the allele for the disease in the population. The number of lethal or severely detrimental genes on the X is kept low by the hemizygous state of the males.*
- Pedigree analysis of X-linked recessive phenotypes reveal certain patterns: The phenotype appears much more often in males than in females. A male with the mutation can pass it on only to his daughters, through an X-bearing sperm; his sons get his Y chromosome, which does not carry the trait. Daughters who receive one mutant X are heterozygous carriers. They pass the allele to approximately half of their sons and daughters. The mutant phenotype can skip a generation if the mutation is passed from a male to his daughter and then to her son. The most common forms of **muscular dystrophy and hemophilia, as well as red-green color blindness**, are a few X-linked human phenotypes.
- *Contrary to popular opinion, male pattern baldness is not X-linked. This is a* ***sex-influenced trait*** *that is probably subject to hormonal influence. Males require only one gene for baldness to appear; female baldness requires the presence of two genes.*

Cytoplasmic Inheritance: Extra chromosomal Inheritance

- Mendelian genetics is the genetics of the nucleus, yet other cytoplasmic organelles carry genetic material. Mitochondria, chloroplasts, and other plastids possess a small amount of DNA. Humans have about 600,000 genes in the nucleus and 37 genes in mitochondria.
- Plastid genomes are five times larger than those of mitochondria. The genome is the total configuration of genetic material. Mitochondria and plastids are passed on by the mother only, as the egg contains abundant cytoplasm and organelles. The mitochondria in sperm do not take part in gamete union. Some chloroplasts are white, not green, because of a mutation in their DNA. Mitochondrial mutations may also be linked to human genetic diseases.
- Mitochodria is responsible for cytoplasmic Male sterlity in Maize

One Gene, One Polypeptide

- There are many steps between genotype and phenotype; genes cannot by themselves directly produce a phenotype. A gene is defined as a DNA sequence.
- In the 1940s, Beadle and Tatum showed that an altered gene resulted in an altered phenotype that showed up as an altered enzyme.
- They used the bread mold *Neurospora crassa.* This is an organism with a haploid vegetative life cycle, so recessive mutations are easy to detect. *Neurospora* were grown on minimal medium consisting of just sucrose, minerals, and a few vitamins.

Wild-type *Neurospora* were treated with a mutagen, an agent that causes changes in the DNA. After treatment, they were grown in a complete medium. When testing some of the treated strains, some were found that could no longer grow on minimal medium, but instead needed certain supplements. These nutrient-requiring auxotrophs were assumed to have mutated. For each auxotrophic strain, Beadle and Tatum were able to find a single compound that could support its growth. One group of mutants needed arginine to grow. Mapping studies established that some of these *arg* mutations are at different loci, and therefore are in different genes. Beadle and Tatum demonstrated that these different mutants had defective genes for the same biochemical pathway, the pathway leading to arginine synthesis.

- If the gene defect affected earlier enzyme steps in the pathway, several different substances could substitute for arginine. If the defect was for the enzyme step just before arginine synthesis, only arginine could substitute. Beadle and Tatum thus postulated the *one gene, one enzyme hypothesis*.
- Later it was learned that some enzymes are composed of different subunits coded for by separate genes. *The one gene, one enzyme hypothesis was later changed to the one-gene, one-polypeptide hypothesis.* Even this hypothesis requires modification because some genes code for RNA molecules that are never translated into polypeptides.

MUTATIONS: Heritable Changes in Genes

- Mutations are heritable changes in DNA—changes that are passed on to daughter cells. In single-celled organisms, any mutations that occur are passed to the daughter cells at the time of cell division.
- Multicellular organisms have two types of mutations:
- Somatic mutations are passed on during mitosis, but the affected cells never become gametes and so do not pass to subsequent generations and
- Germ-line mutations are mutations that occur in cells that might give rise to gametes.
- Some mutations cause visible phenotypic change. Others cause metabolic changes that might not yet be detectable.
- Some mutations exert their effect only under certain restrictive conditions. These are called **conditional mutants**. They are unaffected under permissive conditions, but express the mutant phenotype at the restrictive condition. Temperature-sensitive mutants are an example.
- All mutations are alterations of the DNA nucleotide sequence and are of two types: Point mutations are mutations of single genes and Chromosomal mutations are changes in the arrangements of chromosomal DNA segments.

Point mutations are changes in single bases

- Point mutations result from the addition or subtraction of a nucleotide base or the substitution of one base for another. Point mutations can occur as a result of mistakes during DNA replication, or by environmental mutagens, such as chemicals and radiation. Because of redundancy in the genetic code, some point mutations result in no change in the amino acids in the protein. **These are called silent mutations.**
- Some mutations cause an amino acid substitution. These are called **missense mutations.** An example in humans is sickle-cell anemia, a defect in the β-globin

subunits of hemoglobin. The red blood cells collapse when oxygen levels are low. Missense mutations might reduce the functioning of a protein or disable it completely.

- **Nonsense mutations** are base substitutions that cause a change from a codon that instructs the incorporation of an amino acid to a codon that terminates translation.
- A **frame-shift mutation** is when a single base is inserted or deleted in a gene. This causes the most disruption when the event occurs at or near the beginning of the template. This type of mutation shifts the code, changing many of the codons to different codons. These shifts almost always lead to the production of nonfunctional proteins.

Chromosomal mutations are extensive changes in the genetic material

- DNA molecules can break and re-form. This can cause four different types of mutations: deletions, duplications, inversions, and translocations. Deletions are a loss of a chromosomal segment. Duplications are a repeat of a segment. Breaking and rejoining leads to inversions if segments get reattached in the opposite orientation. Translocations result when a portion of one chromosome attaches to another. Translocations can be reciprocal or nonreciprocal. Translocations can make synapses in meiosis difficult and can lead to aneuploidy (too many or too few chromosomes).

Human Disorders due to Chromosome Alterations

- **Trisomy 21 (Down Syndrome):** Affects on average one out of 700 children born in USA. individuals are short in stature, suffer varying degrees of mental retardation and are susceptible to a variety of diseases (leukemia, Alzheimer's) Higher incidence of Down's children born to mothers over 35 years old.
- **Trisomy 18 (Edward Syndrome)**
- **Trisomy 13 (Patau Syndrome)**
- **Klinefelter Syndrome (XXY)**: occurs one in every 2000 births. male sex organs, but individuals are sterile and have feminine body characteristics
- **Turner Syndrome (XO):** females are monosomic for X chromosome, normal intelligence but do not fully develop secondary sex characteristics are puberty., short in stature

Structural Alterations

- **"Cri du Chat"** is result of deletion of a region of chromosome 5: Individuals are mentally retarded and have a cry that sounds like a cat.
- Chromosomal Translocations: associated with some diseases e.g.. Translocation of a part of chromosome 22 with a part of chromosome 9 results in chronic myelogenous leukemia (**Philadelphia 22**).

Mutations can be spontaneous or induced

- Spontaneous mutations are permanent changes that occur without outside influence. Spontaneous mutations may be caused by any of several mechanisms. Nucleotides occasionally change their structure (called a **tautomeric shift**). A base may temporarily change to its unusual tautomer at the same time that replication is occurring. The tautomer may pair with the alternate purine if it is a purine, or the alternate pyrimidine if it is a pyrimidine.

  - DNA polymerase sometimes makes errors in replication. These errors are often repaired by the proofreading function of the replication complex, but some errors escape and become permanent.
  - Meiosis is imperfect. Nondisjunction can occur. Random chromosome breaks rejoin incorrectly, leading to translocations.
- Induced mutations are permanent changes caused by some outside agent.
  - Some chemicals alter covalent bonds in nucleotides. Nitrous acid deaminates cytosine, converting it to uracil. DNA polymerase mistakes uracil for thymine and puts an A in during replication instead of the G that would have been incorporated otherwise.
  - Benzoapyrene, a product of incomplete combustion, which is found in all smoke, adds a large chemical group to guanine, making it unavailable for base pairing. Any base might be inserted to fill the gap.
  - Radiation damages DNA. Ionizing radiation (X rays) produces highly reactive compounds and atoms called free radicals. *Gamma rays also produce free radicals.* Free radicals can alter bases or break the sugar–phosphate backbone, causing chromosomal abnormalities. Ultraviolet radiation is absorbed by pyrimidines in the DNA, and when two thymines or two cytosines are next to each other on the same strand of a double-stranded DNA molecule, a covalent bond can form. Their interstrand covalent bonds make the DNA unreplicable.
  - The long-term benefit of mutations is that they provide a genetic diversity for evolution and account for all the differences between and within organisms, excluding the effect of different environments. The detriment of mutation is the outright death or poor fit of an organism to its environment.

Mutations are the raw material of evolution

- Mutations are rare events and most of them are point mutations involving one nucleotide. Frequency of mutations is much lower than one mutation per 10^4 genes per DNA duplication. Sometimes they are as rare as one per 10^9 genes per duplication. Different organisms vary in mutation frequency.
- Mutations can be detrimental, neutral, or occasionally beneficial. Humans have 1,000 times the DNA of a prokaryote. This is at least partially due to duplication of DNA sequences, and then to divergence of the sequences over time. Random accumulation of mutations in the extra copies of genes can lead to the production of new useful proteins.

Mutation and Variation

- Genetic variation refers to differences in genotype among organisms. Genotypes can be classified according to inheritance patterns
  - **nuclear genes**: inherited through both male or female gamete
  - **maternally inherited:** mitochondria in animals and chloroplast in angiosperms.
  - **paternally inherited**: chloroplasts in conifers.
- Environmental variation: differences in the environment due to phenotypic plasticity.

- Maternal effects: characteristics of a mothers offspring due to nongenetic-influences, e.g., via deposition of yolk in eggs. Differences among offspring are a reflection of genotypic/environmental variation in the mother.

Since only genetic variation is heritable, one needs to have means to distinguish between genetic and other sources of variation.

- For *traits influenced by few genes* crosses to produce F1, F2, and backcrosses may yield Mendelian ratios, and thus indicate genetic variation.
- For *polygenic traits*, correlations between (i) parents and offpring, (ii) among siblings, indicate genetic variation. To exclude the possibility of maternal effects, one can, e.g., determine the correlation between fathers and the offspring. To exclude the possibility that the observed correlations are due to a shared environment, one can either (i) randomize the offsprings' environment (e.g., distribute bird's eggs among different foster parents) or (ii) rear the organisms for several generations in the same environment, and observe parent offspring correlations (*common-garden experiments*).

Sources of genetic variation

Here, sources of variation less likely to be discussed in other courses are emphasized.

- **Point mutations** Transitions (C <-> T, A <->G) Transversions (A <-> C, A <-> T, G<-> C, G<-> T)

  In coding regions point mutations can be *synonymous* or *non-synonymous*, be *missense* or *nonsense* mutations. Mutation rates are of the order of 10^{-9} per base pair per generation.

Insertions/Deletions

May lead to frame shift mutations and gene duplications.

- replication slippage: short indels
- unequal crossing over: longer indels

Recombination

homologous recombination in meiosis

- reciprocal recombination
- gene conversion (in fungi)
- non-homologous recombination (unequal crossing over)

Chromosome rearrangements

polyploidization

- duplications/deletions
- inversions -pericentric (including the centromere) & paracentric
- fissions/fusions (are a special case of translocastions involving one minichromosome
- (reciprocal) translocations

All these are important because of *position effects*. Prominent causes of chromosome rearrangements are unequal cross-over and transposable element activity (see below). The rate of any given class of rearrangements is high, 10^{-3} – 10^{-4} per gamete per generation.

TRANSPOSITION

Three main kinds of transposition are non-replicative transposition, replicative transposition, and retroposition. In all three, a duplication (direct repeat) in donor DNA is generated that is a few base pairs long.

Classes of transposable elements

- **Insertion sequences (Selfish DNA)**: (ISs) are the simplest transposable elements and are abundant in bacteria, bacteriophages, plasmids, maize (the mobile elements characterized by B. McClintock). They carry only the transposase function, e.g., IS1 : insA and insB encode for transposase, flanked by inverted repeats.
- **Transposons (Jumping genes):** similar to IS, but they carry additional genes which frequently confer: antibiotic resistance, heavy metal resistance, heat resistance Examples, cat is chloramphenicol resistance, bla is streptomycin resistance). Some transposons, such as Tn 9 are compound transposons consisting of more than one IS sequence (Here, the entire element can transpose or only the IS sequences). Transposons are very widespread, e.g., *Drosophila* contains 50 – 100 kinds. The bacteriophage **Mu** is a transposon that also contains genes for phage packaging.
- The prototype Drosophila transposons are called **copia**, because it is present in copious quantity. Similar transposable elements in yeast are called **Ty** for 'Transposon yeast', other type petite also occur. They are named as **AC-Ds** (Activator-Dissociator) elements in maize.
- The evolutionary relevance of transposons is underscored by the phenomenon of *hybrid dysgenesis* associated with P-elements in *Drosophila*. **P-elements** in D. *melanogaster* are <40 yrs old, and have probably been transferred via horizontal transfer from another species. In hybrid dysgenesis, P elements become activated only in the germline, and only in particular types of crosses. They generate many mutations that cause failure of the germline to develop. In somatic cells, a repressor is produced by alternative splicing that eliminates the mobility of P-elements. P-elements may provide mechanisms for reproductive isolation in fruit flies.

Retroelements

All elements that carry reverse transcriptase, whether transposable or not. They fall into several categories.

- ***Retroviruses***

  Their minimal gene content consists of the *gag* gene encoding the viral capsid, the *pol* gene encoding replication functions including reverse transcriptase, and the *env* gene encoding the envelope.

- ***Retrotransposons***

  They do not have an *env* gene, thus they cannot undergo proper packaging. Examples are copia, gypsy, and Ty1

- ***Retroposons***

  Like retrotransposons, but they lack LTRs. Examples include LINEs (long interspersed nucleotide elements) in mammals.

- ***Retrons***

  They have no LTRs, and encode only the reverse transcription function. They occur in bacteria and in the mitochondrial genome of plants, do not excise, and thus form part of the genome.

- ***(Processed) retrosequences***

  Are genomic DNA sequences that are similar to other, intron-carrying genes, but are characterized by lack of introns, boundaries corresponding to transcribed regions of a gene, stretches of poly-A at 3'-end , short direct repeats at both ends, indicating past transpotsition and no linkage with the original gene. The process of generating processed retrosequences involves reverse transcriptase.

- They are often nonfunctional, because reverse transcriptase has a high error rate, no regulatory signals are transposed & their 5' end is truncatd. Such non-functional retrosequences are called **retropseudogenes.** Examples include SINE (short interspersed nucleotide elements), LINE, and Alu elements (Alu is a retrosequence derived from the 7SL RNA gene which is a part of the signal recognition particle.
- Some of these elements have acquired additional sequences, e.g., LINE elements may have a reverse transcriptase. Functional retrosequences also exist. They are called **retrogenes**. Examples are human phosphoglycerate kinase and muscle-specific calmodulin gene in chicken.

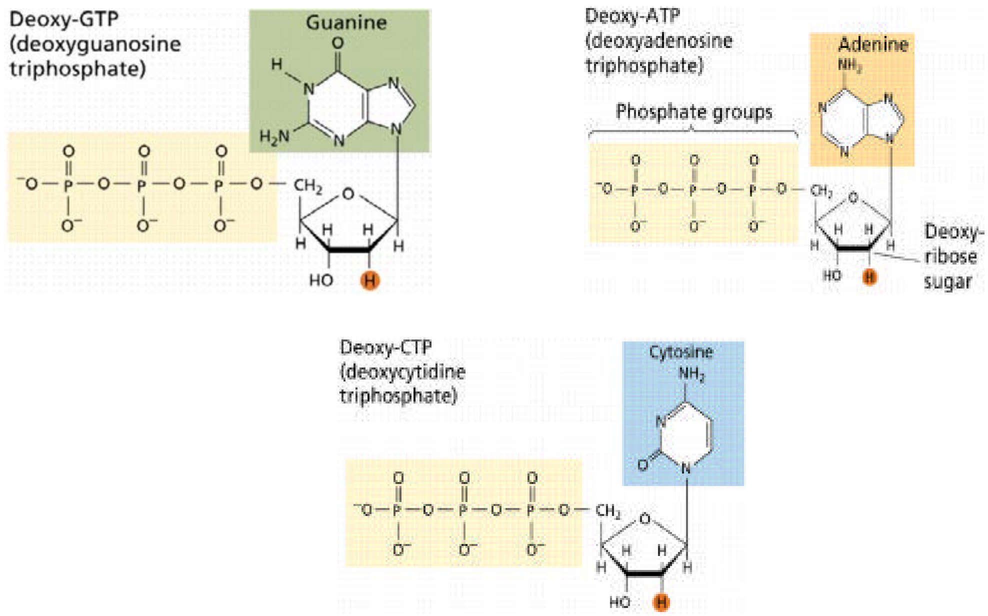
Evolutionary effects of transposable elements

They ccnfer various resistances, cause an increase in host genome size, cause alteration of host gene expression, either by inserting into control regions, or into coding regions. Example: The humen theta1 globin gene has a truncated Alu sequence as part of its promoter. Elevate the mutation rate of host genes, cause chromosome rearrangements: deletions/duplications, inversions, and translocations. These are sometimes mediated by transposition itself (two transposable elements with intervening DNA transposing as a unit) & unequal cross-over between repeated copies of transposable elements, which may duplicate genes in the region. Unequal cross-over may cause changes in the domain structure of genes via unequal cross-over. For example, a mutation of the low-density-lipoprotein gene in humans causing high cholesterol levels is thought to have originated by unequal crossing-over involving Alu sequences.

DNA: The Genetic Material —The physical carrier of inheritance

- **Friedrich Meischer** in 1869 isolated DNA from fish sperm and the pus of open wounds. Since it came from nuclei, Meischer named this new chemical, nuclein. Subsequently the name was changed to nucleic acid and lastly to deoxyribonucleic acid (DNA). Robert Feulgen, in 1914, discovered that fuchsin dye stained DNA. DNA was then found in the nucleus of all eukaryotic cells.
- During the 1920s, biochemist **P.A. Levene** analyzed the components of the DNA molecule. He found it contained four nitrogenous bases: cytosine, thymine, adenine, and guanine; deoxyribose sugar; and a phosphate group. He concluded that the basic unit (nucleotide) was composed of a base attached to a sugar and that the phosphate also attached to the sugar. He (unfortunately) also erroneously concluded that the proportions of bases were equal and that there was a tetranucleotide that was the repeating structure of the molecule. The nucleotide, however, remains as the

fundamental unit (monomer) of the nucleic acid polymer. There are four nucleotides: those with cytosine (C), those with guanine (G), those with adenine (A), and those with thymine (T).



- Molecular structure of three nirogenous bases. In this diagram, there are three phosphates instead of the single phosphate found in the normal nucleotide.

DNA as Genetic Material

- During the early 1900s, the study of genetics began in earnest: the link between Mendel's work and that of cell biologists resulted in the chromosomal theory of inheritance; **Garrod** proposed the link between genes and "inborn errors of metabolism"; and the question was formed: what is a gene? The answer came from the study of a deadly infectious disease: pneumonia.
- During the 1920s **Frederick Griffith** studied the difference between a disease-causing strain of the pneumonia causing bacteria (*Streptococcus peumoniae*) and a strain that did not cause pneumonia. The pneumonia-causing strain (the S strain) was surrounded by a capsule. The other strain (the R strain) did not have a capsule and also did not cause pneumonia. Frederick Griffith (1928) was able to induce a nonpathogenic strain of the bacterium *Streptococcus pneumoniae* to become pathogenic. Griffith referred to a transforming factor that caused the non-pathogenic bacteria to become pathogenic. Griffith injected the different strains of bacteria into mice. The S strain killed the mice; the R strain did not. He further noted that if heat killed S strain was injected into a mouse, it did not cause pneumonia. When he combined heat-killed S with Live R and injected the mixture into a mouse (remember neither alone will kill the mouse)

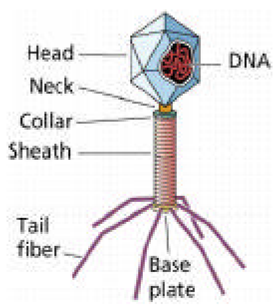
that the mouse developed pneumonia and died. Bacteria recovered from the mouse had a capsule and killed other mice when injected into them.

Hypotheses

1. The dead S strain had been reanimated/resurrected.
2. The Live R had been transformed into Live S by some "transforming factor".

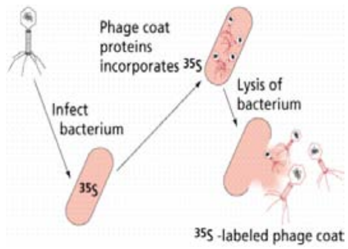
Further experiments led Griffith to conclude that number 2 was correct.

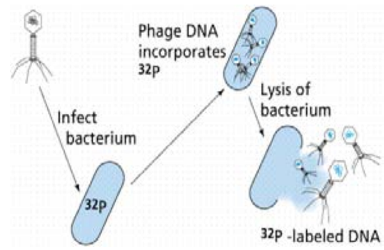
- **In 1944, Oswald Avery, Colin MacLeod, and Maclyn McCarty** revisited Griffith's experiment and concluded the transforming factor was DNA. Their evidence was strong but not totally conclusive. The then-current favorite for the hereditary material was protein; DNA was not considered by many scientists to be a strong candidate.

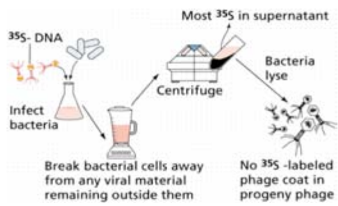


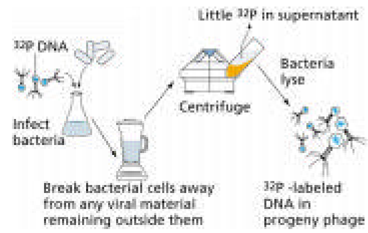
- The breakthrough in the quest to determine the hereditary material came from the work of **Max Delbruck and Salvador Luria** in the 1940s. Bacteriophage are a type of virus that attacks bacteria, the viruses that Delbruck and Luria worked with were those attacking *Escherichia coli*, a bacterium found in human intestines. Bacteriophages consist of protein coats covering DNA. Bacteriophages infect a cell by injecting DNA into the host cell. This viral DNA then "disappears" while taking over the bacterial machinery and beginning to make new virus instead of new bacteria. After 25 minutes the host cell bursts, releasing hundreds of new bacteriophage. Phages have DNA and protein, making them ideal to resolve the nature of the hereditary material.
- In 1952, **Alfred D. Hershey and Martha Chase** conducted a series of experiments to determine whether protein or DNA was the hereditary material. By labeling the DNA and protein with different (and mutually exclusive) radioisotopes, they would be able to determine which chemical (DNA or protein) was getting into the bacteria. Such material must be the hereditary material (Griffith's transforming agent). Since DNA contains Phosphorous (P) but no Sulfur (S), they tagged the DNA with radioactive Phosphorous-32. Conversely, protein lacks P but does have S, thus it could be tagged with radioactive Sulfur-35. Hershey and Chase found that the radioactive S remained outside the cell while the radioactive P was found inside the cell, indicating that DNA was the physical carrier of heredity.

  Diagrams illlustrating the Hershey and Chase experiment that supported DNA as the hereditary material while it also showed protein was not the hereditary material.









GENETIC DISORDERS

Human Allelic Disorders (Recessive)

- The first Mendelian trait in humans was described in 1905 (brachydactly) by Dr. Farabee (no relation to your author). Now more than 3500 human genetic traits are known.
- **Albinism**, the lack of pigmentation in skin, hair, and eyes, is also a Mendelian human trait. Homozygous recessive (aa) individuals make no pigments, and so have face, hair, and eyes that are white to yellow. For heterozygous parents with normal pigmentation (Aa), two different types of gametes may be produced: A or a. From such a cross 1/4 of the children could be albinos. The brown pigment melanin cannot be made by albinos. Several mutations may cause albinism: 1) the lack of one or another enzyme along the melanin-producing pathway; or 2) the inability of the enzyme to enter the pigment cells and convert the amino acid tyrosine into melanin.
- **Phenylketonuria (PKU)** is recessively inherited disorder whose sufferers lack the ability to synthesize an enzyme to convert the amino acid phenylalanine into tyrosine. Individuals homozygous recessive for this allele have a buildup of phenylalanine and abnormal breakdown products in the urine and blood. The breakdown products can be harmful to developing nervous systems and lead to mental retardation. 1 in 15,000 infants suffers from this problem. PKU homozygotes are now routinely tested for in most states. If you look closely at a product containing Nutra-sweet artificial sweetener, you will see a warning to PKU sufferers since phenylalanine is one of the amino acids in the sweetener. PKU sufferers are placed on a diet low in phenylalanine, enough for metabolic needs but not enough to cause the buildup of harmful intermediates.
- **Tay-Sachs Disease** is an autosomal recessive resulting in degeneration of the nervous system. Symptoms manifest after birth. Children homozygous recessive for this allele rarely survive past five years of age. Sufferers lack the ability to make the enzyme N-acetyl-hexosaminidase, which breaks down the GM2 ganglioside lipid. This lipid accumulates in lysosomes in brain cells, eventually killing the brain cells. Although

rare in the general population (1 in 300,000 births), it was (until recently) higher (1 in 3600 births) among Jews of eastern central European descent. One in 28 American Jews is thought to be a carrier, since 90% of the American Jewish population emigrated from those areas in Europe. Most Tay-Sachs babies born in the US are born to non-Jewish parents, who did not undergo testing programs that most US Jewish prospective parents had.

- **Sickle-cell anemia** is an autosomal recessive we have discussed in other sections. Nine-percent of US blacks are heterozygous, while 0.2% are homozygous recessive. The recessive allele causes a single amino acid substitution in the beta chains of hemoglobin. When oxygen concentration is low, sickling of cells occurs. Heterozygotes make enough "good beta-chain hemoglobin" that they do not suffer as long as oxygen concentrations remain high, such as at sea-level.
- **Cystic fibrosis** is common in whites of European descent (1 in 2500 affected), one out of 25 whites is a carrier (4%), gene codes for chloride channel (defective gene due to addition or delertion of extra TTT sequence results in mucous buildup in lungs)
- Patients with **Alcaptonuria** excreted copious amount of homogenitisic acid, which has startling effect of coloring their urine black.

Human Allelic Disorders (Dominant)

- Autosomal dominants are rare, although they are (by definition) more commonly expressed.
- **Achondroplastic dwarfism** occurs, even though sufferers have reduced fertility.
- **Huntington's disease** (also referred to as Woody Guthrie's disease, after the folk singer who died in the 1960s) is an autosomal dominant resulting in progressive destruction of brain cells. If a parent has the disease, 50% of the children will have it (unless that parent was homozygous dominant, in which case all children would have the disease). The disease usually does not manifest until after age 30, although some instances of early onset phenomenon are reported among individuals in their twenties. -Incurable; brain deterioration leads to death. Gene is present on **chromosome no 4** and there is **addition of extra CAG sequences (normally 25 repeats are present)** at end of **huntigtin** gene.
- **Neurofibromatosis:** It is one of the most common autosomal dominant genetic diseases in human. It is of two types namely NF1 and NF2. Individuals with this disease develop small-pigmented skin lesions called ***café-au-lait*** spots and small soft fleshy growth called **neurofibromata, which** are benign tumors. These appear during adolescence and tend to increase with the age. The defective gene is NF1 located on chromosome 17 abd codes a protein **neurofibromin** which acts as a tumor suppressor protein while NF2 gene is located on chromosome 22 and encodes a protein called **merlin** which like NF1 gene product act as tumor suppressor gene.
- **Polydactly** is the presence of a sixth digit. In modern times the extra finger has been cut off at birth and individuals do not know they carry this trait. One of the wives of Henry VIII had an extra finger. In certain southern families the trait is also more common. The extra digit is rarely functional and definitely causes problems buying gloves, let alone fitting them on during a murder trial.

Sex-linked Traits

- **Color blindness** afflicts 8% of males and 0.04 % of human females. Color perception depends on three genes, each producing chemicals sensitive to different parts of the visible light spectrum. Red and green detecting genes are on the X-chromosome, while the blue detection is on an autosome.

- **Hemophilia** is a group of diseases in which blood does not clot normally. Factors in blood are involved in clotting. Hemophiliacs lacking the normal Factor VIII are said to have Hemophilia A, the most common form. Normal Factor VIII can be supplied at a high dollar and health risk cost, although the development of biotechnologically engineered Factor VIII produced by bacteria lessens the health risk. England's Queen Victoria was a carrier for this disease. The allele was passed to two of her daughters and one son. Since royal families in Europe commonly intermarried, the allele spread, and may have contributed to the downfall of the Russian monarchy (Czar Nicholas' son Alexei suffered from hemophilia A inherited from his mother who carried Victoria's genetic secret).
- **Muscular dystrophy** is a term encompassing a variety of muscle wasting diseases. The most common type, **Duchenne Muscular Dystrophy (DMD)**, affects cardiac and skeletal muscle, as well as some mental functions. DMD is an X-linked recessive occurring in 1 in 3500 newborns. Most sufferers die before their 20th birthday. In 1987, Louis Kunkel claimed to have isolated a protein, dystrophin, present in normal individuals (about 0.002 % of their muscle protein) but absent in two individuals with DMD. The lack of dystrophin is accompanied with a condition of muscle hardening known as fibrosis, which restricts blood supply to the muscle which then die.
- **Other diseases X-Linked disease** include **Lesch-Nyann syndrome** (Mutated HGPTR gene) and **Fragile X syndrome** (Due to fragile site on X chromosome at site Xq27)

Sex limited traits: The genes of these traits are autosomal and found in both sexes but express in one sex only e.g., milk glands in female, beard in man, deep male voice, antlers in male deers, brilliant plumage in peacock, female or male musculature etc. The expression of these genes is affected by sex hormones.

Sex influenced traits: In contrast to sex limited genes where the expression of a trait is limited to one sex only, sex influenced genes are those autosomal genes which are influenced by the sex of a bearer e.g., pattern of baldness, short index finger in male. These traits appear more frequently in one sex than in the other. The baldness is affected by male hormone (testosterone).

- Some diseases are **multifactorial** which means they are due to both genetic and environmental components. **Examples:** heart disease, diabetes, cancer.

III. Technology for Genetic Testing

1. If two parents are carriers (heterozygous) for a disease then there is a 1/4 chance that their child will be affected (homozygous recessive).
    - Carriers can be identified by molecular genetic tests.
    - Fetal testing can be performed by **amniocentesis** (14 to 16 weeks gestation) or **chorionic villus sampling** (10 weeks gestation).
        - karyotyping, biochemical, or molecular tests can be performed.
    - Newborn screening: Phenylketonuria (PKU) test is routinely performed on newborns (affects 1 out of 10,000 births). Affected individuals cannot breakdown phenylalanine and buildup toxic levels of its byproduct phenylpyruvate.

PRACTICE TEST PAPER-I

1. Which of the following chromosomal alterations would you expect to have the most drastic consequences?
   (*a*) inversion
   (*b*) duplication
   (*c*) translocation
   (*d*) deletion

2. The most common lethal genetic disease in the United States is
   (*a*) sickle-cell an emia
   (*b*) cystic fibrosis
   (*c*) Huntington's disease
   (*d*) hemophilia.

3. There are various procedures that can be used to detect genetic disorders before birth. Among the tests discussed in this chapter, ____ is the least invasive, while ____ carries the highest risk.
   (*a*) chorionic villi sampling . . . amniocentesis
   (*b*) ultrasound imaging . . . fetoscopy
   (*c*) fetoscopy . . . chorionic villi sampling
   (*d*) fetoscopy . . . amniocentesis

4. Tay-Sachs disease runs in Seema's family. On a family pedigree, she saw a half-darkened circle. This represented
   (*a*) a male with Tay-Sachs
   (*b*) a female with Tay-Sachs
   (*c*) a carrier male
   (*d*) a carrier female.

5. On a pedigree tracing the inheritance of PKU, a horizontal line joins a black square and a half-black circle. What fraction of this couple's children would you expect to suffer from PKU?
   (*a*) none
   (*b*) 1/4
   (*c*) 1/2
   (*d*) 3/4

6. Ram and Nidhi are apparently normal, but their daughter was born with alkaptonuria, an inherited metabolic disorder. If alkaptonuria is like most human hereditary disorders, the probability of their next child being born with alkaptonuria is
   (*a*) 0
   (*b*) 1/4
   (*c*) 1/2
   (*d*) 2/3

7. Several inherited disorders are much more common in close-knit religious communities, such as the Amish(Jews), than in the general population. This is at least partly due to the fact that
   (*a*) people in such communities are more likely to marry relatives
   (*b*) shared environmental conditions such as diet can increase mutation rate
   (*c*) modern medical care is not widely available in such communities
   (*d*) community members care for each other and disorders are possed on.

8. A heritable feature is a ______ and may have two or more variants called______ .
   (*a*) trait/characteristics
   (*b*) character/traits
   (*c*) character/factors
   (*d*) trait/factors

9. In a cross between two heterozygotes (Aa), the F_2 generation will be
   (*a*) in the ratio 1:3 heterozygous to homozygous
   (*b*) all heterozygous
   (*c*) in the ratio 1:1 homozygous to heterozygous
   (*d*) in the ratio 1:3 homozygous to heterozygous

10. You set up an experiment in which you breed two populations of true-breeding pea plants. The first true-breeding population has yellow round seeds and the second has green wrinkled seeds. All of the F_1 plants yield yellow round seeds. When you self fertilize the F_1 the F_2 generation yields a mixture of yellow round, yellow wrinkled, green round and green wrinkled seeds. What does this tell you about the alleles for seed color and shape?
    (*a*) the recessive alleles are always expressed
    (*b*) the alleles are on different chromosomes
    (*c*) the two alleles for each character segregate during gamete production
    (*d*) both genes are on the same chromosome

11. You cross a true-breeding red-flowered snapdragon with a true-breeding white-flowered one. All of the F_1 are pink. What does this say about the parent traits?
    (*a*) red and white are codominant
    (*b*) red is dominant
    (*c*) both red and white are recessive
    (*d*) red and white show incomplete dominance

12. While on a field trip in the jungle you find a new species of mouse. You catch a pair and take them back to the lab. In mice, black coat color, B, is dominant to brown b, yet the female mouse gives rise to a large litter in which 9 of the offspring were black, 3 were brown and 4 were white. You conclude that
    (*a*) a new mutation has occurred in the mice
    (*b*) this is an example of polygenic inheritance
    (*c*) there must be an epistatic interaction influencing coat color
    (*d*) the coat color alleles are codominant

13. A new breed of domestic cat, the Indian Curl Cat, has unusual curled-back ears. When the owners of Shulamith, the foundation cat from which the breed arose, crossed her with a normal straight-eared domestic cat in each of her litters roughly half of the kittens had curled ears. When both parents are curl cats, all the kittens have curled ears. What does this tell you about the curled-ear trait?
    (*a*) curled ears and straight ears are codominant traits
    (*b*) curled ears and straight ears are show incomplete dominance
    (*c*) curled ears are dominant
    (*d*) curled ears are recessive

14. John and Jesica are planning a family, but since each has a brother who has sickle cell anemia, they are concerned that their children may develop sickle-cell disease. Neither John, Jane nor their respective parents have the disease. They consult a genetic counselor who tells them
    (*a*) there is very little chance that any of their children will have sickle-cell disease
    (*b*) that all of their children will have sickle-cell disease
    (*c*) that one out of four of their children could be expected to have sickle cell-disease
    (*d*) that its possible that none of their children will have the disease but blood tests on them both will be required to make sure

15. Why is sickle cell disease so called?
    (*a*) because it makes people sick
    (*b*) its named after a special type of white blood cell
    (*c*) pH changes in the blood cells make them collapse into a sickle shape
    (*d*) because its caused by an infectious microorganism that has sickle shaped cells

16. In people with sickle cell disease the red blood cells breakdown, clump, and clog the blood vessels. The broken cells accumulate in the spleen. Among other things this leads to physical weakness, heart failure, pain, brain damage and spleen damage. Affected individuals become paralyzed and can develop rheumatism, pneumonia and other diseases and kidney failure. This is an example of
    (*a*) the polygenic nature of sickle cell disease
    (*b*) the pleiotropic effects of the sickle cell allele
    (*c*) an epistatic interaction between the sickle cell allele and a proteolytic enzyme gene
    (*d*) infectious organisms acting on the sickle cell allele

17. Heart disease, diabetes, cancer, alcoholism and many mental illnesses can best be described as:
    (*a*) symptoms of a bad life-style
    (*b*) infectious diseases caused by microorganisms
    (*c*) multifactorial disorders with a possible polygenic component
    (*d*) all symptoms of Huntingdon's disease

18. The genetic disease cystic fibrosis is caused by a defective allele that
    (*a*) produces a dysfunctional enzyme that fails to break down brain lipids.
    (*b*) causes hemoglobin molecules to collapse.
    (*c*) produces a defective chlorine-channel membrane transport protein.
    (*d*) produces a neurotoxin

19. Huntington's disease is an example of a genetic disorder caused by
    (*a*) a late-acting lethal dominant allele
    (*b*) a non-lethal dominant allele
    (*c*) a late acting recessive allele
    (*d*) homozygous recessive alleles

20. Which of the following is a form of sexual reproduction?
    (*a*) budding (*b*) fission
    (*c*) hermaphroditism (*d*) regeneration

21. The most common phenotype in a natural population is referred to as the
    (*a*) genotype (*b*) wild type
    (*c*) autosome (*d*) mutant phenotype

22. Human males are much more likely to be have hemophilia (a failure of blood to clot properly) than human females. This is the case because
    (*a*) hemophilia is a contagious disease to which males are more susceptible
    (*b*) the gene for hemophilia is carried on the Y chromosome
    (*c*) hemophilia is carried on the autosomes
    (*d*) the gene for hemophilia is sex-linked

23. In a particular species of mammal black hair (B) is dominant to green hair (b) and red eyes (R) are dominant to white eyes (r). If a BbRr individual is mated with a bbrr individual the expected phenotypic ratio of the offspring is 1 black-red : 1 black-white: 1 green-red : 1 green-white. However, when you mate these individuals you find that the phenotypic ratio of the offspring is 6 black-red : 1 black-white : 1 green-red : 6 green-white. What could account for this difference?
    (*a*) The genes for hair color and the genes for eye color are carried on different chromosomes
    (*b*) The expected results did not take genetic recombination into account
    (*c*) The genes for hair color and eye color are linked
    (*d*) The genes for hair color and eye color show dependent assortment

24. In the problem no. 23 the observed F_2 generation distribution of offspring was: black-red 1,070; black-white 177; green-red 180; green-white1072. Based on this data, what is the recombination frequency ?
    (*a*) 30 percent (*b*) 7 percent
    (*c*) 17 percent (*d*) 14 percent

25. How many map units is a recombination frequency of 5 percent equal to?
    (*a*) 2.5 centimorgans (*b*) 10 centimorgans
    (*c*) 5 centisturtevants (*d*) 5 centimorgans

26. A linkage map
    (*a*) orders genes on a chromosome based on recombination frequencies
    (*b*) can only be constructed for sex chromosomes
    (*c*) orders genes on a chromosome based on their location with respect to a stained band
    (*d*) shows the actual ordering and spacing of genes on a chromosome

27. A male bee is
    (*a*) X Y (*b*) diploid
    (*c*) hapliod (*d*) Z W

28. What is the probability that a male will inherit an X-linked recessive gene from his father?
    (*a*) 0
    (*b*) 25 percent
    (*c*) 50 percent
    (*d*) 75 percent

29. Duchenne muscular dystrophy is caused by a sex-linked recessive allele. Its victims are almost invariably boys, who usually die before the age of 20. Why is this disorder almost never seen in girls?
    (*a*) Sex-linked traits are never seen in girls
    (*b*) The allele is carried on the Y chromosome
    (*c*) Nondisjunction occurs in males but not in females
    (*d*) In order to express an X-linked recessive, a female must have two copies of the gene

30. Which of the following human genetic disorders is sex linked?
    (*a*) hemophilia
    (*b*) PKU
    (*c*) cystic fibrosis
    (*d*) achondroplasia

31. A genetic defect in humans results in the absence of sweat glands in the skin. Some men have this defect all over their bodies, but in women it is usually expressed in a peculiar way. A woman with this defect typically has small patches of skin with sweat glands and other patches where sweat glands are lacking. This pattern suggests the phenotypic effect of
    (*a*) a mutation
    (*b*) chromosome inactivation
    (*c*) RNA splicing
    (*d*) an operon

32. Which of the following is correct with regard to aneuploidy?
    (*a*) inversion
    (*b*) 2n + 1
    (*c*) All aneuploid individuals die before birth
    (*d*) 4n

33. If a fragment of a chromosome breaks off and then reattaches to the original chromosome but in the reverse direction, the resulting chromosomal abnormality is called
    (*a*) a deletion
    (*b*) an inversion
    (*c*) a translocation
    (*d*) a nondisjunction

34. Why are individuals with an extra chromosome 21, which causes Down syndrome, more numerous than individuals with an extra chromosome 3 or chromosome 16?
    (*a*) There are probably more genes on chromosome 21 than on the others
    (*b*) Chromosome 21 is a sex chromosome and 3 and 16 are not
    (*c*) Down syndrome is not more common, just more serious
    (*d*) Extra copies of the other chromosomes are probably fatal

35. Humans have 23 pairs of chromosomes, while our closest relatives, chimpanzees, have 24. Chromosome studies indicate that at some point early in human evolution, two chromosomes simultaneously broke into a large portion and a small portion. The large parts combined to form a large chromosome, and the small parts combined to form a much smaller chromosome (which was subsequently lost). This important chromosomal change could best be described as
   (*a*) nondisjunction followed by deletion
   (*b*) translocation followed by deletion
   (*c*) duplication followed by deletion
   (*d*) translocation followed by inversion

36. Each cell in an individual with Down syndrome contains ____ chromosomes.
   (*a*) 47 (*b*) 22
   (*c*) 24 (*d*) 45

37. Disorders involving unusual numbers of sex chromosomes show that maleness is caused by the
   (*a*) presence of an X chromosome
   (*b*) presence of a Y chromosome
   (*c*) absence of an X chromosome
   (*d*) absence of a Y chromosome

38. A particular allele can have different effects if it was inherited from a male rather than a female. This phenomenon is known as
   (*a*) extranuclear inheritance
   (*b*) genome imprinting
   (*c*) sex-linkage
   (*d*) Prader-Willi syndrome

39. Human mitochondria
   (*a*) are inherited as an X-linked trait
   (*b*) are all inherited from the father
   (*c*) have linear DNA
   (*d*) are all inherited from the mother

40. Both chloroplasts and mitochondria
   (*a*) are found within the nucleus
   (*b*) have linear DNA
   (*c*) carry extranuclear genes
   (*d*) display a Mendelian pattern of inheritance

41. Who demonstrated that genes are located on chromosomes?
   (*a*) Morgan (*b*) Meselson and Stahl
   (*c*) Chargaff (*d*) Franklin

42. In Griffith's experiments, a harmless variant of *S. pneumoniae* became pathogenic when mixed with a heat-killed pathogenic variant as a result of
    (*a*) conjugation (*b*) transduction
    (*c*) mutation (*d*) transformation

43. In an important experiment, bacteriophages were allowed to infect bacteria. In the first trial, the phages used contained radioactive DNA, and radioactivity was detected in the bacteria. Next, other phages containing radioactive protein were allowed to infect bacteria, and no radioactivity was detected in the bacteria. When the experimenters compared the results of these two trials, they concluded that
    (*a*) genes are made of DNA
    (*b*) bacteriophages can infect bacteria
    (*c*) DNA is made of nucleotides
    (*d*) genes carry information for making proteins

44. A geneticist raised a crop of T2 bacteriophages in a medium containing radioactive phosphorus, so that the DNA of the bacteriophages was labeled with radioactivity. The labeled phages were then allowed to infect nonradioactive bacteria. In a few hours, these bacteria burst open, releasing many bacteriophages. Some of these phages contained labeled
    (*a*) DNA
    (*b*) RNA
    (*c*) protein
    (*d*) DNA and protein only

45. Scientists have discovered how to put together a bacteriophage with the protein coat of phage T2 and the DNA of phage T4. If this composite phage were allowed to infect a bacterium, the phages produced in the host cell would have
    (*a*) the protein of T2 and the DNA of T4
    (*b*) the protein of T4 and the DNA of T2
    (*c*) the protein and DNA of T2
    (*d*) the protein and DNA of T4

46. Chargaff found that for DNA
    (*a*) the ratio of A to C is close to 1:1 and the ratio of G to T is close to 1:1
    (*b*) the ratio of A to T is close to 1:1 and the ratio of G to C is close to 1:1
    (*c*) the ratio of A to G is close to 1:1 and the ratio of T to C is close to 1:1
    (*d*) A + T = G + C

47. The X-ray diffraction studies conducted by ______ were key to the discovery of the structure of DNA.
    (*a*) McClintock (*b*) Franklin
    (*c*) Meselson and Stahl (*d*) Chargaff

48. Which of the following is not true of DNA?
(*a*) A pairs with T and G pairs with C
(*b*) Nitrogen bases are 0.34 nm apart on a DNA strand
(*c*) The double helix is 2.0 nm wide
(*d*) The double helix is 3.4 nm wide

49. Which of the following is correct?
(*a*) A forms 2 hydrogen bonds with G; T forms 3 hydrogen bonds with C
(*b*) A forms 3 hydrogen bonds with T; G forms 2 hydrogen bonds with C
(*c*) A forms 2 covalent bonds with T; G forms 3 covalent bonds with C
(*d*) A forms 2 hydrogen bonds with T; G forms 3 hydrogen bonds with C

50. Which of the following is not needed for DNA replication?
(*a*) ribosomes (*b*) DNA
(*c*) nucleotides (*d*) enzymes

51. If reciprocal cross to not yield equal result it suggest that characters are-
(*a*) X-linked (*b*) Autosomal
(*c*) Extra-chromosomal (*d*) None

52. The difference which distinguish prokaryotic cell from eukaryotic is-
(*a*) ER
(*b*) Mesosome
(*c*) Nuclear Membrane
(*d*) Plasma membrane

53. During crossing over, exchange of genetic material takes place between
(*a*) Two chromatids
(*b*) Two chromosomes
(*c*) the non-sister chromatids of the paired chromosomes
(*d*) Two sister chromatids of each homologue

54. The segregation of Mendelian factors takes place during-
(*a*) Meiosis I (*b*) Meiosis II
(*c*) Mitosis (*d*) Inter phase

55. During Mitosis suddenly the chromosomes starts moving toward the opposite poles during-
(*a*) Prophase (*b*) Metaphase
(*c*) Anaphase (*d*) Telophase

56. Extra nuclear genetic material is found in-
(*a*) Ribosome (*b*) ER
(*c*) Chloroplast (*d*) Centriole

57. Dosage Compensation in case of human is achieved by-
    (*a*) Hyper activation of X Chromosome
    (*b*) Hyper activation of Y chromosome
    (*c*) Heterochromatization of X chromosome
    (*d*) Heterochromatization of Y chromosome

58. Extra nuclear inheritance is due to which organelle-
    (*a*) Ribosome (*b*) Centriole
    (*c*) Plastid (*d*) Nucleus

59. The introduced cells in a tissue culture are made to divide and form a mass of undifferentiated tissue cells called callus by
    (*a*) adjusting the ratio of auxin-cytokinin
    (*b*) transferring the plantlets to pots in natural environment
    (*c*) keeping the inoculated vessels at a desired constant temperature in an incubator
    (*d*) solidifying the enriched mineral medium with agar

60. The first step in the technique of protoplasmic fusion is the
    (*a*) hybridization
    (*b*) collection of somatic cells
    (*c*) isolation of protoplasts
    (*d*) selection and isolation of somatic cells

61. The acrosome of the sperm is formed from the
    (*a*) mitochondria (*b*) centrosome
    (*c*) lysomome (*d*) golgi bodies

62. A technician wanted to make antibody specific for mouse IgM. Accordingly he injected a rabit with purified mouse IgM and obtained an an antiserum that reacted strongly with mouse IgG. Unfortunately, however antiserum was also found to react with other mouse Ig classes. Such result would be obtained if antiserum contained antibodies directed against-
    (*a*) The variable region of heavy chain
    (*b*) The constant region of heavy chain
    (*c*) The Fc portion of Ig molecule
    (*d*) The light chain of Ig molecule

63. The average length of gene is –
    (*a*) 500 bp (*b*) 1000bp
    (*c*) 2000bp (*d*) 5000bp

64. Aleurone layer is outermost layer of endosperm in cereals. It helps in-
    (*a*) Protection of endosperm
    (*b*) Growth of endosperm
    (*c*) Mobilization of reserve food in endosperm
    (*d*) Accumulation of reserve food in endosperm

65. Genetically engineered male sterile crops plants have been produced by inserting-

(*a*) Viral coat protein gene (*b*) Chitinase gene

(*c*) Barnase gene (*d*) Opaque Z-gene

66. How many mitotic division are required to produce 12 pollen grains in cyperaceae family-

(*a*) 2 (*b*) 6

(*c*) 3 (*d*) 12

67. Which plant is used as model system to study developmental genetics of zygotic embryogenesis-

(*a*) *Dacus carota*

(*b*) *Arabidposis thaliana*

(*c*) *Zea mays*

(*d*) *Nicotiana tobacum*

68. Your friend has just returned from the exam hall looking very nervous. He was asked to choose a method for separating 3 amino acids differing in their polar side chains. This method he choose was paper electrophoresis-

(*a*) You tell him he choose the right technique since this is a method of choice for separating amino acids with different polarities

(*b*) You tell him he chooses wrong technique relies on net charge

(*c*) You tell him he is wrong because this technique also depends on how strongly the amino acids bind to paper

(*d*) You tell him he is safe as long as he chooses a separation technique used for amino acids

69. Protein folding is mainly driven by all of the following except-

(*a*) Hydrophobic interactions (*b*) Hydrogen bonds

(*c*) Covalent bonds (*d*) Electrostatic attractions

70. How many Barr bodies would be present in the WBC of an individual with 49 XXXYY paratype-

(*a*) 1 (*b*) 3

(*c*) 2 (*d*) 5

71. An open reading frame is one that has-

(*a*) No start and stop codon (*b*) A start & stop codon

(*c*) No start but stop codon (*d*) A start but no stop codon

72. When the human genome draft sequence was released, which was least expected-

(*a*) The large amount of repetitive DNA

(*b*) The size of total genome

(*c*) The size of individual chromosomes

(*d*) The small number of protein coding genes

73. In Sanger's Method of DNA sequencing, the growing DNA chains are terminated because-
   (*a*) DNA polymerase is not very processive
   (*b*) A radioactive nucleotide is incorporated
   (*c*) The substrates become limitation
   (*d*) A phosphodiester bond can not be made

74. A recessive mutation is that-
   (*a*) Not expressed
   (*b*) Expressed only when heterozygous
   (*c*) Expressed only when homozygous or hemizygous
   (*d*) Eliminated by natural selection

75. Catalytic antibodies function as enzymes on the principle of-
   (*a*) Enzymatic conversion of antibodies
   (*b*) Stabilizing transition state analogue of substrates
   (*c*) Antigen antibody affinity
   (*d*) Monoclonal antibodies with chemical

76. In a Sephadex gel filteration column, a mixture of albumin, lysozyme and thymidine was loaded. In what sequence these will be eluted from the column-
   (*a*) Albumin > Lysozyme > Thymidine
   (*b*) Lysozyme > thymidine > Albumin
   (*c*) Thymidine > albumin > Lysozyme
   (*d*) Thymidine > Lysozyme > Albumin

77. Animal viruses cannot be seen under phase contrast microscope because-
   (*a*) They do not have a defined morphology
   (*b*) They are too small to be seen under microscope
   (*c*) They do not have any envelop that make them transparent under microscope
   (*d*) Since they have no color, they are not visible

78. You have homogenized plant tissue and would like to separate chloroplast from nuclei. Which of the following methods would be most suitable-
   (*a*) PAGE
   (*b*) Equilibrium density gradient centrifugation on CsCl gradients.
   (*c*) Differential centrifugation using sucrose gradients.
   (*d*) Gel filtration.

79. Which is not antibacterial antibiotic-
   (*a*) Tetracycline (*b*) Streptomycin
   (*c*) Nystanin (*d*) Nalidixic acid

80. Degradation of RNA by RNaseA is an example of-
   (*a*) covalent catalysis
   (*b*) Acid- base catalysis
   (*c*) Electrostatic catalysis
   (*d*) Nucleic acid catalysis

81. Dehydrogenase enzymes of hexose mono phosphate shunt pathway are-
   (*a*) NAD specific (*b*) NADP specific
   (*c*) FAD specific (*d*) TPP specific

82. Which of the following biochemical Rx is most commonly utilized by living cells to propagate intracellular signals?
   (*a*) Acylation (*b*) Phosphorylation
   (*c*) Methylation (*d*) Decarboxylation

83. Suppression mutation results in restoration of wild type phenotype. The suppression of mutant phenotype is usually brought about-
   (*a*) By misreading of mutant codon and incorporation of a correct amino acid
   (*b*) By insertion of anather copy of gene
   (*c*) By revertion of mutation to wild type
   (*d*) Any deletion of mutant gene

84 A mouse in which one particular gene has been replaced by its inactivated form generated in vitro is called-
   (*a*) Transgenic mouse (*b*) Nude mouse
   (*c*) Knock out mouse (*d*) Mutant mouse

85. Which is not a signal transducting molecule-
   (*a*) G protein coupled receptor (*b*) MAP kinase
   (*c*) Protein kinase C (*d*) Insulin

86. Fibronectin is a protein found in –
   (*a*) RER (*b*) Extracellular matrix
   (*c*) SER (*d*) Nuclear membrane

87. After translation proteins are modified in-
   (*a*) Golgi apparatus (*b*) Lysosome
   (*c*) Centrosome (*d*) Ribosome

88. In AIDS the primary problem is-
   (*a*) B cells are not functional
   (*b*) Natural killer cells kill autulogous cells
   (*c*) Macrophages are not functional
   (*d*) T helper are not functional

89. Which one of the following group of proteins will be most conserved among different organisms-
   (*a*) Metabolism (*b*) Transcription
   (*c*) Translation (*d*) Cell signaling

90. The following are samples of repetitive elements that are found in a typical eukaryotic genome-
   (*a*) r-RNA (*b*) t-RNA
   (*c*) SINES and LINES (*d*) Microsatellite

   The ascending order in terms of number of repeats
   (*a*) ABCD (*b*) DCBA
   (*c*) CBAD (*d*) ADBC

91. Which sequence are best to evaluate the phylogeny of closely related mammals-
   (*a*) Coding sequences
   (*b*) Ribosomal proteins
   (*c*) SINES and LINES
   (*d*) Centromeric and telomeric sequences

92. Leber hereditary optic neuropathy is an inherited condition what causes a loss of central vision resulting from a mutation in mitochondrial DNA. What is the probability of the children of a man with mutations in two genes and a woman with normal mitochondrial DNA inheriting this disorder as carriers?
   (*a*) 0 % (*b*) 100 %
   (*c*) 50 % (*d*) 66.67 %

93. A contig from the genome sequence of *Plasmodium falciparum*, with a single start codon when translated, was found to have high similarity with the enzyme dihydrofolate reductase and thymidylate synthase. Which of following statement is correct-
   (*a*) It contains domains present in both proteins, but neither in two enzymes
   (*b*) It is single bi-functional protein
   (*c*) Both the protein share a common domain
   (*d*) The protein is unrelated to both the enzymes. There is a problem with the similarity search program used for the study

94. The consensus sequence of 5′ and 3′ splice junctions in eukaryotic m-RNA contains-
   (*a*) GU-GA (*b*) GU-AG
   (*c*) AG-GU (*d*) CG-AG

95. Small cytoplasmic RNA (Sc-RNA) in eukaryotic cell-
   (*a*) Splice primary transcript
   (*b*) Direct primary transcript
   (*c*) Direct protein Traffic
   (*d*) Transport amino acids

96. In an experiment involving polymerase chain reaction (PCR) you have started with 100 ng of primers and 1 ng of genomic DNA. After a number of cycles, the same amount of amplified product was observed. Indicate which of the following is the reason for observation-
    (*a*) Enzymes gets inactivated
    (*b*) Limitations of primers
    (*c*) Degradation of template
    (*d*) Substrate inhibition of enzyme

97. A genetic cross between two F_1-hybrid pea plants for spherical seeds will yield what percent spherical-seeded plants in the F_2 generation? (spherical is dominant over dented)
    (*a*) 100% (*b*) 75%
    (*c*) 50% (*d*) 25%

98. A genetic cross between two F_1-hybrid pea plants having yellow seeds will yield what percent green-seeded plants in the F_2 generation? Yellow seeds are dominant to green.
    (*a*) 100% (*b*) 25%
    (*c*) 50% (*d*) 75%

99. When true-breeding tall stem pea plants are crossed with true-breeding short stem pea plants, all of the _________ plants, and 3/4 of the __________ plants had tall stems. Therefore, tall stems are dominant.
    (*a*) F_1, F_2 (*b*) G_1, G_2
    (*c*) parental, F_2 (*d*) F_2, parental

100. To identify the genotype of yellow-seeded pea plants as either homozygous dominant (YY) or heterozygous (Yy), you could do a test cross with plants of genotype _______.
    (*a*) y (*b*) Y
    (*c*) yy (*d*) YY

Practice Test Paper-II

1. mRNA can be isolated by passing cell lysate through a column of oligo (dT)-Cellulose. The method is example of-
   (*a*) Partition chromatography
   (*b*) Ion-exchange chromatography
   (*c*) Affinity chromatography
   (*d*) Adsorption chromatography

2. Which of the following is most commonly involved in globular shape of protein in aqueous solutions-
   (*a*) Hydrogen bonds (*b*) Disulphide bonds
   (*c*) Salt bridges (*d*) Hydrophobic interactions

3. How many different gametes can be formed by an organism with genotype AaBbCCddEe ?
   (*a*) 8 (*b*) 16
   (*c*) 32 (*d*) 64

4. In many situations it has been found that the nucleotide sequences of two highly homologous proteins are different. It may be due to use of-
   (*a*) different amino acids
   (*b*) non-overlapping genes
   (*c*) different strands of DNA for encoding gene
   (*d*) synonymous codons due to degeneracy

5. DNA binding protein that prevents transcription are-
   (*a*) Activators (*b*) Operators
   (*c*) Repressors (*d*) Silencers

6. The pollen tube discharges its content in-
   (*a*) The egg (*b*) One of synergid
   (*c*) The central cell (*d*) Antipodal Cell

7. The spindle fibres in a mitotic cell are composed of-
   (*a*) Chromatin (*b*) Actin
   (*c*) Nucleoprotein (*d*) Tubulin

8. In heterozygous cell the gene of recessive allele
   (*a*) Is always turned off
   (*b*) May be expressed but product is quickly degraded
   (*c*) May be expressed without measurable effect
   (*d*) Is deleted

9. The first step in the initiation of protein synthesis requires
   (*a*) The 30 S ribosomal subunit (*b*) ATP
   (*c*) The ribosomal A site (*d*) Translational factor Tu

10. House keeping genes are-
    (*a*) inducible genes
    (*b*) expressed only in tumour cells
    (*c*) expressed in all cells
    (*d*) do not express at all

11. Reduction of chromosome number occurs in-
    (*a*) Mitotic anaphase
    (*b*) Anaphase –I of meiosis
    (*c*) Anaphase-II of meiosis
    (*d*) Mitotic as well as meiotic anaphases

12. When a plant of chromosomal type aa pollinates a plant of type AA, what chromosome constitution of embryo and endosperm is expected in the resulting seeds-
    (*a*) Diploid zygote of type Aa and Triploid endosperm of type AAa
    (*b*) Diploid zygote of type aa and Triploid endosperm of type Aaa
    (*c*) Diploid zygote of type AA and Triploid endosperm of type AAa
    (*d*) Diploid zygote of type Aa and Triploid endosperm of type aaa

13. A culture of tetracycline sensitive bacteria was infected by a phage that is delivered from the lysis of a tetracycline resistant bacterial strain. This results in development of tetracycline resistant in the original culture. What phenomenon has occurred-
    (*a*) Conjugation (*b*) Recombination
    (*c*) Transformation (*d*) Transduction

14. If the molecular mass of amino acid is 150 dalton, the molecular weight of its tripeptide will be-
    (*a*) 450 (*b*) 486
    (*c*) 504 (*d*) 414

15. If the number of heterozygous pairs involved in a particular cross is three, the phenotype ratio obtained in their F_2 generation will be-
    (*a*) 9:3:3:1 (*b*) 27:9:9:9:6:6:3:3:1
    (*c*) 27:9:9:9:3:3:3:1 (*d*) 1:2:1:2:4:2:1:2:1

16. Rheumatoid arthritis is a/an-
    (*a*) immunodeficiency disease
    (*b*) sexually transmitted disease
    (*c*) insect born disease
    (*d*) autoimmune disease

17. A linkage group corresponds to a-
    (*a*) chromosome
    (*b*) set of independently assorting genes
    (*c*) set of independently segregating alleles
    (*d*) set of non complementing alleles

18. Which of the following restriction enzymes produces blunt end DNA fragments-
    (*a*) EcoR I (*b*) EcoR II
    (*c*) EcoR V (*d*) Bam H1

19. Who discovered that DNA is the genetic material-
    (*a*) Arthur Kornberg (*b*) James Watson
    (*c*) Ostawald avery (*d*) Severo Ochoa

20. Which of the common bases (A,C,G,T) if DNA has no oxygen in its structure-
    (*a*) Thymine (*b*) Adenine
    (*c*) Cytosine (*d*) Guanine

21. What is main damaging effect of UV radiations on DNA-
    (*a*) Depurination
    (*b*) Formation of thymine dimmers
    (*c*) Single strand break
    (*d*) Double strand break

22. In a cross between a pure tall pea plant with green pods and pure dwarf pea plant with yellow pods, how many plants in F_2 generation will be dwarf out of 16 plants-
    (*a*) 1 (*b*) 3
    (*c*) 4 (*d*) 9

23. If parents have AB and O blood group, their offspring could be of-
    (*a*) O grp only (*b*) A & B grp
    (*c*) A, B, O grp (*d*) A, B, O and AB

24. Similar set of regulatory genes control development in Arabidopsis, Drosophila and mice. These genes are called-
    (*a*) Homologous genes (*b*) Heterologous
    (*c*) Homeotic (*d*) Orthologous

25. TATA box and Pribnow box are components of-
    (*a*) Operators (*b*) Promoters
    (*c*) Enhancers (*d*) Activators

26. Lampbrush chromosomes occur through-
    (*a*) diplotene of meiosis (*b*) Prophase of mitosis
    (*c*) Interphase (*d*) Metaphase of meiosis

27. Which of the following is not associated with cell cycle-
    (*a*) Cyclins (*b*) Myosins
    (*c*) CDK (*d*) DNA polymerases

28. Segregation of alleles takes place during the following stage of meiotic division-
    (*a*) Metaphase I (*b*) Anaphase I
    (*c*) Diplotene (*d*) Anaphase II

29. A single crossing over between two homologous chromosomes involves-
    (*a*) Two chromatids
    (*b*) Three chromatids
    (*c*) Four chromatids
    (*d*) The centromere of the chromosomes

30. Haploids are considered better genetic stock because they-
    (*a*) Are healthier then diploids
    (*b*) Require only half of the nutrients
    (*c*) Easy to culture
    (*d*) Form homozygous individual on doubling

31. A yellow round seeded pea plant is crossed with green and wrinkled pea plant and the F1 of this are back crossed to the homozygous recessive parents. The progeny will appear-
    (*a*) 9:3:3:1 (*b*) 12:3:3:1
    (*c*) 3:3:3:1 (*d*) 1:1:1:1

32. Which of the following is the approximately size of human genome-
    (*a*) 4×10^{6} bp (*b*) 1×10^{10} bp
    (*c*) 3×10^{9} bp (*d*) 5×10^{5} bp

33. Which of the following type of DNA is the most conserved amongst organisms-
    (*a*) Mitochondrial DNA (*b*) Chloroplast DNA
    (*c*) rDNA (*d*) DNA that codes for t-DNA

34. Which of the following is incorrect regarding chargaff's rule-
    (*a*) [A] = [T] (*b*) [G] =[C]
    (*c*) [A] + [T] = [G] + [C] (*d*) [A]+ [G] = [T] + [C]

35. If total concentration of A=T is 56 %. What will be concentration of cytosine in genome:
    (*a*) 56 (*b*) 23
    (*c*) 44 (*d*) 22

36. In the B form of DNA, the paired bases are planar , parallel to one another and they are-
    (*a*) Parallel to long axis of double helix
    (*b*) Perpendicular to long axis of double helix
    (*c*) Inclined to long axis
    (*d*) Inverted in respect to long axis

37. Among the Following staggered cut is obtained by-
    (*a*) Alu I (*b*) Rsa I
    (*c*) Pst I (*d*) Pvu (II)

38. Which one is the essential feature of restriction sites cut by restriction endonucleases II-
    (*a*) Palindromic (*b*) Within recognisation site
    (*c*) Always methylated (*d*) All the above

39. The genomic size of E. coli is 4.6 X 10^{6} bp, if a 6 base pair cutter is utilized to obtain restriction fragments, then what will be total number of fragments obtained-
(*a*) 1.12×10^{3} (*b*) 7.66×10^{5}
(*c*) 25×10^{4} (*d*) 3.83×10^{3}

40. Tm (Melting temperature) would be maximum for-
(*a*) *Saricina lutea* (*b*) *E. Coli*
(*c*) Drosophila (*d*) Human

41. Natural absorption of UV by DNA is due to nucleotide base pairs which increase on denaturation. They absorb maximum amount of UV wavelength of-
(*a*) 200 nm (*b*) 260 nm
(*c*) 280 nm (*d*) 355 nm

42. For Nucleic acid hybridization which condition is not essential –
(*a*) The salt conc. must be high (>25 M)
(*b*) Primers
(*c*) High temperature, under control
(*d*) Complementary strands

43. Genetic variations, in form of multiple alleles of many genes, exist in most of natural population. Such genetic differences between individuals are called DNA polymorphism. Such a DNA polymorphism is used as-
(*a*) DNA markers (*b*) DNA probes
(*c*) c-DNA (*d*) Heteroduplex DNA

44. The best DNA markers utilized to differentiate different human individuals (to establish paternity & divergence) are-
(*a*) Single Nucleotide Polymorphism
(*b*) Rest Fragment Length Polymorphism
(*c*) Random Amplified Polymorphic DNA
(*d*) Simple tandem repeats polymorphism

45. Which chemical group are present at the extreme 3' ends of single polynucleotide strand-
(*a*) Phosphate group (*b*) Hydroxyl group
(*c*) Oxo group (*d*) CH_2OH

46. The template DNA strand utilized for DNA replication is-
(*a*) 5′-3′ direction (*b*) 3′-5 direction
(*c*) Random (*d*) In both direction

47. The enzyme coded by allele I^A transferase which adds N-acetyl glucasmine and blood group is designated as A, similarly I^B encodes transferase which adds galactose to precursor sugar, similarly I^O encodes transferase which adds-
(*a*) No sugar
(*b*) N-acetyl glucasamine
(*c*) Galactose
(*d*) Both galactose and N acetyl glucasmine

48. If two recessive mutations are alleles of different genes, then F_1 progeny are wild type, this is due to-
   (*a*) Incomplete dominance
   (*b*) Complementation
   (*c*) Supplementation
   (*d*) Co-dominance

49. Sexual differentiation in Drosophila is controlled by gene called sex lethal (sxl). The genes sensing the number of x chromosomes are called as-
   (*a*) Supernumery genes
   (*b*) Denominator genes
   (*c*) Numerator genes
   (*d*) Sex sensing genes

50. What would be sex of Drosophila with chromosome complement 3A + XXYY-
   (*a*) Male
   (*b*) Female
   (*c*) Inetersex
   (*d*) Metamale

51. Eukaryotic gene regulation occurs at the level of:
   (*a*) posttranslational control
   (*b*) transcriptional control
   (*c*) genomic control
   (*d*) all of the above

52. Ubiquitin binds to _____ residues, therefore targeting proteins for degradation by _____.
   (*a*) lysine, proteasomes
   (*b*) arginine, lysosomes
   (*c*) arginine, proteasomes
   (*d*) lysine, lysosomes

53. Protein phosphoryation, dephosphorylation and proteolytic cleavage are examples of:
   (*a*) posttranslational control
   (*b*) transcriptional control
   (*c*) translational control
   (*d*) control of RNA processing

54. Steroid hormone receptors are involved in:
   (*a*) control of RNA processing
   (*b*) posttranslational control
   (*c*) transcriptional control
   (*d*) genomic control

55. Which of the following is NOT an example of genomic control of gene regulation?
   (*a*) alternative RNA splicing
   (*b*) DNA rearrangement
   (*c*) gene deletion
   (*d*) gene amplification

56. Which of the following is true of homeotic genes?
   (*a*) the homeodomain functions in binding to DNA
   (*b*) they serve as an example of transcriptional gene control
   (*c*) all homeotic genes contain a 180-bp segment called a homeobox
   (*d*) all of the above are correct

57. ______ is an allosteric protein that is inactive until it binds to_____ , thus activating transcription.
(*a*) RNA polymerase, cAMP
(*b*) CRP, ATP
(*c*) CRP, cAMP
(*d*) RNA polymerase, ATP

58. The trp leader sequence contains a control region that is sensitive to tryptophan levels such that it determines whether transcription will continue to completion. The effect of this control element in the trp operon in E. coli is known as:
(*a*) gene amplification
(*b*) RNA splicing
(*c*) attenuation
(*d*) repression

59. Histone structure can be altered by:
(*a*) DNA rearrangement
(*b*) acetylation
(*c*) sigma factors
(*d*) methylation

60. Which of the following is true of heat-shock genes?
(*a*) they are only found in prokaryotes
(*b*) they encode for proteins such as progesterone and estrogen
(*c*) they are only found in eukaryotes
(*d*) they are known to respond to stressful conditions

61. A gene is
(*a*) the same thing as a chromosome.
(*b*) the information for making a polypeptide.
(*c*) made of RNA.
(*d*) made by a ribosome.

62. In Eukaryotes, DNA packing affects gene expression by
(*a*) controlling access to DNA.
(*b*) positioning related structural genes near each other.
(*c*) protecting DNA from mutations.
(*d*) enhancing recombination of genes.

63. Dioxin, produced as a by-product of various industrial chemical processes, is suspected of causing cancer and birth defects in animals and humans. It apparently acts by entering cells and binding to proteins, altering the pattern of gene expression. The proteins affected by dioxin are probably
(*a*) water-soluble proteins.
(*b*) DNA polymerase.
(*c*) transcription factors.
(*d*) enhancers.

64. In humans, the hormone testosterone enters cells and binds to specific proteins, which in turn bind to specific sites on the cells DNA. These proteins probably act to
(*a*) help RNA polymerase transcribe certain genes.
(*b*) alter the pattern of DNA splicing.
(*c*) inhibit transcription.
(*d*) unwind the DNA for gene transcription.

65. It is possible for a cell to make proteins that last for months; hemoglobin in red blood cells is a good example. However, many proteins are not this long-lasting. They may be degraded in days or even hours. Why do cells make proteins with such short lifetimes if it is possible to make them last longer?
    (*a*) Most proteins are used only once
    (*b*) Most cells in the body live only a few days
    (*c*) Cells lack the raw materials to make most of the proteins they need
    (*d*) Only cancer cells, which can keep dividing, contain long-lasting proteins.

66. The genes that malfunction in cancer normally
    (*a*) control RNA transcription
    (*b*) are responsible for sex determination
    (*c*) code for enzymes that repair damaged DNA
    (*d*) are not present in most body cells

67. Which of the following are arranged in the correct order by size, from largest to smallest?
    (*a*) chromosome-gene-codon-nucleotide
    (*b*) nucleotide-chromosome-gene-codon
    (*c*) codon-chromosome-gene-nucleotide
    (*d*) gene-chromosome-codon-nucleotide

68. Imagine an error occurring during DNA replication in a cell, so that where there is supposed to be a T in one of the genes there is instead a G. What effect will this probably have on the cell?
    (*a*) Each of its kinds of protein will contain an incorrect amino acid
    (*b*) An amino acid will be missing from each of its kinds of protein
    (*c*) One of its kinds of protein might contain an incorrect amino acid
    (*d*) The amino acid sequence of one of its kinds of protein will be completely changed

69. How does RNA polymerase know where to start transcribing a gene into mRNA?
    (*a*) Transfer RNA acts to translate the message to RNA polymerase
    (*b*) It starts at a certain nucleotide sequence called a promoter
    (*c*) The ribosome directs it to the correct portion of the DNA molecule
    (*d*) It looks for the AUG start codon

70. All your cells contain proto-oncogenes, which can change into cancer-causing genes. Why do cells possess such potential time bombs?
    (*a*) Viruses infect cells with proto-oncogenes
    (*b*) Proto-oncogenes are genetic junk and have no known function
    (*c*) Proto-oncogenes are unavoidable environmental carcinogens
    (*d*) Cells produce proto-oncogenes as a by-product of mitosis

71. In Eukaryotes, which of the following mechanisms of gene regulation operates after mRNA transcription but before translation of mRNA into protein?
    (*a*) mRNA splicing and editing
    (*b*) DNA packing
    (*c*) repressors and activators
    (*d*) protein degradation

72. A cell biologist found that two different proteins with largely different structures were translated from two different mRNAs. These mRNAs, however, were transcribed from the same gene in the cell nucleus. Which mechanism below could best account for this?
    (*a*) Different systems of DNA unpacking could result in two different mRNAs
    (*b*) A mutation might have altered the gene
    (*c*) Exons from the same gene could be spliced in different ways to make different mRNAs
    (*d*) The two mRNAs could be transcribed from different operons

73. A particular ____ carry the information for making a particular polypeptide, but ____ can be used to make any polypeptide.
    (*a*) gene and ribosome . . . a tRNA and an mRNA
    (*b*) gene and mRNA . . . a ribosome and a tRNA
    (*c*) ribosome and mRNA . . . a gene and a tRNA
    (*d*) gene and tRNA . . . a ribosome and an mRNA

74 Which of the following processes occurs in the cytoplasm of a eukaryotic cell?
    (*a*) DNA replication
    (*b*) translation
    (*c*) transcription
    (*d*) DNA replication and translation

75. The nucleotide sequence of a DNA codon is GTA. A messenger RNA molecule with a complementary codon is transcribed from the DNA. In the process of protein synthesis, a transfer RNA pairs with the mRNA codon. What is the nucleotide sequence of the tRNA anticodon?
    (*a*) CAT (*b*) GUA
    (*c*) CAU (*d*) GTA

76. The nucleotide sequence of a DNA codon is ACT. A messenger RNA molecule with a complementary codon is transcribed from the DNA. In the process of protein synthesis, a transfer RNA pairs with the mRNA codon. What is the nucleotide sequence of the tRNA anticodon?
    (*a*) TGA (*b*) UGA
    (*c*) TGU (*d*) ACU

77. During the process of translation (polypeptide synthesis), ____ matches an mRNA codon with the proper amino acid.
    (*a*) a ribosome (*b*) DNA polymerase
    (*c*) ATP (*d*) transfer RNA

78. A sequence of pictures of polypeptide synthesis shows a ribosome holding two transfer RNAs. One tRNA has a polypeptide chain attached to it; the other tRNA has a single amino acid attached to it. What does the next picture show?
    (*a*) The polypeptide chain moves over and bonds to the single amino acid
    (*b*) The amino acid moves over and bonds to the polypeptide chain
    (*c*) The tRNA with the polypeptide chain leaves the ribosome
    (*d*) A third tRNA with an amino acid joins the pair on the ribosome

79. A geneticist found that a particular mutation had no effect on the polypeptide coded by a gene. This mutation probably involved
(*a*) deletion of one nucleotide
(*b*) alteration of the start codon
(*c*) insertion of one nucleotide
(*d*) substitution of one nucleotide

80. A mutagen is
(*a*) a gene that has been altered by a mutation
(*b*) something that causes a mutation
(*c*) an organism that has been changed by a mutation
(*d*) the portion of a chromosome altered by a mutation

81. There are thought to be about ____ genes in a human cell.
(*a*) 30 – 100
(*b*) 300 – 1,000
(*c*) 3,000 – 10,000
(*d*) 30,000 – 50,000

82. Histones are
(*a*) master genes that affect development
(*b*) groups of genes that respond to environment
(*c*) proteins around which DNA is coiled
(*d*) portions of genes that are transcribed

83. During Interphase, _____ can be seen with a light microscope.
(*a*) nucleosomes
(*b*) introns
(*c*) heterochromatin
(*d*) euchromatin

84. There is about 1,000 times as much DNA in a human cell as in an E. coli cell, but only about 50 times as many genes. Why?
(*a*) A human cell has much more noncoding DNA
(*b*) The DNA packing is much more complex in a prokaryotic cell
(*c*) Most of the genes in a human cell are turned off
(*d*) E. coli are less able to respond to their environment than humans. Moreover, this response confuses cause and effect

85. The difference between tandemly repetitive and interspersed repetitive DNA is that
(*a*) interspersed DNA is also referred to as satellite DNA
(*b*) interspersed repetitive DNA is found throughout the genome.
(*c*) most tandemly repetitive DNA are transposons
(*d*) most interspersed repetitive DNA is at the telomeres

86. Multigene families arise as a result of
(*a*) transformation
(*b*) errors during DNA replication and recombination
(*c*) RNA splicing
(*d*) protein degradation

87. Retrotransposons differ from other transposons in that
 (*a*) retrotransposons have lost the ability to move about a genome
 (*b*) retrotransposons are likely to be the remains of a viral infection
 (*c*) retrotransposons have retained the ability to move about a genome, an ability that has been lost by other transposons
 (*d*) retrotransposons move via an RNA transcript, whereas other transposons do not

88. Your muscle and bone cells are different because
 (*a*) they contain different sets of genes
 (*b*) they are differentiated
 (*c*) they contain different operons
 (*d*) different genes are switched on and off in each type of cell

89. Gene expression in animals seems to be regulated largely by
 (*a*) controlling gene packing and unpacking
 (*b*) controlling the transcription of genes into mRNA
 (*c*) controlling the translation of mRNA into protein
 (*d*) selectively eliminating certain genes from the genome

90. The control of gene expression is more complex in multicellular eukaryotes than in prokaryotes because
 (*a*) eukaryotic cells are much smaller
 (*b*) in a multicellular eukaryote, different cells are specialized for different functions
 (*c*) prokaryotes are restricted to stable environments
 (*d*) eukaryotes have fewer nucleotide, so each nucleotide sequence must do several jobs

91. Which of the following would be most likely to lead to cancer?
 (*a*) multiplication of a proto-oncogene and inactivation of a tumor-suppressor gene
 (*b*) hyperactivity of a proto-oncogene and activation of a tumor-suppressor gene
 (*c*) failure of a proto-oncogene to produce a protein and multiplication of a tumor-suppressor gene
 (*d*) the failure of both a proto-oncogene and a tumor-suppressor gene to produce proteins

92. Your bone cells, muscle cells, and skin cells look different because
 (*a*) different kinds of genes are present in each kind of cell
 (*b*) they are present in different organs
 (*c*) different genes are active in each kind of cell
 (*d*) they contain different numbers of genes

93. Linkage groups are equivalent to haploid set of chromosomes, if male butterfly has 12 linkage groups, then female will have-
 (*a*) 12 (*b*) 11
 (*c*) 13 (*d*) 6

94. Maximum possible recombination frequency is:
(*a*) 25 % (*b*) 50 %
(*c*) 75 % (*d*) 100 %

95. The linkage of genes in chromosomes can be represented in form of-
(*a*) genetic maps (*b*) Linkage maps
(*c*) Chromosome map (*d*) All

96. Physically 1 map unit on linkage maps can be defined as length of chromosome in which, average crossover formed during 50 cells undergoing meiosis is-
(*a*) 1 (*b*) 25
(*c*) 50 (*d*) 100

97. Assuming equal sex ratio, what is probability that a sib ship of four children consists entirely of boys-
(*a*) 25 % (*b*) 12. 5 %
(*c*) 6.25 % (*d*) 3.125 %

98. The spindle fibres attach to each chromosome in the region technically known as-
(*a*) Centromere (*b*) Centriole
(*c*) Kinetochoere (*d*) Astrals

99. Which among the following do not have DNA-
(*a*) Kinetoplast (*b*) Centriole
(*c*) Dictyosomes (*d*) Chindriosomes

100. During meiosis the centromeric division takes place during-
(*a*) Prophase I (*b*) Anaphase I
(*c*) Prophase II (*d*) Anaphase II

5

Evolutionary Biology

EARLY EARTH AND THE ORIGIN OF LIFE

ORIGIN OF EARTH AND PRE-BIOTIC ENVIRONMENT

- Our planet and our solar system has a history of about 4.55 to 4.60 Ga (Ga = billion years). Our solar system originated LONG after the origin of the universe in the **Big Bang** about 10 to 15 billion years ago. **Big Bang** is a theoretical explosion of thick concentrated cosmic matter that occurred 10,000-20,000 million years ago to form our universe and 100,000 galaxies. It was suggested by **Abbe Lemaitre** (1931).
- All matter formed during the Big Bang consisted of the element hydrogen. The hydrogen atoms had to undergo nuclear reactions in stars, and the stars had to explode as supernovas, before heavier elements than hydrogen (such as carbon, the main building block of life on Earth) came into existence. Our Sun did thus not originate straight at the origin of the universe.
- Sun, earth and other stars are formed from Nebula (cosmic dusts and clouds of gases). Nebular hypothesis of **Kant** is for origin of solar system. The origin of our universe is 10-20 billion years (10,000-20,000 million years or 10^4 to 20^4 million years) old. The universe has 1 lakh million (100000 million) galaxies and 10000 million stars in the milky way.
- The Sun was not as hot as it is today. The amount of solar radiation reaching the Earth was only 70-80% of that of today, because nuclear reactions in the Sun were in an earlier stage – we know that from observations on other stars.
- At first there was no Moon. The chemical composition of Moon rocks and the way in which the Moon moves together with the Earth around the Sun indicate that the Moon was formed by the collision of a Mars-size asteroid with early Earth, probably at some time during the big meteor bombardment that ended about 4 billion years ago (4 Ga). The material from the core of the big asteroid was added to Earth, its

mantle moved on and formed the Moon. The Moon was closer to Earth after it originated, so the tides were much more pronounced than today's tides.

- The Earth's rotation rate was faster because tidal friction resulting from the presence of the Moon had not yet slowed it down. Days may have been between 8 and 14 hours long. Growth rings in Paleozoic corals shows that even as recently as 450 million years ago there were more than 400 days in a year (a year is the time that it takes the Earth to circle the Sun). Earth in the beginning was a hot spinning ball with a temperature of 5273-6273 Kelvin (5000-6000 °C). The continents were probably smaller than today's, with more ocean surface, especially more than 3 billion years ago.
- The atmosphere had a very different composition. Our atmosphere at the moment consists for about 80% of dinitrogen gas (N_2) and 20% oxygen gas (O_2), with traces of other gases. CO_2 (carbon dioxide) at the moment makes up about 360 parts per million of the atmosphere (much less than 1%, which is one part per hundred). Before the industrial revolution atmospheric CO_2 levels were about 280 ppm.
- The early Earth's atmosphere was different: there was no free oxygen gas. The primary atmosphere of the Earth, inherited from the swirling cloud of gas from our solar system formed, would have been dominated by hydrogen gas, H_2, with ammonia, NH_3, and methane, CH_4. Atmosphere was reducing and called atmosphere I. Present atmosphere is oxidizing and is called atmosphere II and has about 21% oxygen.
- Hydrogen gas is too light for a planet with the size of Earth to hold by its gravity, and the primary atmosphere would have been blown away by the violent radiation of the Sun in its so-called T-tauri stage. A secondary atmosphere would then be supplied by outgassing from the Earth's interior; either rapidly (big - theory) or more gradual. This secondary atmosphere consisted of dominantly CO_2 (carbon dioxide), with some N_2 (dinitrogen gas), H_2O (water vapor), minor CO (carbon monoxide), SO_2 (sulfur dioxide), and H_2S (hydrogen sulfide).
- **Biopoiesis** is the study of origin of life on earth. **Cosmology** is the study of universe (cosmos).

MAJOR EPISODES IN THE HISTORY OF LIFE: A PREVIEW

- Life originated in Archaeozoic era but first evidence of life is from Precambrian period of Proterozole era in ocean about 3.6-4.2 billion years ago. Scientists have found isotopes of carbon in 3.8 billion year old rocks in Greenland.
- Oldest record of fossils is 3200-3500 (3.2 to 3.5 billion) million years old. The oldest recorded fossil is from the banded domes of calcareous sediments (Stromatolites) in Zimbawe (Rhodesia). It is 2.9 billion years old. Age of fossils is determined either by ^{14}C dating technique or by amount of lead in a rock.
- Fossil evidence suggests that prokaryotes appeared at least 2 billion years before the oldest eukaryotes
- Two distinct groups of prokaryotes, Bacteria and Archaea, diverged early, between 2 to 3 billion years ago. Photosynthetic bacteria started the production of oxygen about 2.5 billion years ago, setting the stage for aerobic life.
- Eukaryotes emerged some 2 billion years ago. Strong evidence supports the hypothesis that eukaryotic cells evolved from a symbiotic community of prokaryotes.

- Plants, fungi, and animals arose from distinct groups of unicellular eukaryotes during he Precambrian. Plants evolved from green algae. Fungi and animals arose from different groups of heterotrophic unicells. Based on molecular evidence, fungi are more closely related to animals than they are to plants.
- The oldest fossils of animals are those of soft-bodied invertebrates from about 700 million years ago. The basic body plans of most of the modern animal phyla probably arose in the late Precambrian.
- The transition from the aquatic environment to land was a pivotal point in the history of life. The first terrestrial colonization was by plants and fungi some 475 million years ago (Paleozoic); the move may have depended upon a beneficial association between the two groups. The transformation of the landscape by plants created new opportunities for all forms of life.
- Origin of life and evolution of life are independent processes. Origin of life is a chemical process and evolution of life is a biological process.

PREBIOTIC CHEMICAL EVOLUTION AND THE ORIGINS OF LIFE

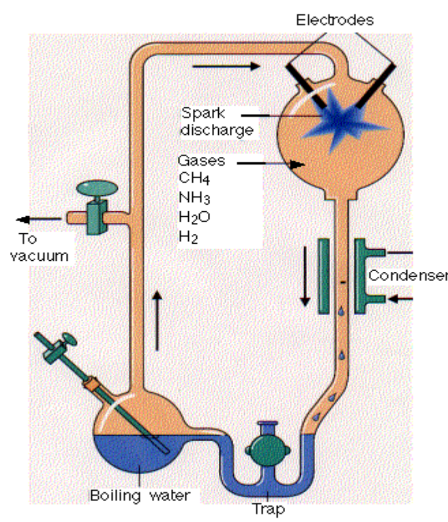
- The first life was anaerobic **chemoheterotrophic marine prokaryotic.** First photoautotrophs were anoxygenic and anaerobic chemoautotrophos. Ribonucleotides appeared prior to deoxyribonucleotides.
- Appearance of nucleoproteins gave the first sign of life. Thus, in origin of life, trend was: anaerobic, marine prokaryotic chemoheterotrophic life $\rightarrow$anaerobic, chemoautrotrophs $\rightarrow$ aerobic oxygenic photoautotrophs (cyanobacteria) $\rightarrow$ eukaryotes $\rightarrow$ plants $\rightarrow$ animals.
- Nucleic acids having power of self duplication were the first biochemical compounds appeared in chemical evolution. It markets the beginning of life. Later on nucleoprotein and then large lipoprotein colloidal particles called **coacervates** were evolved in broth (hot dilute soup) of ocean. A **coacervate** is a hypothetical term used by Oparin & Haldane consisting of nucleoproteins, lipids and polysaccharides which grew by absorbing molecules from outside and like bacteria can divide by budding.
- **Coacervation**: Due to zwitterionic nature, protein molecules formed colloidal hydrophilic complex which got surrounded by water molecules. These bodies may separate from the body of the liquid in which these are suspended (aqueous phase) and form a type of emulsion. Coalescence of such structure produces a separation of colloids from their aqueous phase (concervation). These colloid rich coacervates must been able to exchange substance with their environment and selectively concentrate compounds within them.
- **Fox** (1957) synthesized *in vitro* the proteinoids (microspheres) by prolonged heating of 18-20 types of amino acids.
- **Theory of special creation** states that life was created by supernatural power in that form which has not undergone any change. It was given by **Father Saurez**. God has created life in six days from media prima and man was created by him on the sixth day.
- **Theory of catastrophism** (cataclysm) was given by **Cuvier**, according to which after a gap of certain period (called age), the world undergoes a catastrophe (sudden

calamity) to kill almost all the living organisms and then God created new generation or new life from inorganic matter.

- **Theory of spontaneous generation** (abiogenesis or autogenesis) states that living beings are formed from rain, mud, air, dung and other decaying organic matter**. Van Helmont** claimed to produce mice from human sweat.
- **Theory of biogenesis** (i.e. life from life, *omnis vivum ex. vivo*) was proved by **Redi**, **Spallanzani** and **Pasteur** independently. They disproved (refuted) theory of spontaneous generation (abiogenesis). Francesco Redi (1668) proved that flies could not arise from putrefying meat without their eggs. Spallanzani (1767) demonstrated that putrefaction of meat is due to microbes in the air and it can be prevented by boiling and sealing the meat in air tight containers. Pasteur gave a definite proof of life arising from pre-existing life using microbes and sterilization methods.

A. Naturalistic theory or chemosynthetic origin (Oparin-Haldane)

Life originated from inorganic substance through chemical processes, **i.e., chemical evolution preceeds biological evolution.** In the 1920's, **A.I. Oparin and J.B.S. Haldane** independently postulated that the reducing atmosphere and greater UV radiation on primitive Earth favored reactions that built complex organic molecules from simple monomers as building blocks. According to this theory the first living organisms are products of a chemical evolution that occurred in four stages:



1. Abiotic synthesis and accumulation of monomers, or small organic molecules, that are the building blocks for more complex molecules
2. Joining of monomers into polymers (e.g., proteins and nucleic acids)
3. Formation of protobionts, named coacervates, a colloidal suspension (droplets) which formed from aggregates of abiotically produced molecules and later on differed chemically from their surroundings due to enclosure of membrane like structure and named microspheres by Sydney fox.
4. Origin of heredity during or before protobiont appearance.

The origin of life was possible in Earth's ancient environment:

- There was little atmospheric oxygen.
- Lightning, volcanic activity, meteorite bombardment, and ultraviolet radiation were more intense.

This is not possible today because

1. Oxygen in Earth's oxidizing environment attacks chemical bonds, removing electrons. An important characteristic of the early atmosphere must have been the rarity of oxygen.
2. The modern atmosphere has a layer of ozone that screens UV radiation, so the energy required to abiotically synthesize organic molecules is not available. On primitive Earth, energy was available from frequent lightning and intense UV radiation that penetrated the atmosphere.

Stanley Miller and Harold Urey tested the Oparin/Haldane hypothesis by Experiment

Stanley Miller, a graduate student in biochemistry, built the apparatus shown here. He filled it with water (H_2O) methane (CH_4) ammonia (NH_3) and hydrogen (H_2) but no oxygen. He hypothesized that this mixture resembled the atmosphere of the early earth. (Some are not so sure). The mixture was kept circulating by continuously boiling and then condensing the water. The gases passed through a chamber containing two electrodes with a spark passing between them. At the end of a week, Miller used paper chromatography to show that the flask now contained several amino acids as well as some other organic molecules. In the years since Miller's work, many variants of his procedure have been tried. Virtually all the small molecules that are associated with life have been formed: 17 of the 20 amino acids used in protein synthesis, and all the purines and pyrimidines used in nucleic acid synthesis. But abiotic synthesis of ribose — and thus of nucleosides — has been much more difficult.

One difficulty with the primeval soup theory is how polymers — the basis of life itself — could be assembled. In solution, hydrolysis of a growing polymer would soon limit the size it could reach. Abiotic synthesis produces a mixture of L and D enantiomers. Each inhibits the polymerization of the other. So, for example, the presence of D amino acids inhibits the polymerization of L amino acids (the ones that make up proteins here on earth). This has led to a theory that early polymers were assembled on solid, mineral surfaces that protected them from degradation, and in the laboratory polynucleotides and polypeptides containing about ~50 units have been synthesized on mineral (e.g., clay) surfaces.

Controversy over Classical Oparin-Haldane Theory

The classical theory held that life originated as a result of such actions as lightning strikes, putting energy into a strongly reducing atmosphere, which would result in the formation of many of the 'building blocks of life' – as shown by the laboratory tests done by Miller. This theory in its simplest form has run into major problems, and has been practically abandoned by scientists mainly because of three lines of evidence.

1. The atmosphere was probably not by far as reducing as had been thought (no free H_2, NH_3, CH_4), but more neutral. The reactions to organic material, fired by electric discharge, will still take place in such an atmosphere, but at a much slower rate than in a more reducing atmosphere. At such slow rates it is very difficult to build up a rather large reservoir of organic building blocks, thus chances of getting enough bits and pieces to react to big molecules are very small: in a very dilute soup – type ocean the molecules never meet in large numbers.

2. **The time available for the development of the first living cells has been getting shorter** and shorter, much less than the billions of years envisaged. The big meteorite bombardment that also hit the moon stopped only by about 4.0 Ga. Life developed earlier would prbably have been obliterated by the impacts. Organic material that carries the carbon isotope signature of having originated by photosynthesis has been dated at 3.85 Ga. The remains of not only cell-like organisms, but of stromatolites, are dated at 3.5 Ga. Stromatolites are limestones secreted by the actions of photosynthesizing bacteria: not just very simple semi-life forms were around, but fairly complex bacteria that could perform the difficult reaction of photosynthesis, i.e., Eubacteria. The secretion of limestone ($CaCO_3$) was probably mediated by the chemistry coupling of reactions 1 and 2

$H_2O + CO_2 \rightarrow CH_2O + O_2$ (Reaction 1)

$2\ HCO_3^- + Ca^{2+} \rightarrow CaCO_3 + CO_2 + H_2O$ (Reaction 2)

If organisms use up CO_2 in photosynthesis (reaction 1), they drive at the same time reaction 2 towards the right, thus causing precipitation of calcite.

3. **RNA was probably the first genetic material: An RNA Beginning?**

Much more is known about how incredibly chemically complex even simple organisms (bacteria) are, and about the complexity of inheritance. All organisms alive today store and transmit hereditary information in two kinds of molecules called DNA (Deoxyribonucleic Acid, a double spiral shape) and RNA (Ribonucleic Acid, a single spiral shape). Both DNA and RNA are made up of four kinds of subunits called nucleotides. Sequences of nucleotides make up the genes, and direct the formation of proteins, on which all life depends. Proteins consist of 20 different subunits called aminoacids, and the sequence of the nucleotides on DNA and RNA determines the sequence of the amino-acids in proteins. There are large parts of DNA, however, that do not code for proteins and appears to have no function ('junk DNA'). Such junk DNA occurs in Archaebacteria and Eukaryotes, not in Eubacteria. The formation of the proteins is helped along by enzymes, which function as catalysts (catalysts help a reaction along without participating in it). We call the nucleotides and aminoacids the building blocks of life; both have been found in meteorites. We have a chicken and egg problem: DNA and RNA "tell" the organism how to make proteins, but these same proteins are needed to make DNA and RNA, by acting as catalysts to form these big, complex molecules. DNA and RNA are very complex molecules and it appears to be very difficult to let these originate from simple amino acids. But there is no way in which we can get proteins to duplicate themselves.

More and more evidence has become available that helps in solving the chicken and egg problem. It is now known that some molecules made of RNA, called **ribozymes**, can act as catalysts in modern cells. That means, that such RNA molecules could have used bits and pieces of themselves to help them to replicate, without any use of proteins. There may thus have been a 'RNA-world' in which RNA could have performed the functions of both nucleic acids (DNA, RNA) and proteins. The theory that the first proto-living things were RNA-only organisms is becoming widely accepted (and is called the theory of the RNA-world).

Several other bits of evidence support this notion of an original "RNA world": Many of the cofactors that play so many roles in life are based on ribose; for example: ATP NAD FAD coenzyme A cyclic AMP GTP. In the cell, all deoxyribonucleotides are synthesized from ribonucleotide precursors. Many bacteria control the transcription and/or translation of certain genes with RNA molecules (Link to "riboswitches"), not protein molecules.

Even so, we keep the problems of a not reducing (neutral, also not oxidizing) atmosphere, and very little time to get to the first photosynthesizing bacteria. There are two main schools of thought (with many variants), often combined in one way or another.

1. The original source-material for life was not really carbon-based "life", but some form of self-replicating crystal. We are looking at: different and innovative ways in which we could have used different commonly occurring, natural compounds as some kind of template, or even as a real part of earlier organisms. The most commonly cited possible inorganic compounds are pyrite, FeS_2 (positively charged surface); and clay minerals (negatively charged surface). The floating bits and pieces of 'building blocks of life' could have become organized in patterns using the crystals as a template, and they could have stuck first to the charged surface (the building blocks commonly have a positively and a negatively charged end). Note that crystals (regularly shaped structures) have the possibilities of carrying "information" in their irregularities (similar to the supermarket bar codes).
2. We looked in the wrong place (warm, shallow pond). Reducing circumstances may not have been average in the atmosphere, but may have occurred locally, around volcanic hot springs, and the first forms of life may have been similar to chemosynthetic bacteria. Nice extra: if life originated in rather deep water (no sunlight needed): no problems with high rate of UV-irradiation in the absence of an ozone shield (no O_2). Additionally, many metals that are required in very small amounts because they play a role in complex organic molecules (such as chlorophyll) are present in waters streaming out of hydrothermal vents – e.g., iron, nickel, manganese, magnesium, molybdenum, selenium, copper.

(B). Cosmozoic theory (Theory of panspermia) given by Richter (1865), Helmholtz (1884), Arrhenius (1908)

They suggested that life reached the earth from some heavenly body through meteorites. **Panspermia** (primitive form of life, as suggested by **Arrhenius** (1908) consisted of spores and microbes existed throughout universe and produced different forms of life.

The Murchison Meteorite

This meteorite, that fell near Murchison, Australia on 28 September 1969, turned out to contain a variety of organic molecules including: purines, pyrimidines & polyols — compounds with hydroxyl groups on a backbone of 3 to 6 carbons such as glycerol and glyceric acid. Sugars are polyols. The amino acids obtained were glycine, alanine, aspartic acid, valine and were quite similar to the products formed in Miller's experiments.

The question is: were these molecules simply terrestrial contaminants that got into the meteorite after it fell to earth. **Probably not**: Some of the samples were collected on the same day it fell and subsequently handled with great care to avoid contamination. The polyols contained the isotopes carbon-13 and hydrogen-2 (deuterium) in greater amounts than found here on earth. The samples lacked certain amino acids that are found in all earthly proteins. Only L amino acids occur in earthly proteins, but the amino acids in the meteorite contain both D and L forms (although L forms were slightly more prevalent).

OXYGENATION OF EARTH

Photosynthesis (which generates free oxygen) originated in Prokaryotes (Bacteria and Archaea) very early in Earth history: we have evidence from stromatolites that photosynthesis occurred about 3.5 Ga ago. The photosynthesizing organisms were probably similar to the modern cyanobacteria (formerly called blue-green algae), which are Eubacteria.

When photosynthesizing organisms first became common, the free oxygen gas that they generated did not immediately start to accumulate in the atmosphere: there were many chemical compounds around in the oceans and on land that were not stable in the presence of free oxygen gas, and that became oxidized.The most common of 'things' to be oxidized were iron (Fe) on land, and sulfur (S) in the oceans. Presently, iron occurs in Fe_2O_3 (rust), sulfur occurs in sulfate (SO_4^{2-}) in the oceans. The free oxygen gas was thus used up in oxidation reactions for a considerable time, and during this considerable time we think that the oxygen concentrations in the atmosphere did not become higher than 1 or a few percent of the present atmospheric level (PAL). Most evidence thus suggests that the Earth's atmosphere (thought not necessarily its oceans) had a level of oxygen equal to about 10-15% of its present levels around 2 Ga.

THE GEOLOGIC TIME SCALE AND EVOLUTIONARY RECORD (dates in millions of years.)

A remarkable feature of the table below is how often evolutionary changes coincided with geologic changes on the earth. But consider that changes in geology (e.g., mountain formation or lowering of the sea level) cause changes in climate, and together these alter the habitats available for life. Two types of geologic change seem to have had especially dramatic effects on life: continental drift and the impact of asteroids.

Important Points

- **Azoic Era** –Era of invisible life.
- **Archaeozoic Era-**Era of former life or era of early life.
- **Proterozoic Era-**Era of former life or Era of early life.
- **Palaeozoic Era-**Era of old life or Era of ancient life.
- **Mesozoic Era-**Era of middle (life also called "age of reptiles").
- **Coenozoic Era-**Era of recent life (also called "age of mammals, birds, insects and angiosperms").
- **Ordovician Period**: "age of invertebrates"-and origin of amphibians.
- **Devonians Period**: "age of fishes" and of origin of amphibians.
- **Carboniferous Periods**: "age of amphibians"-and origin of reptiles. Earliest reptiles evolved in carboniferous period.
- First mammals appeared in **Triassic periods**.
- **Jurassic Period**: "age of Reptiles".
- **Holocene Epoch**: "age of Man".

Continental Drift

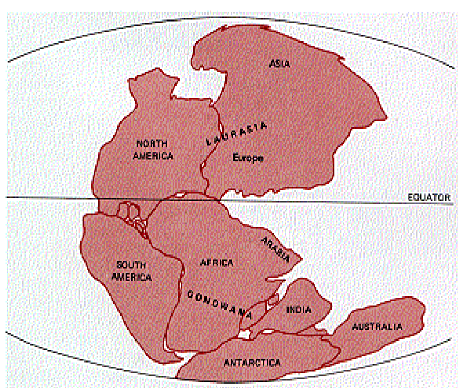
A body of evidence, both geological and biological, supports the conclusion that 200 million years ago, at the start of the Mesozoic era, all the continents were attached to one another in a single land mass, which has been named Pangaea.

This drawing of Pangaea (adapted from data of R. S. Dietz and J. C. Holden) is based on a computer-generated fit of the continents as they would look if the sea level were lowered by 6000 feet.

The Geological Time Scale With Dates in Millions of year in bracket

Eras	**Periods**	**Epochs**	**Aquatic Life**	**Terrestrial Life**
Cenozoic (65) The Age of Mammals	Quaternary (1.8)	Recent (0.1)		Humans in the new world
		Pleistocene (1.8)	Periodic glaciation Continental drift continues	First humans
	Tertiary (65)	Pliocene	All modern groups present	Hominids and pongids
		Miocene		Monkeys and ancestors of apes
		Oligocene		Adaptive radiation of birds
		Eocene		Adaptive radiation of mammals
		Paleocene		
Mesozoic (251) The Age Of Reptiles	Cretaceous (146)	Still attached: N. America & N. Europe; Australia & Antarctica	Modern bony fishes, Extinction of ammonites, plesiosaurs, ichthyosaurs	Extinction of dinosaurs, pterosaurs Rise of woody angiosperms, snakes; first placental mammals (Eutheria)
	Jurassic (200)	Africa & S. America begin to drift apart	Plesiosaurs, ichthyosaurs abundant; first diatoms Ammonites again abundant Skates, rays, and bony fishes abundant	Dinosaurs dominant; first angiosperms First mammals; Archaeopteryx; first lizards Adaptive radiation of dinosaurs; insects abundant
	Triassic (251)	At the end Pangaea splits into Laurasia and Gondwana	First plesiosaurs, ichthyosaurs Ammonites abundant at first Rise of bony fishes	Adaptive radiation of reptiles: thecodonts, therapsids, turtles, crocodiles, first dinosaurs
Paleozoic (542)	Permian (299)	Appalachian Mts. formed; periodic glaciation and arid climate	Extinction of trilobites, placoderms	Reptiles abundant: cotylosaurs, pelycosaurs. Cycads, conifers, ginkgos
	Carboniferous **Periodic aridity**	Pennsylvanian (320)	Ammonites, bony fishes	First reptiles Coal swamps
		Mississippian (359)	Adaptive radiation of sharks	Forests of lycopsids, sphenopsids, and seed ferns Amphibians abundant Land snails

	Devonian (416) The "Age of Fishes"	Extensive inland seas	Placoderms, cartilaginous and bony fishes. Ammonites, nautiloids Adaptive radiation of ostracoderms, erypterids	Ferns, lycopsids, and sphenopsids First gymnosperms First amphibians Arachnids (scorpions)
	Silurian (444)	Mild climate; inland seas	Nautiloids, Pilina, other mollusks	First insects
	Ordovician (488)	Mild climate, inland seas	Trilobites abundant First jawless vertebrates	First fungi First plants (liverworts?) First millipedes?
	Cambrian (542) Periodic glaciation		Trilobites dominant. Eurypterids, crustaceans mollusks, echinoderms sponges, cnidarians, annelids, and tunicates present	No fossils of eukaryotes, but phylogenetic trees suggest that lichens, mosses, perhaps even vascular plants were present.
Proterozoic (2500)	Ediacaran (620)		Fossils rare but evidence of several types of invertebrates	No fossils of eukaryotes, but phylogenetic trees suggest that lichens, mosses, perhaps even vascular plants were present towards the end.



During the Triassic, Pangaea began to break up, first into two major land masses: Laurasia in the Northern Hemisphere and Gondwana in the Southern Hemisphere. The present continents separated at intervals throughout the remainder of the Mesozoic and through the Cenozoic, eventually reaching the positions they have today. Let us examine some of the evidence.

Shape of the Continents

The east coast of South America and the west coast of Africa and are strikingly complementary. This is even more dramatic when one tries to fit the continents together using the boundaries of the continental slopes (e.g., 6000 feet down) rather than the shorelines.

Geology

In both mineral content and age, the rocks in a region on the east coast of Brazil match precisely those found in Ghana on the west coast of Africa. The low mountain ranges and rock types in New England and eastern Canada appear to be continued in parts of Great Britain, France, and Scandinavia. India and the southern part of Africa both show evidence of periodic glaciation during Paleozoic times (even though both are now close to the equator). The pattern of glacial deposits in the two regions not only match each other but also glacial deposits found in South America, Australia, and Antarctica.

Fossils

Fossil reptiles found in South Africa are also found in Brazil and Argentina. Fossil amphibians and reptiles found in Antarctica are also found in South Africa, India, and China. Most of the marsupial alive today are confined to South America and Australia. But if these two continents were connected by Antarctica in the Mesozoic, one might expect to find fossil marsupials there. In March 1982, this prediction was fulfilled with the discovery in Antarctica of the remains of Polydolops, a 9-ft marsupial.

Rules to Remember

- **Williston's Rule**: During evolution of lineage, serially homologue parts tend to reduce in number but get more and more differentiated e.g. prawn's leg.
- **Cope's Law**: it states that warm blooded animals to increase in size during the long course of evolution.
- **Bergman's law**: it states that warm blooded animals become larger in the northern and colder parts of their range.
- **Allen's law**: It states that extremities (like pinnae, nose) of animals living in the northern and colder parts of their range have reduced.
- **Gause's law**: (Gause, 1934) or the **Competitive Exclusion Principle** (Hardin, 1960).it states that two species having same ecological requirements cannot to occupy indefinitely the same habitat.
- **Gloger's rule**: it state that among warm blooded animals those living in warm and moist climate develop more melanin pigment (are darker than animals in cold, dry climates) whereas forms in dry, hot climates have more yellow and red pigment.
- **Jordan's rules**: temperature also influences the morphology of certain fishes and is found to have some relation with the number of vertebrae. Fishes inhabiting water of low temperature tend to have more vertebrae than those of warmer water.

THE HISTORY OF EVOLUTIONARY THEORY

The history of evolutionary theory is written in the life works of many persons. It continues today. A short list of early contribuitors follows.

Anaximander (611-547 BC) proposed the **theory of spontaneous generation** (Abiogenesis). It was supported by Plato, Aristotle, and Van Helmont.

Father Suarez (1548-1617) was the greatest supporter of the **theory of special creation**.

Francesco Redi (1626-1698) proposed the **theory of bio genesis**. It was supposed by Spallanzani, Louis Pasteur.

George Louis Leclerc (1707-1778) – The French naturalist, also known as the Conte de Buffon, who wrote a 44 volume Natural History of all known plants and animals. He suggested evolution but offered no proof.

Carl Linneus (1707-1778) – A Swedish botantist known as the "Father of Taxonomy". He developed the system of binomial nomenclature used to name and classify organisms today. He believed in seperate creation and the fixity of species. Although he did not belive in evolution his systematic methods for classifing are used to develop phylogenetic trees.

George Cuvier (1769-1832) – A vertebrate zoologist. He used comparative anatomy to classify animals. Proposed the Theory of Catastrophism which stated that after each worldwide castastrophe the world was repopulated by the surviving species which gave the appearance of chance over time.

Erasmus Darwin (1769-1802) – The grandfather of Charles Darwin, he was also a physician and naturalist. He suggested the possibility of evolution based on his studies of animal development, artifical breeding and vestigal organs.

James Hutton (1726- 1797) – Proposed the Uniformation Theory of Geology. According to Hutton, the earth is not static but subject to continueous cycles of erosion and uplifting. Weathered materials were deposited in layers which became sedimentary rock. This rock often contained fossils and would eventually be lifed from the sea beds to form land. It was called the uniformation theory because the forces at work were though to always act at a uniform rate. We known that is not the case today.

Charles Lyell (1796-1875) – Wrote the Principals of Geology which provided support for Hutton's theory.

Alfred Wegener 1880-1930) – The German earth scientist who proposed the Theory of Continental Drift in 1915. Controversial at the time, he propose the continents had undergone large movements over the past 300 million years. Today the science of Plate Tectonics studies the movement of the earth's crust.

Thomas Malthus (1766-1834) – Malthus was an English sociologist who wrote an Essay of Population in 1798. In his essay, he proposed that death and famine were inevitable because the human population tended to increase faster than the supply of food. This essay influenced Darwin greatly and was used in his formulation of the Theory of Natural Selection.

EVIDENCES OF EVOLUTION

1. Fossil Evidence

Fossils: Any body, body parts (traces) of animals and vegetables buried and preserved by natural causes. Fossils are remains, traces or other direct evidence of past life forms. Most fossils form from burial of plants and animals in sediment; soft parts are more often consumed or decomposed but may leave imprints if buried rapidly. Most fossils are embedded in sedimentary rock, weathered particles that provide strata from lower older layers to upper newer layers. Paleontologists study the fossil record based on boundaries between strata, where one mix of fossils gives way to another. Transitional links are intermediate between major groups. The fossil record allows us to trace the history of the modern-day horse Equus. The earliest fossils in this lineage is Hyracotherium , which was the size of a dog, with cusped low-crowned molars, four toes on each front foot, three on each hind foot—all adaptations for forest living. When forests were replaced by grasslands, the intermediates were selected for durable grinding teeth, speed, etc.with an increase in size and decrease in toes.

Types of fossils

(*i*) **Body fossils:** hard part of organism such as shell, tooth, bone etc.e.g. bones of dinosaurs.

(*ii*) **Subfossils:** Remains of animals and plants preserved in rocks less than 10,000 years e.g. vision in frozen ice. Sub fossils were formed after the last ice age during Holocene epoch.

(*iii*) **Microfossils:** microscopic remains less than 0.5 mm or 1/50th inch.

(*iv*) **Macrofossils:** Larger than 1 cm in size.

(*v*) **Unusual fossils:** Sudden preservation of entire organism e.g. Solenhofen Limestone of Southern Germany – containing fossils Archaeopteryx.

(*vi*) **Coprolities:** fossils of droppings of animal faecal matter. Large coprolities of crocodiles, Dinosaurs etc.

(*vii*) **Bioclast:** Fossils of fragments of fossils enclosed in sediments. The term is usually applied to thin sections of fossils under microscope.

(*viii*) **Gastroliths:** These are found in abundance in the body cavities of certain reptiles.

(*ix*) **Pseudofossils:** Many objects of inorganic origin closely resemble the forms of organic origin and are found in sedimentary rock.

Examples

- **Preservation in ice:** Woolly mammoths from Siberia. The flesh is so well preserved that it can be fed to dogs several thousand years. Discovered from Lena Delta in 1790 and Siberia in 1901.
- **Fossils in petroleum springs and asphalts:** Rancho La Brea now in Los Angeles.
- **Fossils in resins and ambers:** e.g. Fossil fly in amber from Baltic forests of Europe during Oligocene period.
- **Pterification of hard parts:** Fossils are found in sedimentary rocks. Soft parts disintegrate leaving the fossil porous. Water seeps into fossil and replaces the hard

part particle by silica or iron pyrite. The process of so gradual and slow that even the outlines of cellular structure are preserved.

- This process of fossilization to preserve the finer details is known as histometabasis.
- **Moulds and casts**: The material surrounding the fossil hardens and preserves the outer details. The actual bodies disintegrate and are removed by slippage of the ground leaving the harden cavities called moulds. When moulds are filled with natural deposits. They are called as casts e.g. fossils of Pompeii city buried in volcanic ash of mount Vesuvious in A.D.79.
- **Impressions**: Impressions of leaves of plants, feathers of extinct birds, wing membranes of flying reptiles, skin of dinosaur.
- **Tracks and trails**: The footprints or tracks left in the soft moist mud gets hardened up e.g. tracks of amphibians discovered near Pittsburg, Germany from Pennsylvanian period.
- **Mummies**: Bodies of dead animals or plants become dehydrated in the deserts and are preserved as mummies.

Law of Superposition: the lower strata of a geological formation were first to be deposited and is the oldest.

Connecting links are those living organisms which exhibit the characters of two different groups of organisms. For examples, protopterus between osteichthyes (bony fish) and amphibian; ***Ornithor-hynchus*** between reptilian and mammalian; ***Peripatus*** between annelida and arthropoda: *Fritschiella* between aquatic and land plants.

Pseudofossils – are the fossils like impressions formed on some rocks due to mineral deposition.

Missing links are those extinct organisms which possessed the characters of two different groups of organisms. For ex. *Archaeopteryx* (lizard -bird) is a missing links between the reptiles and the aves.

Synapsid reptiles were mammals like that gave rise to mammals. They had a single temporal fossa on the lateral side of skull and heterodon teeth. They are extinct.

2. Geological Time Scale

Geological time scale is the tabulate presentation of sequence and duration of different eras and periods with their dominant form or life. It had 5 principle eras: **Proterozoic, Archoeozoic, Paleozoic, Mesozoic and Cenozoic.** Geological history of earth is divided into eras, periods, and epochs. Fossil record provides relative dating of rock layers; top layers of rock are younger than lower layers. Absolute dating method uses radioactive isotopes. Isotopes each have particular half-life or time it takes for half of isotope to decay and become non-radioactive. Carbon-14 (14C) used to date organic matter; half decays to 14N each 5,730 years; limited to about last 50,000 years. Half of potassium-40 (40K) decays to argon-40 (40Ar) each 1.3 million years; estimates age of younger rocks. Uranium-238 decays to lead-207; estimates age of older rocks.

3. Mass Extinctions

Extinction is death of all members of species in wild; mass extinctions are extinctions of many species in short time. Five mass extinctions in fossil record define end of:

(*i*) Ordovician

(*ii*) **Devonian**

(*iii*) **Permian**

(*iv*) **Triassic**

(*v*) **Cretaceous**

Following extinctions, remaining groups expand to fill habitats vacated by extinct species. **Extinction of dinosaurs at end of Cretaceous:** Proposed in 1977 that Cretaceous extinction was caused by asteroid impact. Cretaceous-Tertiary border has high level of iridium, rare in earth's crust but common in meteorites. Calculations of effects of nuclear bomb explosions ("nuclear winter") compare with worldwide climate cooling expected from large asteroid impact. Worldwide layer of soot also defines iridium layer. Huge meteorite crater of correct age found in Caribbean Ocean and Yucatan peninsula; suspected site of impact of meteor that resulted in dinosaur extinction, Marine animal fossil record indicates mass extinctions occur every 26 million years; corresponds to movement of solar system within Milky Way galaxy.

The Alvarez Theory

Louis Alvarez, his son Walter, and their colleagues proposed that a giant asteroid or comet striking the earth some 65 million years ago caused the massive die-off at the end of the Cretaceous. Presumably, the impact generated so much dust and gases that skies were darkened all over the earth, photosynthesis declined, and worldwide temperatures dropped. The outcome was that as many as 75% of all species — including all dinosaurs — became extinct.

The key piece of evidence for the Alvarez hypothesis was the finding of thin deposits of clay containing the element iridium at the interface between the rocks of the Cretaceous and those of the Tertiary period (called the K-T boundary after the German word for Cretaceous). Iridium is a rare element on earth (although often discharged from volcanoes), but occurs in certain meteorites at concentrations thousands of times greater than in the earth's crust.

After languishing for many years, the Alvarez theory gained strong support from the discovery in the 90s of the remains of a huge (180 km in diameter) crater in the Yucatan Peninsula that dated to 65 million years ago. The abundance of sulfate-containing rock in the region suggests that the im pact generated enorm ous am ounts of sulfur dioxide (SO_2), which later returned to earth as a bath of acid rain. A smaller crater in Iowa, formed at the same time, many have contributed to the devastation. Perhaps during this period the earth passed through a swarm of asteroids or a comet and the repeated impacts made the earth uninhabitable for so many creatures of the Mesozoic.

4. Biogeographical Evidence

Biogeography is study of distribution of plants and animals throughout the world.Current distribution of organisms reflects evolutionary history; organisms evolve in one location and spread out into other regions; for example, no rabbits are found in South America—they originated elsewhere and did not each South America. Physical factors, including location of continents, limit population range.

Continental drift states that continents have slowly moved over time. Explains close puzzle-piece fit of east coast of South America with west coast of Africa, and other continent edges, distribution of seed ferns throughout southern continents. Explains distribution of early reptiles across many continents from time when land was conjoined and divided distribution of mammals that evolved after continents parted.

5. Anatomical Evidence

Many organisms share a unity of plan; for example, vertebrate forelimbs contain same sets of bones used for different functions in bat wings, whale fins, etc. Simplest explanation is having a common ancestor whose basic forelimb plan was modified in succeeding groups as each continued along its own evolutionary pathway.

Homologous organs are those which are similar in origin and basic structure but are adapted different to perform different functions e.g. fore limbs of vertebrates having pentadactyl limb origin and similar resemblance in arrangement of bones, muscles etc. Other examples of homologous organs include legs in different insects' teeth of man, thorn of *Bougainvillea* and tendril of *Passiflora.*

Analogous organ are those organs which do perform similar function but are different in basic structure and origin. For example, wing of insect and wing of bird leaf of plant and cladode of *Rucus* etc.

Vestigial structures are reduced and functionless anatomical features that are fully developed and functional in other ancestral groups. Vestigial structures are evidence of an organism's evolutionary history. eg. , Flightless birds have vestigial wings, Snakes have remnants of a pelvic girdle, Humans have a tail bone but no tail, Whale – femur (large bone). Related species share embryological development.

(*a*) All vertebrates exhibit notochord during development.

(*b*) All vertebrates, including humans, exhibit paired pharyngeal pouches.
  (*i*) In fishes and amphibians, these become functioning gills.
  (*ii*) In humans, they become the eustachian tubes, middle ear cavity, tonsils, and thyroid and parathyroid glands.

(*c*) Simplest explanation is that fish notochord and pharyngeal pouches are primitive fish features and fish are ancestral to other vertebrates.

Development of all **triploblastic** animals starts from zygote undergoes similar changes to form gastrula having 3 primary germ layers (ectoderm, mesoderm and endoderm) which have same fate in organogenesis. Earlier embryos of different vertebrates resembles in possessing similar structures like gills slits, notochord, tail etc. Not this only in the course of development at different stages an embryo looks like the embryo of different phyla form which the given organism has evolved. It is the **recapitulation theory** (modified into Biogenetic law by Haeckel) which states that "**ontogeny repeats phylogeny".**

6. Biochemical Evidence

Almost all living organisms use the same basic biochemicals: DNA, ATP, many identical enzymes, DNA triplet code, 20 amino acids, introns, and hypervariable regions. (Prokaryotes i.e. true bacteria (Domain Eukarya), do not have introns. This points to a long period of time since all living things shared common acestory. Similarity of biochemistry is explained by descent from common ancestor.

DNA base sequences differences in DNA between a number of organisms shows less difference the more closely related they are; for example, 2.5% difference between humans and chimpanzees but 42% difference between humans and lemurs. Amino acid sequences of cytochrome c show similarity between human and monkey, distance from human to duck and greater distance to Candida yeast. Data are understandable assuming humans and chimpanzees share a more recent common ancestor than do humans and lemurs, ducks, or yeast. Biochemical evidence is generally consistent with anatomical similarity of organisms.

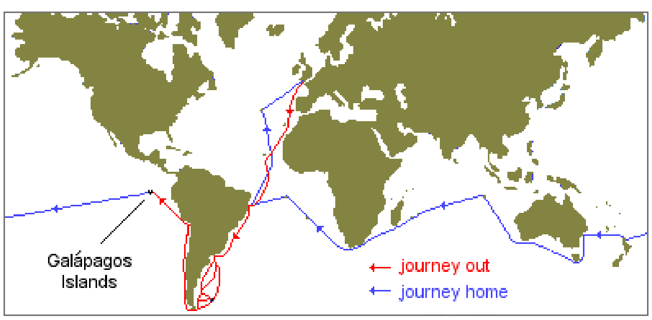
THEORIES OF EVOLUTION

1. Lamark's theory of inheritance of acquired characteristics

Jean Batiste de Lamarck (1809) proposed the theory of "inheritance of acquired characters" in his book "**PHILOSOPHIC ZOOLOGIQUE**". He believed that changes in the environmental factors or migration result in new disuse of certain other organs. This extra use and disuse of organs induce the development and degeneration respectively of certain characters. These change characters called acquired characters are inherited by next generation and gradually accumulate over many generations leading to the origin of new species. **Lamarck** supported his theory by giving the examples of evolution of long forelimbed and long-necked giraffe from the deer-like ancestors. But Lamarckism was also objected to by a number of scientists. Strong evidence against Lamarckism was Theory of Continuity of Germplasm proposed by **August Weismann** in 1892 A.D.

2. Evolution by Natural Selection

The idea (given voice by Lamarck) that species could change over time was not immediately acceptable to many: the lack of a mechanism hampered the acceptance of the idea as did its implications regarding the biblical views of creation. Charles Darwin and Alfred Wallace both worked independently of each other, traveled extensively, and eventually developed similar ideas about the change in life over time as well as a mechanism for that change: **natural selection.** Charles Darwin secured an unpaid position as ship's naturalist on the H.M.S. Beagle. The voyage would provide Darwin a unique opportunity to study adaptation and gather a great deal of proof he would later incorporate into the theory of evolution. Darwin spent much time ashore collecting plant, animal and fossil specimens, as well as making extensive geological observations. On his return to England in 1836, Darwin began to catalog his collections and ponder the seeming "fit" of organisms to their mode of existence. He eventually settled on four main points of the theory.



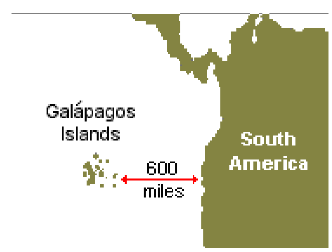


Fig: Five year voyage of H.M.S. Beagle (1831-1836)

1. **Adaptation**: all organisms adapt to their environments.
2. **Variation:** all organisms are variable in their traits.
3. **Over-reproduction:** all organisms tend to reproduce beyond their environment's capacity to support them (this is based on the work of Thomas Malthus, who studied

how populations of organisms tended to grow geometrically until they encountered a limit on their population size).

4. Since not all organisms are equally well adapted to their environment, some will survive and reproduce better than others — this is known as **natural selection**. Sometimes this is also referred to as "survival of the fittest". In reality this merely deals with the reproductive success of the organisms, not solely their relative strength or speed.

The Wallace-Darwin Theory

- Individuals in a population have variable levels of agility, size, ability to obtain food, and different successes in reproduction.
- Left unchecked, populations tend to expand exponentially, leading to a scarcity of resources.
- In the struggle for existence, some individuals are more successful than others, allowing them to survive and reproduce.
- Those organisms best able to survive and reproduce will leave more offspring than those unsuccessful individuals.
- Over time there will be heritable changes in phenotype (and genotype) of a species, resulting in a transformation of the original species into a new species similar to, but distinct from, its parent species.

Support to Natural Selection

1. **Industrial melanism**: before industrial revolution the dull grey forms of peppered moth– *Biston betularia*-were dominant the carbonaria form (black) was rare because it was susceptible to predation by birds. The reason was that it was conspicuously visible while resting on tree trunks.

   The industrial revolution resulted in large scale smoke which got deposited on tree trunks turning them black. Now grey varieties became susceptible the black forms flourished. Replacement of coal by oil and electricity, reduced shoot production – the frequency of grey moths increased again.
2. **Sickle cell anemia and malaria**: Individuals homozygous for sickle cell anaemia die at an early age. In heterozygous individuals, the cell containing abnormal hemoglobin become sickle shaped, it kills malarial parasites effectively so that these individuals are able to come with malaria infection much better than normal person.
3. **J. Lederberg and E. Lederberg** provided experimental evidence for '**selection**' in bacteria. By using replica plating techniques they demonstrated the process of '**selection**' of antibiotic resistance strains of bacteria.

Natural Selection and Genetics (Neo-Darwinism)

Neither Darwin nor Wallace could explain how evolution occurred: how were these inheritable traits (variations) passed on to the next generation? (Recall that Gregor Mendel had yet to publish his ideas about genetics). During the 20th century, genetics provided that answer, and was linked to evolution in neoDarwinism, also known as the Modern Synthesis.

Populations: Without variation (which arises from mutations of DNA molecules to produce new alleles) natural selection would have nothing on which to act. A population is a group of individuals living in the same geographical area and sharing a common gene pool. The gene pool is the sum of all genetic information carried by the members of a population.

All genetic variation in a population is generated by mutation. Mutation is any heritable change in DNA. Mutations can be changes of a single nucleotide base or may involve changes in chromosome number. Whether a mutation is good, neutral, or harmful depends on how it affects survival and reproductive success.

Mutation Rate: Gene mutations result in new alleles, and are the source of variation within populations. Gene mutations are ultimately behind the other mechanisms that provide variation. Due to DNA replication and DNA repair mechanisms, mutation rates of individual genes are low, but since each organism has many genes, and a population has many individuals, new mutations arise in populations all the time. Thus, mutations are relatively common, and the mutation rate is an adequate source of new alleles. High levels of molecular variation are common in natural populations, although many mutations (usually recessive) are hidden. The mutation rate varies greatly among species and even among genes of an individual. Mutations are caused by errors in DNA replication, chemicals, or radiation. Large scale effects of mutation result only when mutation is combined with other factors that reshuffle the gene pool. Selection acts on individuals, not their individual genes. Sexual reproduction increases variation by reshuffling the genetic information from parents into new combinations in their offspring. Mutations produce new alleles.

Additional Sources of Variation

1. Genetic Drift

Gene flow moves alleles among populations through interbreeding as well as by migration of breeding individuals. Gene flow increases variation within a population by introducing new alleles produced in another population. Continued gene flow tends to decrease the diversity among populations, causing gene pools to become similar. Reduction or restriction of gene flow between populations is essential for the development of new species. The frequency of alleles can change from generation to generation as a result of chance alone in a small gene pool. This phenomenon is known as **genetic drift.**

Random mating involves individuals pairing by chance, not according to their genotypes or phenotypes. Nonrandom mating involves individuals inbreeding and assortative mating. Inbreeding is mating between relatives to a greater extent than by chance; inbreeding can occur if dispersal is so low that mates are likely to be related and does not change allele frequencies, but it does decrease the proportion of heterozygotes and increase the proportions of both homozygotes at all gene loci. Assortative mating occurs when individuals tend to mate with those that have the same phenotype. Assortative mating divides a population into two phenotypic classes with reduced gene exchange. Genetic drift is changes in allele frequencies of a gene pool due to chance or random events. This can occur in large or small populations. Genetic drift causes gene pools of two isolated populations to become dissimilar as some alleles are lost and other are fixed. Genetic drift occurs when founders (or colonizers) establish a new population, or after a genetic bottleneck and resultant interbreeding. The founder effect is a case of genetic drift in which rare alleles, or combinations of alleles, occur in higher frequency in a population isolated from the general population. Founding individuals contain a fraction of the total genetic diversity of original gene pool. The allele carried by founders is determined by chance alone. Consider the Pilgrim colonists in New England. By no means did they represent all the genetic variation of the human species or even genetic variations among Europeans.

2. A bottleneck effect

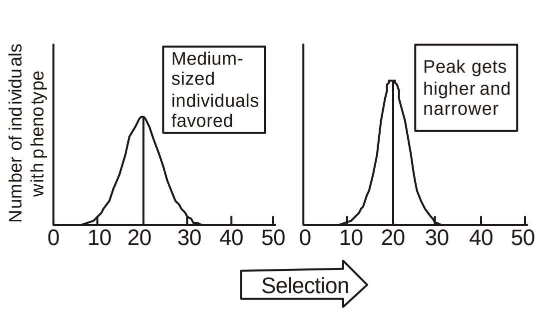
Drastic short-term reductions of population size caused by natural disasters, disease, or predators may result in (by chance) the survivors representing only a small portion of the original gene pool. Even when the population increases to its original size, a portion of its original genetic diversity remains lost. This feature, termed a **bottleneck**, is a problem with many endangered species. A bottleneck effect is genetic drift in which a severe reduction in population size results from natural disaster, predation, or habitat reduction. This results in a severe reduction of the total genetic diversity of the original gene pool. The cheetah bottleneck causes relative infertility because of the intense inbreeding. Similarly, the Hawaiian silversword has passed recently through its own bottleneck. Recent studies on humans suggest that there may have been one or more instances of severe genetic bottlenecks in our own prehistory. The bottleneck effect prevents most genotypes from participating in production of next generation.

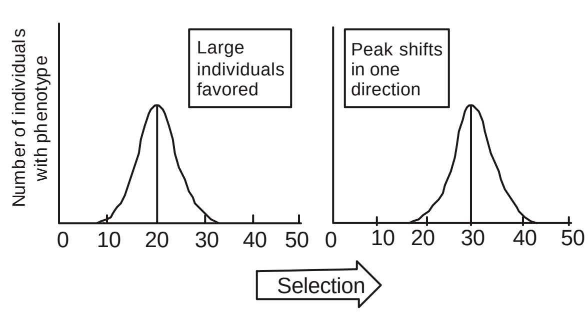
3. Migration (Gene Flow)

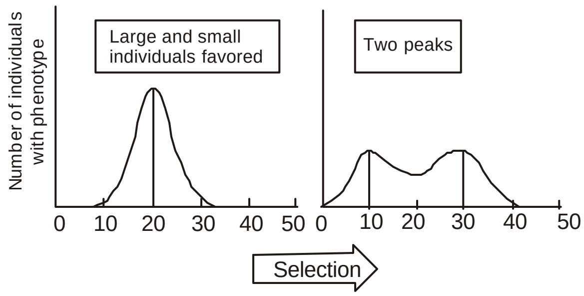
Into or out of a population can breakdown genetic differences between populations. Mutations developing in one population may be spread to other populations by migration. This serves, like mutation, to introduce new alleles into populations.

4. Natural Selection

Not all members of a population necessarily have an equal chance of surviving and reproducing (due to competition for resources and mates). By virtue of small phenotypic variations, some individuals are better adapted to their environment than are others. The better adapted individuals are more “fit” and tend to survive and reproduce, passing on their adaptations to the next generation in greater frequency than those adaptations of the less “fit” members of the population. Fitness is a measure of an individuals ability to survive and reproduce. Those with the highest fitness are more likely to survive and reproduce. Thus, they make a greater contribution to the gene pool, of the next generation than do those less “fit”. Natural selection is the process of differential survival and reproduction that inevitably leads to changes in allele frequencies over time as those individuals who are the most “fit” survive and leave more offspring. There are three patterns, or types, of natural selection.







1. Stabilizing Selection

Stabilizing selection favors the intermediate phenotype out of a range of phenotypes. The extremes in variation are selected against. Selection works against both extremes.

2. Directional Selection

Directional selection tends to favor phenotypes at one extreme of the range of variation. Insecticide resistance is an example. DDT was a widely used insecticide. After a few years of extensive use, DDT lost its effectiveness on insects. Resistance to DDT is a genetic trait that the presence of DDT in the environment made into a favored trait. Only those insects resistant to DDT survived, leading over time to populations largely resistant to DDT. Another example is **Industrial melanism** in the peppered moth (Biston betularia)**)**. Before the Industrial Revolution in the 18th and early 19th centuries, only light-colored moths were collected in light-colored woodlands in England.There was a rare, dark form. With the pollution caused by the buring of coal, the light-colored tree trunks became darker due to soot. The once rare dark-colored moths became more prevalent, while the once-common light-colored moths became increasingly rare. Reason: predation by birds. The color that had the greatest contrast with the background (tree trunk) was at a disadvantage. Cleanup of the forest during the 1950s caused the allele frequencies of light and dark moths to reverse to pre-Industrial Revolution levels, dark moths are now rare, light moths are now common. The resistance of many bacterial species to antibiotics ia another example of directional selection. Over 200 species show some degree of antibiotic resistance, necessitating the development and more prudent use of a new generation of antibiotic medicines.

3. Disruptive Selection

In some circumstances, individuals at both extremes of a range of phenotypes are favored over those in the middle. This is called disruptive selection. An example: The residues (“tailings”) of mines often contain such high concentrations of toxic metals (e.g., copper, lead) that most plants are unable to grow on them. However, some hardy species (e.g. certain grasses) are able to spread from the surrounding uncontaminated soil onto such waste heaps. These plants develop resistance to the toxic metals while their ability to grow on uncontaminated soil decreases. Because grasses are wind pollinated, breeding between the resistant and nonresistant populations goes on. But evidently, disruptive selection is at work. Higher death rates of both less resistant plants growing on contaminated soil and more resistant plants growing on uncontaminated soil leads to increasing divergence of the populations into two subpopulations with the extreme manifestations of this trait. The evolutionary significance of disruptive selection lies in the possibility that the gene pool may become split into two distinct gene pools. This may be a way in which new species are formed.

Mortality Selection: Certain genotypes are less successful than others in surviving through to the end of their reproductive period.The evolutionary impact of mortality selection can be felt anytime from the formation of a new zygote to the end (if there is one) of the organism's period of fertility. Mortality selection is simply another way of describing Darwin's criteria of fitness: survival.

Fecundity Selection: Certain phenotypes (thus genotypes) may make a disproportionate contribution to the gene pool of the next generation by producing a disproportionate number of young. Such fecundity selection is another way of describing another criterion of fitness described by Darwin: family size. In each of these examples of natural selection certain phenotypes are better able than others to contribute their genes to the next generation. Thus, by Darwin's standards, they are more fit. The outcome is a gradual change in the gene frequencies in that population.

Microevolution: Accumulation of small changes in gene pool over a relatively short period of two or more generations. In classic observations and experiments, dark colored moths went from being 10% of population to 80% when soot colored trees and switched success of predators.

Place and Sequence of Human Evolution

There is evidence that almost all of Hominid evolution occurred in Africa and Asia and that the evolution of the human species took place in Africa. Several species belonging to the genus *Homo* can be recognized from the fossil record. For example, *Homo habilis* lived in Africa about two million years ago and was characterized by having a larger brain that *Australopithecus*, using tools and being bipedal. Another species, *Homo erectus* appeared about 1.7 million years ago, used fire and is believed to have migrated to Asia and Europe. Fossils of the so-called 'Java man' and 'Peking man' belong to *Homo erectus*. *Homo erectus* was replaced by *Homo sapiens*.

A primitive form of *Homo sapiens*, called Neanderthal man (*Homo sapiens neanderthalensis*), was common in Europe and Asia. The Neanderthal men resembled us, though they were relatively short and stocky and more powerfully built. The Neanderthals made tools and used animal hides as clothing. They built hut-like structures for dwelling and buried their dead. There is evidence that an abrupt transition occurred all over Europe whereby the Neanderthal man was wiped out and gave way to the more efficient cousin, the Cro-Magnon, about 34000 years ago. The Cro-Magnon people left behind very elaborate cave paintings showing the attainment of a form of culture not unlike our own. After the last glacial period (about 10,000 years ago), modern *Home sapiens* began to spread all over the globe, cultivated plants, domesticated animals and reached enormous population sizes.

Homo sapiens appeared in Africa about 500,000 years and probably replaced *Homo erectus* there. But in Asia *Homo erectus* appears to have survived for another 250,000 years when it was finally replaced by *Homo sapiens* migrating from Africa.

POPULATION GENETICS

A population is a group of potentially interbreeding organisms of the same species occupying a certain area. Members of a population vary from one another. This variation is the raw material on which natural selection operates. There are several types of mutations, both at the gene-level and the chromosome-level. Gene mutations provide new alleles, making these mutations the ultimate source of variation. A gene mutation is an alteration in the DNA nucleotide sequence, producing an alternate sequence, termed an allele.

Mutations occur at random, and can be beneficial, neutral, or harmful. Some chromosomal mutations are changes in the number of chromosomes inherited, while others are alterations in arrangement of alleles on chromosomes due to inversions and translocations.

In sexually reproducing organisms, genetic recombination is the reallocation of alleles and chromosomes. Recombination results from crossing-over during meiosis, the random segregation of chromosomes to gametes during meiotic division, and the random combination of gametes during fertilization.

The entire genotype is subject to natural selection since new combinations of alleles may have improve the reproductive success of the organism. For polygenic traits, the most favorable combination may occur when the right alleles group by recombination. Not only are variations created, they are also preserved and passed on from one generation to the next. The gene pool is the total of all the alleles in a population, in the context of gene frequencies. Neither dominance nor sexual reproduction will change allele frequencies.

Hardy-Weinberg equilibrium is a constancy of gene pool frequencies that remains across generations, and might best be found among stable populations with no natural selection or where selection is stabilizing. Microevolution is the accumulation of small changes in a gene pool over a relatively short period.

The Hardy-weinberg Equilibrium

The Hardy-Weinberg equilibrium is the central theoretical model in population genetics. The concept of equilibrium in the Hardy-Weinberg model is subject to the following hypotheses/ conditions:

1. The population is panmictic [couples form randomly (panmixia), and their gametes encounter each other randomly (pangamy)].
2. The population is "infinite" (very large: to minimize differences due to sampling).
3. There must be no selection, mutation, migration (no allele loss /gain).
4. Successive generations are discrete (no crosses between different generations).

Under these circumstances, the **genetic diversity** of the population is maintained and must tend towards a **stable equilibrium** of the distribution of the genotype.

The Hardy-Weinberg law can be used under some circumstances to calculate genotype frequencies from allele frequencies. Let A1 and A2 be two alleles at the same locus,

p is the frequency of allele A1 $0 =< p =< 1$

q is the frequency of allele A2 $0 =< q =< 1$ and $p + q = 1$

where the distribution of allele frequencies is the same in men and women, then

$p \times p = p^2$ $p \times q = pq$ $q \times p = pq$ $q \times q = q^2$

they procreate : $(p + q)^2 = p^2 + 2pq + q^2 = 1$

where

p^2 = frequency of the A1 A1 genotype ← HOMOZYGOTE

$2pq$ = frequency of the A1 A2 genotype ← HETEROZYGOTE

q^2 = frequency of the A2 A2 genotype ← HOMOZYGOTE

these frequencies remain constant in successive generations.

Example: autosomal recessive inheritance with alleles A and a, and allele frequencies p and q:

→ frequency of the genotypes: : AA = p^2 and the phenotypes [ ]: [A] = p^2 + 2pq

Aa = 2pq [a] = q^2

aa = q^2

Example: phenylketonuria (recessive autosomal), of which the deleterious gene has a frequency of 1/100:

$$\rightarrow \quad q = 1/100$$

therefore, the frequency of this disease is $q^2 = 1/10\ 000$,

and the frequency of heterozygotes is $2pq = 2 \times 99/100 \times 1/100 = 2/100$;

Note that there are a lot of heterozygotes: 1/50, two hundred times more than there are individuals suffering from the condition. .

For a rare disease, p is very little different from 1, and the frequency of the heterozygotes = 2q.

We use these equations implicitly, in formal genetics and in the genetics of pooled populations, usually without considering whether, and under what conditions, they are applicable.

Species Concept and Mechanisms of Speciation

Evolutionary theory must explain macroevolution, the origin of new taxonomic groups (e.g., new species, new genera, new families). Speciation, or the origin of new species, is a central process of macroevolution because any genus, family, or higher taxon originates with a new species novel enough to be the first member of the higher taxon. The fossil record provides evidence for two patterns of speciation: anagenesis and cladogenesis.

1. **Anagenesis (phyletic evolution)** = The transformation of an unbranched lineage of organisms, sometimes to a state different enough from the ancestral population to justify renaming it as a new species.
2. **Cladogenesis (branching evolution)** = The budding of one or more new species from a parent species that continues to exist; is more important than anagenesis in life's history, because it is more common and can promote biological diversity.

Species are often considered the bridge between micro- and macroevolution. Traditionally, taxonomists (e.g., Carl Linnaeus) used a typological species concept. Individual members of a species are characterized by a particular (morphological) type. However, the problem arises here that there is almost always phenotypic variation within populations, which can be extreme. Examples of significant variation caused by single-locus polymorphisms that can thus occur within one litter snow goose and king snake color patterns, variation in duration of circadian cycle in Drosophila through variation at the per locus. The widespread existence of variation together with Darwin's view that species specific characteristic traits can evolve lead to an abandonment of the typological species concept.

The most widespread species concept currently in use is the Biological Species Concept (BSC), as defined by Ernst Mayr: **Species are groups of actually or potentially interbreeding populations which are reproductively isolated from other such groups.**

The criterion here is that interbreeding or gene exchange among organisms must occur, either actually or potentially. Viable offspring alone is not enough. The term potentially refers to a situation where, for instance, there are populations that are geographically isolated but that could interbreed if brought in contact. Such populations represent one species under the BSC.

Merits of the BSC: The definition defines species as units of evolution, by virtue of their interbreeding, which makes it a "natural" species concept from an evolutionary standpoint.

Problems with the BSC: It does not apply to asexual populations, thus raises the question how, for example, many bacterial species are to be defined.In practice, the species concept used for prokaryotes is still a typological species concept.

Interbreeding vs. reproductive isolation is not an all-or-none distinction

Examples: Hybrid zones of the hooded crow and carrion crow where their ranges get into contact. These crow populations are neither fully interbreeding nor fully isolated, hence the name semispecies.

Sympatric hybridization: sometimes species whose ranges have come into contact after allopatric speciation hybridize to a limited extent.

Ring species: For instance, a californian salamander, Ensatina eschscholtzii, occurs on both sides of the central valley in California, but not in the valley. There is a chain of 7 subspecies that form a ring around the valley. Mitochondrial data suggest that the origination of this range was the north, from which the populations migrated southward at both sides of the valley. All adjacent populations interbreed, except for the two southernmost ones.

Practical limitations: For allopatric populations, one would have to assess whether the members actually interbred, which is often not feasible (they might not breed in captivity). However, even if possible to show that they can interbreed in captivity, one can not be sure that they would actually interbreed in nature when brought into contact.

There are many other species concepts with more restricted usage. One example is the **phylogenetic species concept** which emphasizes common evolutionary history. It is defined as a irreducible basal cluster of organisms diagnosably different from other such clusters, and within which there is a parental pattern of ancestry and descent. Any character that distinguishes a population would define it as a species, regardless of whether it interbreeds with others or not. This species concept will lead to a classification of organisms that can sometimes be different from BSC. It also applies to asexual organisms.

Examples for barriers to gene flow

1. Prezygotic barriers

(*a*) *Temporal isolation:* Two species of field crickets reach reproductive age in the fall and in the spring in the N East of U.S.

(*b*) *Habitat isolation:* Two sympatric species of herbivorous ladybird beetles feed on thistles and blue cohosh, respectively. They mate on their respective host plants, which are their microhabitats.

(*c*) *Ethological isolation:* Frequent in animals, the courting individual sends out signals only to conspecific individuals, or, if not, the courted individual does not respond. Female crickes tend to react only to the conspecific male's courtship song. Male moths are often only attracted by conspecific's sex pheromones.

(*d*) *Mechanical isolation*: Two swedish orchids (genus Platanthera) use different moths as pollinators. Their morphologies are such that the pollen masses (pollinia) attach to different parts of the moths, i.e.,the proboscis and the eye. Plants with intermediate flower morphology have lower pollination success.

(*e*) *Gametic incompatibility*: Especially important among external fertilizers, e.g., marine invertebrates. In a species of large marine snails, the sperm contains an enzyme that can dissolve the vitelline membrane only of a conspecific egg. In flowering-incompatible plants, when pollen is placed on the stigma, the growth of the pollen tube through the style may be arrested, a phenomenon not well understood physiologically.

2. Postzygotic barriers

When prezygotic barriers are crossed and a hybrid zygote forms, one of several postzygotic barriers may prevent development of a viable, fertile hybrid.

(*a*) *Reduced hybrid viability:* Genetic incompatibility between the two species may abort development of the hybrid at some embryonic stage. For example, several species of frogs in the genus Rana live in the same regions and habitats. They occasionally hybridize but the hybrids generally do not complete development, and those that do are frail and soon die.

(*b*) *Reduced hybrid fertility:* If two species mate and produce hybrid offspring that are viable, reproductive isolation is intact if the hybrids are sterile because genes cannot flow from one species' gene pool to the other. One cause of this barrier is that if chromosomes of the two parent species differ in number or structure, meiosis cannot produce normal gametes in the hybrid. The most familiar case is the mule which is produced by crossing a donkey and a horse; very rarely are mules able to backbreed with either parent species.

(*c*) *Hybrid breakdown:* When some species cross-mate, the first generation hybrids are viable and fertile, but when these hybrids mate with one another or with either parent species, offspring of the next generation are feeble or sterile. For example, different cotton species can produce fertile hybrids, breakdown occurs in the next generation when progeny of the hybrids die in their seeds or grow into weak defective plants.

Modes of speciation

Reproductive barriers form boundaries around species, and the evolution of these barriers is the key biological event in the origin of new species. An essential episode in the origin of a species occurs when the gene pool of a population is separated from other populations of the parent species. This genetically isolated splinter group can then follow its own evolutionary course, as changes in allele frequencies caused by selection, genetic drift, and mutations occur undiluted by gene flow from other populations.

The main modes here are allopatric, sympatric, parapatric, and peripatric speciation.

1. Allopatric Speciation

Speciation that occurs when the initial block to gene flow is a geographical barrier that physically isolates the population. Such occurrences include emergence of mountain ranges, movement of glaciers, formation of land bridges, subsidence of large lakes. Geographical populations often differ genetically, which includes genetic markers associated with reproductive isolation.

Adaptive radiation = The evolution of many diversely adapted species from a common ancestor. Examples of adaptive radiation are the endemic species (= species confined to a specific small geographical region) of the Galapagos Islands which descended from small populations which floated, flew, or were blown from South America to the islands. Darwin's finches can be used to illustrate a model for such adaptive radiation on island chains. A single dispersal event may have seeded one island with a peripheral isolate of the ancestral finch which diverged as it underwent allopatric speciation. A few individuals of this new species may have reached neighboring islands, forming new peipheral isolates which also speciated.
Vicariant Speciation: Two populations of comparable size ecome separated by a barrier.

2. Peripatric Speciation (Founder Effect Speciation, Speciation via "Shifting Balance")

Small founder populations colonize an area outside the main population range. Populations adapted to an environment can be thought of as occupying peaks in an adaptive landscape. These peaks represent alternative optimal genotypic organizations. The proposed mechanism relies on a combination of genetic drift (which will be strong in small founder populations), and natural selection. Consider a small karyotypic anomaliy in the parental population. If drift can drive this karyotype to a population frequency > 0.5, it may become the dominant, and thus favored karyotype. Selection will then drive it to the nearest adaptive peak. Founder effect speciation is thought to cause a rapid reorganizations of the genetic constitution of populations, which is associated with reproductive isolation. Notice the fundamental difference between the genetic model for allopatric speciation in general, and for peripatric speciation: in peripatric speciation, no environmental differences in the two habitats are required.

Evidence for peripatric speciation: Many examples are available from natural populations, geographic variation of sexual dimorphism (plumage color of male-female) in the robin Petroica multicolor. On mainland Australia, the dimorphism is uniform, whereas on peripheral islands, there is a wide variation in dimorphism.

Experimental populations: Reproductive isolation evolves sometimes in populations of Drosophila and mice that are subjected to repeated population bottlenecks.

3. Sympatric Speciation

Sympatric speciation = Formation of new species within the range of parent populations. Reproductive isolation evolves without geographical isolation. This can occur quickly (in one generation) if a genetic change results in a reproductive barrier between the mutants and the parent population. Many plant species have originated from improper cell division that results in extra sets of chromosomes-a mutant condition called polyploidy. Depending on the origin of the extra set of chromosomes, polyploids are classified in two forms: autopolyploids and allopolyploids.

Autopolyploid = An organism that has more than two chromosome sets, all derived from a single species. For example, Nondisjunction in the germ cell line (in either mitosis or meiosis) results in diploid gametes. Self-fertilization would double the chromosome number to the tetraploid state. Tetraploids can self-pollinate or mate with other tetraploids. The mutants cannot interbreed with diploids of the parent population because hybrids would be triploid (3n) and sterile due to impaired meiosis from unpaired chromosomes. An instantaneous special genetic event would thus produce a postzygotic barrier which isolates the gene pool of the mutant in just one generation.

Allopolyploid = A polyploid hybrid resulting from contributions by two different species. More common than autopolyploidy. Potential evolution of an allopolyploid begins when two different species interbreed and a hybrid is produced. Such interspecific hybrids are usually sterile, because the haploid set of chromosomes from one species cannot pair during meiosis with the haploid set of chromosomes from the second species. These sterile hybrids may actually be more vigorous than the parent species and propagate asexually. They would be more vigorous because they have the best qualities of both species. At least two mechanisms can transform sterile allopolyploid hybrids into fertile polyploids. We will discuss just one of these:

During the history of the hybrid clone, mitotic nondisjunction in the reproductive tissue may double the chromosome number. The hybrid clone will then be able to produce gametes since each chromosome will have a homologue to synapse with during meiosis. Gametes from this fertile tetraploid could unite and produce a new species of interbreeding individuals, reproductively isolated from both parent species. Speciation of polyploids (especially allopolyploids) has been very important in plant evolution. Some allopolyploids are very vigorous because they contain the best qualities of both parent species. The accidents required to produce these new plant species (interspecific hybridization coupled with nondisjunction) have occurred often enough that between 25% and 50% of all plant species are polyploids. Sympatric speciation may also occur in animal evolution through different mechanisms.

A group of animals may become isolated within the range of a parent population if genetic factors cause them to become fixed on resources not used by the parent population as a whole. For example, A particular species of wasp pollinates each species of figs. The wasps mate and lay their eggs in the figs. A genetic change causing wasps to select a different fig species would segregate mating individuals of the new phenotype from the parental population. Divergence could then occur after such an isolation.

4. Parapatric Speciation

Evolution of reproductive isolation within one continuous population in adjacent regions. It may require very strong divergent selection within the population and or selection for reproductive isolation itself, which is controversial.

FACTORS FACILITATING SPECIATION

1. Ecological factors

For example, the low dispersal rates of Drosophila and ample opportunities for geographical isolation may have enabled rapid speciation in the Hawaiian islands.

2. Factors internal to the organism

These are in general poorly understood, but one instructive example exists. Primitive frogs have a short inner ear that restricts them to a small range of frequencies (and thus to a limited potential to distinguish mating calls). "Advanced" frogs have a much longer inner ear and frequency range. Speciation rates seem to have increased in frog evolution, which may be facilitated by increased opportunities for sexual selection, sexual isolation, and speciation.

3. Adaptive divergence

Two populations which adapt to different environments accumulate differences in the frequencies of alleles and genotypes. During this gradual adaptive divergence of the two gene pools, reproductive barriers may evolve between the two populations. Evolution of reproductive barriers would differentiate these populations into two species. A key point in evolution by divergence is that reproductive barriers can arise without being favored directly by natural selection. Divergence of two populations is due to their adaptation to separate environments, with reproductive isolation being a secondary development. Gradual genetic divergence of two populations may also result in the evolution of pre-zygotic barriers. For instance, an ecological barrier to inbreeding may secondarily result from the adaptation of an insect population to a new host plant different from the original population's host.

4. Hybrid zones and the cohesion concept of species

Three possible outcomes are possible when two closely related populations that have been allopatric for some time come back into contact: The two populations may interbreed freely. The gene pools would become incorporated into a single pool indicating that speciation had not occurred during their time of geographical isolation. The two populations may not interbreed due to reproductive barriers. The gene pools would remain separate due to the evolutionary divergence which occurred during the time of geographical isolation. Speciation has taken place. A hybrid zone may be established.

Hybrid zone = A region where two related populations that diverged after becoming geographically isolated make secondary contact and interbreed where their geographical ranges overlap For example, the red-shafted flicker of western North America and the yellowshafted flicker of central North America are two phenotypically distinct populations of woodpeckers that interbreed in a hybrid zone stretching from southern Alaska to the Texas panhandle. The two populations came into renewed contact a few centuries ago after being separated during the ice ages. The hybrid zone is relatively stable and not expanding.

HOW MUCH GENETIC CHANGE IS REQUIRED FOR SPECIATION?

No generalizations can be made about genetic distance between closely related species. Reproductive isolation may result from changes in many loci or only in a few.

The punctuated equilibrium model has stimulated research on the tempo of speciation. Traditional evolutionary trees diagram the descent of species from ancestral forms as branches that gradually diverge with each new species evolving continuously over long spans of time. Big changes thus occur due to the accumulation of many small changes.

Paleontologists rarely find gradual transitions of fossil forms but often observe species appearing as new forms suddenly in the rock layers. These species persist virtually unchanged and then disappear as suddenly as they appeared. Even Darwin, who believed species from a common ancestral stock evolve differences gradually, was perplexed by the lack of transitional forms in the fossil record. Advocates of punctuated equilibrium have redrawn the evolutionary tree to represent fossil evidence for evolution occurring in spurts of relatively rapid change instead of gradual divergence.

This theory was proposed by **Niles Eldredge and Stephen** Jay Gould in 1972. It depicts species undergoing most of their morphological modification as they first separate from the parent species then showing little change as they produce additional species. In this theory gradual change is replaced with long periods of stasis punctuated with episodes of speciation.

The origin of new polyploid plants through genome changes is one mechanism of sudden speciation. For a population facing new environmental conditions, genetic drift and natural selection can cause significant change in only a few hundred or thousand generations. A few thousand generations is considered rapid in reference to the geologic time scale.

The fossil record indicates that successful species survive for a few million years on average. If a species survives for five million years and most of its morphological changes occur in the first 50,000 years; then the speciation episode occurred in just 1% of the species' lifetime. With this time scale, a species will appear suddenly in rocks of a certain age, linger relatively unchanged for millions of years, then become extinct.

An evolutionary spurt preceding a longer period of morphological stasis would explain why paleontologists find so few transitions in the fossils record of a species. Because "sudden" can refer to thousands of years on the geological time scale, differing opinions of punctuationalists and gradualists about the rate of speciation may be more a function of time perspective than conceptual difference.

There is clear disagreement, however, over how much a species changes after its origin. Hybrid sterility has a continuous range, from none to complete, and may be caused by two main factors generation of aneuploid gametes due to structural chromosomal differences between the genes of the parents, which may interact "disharmoniously", as opposed to the "co-adapted" gene complexes within the species.

Arguments against this hypothesis are morphology can change within lineages, stable lineages in the fossil record do fluctuate, the low resolution of the fossil record (<100000yr). If its resolution was higher, the argument goes, one would observe that the apparently sudden transitions are actually gradual transitions.

Punctuated gradualism: Character evolution is episodic, but not necessarily associated with speciation. The most contentious issue here is between hypothesis one and two. To distinguish between the two, one has to assess whether morphological change is usually associated with speciation.

Missing links: They are frequent in the fossil record (e.g., body plan types), and there are two alternative possibilities for why they occur. First, if most major phenotypic changes were brought about by macromutations (saltatory evolution then no links would exist. Goldschmidts macromutations were proposed as a complete "repatterning" of the chromosomal material, not single gene mutations. There is no evidence for such large scale repatterning leading to viable organisms. Single gene "macromutations" occur (e.g., homeotic mutations), but they usually are highly deleterious. If most phenotypic evolution occurs according to the punctuated equilibrium hypothesis via founder effect speciation, the frequent absence of missing links would be explicable by the small transitional population sizes involved.Thus, the phenotypic changes may be continuous, but poorly preserved.

POLYMORPHISM

A polymorphism is a genetic variant that appears in at least 1% of a population. Examples: the human ABO blood groups, the human Rh factor the human major histocompatibility complex (MHC). By setting the cutoff at 1%, it excludes spontaneous mutations that may have occurred in — and spread through the descendants of — a single family.

Protein Polymorphisms: All the examples above are of the protein products of alleles. These can be identified by: serology; that is, using antibodies to detect the different versions of the protein and electrophoresis; if amino acid changes in the protein alter its net electrical charge, it will migrate more or less rapidly in an electrical field.

Enzymes are frequently polymorphic: A population may contain two or more variants of an enzyme encoded by a single locus. The variants differ slightly in their amino acid sequence and often this causes them to migrate differently under electrophoresis. By treating the gel with the substrate for the enzyme, its presence can be visualized. Electrophoretic variants of an enzyme occurring in a population are called **allozymes**.

Restriction Fragment Length Polymorphisms (RFLPs): Proteins are gene products and so polymorphic versions are simply reflections of allelic differences in the gene; that is, allelic differences in DNA. Often these changes create new — or abolish old — sites for restriction enzymes to cut the DNA. Digestion with the enzyme then produces DNA fragments of a different length. These can be detected by electrophoresis.

Single Nucleotide Polymorphisms (SNPs): Developments in DNA sequencing now make it easy to look for allelic versions of a gene by sequencing samples of the gene taken from different members of a population (or from a heterozygous individual). Alleles whose sequence reveals only a single changed nucleotide are called single nucleotide polymorphisms or SNPs. SNPs can occur in noncoding parts of the gene so they would not be seen in the protein product. might not alter the cutting site for any known restriction enzymes so they would not be seen by RFLP analysis.

Copy Number Polymorphisms (CNPs): Genetic analysis (using DNA chips and FISH) has revealed another class of human polymorphisms. These copy number polymorphisms are large (thousands of base pairs) duplications or deletions that are found in some people but not in others. On average, one person differs from another by 11 of these. One or more have been found on most chromosomes, and the list is probably incomplete. While most of this DNA is non-coding, functional genes are embedded in some of it. How, or if, the person adapts to the resulting change in gene number is unknown.

How are polymorphisms useful?

Polymorphism analysis is used: in ***tissue typing***; 1. in order to find the best match between the donor, e.g., of a kidney, and the recipient. 2. finding disease genes. Example: the gene for Huntington's disease was located when the presence of the disease was found to be linked to a RFLP whose location on the chromosome was known. 3. in population studies, for example, assessing the degree of genetic diversity in a population. 4. Determining whether two populations represent separate species or races of the same species. This is often critical to applying laws protecting endangered species. 5. Tracking migration patterns of a species (e.g., whales).

How do polymorphisms arise and persist?

1. **By mutation**. *But what keeps them in the population?* Several factors may maintain polymorphism in a population.
   (*a*) *Founder Effect*: If a population began with a few individuals — one or more of whom carried a particular allele — that allele may come to be represented in many of the descendants. In the 1680s, Ariaantje and Gerrit Jansz emigrated from Holland to South Africa, one of them bringing along an allele for the mild metabolic disease porphyria. Today more than 30000 South Africans carry this allele and, in every case examined, can trace it back to this couple — a remarkable example of the founder effect.
   (*b*) *Genetic Drift:* An allele may increase — or decrease — in frequency simply through chance. Not every member of the population will become a parent and

not every set of parents will produce the same number of offspring. The effect, called random genetic drift, is particularly strong in small populations (e.g., 100 breeding pairs or fewer); when the gene is neutral; that is, is neither helpful nor deleterious. Eventually the entire population may become homozygous for the allele or — equally likely — the allele may disappear. Before either of these fates occurs, the allele represents a polymorphism.

Two examples of reduced polymorphism because of genetic drift

By 1900 hunting of the northern elephant seal off the Pacific coast had reduced its population to only 20 survivors. Since hunting ended, the population has rebounded from this population bottleneck to some 100,000 animals today. However, these animals are homozygous at every one of the gene loci that have been examined. Cheetahs, the fastest of the land animals, seem to have passed through a similar period of small population size with its accompanying genetic drift. Examination of 52 different loci has failed to reveal any polymorphisms; that is, these animals are homozygous at all 52 loci. The lack of genetic variability is so profound that cheetahs will accept skin grafts from each other just as identical twins (and inbred mouse strains) do. Whether a population with such little genetic diversity can continue to adapt to a changing environment remains to be seen.

Balanced Polymorphism

In regions of the world (e.g., parts of Africa) where malaria caused by *Plasmodium falciparum* is common, the allele for sickle-cell hemoglobin is also common. This is because children who inherit one gene for the “normal” beta chain of hemoglobin and one sickle gene are more likely to survive that either homozygote. Children homozygous for the sickle allele die young from sickle-cell disease but children homozygous for the “normal” beta chain are far more susceptible to illness and death from falciparum malaria than are heterozygotes. Hence the relatively high frequency of the allele in malarial regions. When natural selection favors heterozygotes over both homozygotes, the result is **balanced polymorphism.** It accounts for the persistence of an allele even though it is deleterious when homozygous.

Another example: prion proteins: All human populations are polymorphic for the prion protein PrPC. It is encoded by the prion protein gene (PRNP). Two of the alleles have different codons at position 129: one encoding methionine; the other valine. Homozygosity for either allele increases the susceptibility to prion diseases. People who are heterozygous are more resistant. A study of elderly women who had survived the kuru epidemic of the first half of the 20th century (eating the tissues of the deceased was banned in 1950) showed that 76.7% of them were heterozygotes.

MOLECULAR EVOLUTION

Until recently, evolution has been considered an organismal process in as much as whole organisms were the units of natural selection and change was evident in populations only insofar as organisms in the population changed. Now it is readily apparent that evolution can take place at the molecular level, especially within DNA and RNA molecules, and that this evolution arises by processes other than selection. For this reason, it is sometimes considered non-Darwinian evolution.

Evolutionary change detectable at the molecular level: evolution has traditionally been studied by comparing morphological features of organisms and their fossil ancestors. In the 1960's and 1970's, it became possible to look at genetic change directly at first, gene products (enzymes, nonenzyme proteins, etc.) were analyzed using electrophoresis or immunological assay techniques later, DNA and RNA sequences were analyzed directly similarities and differences indicate evolutionary relationships.

Rates of Molecular Evolution: Early studies of genetic variation at the molecular level produced surprising results. First, the genome of most organisms is remarkably diverse, with only a fraction of the genome of eukaryotes consisting of single-copy genes that code for proteins. Also, genomes are not functionally integrated; there are parasitic sequences and repetitive selfish sequences that add nothing to the fitness of the organism within which they reside. Also, there are different sequences in different organelles of the cell.

Additional study of molecular variation indicated that evolutionary change occurs at this level just as it does at the phenotypic level. However, the rates of change at the two levels are frequently different, with the rate being much higher in certain sites within genes than is seen in organisms. How do we account for this? Are there different processes operating at each level? One of the most basic theories in evolution to have appeared since Darwin, called the neutral theory of molecular evolution, was developed to account for evolution at the molecular level. It is also controversial, although not nearly as controversial as Darwin's theory was in 1859.

Neutral Theory of Molecular Evolution

If there is a theory that seems to be diametrically opposed to Darwinian evolution, it is the neutral theory of molecular evolution. First proposed by Kimura (1968) and elaborated further by King and Jutes (1969) and Kimura and Ohta (1971), this theory suggests that evolutionary change measurable at the molecular level can be accounted for in many cases not by selection, but by mutation and random establishment of allele frequencies in populations. It does not oppose the neo-Darwinian argument that natural selection is responsible for change at the phenotypic level; therefore, morphological, physiological and behavioral features of organisms are still assumed to arise by selection that operates on individuals. However, most of the variation we observe at the molecular level is assumed to have little effect on individuals.

The neutral theory suggests that this arises more or less constantly by mutation and becomes established in populations because of random rates of loss and fixation. Since evolution at this level is more or less constant, sequence differences between species can serve as a molecular clock which can provide information about the timing of divergence of species in a lineage.

Initial tests of the theory made use of allozyme data. Briefly, this technique shows the presence/absence of various allozymes (alternative electrophoretic forms of an enzyme coded for by alternative alleles) in polymorphic populations. Although little is known about what variation in the enzymes means in terms of function, they allow one to measure allele frequencies in populations.

More recent data from DNA sequencing indicate that the accumulation of large amounts of variability in noncoding DNA takes place in many organisms (apparently randomly). Even in coding regions (which are far less variable than noncoding regions), many molecular changes are apparent at sites less important in determining function. This information supports the neutral theory. However, it is apparent that molecular constraints (minimizing changes in important functional regions, for example) are influenced strongly by selection. These constraints are different for different proteins and help to explain the rapid rates of change of some molecules and slow rates of others. Therefore, it is not correct to consider the Neutral Theory and Natural Selection to be alternative and opposing views in evolution. Clearly, they are both involved and evidence for both is available, no matter which point of view (molecular or phenotypic) is taken.

The theory makes three basic predictions concerning molecular evolution:

1. rates of change of genes (and the proteins they code for) will be constant over time;
2. the highest rates of change will be observed for those portions of the genome that are least subject to functional constraints, changes in which would lead to elimination by selection; and
3. the maximum rate of molecular evolution is equal to the neutral mutation rate since most mutations are neutral and any advantageous mutations are so rare they can have little influence on the overall rate of molecular change.

The first prediction (constant rates of molecular change) is supported by molecular data (for example, rates of change of various proteins like hemoglobin and cytochrome c, which are discussed in many texts (e.g., Avers, 1989) that has been collected since Kimura first began publishing on the Neutral Theory. The uniformity of protein change with time (different rates for different proteins) suggests selection is not a particularly important factor because if it were, rates of change would vary as the selection pressure changed with environmental change (low in constant environments and high in variable environments, for example). This also indicates that the amount of structural change to proteins produced by various taxa can be used as an indicator of the amount of time since the taxa diverged (molecular clocks). However, the rate of evolution depends on the DNA sequence examined, and even when the same sequence is examined in numerous lineages, there are measurable differences in rates. For example, mitochondrial DNA sequences have evolved more slowly in turtles than in other vertebrates

The second prediction (rates of molecular evolution will be highest in DNA positions that have the least effect on function) is supported by most of the evidence we have from molecular genetics, for example:

1. introns (noncoding regions of the genome) vary far more than exons (coding regions) in lineages.
2. pseudogenes (nonfunctional regions of the genome corresponding to functional regions) vary considerably more than functional genes.
3. the third position of codons varies more than the first two; substitutions at this third position are called synonymous since they do not change the amino acid coded for by the codon.

The third prediction (the neutral mutation rate sets the upper limit to change; positive selection for favorable mutations is negligible) is supported by the observations given above. Rates of sequence change in nonfunctional regions of a genome are much faster than those at functionally constrained regions. However, the idea that positive selection for favorable changes cannot influence molecular evolution is an extension of the theory that is not warranted in all cases. A recent test of this idea by McDonald & Kreitman (1991) compared sequence data from the alcohol dehydrogenase gene of three Drosophila species, individuals of which were sampled from different geographic regions. They considered differences observed between species as fixed and differences among individuals of the same species to be polymorphisms. The neutral theory predicts that the ratio of silent substitutions (which do not alter the function of a gene product) to replacement substitutions (which alter the amino acid sequence of a protein) should be the same at all sites even if changes at some sites are functionally constrained; therefore, the ratio of silent to replacement substitutions will be the same for both polymorphisms (within-species differences) and fixed substitutions (between-species differences). What they found was a much higher ratio (29%) of replacement to silent substitutions at fixed sites that distinguish species when compared with polymorphic sites (5%) which do not distinguish species. This suggests that some amino acid-replacing substitutions are adaptive and fixed not by drift but by selection operating on individuals carrying these altered genes. This causes the frequency of these altered genes to increase more rapidly than by drift alone, and spend less time in a polymorphic state than selectively neutral silent changes. This contradicts one of the basic assumptions of the neutral theory.

The neutral theory has engendered much controversy among population geneticists, but has been of immeasurable importance for several reasons. First, it accounts for much of the variation observed within and between species at the molecular level. Second, it furnishes a null model for how molecular evolution will operate in the absence of selection

Molecular Clocks

If macromolecules change constantly over time, then we should expect that the structure of these molecules obtained from different organisms will be different and that the amount of differences will be an indication of the length of time since these organisms diverged from a common ancestor. It is as if a "molecular clock" were keeping time in organisms. This idea has been used to estimate the timing of divergence of various groups of organisms. However, it depends heavily on the neutral theory.

One must assume that the molecules in question (or sequences within DNA molecules) are changing randomly and constantly (and therefore not in response to selection, which would vary the rate). One also needs to be able to calibrate molecular clocks using some reliable secondary source of information (just as we use the news services as a source of "real" time to set our watches). This could be fossil evidence indicating the actual time two groups shared a common ancestor. However, this is not always available.

These assumptions are not always met. A basic problem with molecular clocks is that they do not keep perfect time. Every gene (or gene product) appears to change at a rate independent of others. For example, cytochrome c and globin genes are known to evolve at different rates. Also, different organisms exhibit different rates (molecular evolution in humans is slower than other anthropoid apes, for example); and organisms in the same clade may exhibit different rates at different times.

Also, DNA from different genomes evolves at different rates (mitochondrial DNA evolves at a 10-fold higher rate than nuclear DNA; chloroplast DNA is known to change very slowly; rDNA has coding regions that are highly conserved and noncoding regions that are variable). Rates are determined directly by calibration using fossil evidence or indirectly by comparing with an out-group.

There have been many controversies about rates, however, and this is one area in which phylogenies based on different techniques can differ widely. For example, consider the concept of "mitochondrial Eve", a paleolithic female who lived 200,000 years go in Africa and from whom all present-day humans descended. This is based on a analysis of mitochondrial DNA, which is inherited exclusively through the female and modified only by mutation; it also uses a standard estimate of mutation rate of 2-4% per million years. However, the chronology and origin are disputed by paleontologists, who use fossil and cultural evidence to track human origins and consider the origin to be further back in time and to have included multiple sites in Asia, Africa and Europe.

MOLECULAR ANALYSIS

DNA and DNA products (proteins) can be obtained from living plant and animal cells fairly easily, and then analyzed to determine evolutionary relationships among individuals representing various taxonomic groups. DNA can even be removed from dried plant specimens and frozen or mummified plant and animal tissues, although there is usually significant degradation and therefore loss of systematic value.

Protein electrophoresis: Because proteins vary in size and have numerous charges, both positive and negative, on their surfaces, different proteins will migrate differently in a starch or acrylamide gel to which an electric field is applied. Even proteins that differ by one amino acid substitution will exhibit different positions on a gel. These are visualized using substrates specific to the enzymes of interest and stains to which the enzymatic reaction binds. Electrophoresis is used to determine the genotype of individuals in polymorphic populations. Allozyme electophoresis identifies allozymes, forms of an enzyme coded for by different alleles at a locus. ***Isozyme electrophoresis*** is similar but isozymes are products of different loci in a single genome. This technique was more widely used before DNA isolation techniques were developed, but it is still used.

DNA-DNA hybridization: This method basically involves melting double-stranded DNA of two samples at high temperatures (representatives of two sibling species, for example) and then lowering temperatures to reanneal the single strands from each sample (if they come from the same organisms, they are called homoduplexes and if they come from different organisms, heteroduplexes). Reannealed homoduplexes are fairly tightly bound, and relatively high temperatures are required to melt them; however, the more unrelated the two were originally, melting of the reannealed heteroduplexes requires lower temperatures (if they annealed at all originally). This technique has been used in many animal studies (including human and other hominoid groups). However, it doesn't seem to work very well with plants because little reannealing takes place.

Restriction Fragment Length Polymorphism (RFLP): Basically, this method takes a molecule of nuclear (or organelle) DNA and cuts it at known points using various restriction enzymes that are specific for short (usually four or six) sequences of base pairs. The fragments produced by this cutting are then separated electrophoretically to produce genetic markers that can be used to compare individuals from various populations. Visualization of the fragments can be accomplished by either radioactively labeling them or staining. Direct sequencing of the fragments can also be done if they prove of systematic value.

Randomly Amplified Polymorphic DNA (RAPD): This technique essentially uses short synthetic oligonucleotide primers to scan a genome for small inverted repeats and then amplifies the sequence in between using PCR (polymerase chain reaction) to make many copies. Since the segment of DNA being amplified is randomly located and of random length (its sequence is usually not known), the sizes (lengths) of these pieces resolved on gels frequently vary from genotype to genotype. This variation can be assessed in the same way as allozyme or RFLP data. RAPD has become especially useful in population genetics because it can generate genetic markers that are polymorphic among individuals in the same population, so "genetic individuals" can be recognized in clonal species like fungi (for example, a recent RAPD study showed that the world's largest organism was a fungus that reproduced clonally and covered many hectares of land). It has also been used to produce "genetic fingerprints" to resolve legal disputes. RAPD is being chosen frequently over other molecular techniques now because it produces results quickly and reliably at relatively low cost.

Direct Sequencing of Genomes: This involves precisely determining the nucleotide sequence of a portion of a genome. Although this is more laborious, it provides relatively reliable data with which to establish phylogenetic position of related taxa. Choices of genome (or portion thereof) can affect the results obtained, but on the whole sequencing is used (generally in a cladistic analysis) to establish monophyly or polyphyly of groups, ancestral vs derived groups, etc.) when phylogenetic analysis is the object of the study.

As a general rule, choices of DNA sequences to be obtained are based on the amount of evolutionary time involved in producing the variations in the group under study (highly conserved portions of the genome are used when large amounts of time are involved and rapidly-changing portions are used when not much time has passed).

In animals the mitochondrial genome **(mtDNA**) is frequently sequenced for comparisons of taxa from within the same order; this is because mtDNA is maternally inherited, is not subject to recombination and has numerous known **orthogolous genes** (that is, homologies of the same gene in different taxa; as opposed to paralogous genes, which are different versions of a gene in the same organism).

In plants, the chloroplast genome (cpDNA) is frequently chosen for the same reasons.

Few generalizations are:

1. Molecular techniques can be applied to a number of distinct genomes (nuclear, mitochondrial, chloroplast) using a number of different nucleic acids (rDNA, cpDNA, various RNAs, etc.)
2. Molecular clocks do not keep perfect time. Every gene (or gene product) appears to change at a rate independent of others. For example, cytochrome c and globin genes evolve at different rates. Also, different organisms exhibit different rates for the same genes (molecular evolution in humans is slower than other anthropoid apes, for example); and organisms in the same clade may exhibit different rates at different times.

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Assumptions

Rate of molecular change is constant: Clock can be calibrated using a reliable secondary source of information (fossils, for example). Assumptions not always met (cytochrome c appears to change at different rates at different times

DNA analysis: In addition to proteins, DNA is frequently analyzed directly as a source of information about similarities among organisms

Molecular Systematics

Use of molecular data as characters to assess phylogenetic position of taxa for classification. Generally uses sequence data from specific genes (rDNA, mtDNA, cpDNA, etc.). Comparison of sequence across taxa reveals patterns of divergence in the past, molecular clocks are inferred to establish timing of divergence when possible. Choice of genes depends on objective.

Some DNA changes relatively rapidly (mtDNA) and can be used for species within genera or genera within families. Chloroplast DNA of plants changes very slowly and can be used to establish phylogenies at the phylum level as origin of Angiosperms, relationships among gymnosperms and origin of land plants

Ribosomal DNA has both highly conserved regions and spacers that exhibit rapid change, so the choice of region depends on the scale of the phylogeny to be resolved.

Cladistic analysis is normally used to analyze data (which is very complex); outgroups used to root trees

Potential problems

1. molecular clocks variable
2. same genes must be used for comparison

Practice Test Paper-I

1. The oldest microfossil so far of age 3.5 billion year ago was-
   (*a*) Coacervates (*b*) Eobionts
   (*c*) Microspheres (*d*) Cyanobacteria
2. In his book, "The origin of life (1938)" oparin submitted abiogenesis first bur biogenesis ever since, this theory is named as-
   (*a*) Spontaneous generation (*b*) Chemical origin
   (*c*) Primary abiogenesis (*d*) Biogenesis
3. Experimental evidence for molecular evolution of life was provided by-
   (*a*) Oparin (*b*) Haldane
   (*c*) Urey and Miller (*d*) Syndey fox
4. During pre-biotic origin of life which chemical played important role in formation of nucleotide specially guanosine-
   (*a*) CH_4 (*b*) CO_2
   (*c*) NH_3 (*d*) HCN
5. Among the following which molecule till now not synthesized by mimicking the environment of pre-biotic environment-
   (*a*) Ribose (*b*) Pyrimidines
   (*c*) Purine (*d*) L-aminoacids
6. Among the following the evidence of evolution from biogeography is-
   (*a*) Embryo development (*b*) Plate tectonics
   (*c*) Darwin finches (*d*) Darwin turtles
7. Thorns of *Bougenwalia* plant and tendril of cucurbits are-
   (*a*) Homologous organs (*b*) Paralogous organ
   (*c*) Analogous organ (*d*) Orthologous organ
8. Placental mammals such as mouse, wolf, Australian marsupials such as marsupial mouse, Tasmanian wolf shows-
   (*a*) Parallel evolution (*b*) Convergent evolution
   (*c*) Divergent evolution (*d*) Phyletic evolution
9. Which of the following is not an vestigial organ in humans-
   (*a*) Ear muscles (*b*) Tail vertebra
   (*c*) Premolar (*d*) Appendix
10. Which of the following was earliest form with lipid bilayer and can reproduce by budding-
    (*a*) Coacervates (*b*) Micro spheres
    (*c*) protobionts (*d*) Monospheres

11. Biogenetic law of Von Baer & Earnst haekel is
    (*a*) Phylogeny repeats ontogeny
    (*b*) Ontogeny repeats phylogeny
    (*c*) Ontogene repeats phytogene
    (*d*) Ontogeny and phylogeny are cyclic

12. Evidence from fossils records are obtained by calculating age of fossil found in–
    (*a*) Metamorphic rock (*b*) Sedimentary rocks
    (*c*) Igneous rocks (*d*) Earth crust

13. Mammals originated during the period-
    (*a*) Triassic (*b*) Jurassic
    (*c*) Cretaceous (*d*) Permian

14. First plant having seed habit (Heterosporous Pterodophyte) originated during-
    (*a*) Silurian (*b*) Devonian
    (*c*) Carboniferous (*d*) Permian

15. First human appeared during-
    (*a*) Oligocene (*b*) Miocene
    (*c*) Pliocene (*d*) Pleistocene

16. Era of reptiles and gymnosperm is-
    (*a*) Precambrian (*b*) Paleozoic
    (*c*) Mesozoic (*d*) Cenozoic

17. The correct order of evolution of horse is-
    (*a*) Mesohippus, Hyracotherium, Meryhippus, pliohippus, equus.
    (*b*) Mesohippus, Meryhippus, Hyracotherium, pliohippus, equus.
    (*c*) Mesohippus, Meryhippus, pliohippus, Hyracotherium, equus.
    (*d*) Hyracotherium, Mesohippus, Meryhippus, pliohippus, equus.

18. Darwin's theory of pangenesis was refuted by-
    (*a*) Recapitulation theory (*b*) theory of Germplasm
    (*c*) Chromosome theory (*d*) theory of biogenesis

19. Mutation theory of Hugo de vries was put forward while working on-
    (*a*) *Drosophila* (*b*) *Ancon sheep*
    (*c*) *Oenothera amarckiana* *(d) Antirrhinum*

20. Evolution at genetic level is termed as-
    (*a*) Microevolution (*b*) Macroevolution
    (*c*) Gene Evolution (*d*) Point mutation

21. Which of them do not cause variation at genetic level-
    (*a*) Mutation and recombination
    (*b*) Gene migration and drift
    (*c*) Natural selection and artificial selection
    (*d*) Panmictic population

22. The raw material for evolution is variability of gene or allele at/in-
    (*a*) individual level (*b*) population
    (*c*) gene pool (*d*) community

23. Founder effect is concerned with-
    (*a*) Gene migration (*b*) Genetic drift
    (*c*) Natural selection (*d*) Mutation

24. If the individual ar one extreme of the size distribution (eg., larger one) contribute more offspring to next generation then such selection is called as-
    (*a*) Directional
    (*b*) Disruptive
    (*c*) Cyclic
    (*d*) Stabilizing

25. Examples of polymorphism in human is-
    (*a*) ABO blood group (*b*) Sickle cell anaemia
    (*c*) height and Intelligence (*d*) All of the above

26. When the preservation of genetic variability is through heterozygote superiority it is termed as-
    (*a*) Heteropolymorphism (*b*) Balanced polymorphism
    (*c*) Stabilizing polymorphism (*d*) Directional polymorphism

27. Type of speciation due to polyploidy is-
    (*a*) Allopathic (*b*) Parapatric
    (*c*) Peripatric (*d*) Sympatric

28. When the two species are morphologically almost identical but reproductively isolated, are termed as-
    (*a*) Taxonomic species (*b*) Ecotypes
    (*c*) Sibling species (*d*) Morphospecies

29. Methanogens are found in-
    (*a*) Marshy areas (*b*) Flora of cattle rumen
    (*c*) Biogas fermentor (*d*) All such places

30. Each of us is part of the ongoing evolution of the human species. Which of the following occurrences would have the greatest impact on the future biological evolution of the human population?
    (*a*) You work out every day so that you stay physically fit and healthy.
    (*b*) A mutation occurs in one of your skin cells.
    (*c*) You move to Hawaii, the state with the longest life expectancy.
    (*d*) A mutation occurs in one of your sperm or egg cells.

31. The processes of ____ and ____ generate variation, and____ produces adaptation to the environment.
    (*a*) sexual recombination . . . natural selection . . . mutation
    (*b*) mutation . . . sexual recombination . . . genetic drift

(*c*) genetic drift . . . mutation . . . sexual recombination
(*d*) mutation . . . sexual recombination . . . natural selection

32. Birds with average-sized wings survived a severe storm more successfully than other birds in the same population with longer or shorter wings. This illustrates
(*a*) the founder effect
(*b*) stabilizing selection
(*c*) artificial selection
(*d*) gene flow

33. Which of the following scenarios would most likely result in microevolution of a population of humans?
(*a*) Only random mating took place in all people that reproduced in North America
(*b*) A colony of humans on the moon was isolated from earth
(*c*) The incidence of skin cancer in adults over age 40 rose significantly
(*d*) Both a and c

34. Which of the following is the best example of gene flow.
(*a*) A polyploid plant develops
(*b*) Genes are shuffled by crossing over of chromosomes during meiosis
(*c*) An earthquake results in the formation of a canyon splitting a population of toads apart
(*d*) Wind blows pollen from one population of plants to another and cross fertilization occurs

35. Stabilizing selection
(*a*) favors intermediate variants in a population
(*b*) prevents mutations from occurring
(*c*) occurs when some individuals migrate to an area with different environmental conditions
(*d*) can only take place in species exhibiting sexual dimorphism

36. According to the Hardy-Weinberg theorem, the frequencies of alleles in a population would remain constant if ______________ is the only process that affects the gene pool.
(*a*) mutation
(*b*) genetic drift
(*c*) sexual reproduction
(*d*) microevolution

37. In the Hardy-Weinberg theorem p2 represents
(*a*) the total alleles in the gene pool
(*b*) the heterozygous dominants in the gene pool
(*c*) the homozygous recessives in the gene pool
(*d*) the homozygous dominants in the gene pool

38. In the Hardy-Weinberg theorem, 1 represents
(*a*) The total alleles in the gene pool
(*b*) the heterozygous dominants in the gene pool
(*c*) the homozygous recessives in the gene pool
(*d*) all the possible phenotypes in the gene pool

39. Two animals are considered of different species if they
    (*a*) look different
    (*b*) cannot interbreed
    (*c*) live in different h
    (*d*) are geographically isolated

40. Which of the following is the first step in allopatric speciation?
    (*a*) genetic drift
    (*b*) geographical isolation
    (*c*) polyploidy
    (*d*) hybridization

41. Most of the time, species are identified by their appearance. Why?
    (*a*) If two organisms look alike, they must be the same species
    (*b*) This is the criterion used to define a biological species
    (*c*) If two organisms look different, they must be different species
    (*d*) This is the most convenient way of identifying species

42. A new species can arise in a single generation
    (*a*) through geographical isolation
    (*b*) in a very large population that is spread over a large area
    (*c*) if a change in chromosome number creates a reproductive barrier
    (*d*) if allopatric speciation occurs

43. The evolution of numerous species, such as Darwin's finches, from a single ancestor is called
    (*a*) adaptive radiation
    (*b*) sympatric speciation
    (*c*) gradualism
    (*d*) nondisjunction

44. According to the _________ model, evolution occurs in spurts; species evolve relatively rapidly, then remain unchanged for long periods.
    (*a*) nondisjunction
    (*b*) gradualist
    (*c*) adaptive radiation
    (*d*) punctuated equilibrium

45. Sympatric speciation is
    (*a*) the appearance of a new species in the same area as the parent population.
    (*b*) initiated by the appearance of a geographical barrier
    (*c*) the emergence of many species from a single ancestor
    (*d*) especially important in the evolution of island species

46. In some animals eg. Axolatal larvae of Ambystoma, the larvae fails to undergo metamorphosis (iodine deficiency). It develops gonads, attains sexual maturity and start reproduction. This is called-
    (*a*) Parthenogenesis
    (*b*) Neoteny or paedogenesis
    (*c*) Retrogress metamorph
    (*d*) Stagnant metamorphosis

47. Darwin finches from various islands of Galapagos island differed in size and shape of bill due to-
    (*a*) Mutation
    (*b*) Adaptive radiation
    (*c*) Competition
    (*d*) Gene migration

48. The enzyme which is occurs in all eukaryotes and show great homology is-
(*a*) Cytochrome oxidase (*b*) Cytochrome c
(*c*) Cytochrome b (*d*) Cytochrome a

49. The hormone which is almost identical and occurs in all vertebrates is-
(*a*) Insulin (*b*) Thyroxine
(*c*) Glucagon (*d*) ACTH

50. The phylogenictically closed relative of humans are-
(*a*) Langurs (*b*) Apes
(*c*) Mokeys (*d*) Shrews

51. Which of the following is not darwin's postulate-
(*a*) Struggle for existence
(*b*) survival of fittest
(*c*) origin of new species
(*d*) Inheritence of Acquired character

52. Which is main cause of genetic variation at individual level-
(*a*) Gene mutation (*b*) Crossing over
(*c*) Fertilization & meiosis (*d*) All if the above

53. Total gene content of individual population is termed as-
(*a*) Genome (*b*) Gene pool
(*c*) Gene bank (*d*) Genotype

54. A mutation arising in small population is either fixed or lost just by chance irrespective of its adaptive value is termed as-
(*a*) Silent theory (*b*) Genetic drift
(*c*) Artificial selection (*d*) Directional selection

55. The main reason for evolution of new species is-
(*a*) Geographical isolation (*b*) Natural selection
(*c*) Reproductive barrier (*d*) Mutation

56. Biological method for clean up of contaminated soil and ground water is termed as-
(*a*) Biorestoration (*b*) Biomagnification
(*c*) Bioremediation (*d*) Biosorption

57. Archaebacteria grows at temperature-
(*a*) 0-20^{o}C (*b*) 30-40^{o}C
(*c*) 50-120^{o}C (*d*) All such temperatures

58. Agar-agar used as solidifying agent in bacteriological media is obtained from-
(*a*) Spirulina (*b*) Gelidium
(*c*) Fucus (*d*) Porphyra

59. Which of the following organism can carry out the reaction-
NO_2 + oxygen$\rightarrow$$NO_3$ + energy
(*a*) *Nitrosomanas*
(*b*) *Pseudomonas rubrum*
(*c*) *Micrococcus denitrificans*
(*d*) *Nitrobacter*

60. Evolution of modern wheat *Triticum aestivum* is a result of-
(*a*) Mutation
(*b*) Autopolyploidy
(*c*) Allopolyploidy
(*d*) Segmental polyploidy

61. Protoporphyrin, the ancient solar energy trapping molecules are made from-
(*a*) Succinic acid & glycine
(*b*) Alanine & glutamic acid
(*c*) Lysine & praline
(*d*) Acetyl coA & oxaloacetate

62. Among the following which do not bring variation at Individual level-
(*a*) Gene mutation
(*b*) Fertilization
(*c*) Meiosis and Crossing over
(*d*) Chromosome aberration and Hybridizations

63. Natural selection will operate under condition-
(*a*) Mutational equilibrium
(*b*) Random matting
(*c*) Differential reproduction
(*d*) Equal chances for all genotypes to live and reproduce

64. Natural selection will not operate if-
(*a*) Population is isolated and small
(*b*) Mutating population
(*c*) Random matting population
(*d*) Large population

65. Distinct and stable phenotypes within species are termed-
(*a*) Polymorphic variation
(*b*) Cryptic variation
(*c*) Geographical variation
(*d*) Local variation

66. The main cause of blastogenic and somatogenic variation-
(*a*) Endocrine glands
(*b*) Mutation
(*c*) Natural selection
(*d*) Panmictic repd.

67. Crossing of hybrid to its parents is called-
(*a*) Parental hybridization
(*b*) Interogressive hybrd.
(*c*) Back hybridization
(*d*) Stabilizing hybrd.

68. Both Transition and Transversion type of mutation is induced by-
(*a*) Methyl methane sulfate
(*b*) Nitrous acid
(*c*) Base analogues
(*d*) Acradines

69. Which is best experimental demonstration to prove natural selection-
    (*a*) Lederberg's replica replicating
    (*b*) Kettelwell's Industrial melanism
    (*c*) Pastuer's Swann nech exp
    (*d*) Urey millers exp

70. Among the following which is not prerequisite for natural selection-
    (*a*) Unit capable of reproduction
    (*b*) Occurrence of heritable variations or differences among units
    (*c*) Presence of more then one such unit in same environment
    (*d*) Environmental homeostasis

71. Which is false about stabilizing selection-
    (*a*) Constant or unchanging environment
    (*b*) Introduces heterozygosity
    (*c*) Favours average
    (*d*) It tends to arrest variance & environmental changes

72. Industrial melanism is example of-
    (*a*) Directional selection (*b*) Stabilizing Selection
    (*c*) Cyclic selection (*d*) Disruptive Selection

73. Appearance of abnormal characters which were normal in other supposedly ancestral races for example appearance of cervical fistula in man which actually corresponds to gill slits are-
    (*a*) Race atavism (*b*) Family atavism
    (*c*) Atavism of teratology (*d*) Ontogenic atavism

74. The ascidian larva on metamorphosis changes into degenerate adult. This is example of-
    (*a*) Progressive metamorphosis (*b*) Directional
    (*c*) Retrogressive (*d*) Cyclic

75. C^{14} is used to determine age of fossils up to-
    (*a*) 10000 years old (*b*) 25000
    (*c*) 45000 (*d*) 1 lakh year

76. The clock of rock is usely determined by-
    (*a*) U^{238} (*b*) K^{40}
    (*c*) Both a & c (*d*) C^{14}

77. The transitional fossil form which shows characteristics of two different groups of living organisms is called as-
    (*a*) Missing link (*b*) Connecting link
    (*c*) Living fossil (*d*) Link species

78. Monotremes (egg laying mammals) and marsupials (pouched mammals) are restricted to distribution in-
(*a*) Asia (*b*) Australia
(*c*) Africa (*d*) N. America

79. Among the following hormones, which are present in all animals-
(*a*) Pepsin, trypsin (*b*) Trypsin, Amylase
(*c*) Pepsin, amylase (*d*) Trypsin, secretin

80. Among the following which is most conserved in all eukaryotes and act as respiratory pigment and accepts electron form H^+-
(*a*) Ferrodoxin (*b*) Cytchrome-c
(*c*) Cyctochrome c oxidase (*d*) NAD dehydrogenase

81. Which hormone is identical and interchangeable and present in all animals is-
(*a*) Thyroid (*b*) Adrenalin
(*c*) Somatotropin (*d*) Insulin

82. Artificial selection tends to-
(*a*) Change gene frequency (*b*) Decrease biodiversity
(*c*) Increase vigor (*d*) All of the above

83. Prokaryotes called ____ are similar in many ways to eukaryotic organisms.
(*a*) archae (*b*) protozoa
(*c*) Cyanobacteria (*d*) dinoflagellates

84. Among the following which hormone is almost similar in beef, sheep, pig, whale, horse, rabit and differs only in one to three amino acid position-
(*a*) Glucagon (*b*) Insulin
(*c*) Somatotropin (*d*) Somatostanin

85. The order of following organisms as phylogenetic closeness to human-
(*a*) Chimpanzee > languor > lemur > tree shrews
(*b*) Languor > chimpanzee > tree shrews > lemur
(*c*) Chimpanzee > languor > tree shrews > Lemur
(*d*) Languor > lemur > chimpanzee > tree shrews

86. The gradual mode of speciation in single lineage in which species diverge in spurts of relatively rapid change which result in increase in species is termed as-
(*a*) Punctuated equilibrium (*b*) Adaptive radiation
(*c*) Anagenesis (*d*) Cladogenesis

87. Among the following which statement is false about r-selected species-
(*a*) Long generation time (*b*) Large number of offspring
(*c*) Short life cycle (*d*) Tendency to disperse

88. When an radioactive phosphorus is incorporated into DNA strand, the phospho diester bond generally break after a short while because-
   (*a*) The bond number of phosphorus decreases
   (*b*) Phosphorus on radioactive decay converts into sulphur, which has valency of two
   (*c*) It attacks glycosidic bond
   (*d*) It breaks hydrogen bond

89. Among the following which is generally not utilized for establishing phylogenetic relationship between two species-
   (*a*) % similarity (*b*) Geographical distance
   (*c*) Marcoli distance (*d*) Amino acid sequence

90. Mangroves are highly productive ecosystem but they are poor in bird diversity because-
   (*a*) Lack of structural diversity
   (*b*) Lack of food diversity
   (*c*) More number of predators that feed on birds
   (*d*) Lack of breeding place

91. Among the following which would lead into new species formation-
   (*a*) Increased resources
   (*b*) Niche overlapping tolerance
   (*c*) Niche specialization
   (*d*) Lack of competition

92. Origin of life is not possible under present environmental conditions because-
   (*a*) Hydrogen is absent
   (*b*) Presence of oxygen
   (*c*) Lack of source of energy
   (*d*) Lack of raw material for origin of life

93. Disaster such as earthquake or fire may reduce the size of population drastically and the genetic make up of the small surviving population is unlikely to be representative of make up of original population the situation is termed as-
   (*a*) Bottle neck effect (*b*) Adaptive radiation
   (*c*) Founder effect (*d*) Gene migration

94. A certain organism developed an adaptation as to adapt existing environment but if this adaptation prove useful for some other function as well, it is termed as-
   (*a*) Co-adaptation (*b*) Adaptive radiation
   (*c*) Exadaptation (*d*) Co-evolution

95. In a population frequency of a homozygous recessive disease is 16% then the frequency of dominant allele would be-
   (*a*) 0.84 (*b*) 0.6
   (*c*) 0.16 (*d*) 0.4

96. In a population individuals having heterozygous phenotype are more favored then homozygous dominant which are more favored then homozygous recessive genotypes, under such condition-
    (*a*) Recessive alleles would be lost from population
    (*b*) Dominant alleles would be lost
    (*c*) Both alleles would remain in population
    (*d*) Alleles would be lost randomly

97. A group of species which are phylogenitically closer but they are lacking common ancestor. Such an group is regarded as-
    (*a*) Monophyletic (*b*) Polyphyletic
    (*c*) Paraphyletic (*d*) Sympatric

98. After implication of Green Air Act in England which species become virtually absent-
    (*a*) Biston betularia carbonifera (*b*) Biston betularia typica
    (*c*) Drosophila (*d*) Apes Americana

99. If an allele is linked to the second allele at other locus which is favorably selected are inherited together. Such an movement of an allele without any evolutionary benefit to next generation is termed as-
    (*a*) Selective drive (*b*) Evolutionary drive
    (*c*) Hitch hiking (*d*) Linkage

100. The morphological modification is transferred to next generation without any present application which may prove beneficial in changed environment is termed as –
    (*a*) Exadaptation (*b*) Pre-adaptation
    (*c*) Analogous (*d*) Paralogous

Practice Test Paper-II

1. In the first order chemical reaction, if the time taken for half the reaction to be consumed is *t*, the time taken for three-fourth to be consumed is-
   (*a*) 1.5 t (*b*) ½ t
   (*c*) 2 t (*d*) 1.33 t

2. Which of the following organism is most suitable to serve as a bio-fertilizer?
   (*a*) Chlorella (*b*) Agrobacteria
   (*c*) Azolla (*d*) Frankia

3. A radioactive compound Cs^{137} was collected on 1st February, 2002, and kept in a sealed tube. On the 1st of July, 2002, it was found that only 3.125 % radioactivity was left. This means that the half-life period of the isotope is
   (*a*) 37.5 days (*b*) 30 days
   (*c*) 25 days (*d*) 50 days

4. The two component of lichen is-
   (*a*) Fungus and bacteria (*b*) Fungus and bryophyte
   (*c*) Fungus and algae (*d*) Algae and Bacteria

5. Carbon-14 undergoes β-decay upon which it is converted into a new element having-
   (*a*) Increased atomic number (*b*) Decreased atomic number
   (*c*) Increased atomic mass (*d*) Decreased atomic mass

6. The first organisms that originated on earth were-
   (*a*) Chemolithotrophs (*b*) Bacteriophages
   (*c*) Photoautotrophic bacteria (*d*) Uninucleate eukaryotes

7. *Entamoeba histolytica* is spread by-
   (*a*) Bite of sand fly
   (*b*) Bite of anopheles mosquito
   (*c*) Consuming contaminated food & water
   (*d*) Blood transfusion

8. If the pH of the solution is 9, then
   (*a*) The solution is said to be acidic
   (*b*) The hydroxyl ion concentration is 10^{-9} M
   (*c*) The solution has three times more H^+ ion than the solution of pH 12
   (*d*) The Hydrogen ion concentration is 10^{-9} M

9. Half life of radioactive I^{131} is 8 days. If you have 100 micromoles of this isotope at one instant, how many micromoles will remain at the end of sixteen days?
   (*a*) Zero (*b*) 25
   (*c*) 33.33 (*d*) 50

10. Which of the following will not ionize the gas?
    (*a*) X-rays (*b*) α-rays
    (*c*) Electrons (*d*) γ-rays

11. Which of the following is the fossil form?
    (*a*) Archeopteryx (*b*) Amphioxus
    (*c*) Ornithorhynchus (*d*) Peripatus

12. Mammals originated from-
    (*a*) Fishes (*b*) Amphibians
    (*c*) Reptiles (*d*) Birds

13. "Recapitulation theory" in evolution was proposed by-
    (*a*) Haeckel (*b*) Darwin
    (*c*) Lamarck (*d*) Cuvier

14. The half life of the first order reaction is
    (*a*) Constant & dependent on the initial concentration of the reactant
    (*b*) Constant & independent on the initial concentration of the reactant
    (*c*) Not constant & independent on the initial concentration of the reactant
    (*d*) Dependent on the temperature and pressure

15. One of the following is the characteristics features of the Aves-
    (*a*) Four chambered heart (*b*) Absence of nucleus in RBC
    (*c*) Pneumatic bones (*d*) Ability to fly

16. In the life cycle of malarial parasite (*Plasmodium vivax*), the pre-erythrocytic cycle occurs in-
    (*a*) Liver (*b*) Bone marrow
    (*c*) Blood plasma (*d*) Kidney

17. Where would you place sponges among following-
    (*a*) Parazoa (*b*) Metazoa
    (*c*) Protozoa (*d*) Heliozoa

18. Evolution:
    (*a*) is a reversible process
    (*b*) occurs through variations arising from changes in genetic material
    (*c*) is a fast process
    (*d*) cannot take place any more because of oxidizing environment

19. Crop rotation for restoring soil fertility refers to growing one of the following crops between cereal crops-
    (*a*) Pulse crops (*b*) Grass
    (*c*) Composite (*d*) Trees

20. Kala-azar is caused by:
(*a*) *Leishmania donovani* (*b*) *Trypanosoma gambiense*
(*c*) *Entamoeba histolytica* (*d*) *Plasmodium falciparum*

21. The oldest microfossils discovered so far of age 3.3 to 3.5 billions year ago was-
(*a*) Coacervates (*b*) Eobionts
(*c*) Microshperes (*d*) Cyanobacteria

22. In his book, " The origin of life (1938)" oparin submitted abiogenesis first but biogenesis ever since", this theory is names as-
(*a*) Spontaneous generation (*b*) Chemical origin
(*c*) Primary abiogenesis (*d*) Biogenenesis

23. Experimental evidence for molecular evolution of life was provided by-
(*a*) Oparin (*b*) Haldane
(*c*) Urey & Miller (*d*) Sydney fox

24. During pre-biotic earth of life which chemical played important role in formation of nucleotides-
(*a*) Methane (*b*) Ammonia
(*c*) Hydrogen (*d*) HCN

25. Which of the following have lipid bilayer and can reproduce by budding-
(*a*) Coacervates (*b*) Microsperes
(*c*) Nanospheres (*d*) Protobionts

26. Which of them is evidence of evolution from biogeography as narrated by Darwin-
(*a*) Embryo devp. (*b*) Plate tectonics
(*c*) Darwin finches (*d*) Darwin turtles

27. Placental mammals such as mouse wolf and Australian marsupials such as marsupial mouse, Tasmanian wolf shows-
(*a*) Parallel evolution (*b*) Convergent
(*c*) Divergent (*d*) Phylletic

28. Thorn of Bouganwalia and tendrils of cucurbits are-
(*a*) Homologous organ (*b*) Paralogous
(*c*) Analogous (*d*) Orthologous

29. Which of them is not vestigial organ in human-
(*a*) Ear muscles (*b*) Tail vertebra
(*c*) Premolar (*d*) Appendix

30. The probable energy carrier molecule during initial stage of origin of life was-
(*a*) Amino acids (*b*) Nucleosides
(I) Nucleotides (*d*) Sugars

31. Oparin and Sydney fox held that the large organic molecule synthesized abiotically on primitive earth formed large colloidal aggregates due to intermolecular interactions. The colloidal particles were called-
    (*a*) Micorospheres (*b*) Eobionts
    (*c*) Archaebacteria (*d*) Coacervates

32. Probable the first living form was nutritionally-
    (*a*) Chemoautotrophs (*b*) Chemoheterotrophs
    (*c*) Anoxygenic autotrophs (*d*) Oxygenic autotrophs

33. Which is most essential requirement for origin of life on any planet-
    (*a*) Water (*b*) Reducing environment
    (*c*) Methane (*d*) Nucleic acids

34. Seal flippers, bird and bat wings, horse fore limbs and human arms are –
    (*a*) Homologous organ (*b*) Analogaous organ
    (*c*) Vestigeal organ (*d*) Orthologous organ

35. In bat the wing is formed of fold of a integument termed as-
    (*a*) Pterodactyl (*b*) Patagium
    (*c*) Phalanges (*d*) Carpels

36. Evolution of new forms in several direction from a common ancestor type is termed as –
    (*a*) Phylogenic evolution (*b*) Anagenesis
    (*c*) Cladogenesis (*d*) Adaptive radiation

37. The similar body shape between animals of differently related groups represents-
    (*a*) Convergent evolution (*b*) Co-evolution
    (*c*) Parallel evolution (*d*) All of the above

38. Probable cause of appearance of cervical fistula, tail, hair on face in humans is-
    (*a*) Mutation in homeotic gene (*b*) retrogressive evolution
    (c) Atavism (*d*) Genetic drift

39. Adult frog and other amphibian excretes-
    (*a*) Ammonia (*b*) Urea
    (*c*) Uric acid (*d*) All

40. Retrogressive metamorphosis is seen in-
    (*a*) Amphibian tadpole (*b*) Ascidian larvae
    (*c*) Fishes (*d*) Reptiles

41. Galapagos island, the biologist paradise, are situated on equator about 960 Km west of Ecuador in continent-
    (*a*) South America (*b*) North America
    (*c*) Africa (*d*) Australia

42. The Flora and fauna of south Africa and west south America resembles to-
(*a*) Europe (*b*) North America
(*c*) Australia (*d*) Asia

43. About 375 million years ago, all present continents formed a single giant land mass called pangea which splits in two islands masses Laurasia and Gondwana around-
(*a*) 280 million year ago (*b*) 175 million year ago
(*c*) 120 million year ago (*d*) 80 million year ago

44. Among the following which is an avian character-
(*a*) Homodent dentition
(*b*) Matacarpel separate & carpometacarpus absent
(*c*) V-shaped fercula
(*d*) Eyes have sclerotic ossicles

45. Radioactive isotope of carbon-14 can be used to determine age of fossil up to-
(*a*) 10,000 year old (*b*) 40,000 year old
(*c*) 1 Lakh year old (*d*) 10 lakh year old

46. When the preservation of genetic variability is through heterozygous superiority, it is called-
(*a*) Heteropolymorphism (*b*) Balanced polymorphism
(*c*) Stabilizing polymorphism (*d*) Directional polymorphism

47. Type of speciation due to ploidy level is-
(*a*) Peripatric (*b*) Parapatric
(*c*) Sympatric (*d*) Allopatic

48. When the two species are morphologically almost identical but do not normally interbreed, such species are called-
(*a*) Taxonomic species (*b*) Sibling species
(*c*) Ecospecies (*d*) Ecospecies

49. Methanogens are found in-
(*a*) Hot springs (*b*) Bioreactors
(*c*) Flora of cattle rumen (*d*) All such places

50. Archaebacterial cell wall is made up of-
(*a*) Lipo- polysaccharide (*b*) Polysaccharide and Proteins
(*c*) Polysaccharides only (d) Murien

51. Which of them can change their body shape-
(*a*) Viruses (*b*) Bacteria
(*c*) Mycoplasma (*d*) Eubacteria

52. African sleeping sickness is caused by-
(*a*) Leishmania (*b*) Trypanosoma
(*c*) Dictostelluim (*d*) Physarium

53. The gametophyte and sporophyte of bryophytes are-
(*a*) Dependent on each other
(*b*) Independent to each other
(*c*) Gametophyte dependent on sporophyte
(*d*) Sporophyte dependent on gametophyte

54. The chemical present in flit is-
(*a*) Malathion (*b*) DDT
(*c*) BHC (*d*) Aldicarb

55. Example of green manure is-
(*a*) Rice (*b*) Sorghum
(*c*) Maize (*d*) Sesbania

56. p and q in Hardy-Weinberg law represents-
(*a*) Allele frequency (*b*) genotype frequency
(*c*) Heterozygous frequency (*d*) Total alleles in population

57. Hybrid breakdown occurs in-
(*a*) Donkey (*b*) Mule
(*c*) Liger (*d*) Horse

58. The pre-biotic environment was-
(*a*) Oxidizing (*b*) Reducing
(*c*) No environment (*d*) Humid

59. Which chemical played important role in origin of life-
(*a*) Methane (*b*) Ammonia
(*c*) HCN (*d*) Hydrogen

60. Artificial selection tends to-
(*a*) Change gene frequency (*b*) Decrease biodiversity
(*c*) Increase vigour (*d*) All the above

61. Uniform peeling away of soil surface by the action of flowing water is termed as-
(*a*) Slip erosion (*b*) Rill erosion
(*c*) Gully erosion (*d*) Sheet erosion

62. *Bacillus thuringenesis* is used to control-
(*a*) Bacterial pathogens (*b*) Fungal pathogens
(*c*) Nematode (*d*) Insect pests

63. In the grassland ecosystem, trees donot replace the grasses as part of ecological succession because-
(*a*) Insect and fungi
(*b*) Limited sunlight & nutrients
(*c*) Water limit & regular fire or overgrazing
(*d*) Cool temperature

64. Nitrogen fixation occurs in-
    (*a*) Some bacteria, cyanobacteria & legumes
    (*b*) Legumes and some bacteria
    (*c*) Some herbaceous plants & legumes
    (*d*) All green plants

65. The evolution of numerous species in a short period of time from a single ancestral population, such as Darwin's finches, is called
    (*a*) adaptive radiation
    (*b*) sympatric speciation
    (*c*) gradualism
    (*d*) nondisjunction

66. Mass extinctions that occurred in the past
    (*a*) cut the number of species to the few survivors left today
    (*b*) resulted only from the merging of the continents
    (*c*) were followed by diversification of the survivors
    (*d*) wiped out land animals, but had little effect on marine life

67. What evidence most strongly suggests that an impact by an asteroid or meteorite may have caused the extinction of the dinosaurs?
    (*a*) Fossils show that dinosaurs suffered from cold and starvation
    (*b*) Sedimentary rocks contain a layer of iridium, a mineral that is uncommon on Earth
    (*c*) There have been several near misses in recent years
    (*d*) The dinosaurs disappeared rather abruptly, virtually overnight

68. Which of the following would cast doubt on the asteroid-impact hypothesis for the extinction of the dinosaurs?
    (*a*) finding a crater 200 million years old
    (*b*) finding fossil dinosaur bones beneath a layer of iridium
    (*c*) determining that birds are closely related to dinosaurs
    (*d*) finding fossil dinosaur bones above a layer of iridium

69. Animals that possess homologous structures probably
    (*a*) are headed for extinction
    (*b*) evolved from the same ancestor
    (*c*) have increased genetic diversity
    (*d*) are not related

70. The wings of birds and insects have the same function, but they do not have the same evolutionary origin. Bird and insect wings are
    (*a*) homologous
    (*b*) phylogenetic
    (*c*) analogous
    (*d*) binomial

71. Which of the following would be least useful in determining the relationships among various species of organisms?
    (*a*) DNA base sequences
    (*b*) homologous structures
    (*c*) fossils
    (*d*) amino acid sequences of proteins

72. A phylogenetic tree of bird families constructed by cladistic analysis would most clearly show which of the following?
   (*a*) characteristics shared by all bird families
   (*b*) evolutionary relationships among families
   (*c*) families that look most alike
   (*d*) analogous structures shared by various species

73. Using cladistic analysis, a taxonomist wishes to construct a phylogenetic tree showing the relationships among various species of mammals. Data about which of the following would be least useful for this purpose?
   (*a*) descriptions of various types of limbs (wings, legs, flippers, etc.)
   (*b*) data about skull bones
   (*c*) the fact that teeth vary among different types of mammals
   (*d*) DNA base sequences

74. Which of the following was probably not present in large amounts in the atmosphere at the time life is thought to have originated?
   (*a*) water (H_2O) (*b*) methane (CH_4)
   (*c*) ammonia (NH_3) (*d*) oxygen (O_2)

75. Biologists are interested in the role of clay in the origin of life. They think clay might have
   (*a*) supplied the raw materials for organic compounds
   (*b*) catalyzed the formation of organic polymers such as proteins and RNA
   (*c*) formed primitive cell membranes that could grow and divide
   (*d*) catalyzed the formation of monomers such as amino acids and sugars

76. Which of the following is thought to have been the first step in the origin of life?
   (*a*) formation of polypeptide spheres (*b*) formation of organic monomers
   (*c*) replication of primitive genes (*d*) formation of organic polymers

77. Most bacteria
   (*a*) obtain energy from sunlight and carbon from organic compounds
   (*b*) obtain both energy and carbon from inorganic compounds
   (*c*) obtain energy from inorganic compounds and carbon from CO_2
   (*d*) obtain both energy and carbon from organic compounds

78. Energy metabolism may have evolved when early prokaryotes
   (*a*) used up the oxygen in their environment
   (*b*) began producing poisonous waste products
   (*c*) used up the ATP in their environment
   (*d*) began producing significant amounts of oxygen

79. Until about 500 million years ago, all living things were
   (*a*) asexual (*b*) autotrophic
   (*c*) aquatic (*d*) prokaryotic

80. You set your time machine for 3 billion years ago and push the start button. When the dust clears, you look out the window. Which of the following describes what you would probably see?
   (*a*) plants and animals very different from those alive today
   (*b*) a cloud of gas and dust in space
   (*c*) green scum in the water
   (*d*) land and water sterile and devoid of life

81. Selection of African tribes is more of heterozygous gene for RBC is due to-
   (*a*) Severe malaria
   (*b*) Environment instability
   (*c*) More cases of Sickle cell anaemia
   (*d*) both a & c

82. Molecular clock of evolution could be traced on basis of-
   (*a*) Comparison of Short arm of 16-S RNA
   (*b*) Substitution in amoniacids of polypeptide due to mutation
   (*c*) DNA fingerprinting
   (*d*) Fossil study

83. Among the following the progenitors of mammals were-
   (*a*) Aves (*b*) Pisces
   (*c*) Amphibians (*d*) Reptiles

84. Abrupt change in gene frequency in isolated population is termed as-
   (*a*) Adaptive radiation (*b*) Allopatric speciation
   (*c*) Random drift (*d*) Mutation

85. Main cause of loss of Biodiversity is-
   (*a*) Pollution (*b*) Population explosion
   (*c*) Habitat destruction (*d*) Over exploitation

86. Which radioisotope is used for estimating age of rocks-
   (*a*) U^{238} & K^{40} (*b*) U^{235} & C^{14}
   (*c*) U^{238} & H^{3} (*d*) C^{14} & H^{3}

87. What is main cause of evolution of new species-
   (*a*) Natural selection (*b*) Competition
   (*c*) Mutation (*d*) Hybridization

88. Phylogenetic relationship can be more precisely established by comparing-
   (*a*) Amino acid sequence (*b*) DNA
   (*c*) r-RNA (*d*) m-RNA

89. In a sample from an African population, the frequency of L^M and L^N alleles were 0.78 and 0.22 resp. What are expected frequency of MN phenotypes-
   (*a*) 0.8 (*b*) 0.02
   (*c*) 0.34 (*d*) 0.016

90. Phylogenetic relationship in plants can be best established by-
    (*a*) Allozymes (*b*) Alkaloids
    (*c*) Isoenzymes (*d*) Morphology

91. The Cuvier's theory, which states that there had been several creations, each preceded by another due to some geographical disturbances. Such theory is termed as-
    (*a*) Theory of catastrophism (*b*) Special creation
    (*c*) Pangenesis (*d*) Eternity of life

92. Whih is correct matched among following connecting links-
    (*a*) Euglena- Reptiles and mammals
    (*b*) Proterospongia- Cartilaginous and bony fishes
    (*c*) Peripatus- Annelida & Mollusca
    (*d*) Neoplina- Annelida & Arthopoda
    (*e*) Balaonglossus- Chordate and Non-chordate
    (*f*) Chimera- Fishes and Amphibians
    (*g*) Lung fishes- Protozoa & porifera
    (*h*) Prototheria- Plants and animals

93. Ancient cyanobacteria, found in fossil stromatolites, were very important in the history of life because they
    (*a*) were probably the first living things to exist on Earth
    (*b*) produced the oxygen in the atmosphere
    (*c*) are the oldest known archae
    (*d*) were the first multicellular organisms

94. In terms of nutrition, autotrophs are to heterotrophs as
    (*a*) algae are to slime molds
    (*b*) archae are to bacteria
    (*c*) slime molds are to algae
    (*d*) kelp are to diatoms

95. The bacteria that cause tetanus can be killed only by prolonged heating at temperatures considerably above boiling. This suggests that tetanus bacteria
    (*a*) have cell walls containing peptidoglycan
    (*b*) protect themselves by secreting antibiotics
    (*c*) secrete endotoxins
    (*d*) produce endospores

96. Bacteria such as *Streptococcus pneumoniae* can cause disease in humans when
    (*a*) the hosts immune system is compromised
    (*b*) the bacterium develops resistance to all antibiotics
    (*c*) a co-host such as Staphylococcus is present on the host
    (*d*) that protozoan has pathogenic factors such as pili or capsules

97. Gram-negative bacteria have ________ peptidoglycan than Gram-positive cells and their cell walls are _________ complex structurally.
   (*a*) more . . . more
   (*b*) more . . . less
   (*c*) less . . . less
   (*d*) less . . . more

98. Genes for the resistance of antibiotics are usually located
   (*a*) on the main chromosome
   (*b*) in mitochondria
   (*c*) in the cell wall
   (*d*) on plasmids

99. Bacteria that can convert atmospheric nitrogen into ammonia are called
   (*a*) nitrogen reducers
   (*b*) nitrogen fixers
   (*c*) nitrogen oxidizers
   (*d*) nitrogen heterotrophs

100. Humans are phlyogenetically more close to-
   (*a*) Monkeys
   (*b*) Tree shrews
   (*c*) Lemurs
   (*d*) Sinipsids

6

Environmental Biology

MAJOR COMPONENTS OF ECOLOGY

1. Ecology

(*a*) "The scientific study of the interactions between organisms and their environments is called ecology."

(*b*) "Ecology concerns itself with the interrelationships of living organisms, plant or animal, and their environments; these are studied with a view to discovering the principles which govern the relationships.

2. Environment

(*a*) An organism's environment may be distinguished into an abiotic component and a biotic component.

(*b*) "Organisms are affected by their environment but, by their very presence and activities, they also change it—often dramatically."

3. Abiotic component

(*a*) The abiotic component of an environment are all of the non-living components of an organism's environment.

(*b*) These include such things as Temperature; Light; Water; Wind; Nutrients; Substrate (e.g., rock and soil); Periodic disturbances.

(*c*) Generally, a given organism is capable of surviving over only a limited range of abiotic variables, and the environments in which one (or more) abiotic component ranges outside of an organism's range of tolerance will not be able to support stable populations of that organism.

4. Biotic component

(*a*) The biotic component of an environment are all of the other organisms found in an environment with which an organism makes contact, directly or indirectly. These organisms may be competing, preying upon, being preyed upon, providing shelter, or in some other way impact on the environment.

5. Evolution in real time

(*a*) The complexity associated with ecology explains in part why the study of evolution is so intensely difficult: Evolution happens within a context of ecology, i.e., in real ecosystems, one organism at a time.

(*b*) Part of the complexity associated with ecology, however, is a consequence of the impact of evolution on ecosystems: Ecosystems are not only the products of evolution, they also contain populations that are actively evolving, all of the time.

(*c*) In other words, ecology is essentially evolution running in real time, while evolution is essentially the product of enormous numbers of ecological interactions between organisms and their biotic and abiotic environments.

6. Principle of allocation

(*a*) One way to understand ecology is in terms of flows of energy; organisms take in energy and then use that energy to survive and to reproduce. All adaptations are compromises, no organism is perfectly adapted to everything, and everything costs energy. An organism must balance out its allocation of energy to survival and its need to allocate energy to reproduction.

(*b*) Genotypes that strike a good balance between allocation to survival and to reproduction, such that net reproduction is large compared with other genotypes, are said to have higher relative fitnesses. These ideas form the basis of the principle of allocation.

(*c*) "Each organism has a limited amount of energy that can be allocated for obtaining nutrients, escaping from predators, coping with environmental fluctuations, growth and reproduction."

(*d*) Energy allocated to survival is not available for reproduction.

(*e*) "Complex life like animals and plants needs a lot of energy." Relatively simple organisms have lower energy needs, but tend also to be more limited in where they live or how much energy they can obtain per unit time.

7. Adaptation

(*a*) Organisms can respond to variations in the environment with variety of adaptations.

(*i*) Behavioural adaptations are almost instantaneous in their effects and easily reversed, whereas Physiological adaptations may be implemented and changed over time scales ranging from seconds to weeks.

(*ii*) Morphological adaptations may develop over the lifetimes of individual organisms or between generations.

(*iii*) Adaptive genetic changes in populations are slower still, usually evolving over several generations.

(*b*) The appropriate response to environmental change depends on the duration of that change."

(*c*) "The distinction between short-term adjustments on the scale of ecological time and adaptation on the scale of evolutionary time begins to blur when we consider that the range of responses of an individual to changes in the environment is itself the product of evolutionary history." That is, "**phenotypic plasticity**" is itself a product of evolution

(*d*) "In general, plants are more morphologically plastic than animals; this response helps them compensate for their inability to move from one environmental patch to another."

MAJOR AREAS OF ECOLOGICAL STUDY

8. Hierarchical study of ecology

(*a*) The study of ecology is often achieved by concentrating on a certain level of a hierarchy of ecological study, just as more reductionist forms of biology focus on certain levels of organisms ranging from the molecular, through the cellular, through the organismal

(*b*) "Ecology ultimately deals with the highest levels in the hierarchy of biological organization. The web of interactions at the heart of ecological phenomena is what makes this branch of biology so engaging."

(*c*) The hierarchies in ecological study include

(*i*) Organismal ecology

(*ii*) Population ecology

(*iii*) Community ecology

(*iv*) Ecosystem ecology

9. Organismal ecology

(*a*) Organismal ecology is an attempt to understand how the characteristics of individual organisms impact on the ability of those organisms to interact with their environment.

(*b*) Thus, for example, inferring that giraffes use their long necks to reach leaves found high in trees is an example of organismal ecology (though often inferences are just a bit more subtle and difficult than this example).

10. Behavioral ecology

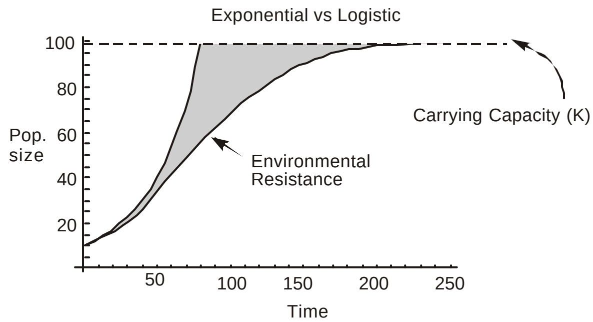
(*a*) Essentially a subset of organismal ecology, behavioural ecology studies the non-physiological, non-mophological/anatomical adaptations organisms possess, and the impact those adaptations have on the survival and reproduction of organisms.

(*b*) Behaviour, in other words, is how organisms act, and different behaviors can have different impacts on the Darwinian fitness of organisms.

11. Population ecology

(*a*) Population ecology is the study of the size and composition of populations of organisms.

(*b*) An example of population ecology would be the study of the factors which influence the carrying capacity of a given environment, i.e., the number of individuals an environment can stably sustain.



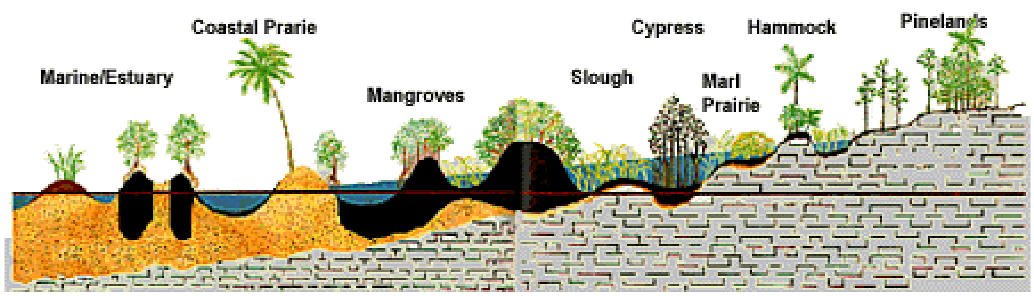
12. Community ecology

(*a*) A community is the assemblage of different species of organisms within a given environment. Community ecology is the study of the interactions between these organisms, e.g., predation, parasitism, competition, etc.

13. Ecosystem ecology

(*a*) An ecosystem is the assemblage of the biotic and abiotic components of a given environment. Often ecosystems are reasonably unambiguously defined (a lake, a forest, etc). Understanding even an approximation of what goes on within an ecosystem, any ecosystem, can be an overwhelming challenge.

(*b*) The everglades ecosystem as a function of altitude and other factors.



14. Landscape ecology

(*a*) "Looking beyond the four basic levels of ecology, we come to landscape ecology, which deals with arrays of ecosytems and how they are arranged in a geographic region. A landscape or seascape consists of several different ecosystems linked by exhanges of energy, materials, and organisms. The landscape level of research focuses on the ways in which interactions among populations, communities, and ecosystems are affected by the juxtaposition of different ecosystems, such as streams, lakes, old-growth forests, and the forest patches that have had their trees removed by clear-cut logging."

15. Maintaining homeostasis

(*a*) Part of the energy expended on survival goes toward maintaining the internal environment of an organism. The active maintenance of the internal environment of an organism (by the organism) is termed **homeostasis.**

(*b*) Some organisms spend considerably more energy on maintaining their internal environment within relatively narrow constraints (**regulators**).

(*c*) Other spend less energy on maintaining their internal environment because they do not constrain it narrowly (**conformers**).

(*d*) Any energy not spent on homeostasis is potentially available for other needs such as reproduction (**principle of allocation**).

(*e*) Note that this principle forms the basis of the conflicting strategies of specialization (e.g., conformers) versus generalization (e.g., regulators).

(*f*) Specialists potentially have more energy available to reproduce because they very efficiently obtain energy necessary for maintaining homeostasis, though this advantage is maintained only so long as the environment remains amenable to the specialist's needs (note: try to avoid equating the concept of specialization with the concept of specialization with respect to foraging; the latter, specialization with regard to diet, is essentially a subset of the former).

16. Conformers

(*a*) For organisms within relatively stable environments, energy can be made available for other uses if internal environments are allowed to vary as external environments vary. Such organisms may be termed conformers.

(*b*) Note that a conformer may be very successful within its relatively stable environment, but less able to survive outside of this environment.

(*c*) **"Conformers that live in very stable environments . . . might be able to channel more energy into growth and reproduction. However, the intolerance of such specialists to environmental change severely restricts their geographical distribution."**

17. Regulators

(*a*) At the opposite end of the spectrum are the regulators (i.e., versus conformers). These organisms expend a great deal of energy to keep their internal environment constant regardless of the nature of their abiotic environment.

(*b*) Such organisms may be more adaptable, but at the cost of great expenditures of energy that could otherwise be put toward such things as reproduction.

(*c*) **"Regulators that allocate a larger fraction of their energy to coping with environmental changes may grow and propagate less efficiently, but such organisms are able to survive and reproduce over a wider range of variable environments."**

18. Graininess

(*a*) Environmental grain refers to the patchiness of an environment, and the patchiness of an environment is perceived differently by different organisms. A coarsely grained environment has patches which are large enough that they may be distinguished. A finely grained environment has patches which are so small that they may not be readily distinguished, and an "organism may not even behave as though patches exist," but what is fine-grained to one (typically larger) organism may by coarse-grained to another (typically smaller) organism.

19. Population ecology

(*a*) Population ecology studies organisms from the point of view of the size and structure of their populations.

(*b*) A population ecologist studies the interaction of organisms with their environments by measuring properties of populations rather than the behavior of individual organisms.

(*c*) Properties of populations include
- Population size (size)
- Population density (density)
- Patterns of dispersion (dispersion)
- Demographics (demographics)
- Population growth (growth)
- Limits on population growth (limits)

(*d*) Note that all of these properties are not those of individual organisms but instead are properties which exist only if one considers more than one organism at any given time, or over a period of time (i.e., they are emergent properties)

(*e*) "The characteristics of a population are shaped by the interactions between individuals and their environments on both ecological and evolutionary time scales, and natural selection can modify these characteristics in a population."

(*f*) Thus, population ecology also goes beyond consideration of just population parameters and additionally considers how the characteristics of individual organisms impact on population parameters.

POPULATION PROPERTIES

1. Population

(*a*) A population in an ecological sense is a group of organisms, of the same species, which roughly occupy the same geographical area at the same time.

(*b*) Individual members of the same population can either interact directly, or may interact with the dispersing progeny of other members of the same population (e.g., pollen). Population members interact with a similar environment and experience similar environmental limitations.

2. Population size

(*a*) A population's size depends on how the population is defined. If a population is defined in terms of some degree of reproductive isolation, then that population's size is the size of its gene pool.

(*b*) If a population is defined in terms of some geographical range, then that population's size is the number of individuals living in the defined area.

(*c*) Ecologists typically are more concerned with the latter means of defining a population since this is both easier to do and is a more practical measure if one is interested in determining the impact of a given population on a given ecosystem, or vice versa.

3. Population density

(*a*) Given that a population is defined in terms of some natural or arbitrarily defined geographical range, then population density may be defined as simply the number of individual organisms per unit area.

(*b*) Different species, of course, exist at different densities in their environments, and the same species may be able to achieve one density in one environment and another in a different environment. Population densities may additionally be determined in terms of some measure other than population size per unit area such as population mass per unit area.

4. Patterns of dispersion

(*a*) Individual members of populations may be distributed over a geographical area in a number of different ways including
- Clumped distribution (attraction)
- Uniform distribution (repulsion)
- Random distribution (minimal interaction/influence)

(*b*) Clumping may result either from individual organisms being attracted to each other, or individual organisms being attracted more to some patches within a range than they are to other patches; the net effect is that some parts of the range will have a large number of individuals whereas others will contain few or none.

(*c*) A uniform distribution means that approximately the same distance may be found between individual organisms; uniform distributions result from individual organisms actively repelling each other.

(*d*) A random distribution means that where individual organisms are found is only minimally influenced by interactions with other members of the same population, and random distributions are *un*common; "Random spacing occurs in the absence of strong attractions or repulsions among individuals of a population."

(*e*) Note that both clumping and uniform distributions suggest that individual organisms are either interacting with one another (actively seeking each other out or actively avoiding each other), or are all competing with one another for the same limited resources, regardless of the overall population density (as in the case of clumping which results from geographical patchiness).

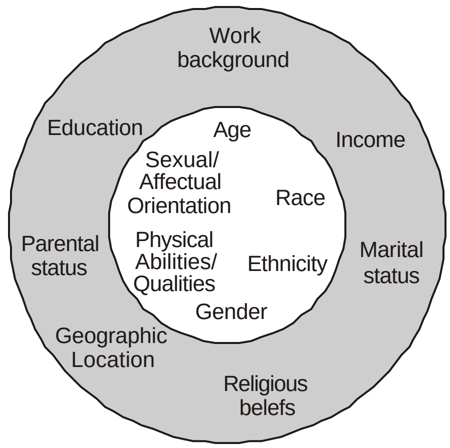
DEMOGRAPHICS

5. Demographics

(*a*) A population's demographics are its vital statistics, particularly those statistics which can impact on present and future population size.

(*b*) Two statistics that are of particular import are a population's age structure and a population's sex ratio.

(*c*) Additional considerations (in human populations and for example) are considered to the right →



6. Age structure

(*a*) Age structure refers to the size of cohorts within a population.

(*b*) Parameters related to age structure include

(*i*) Fecundity (birth rate)

(*ii*) Generation time

(*iii*) Death rate

7. Cohort

(*a*) A cohort is a group of individuals all of whom have the same age.

(*b*) In a typical population, the size of cohorts will vary with age. For example, in a typical population, younger cohorts will be larger (i.e., more individuals per cohort) than older cohorts, all else being equal.

8. Fecundity [birth rate]

(*a*) Fecundity refers to the average birth rate associated with a population.

(*b*) The greater a population's fecundity, all else held constant, the faster a population will increase in size. Note that fecundity typically varies with the age of individuals.

9. Generation time

(*a*) Generation time is simply the average span between the birth of individuals and the birth of their offspring.

(*b*) "Other factors being equal, a shorter generation time will result in faster population growth."

(*c*) Note that species which are capable of reproducing more than once will display an overlapping of generations which basically means that parental cohorts and progeny cohorts can be alive (and potentially competing with one another) at the same time.

(*d*) Note that another way of saying this is that when life expectancies exceed the minimum time between generations, generations will overlap.

10. Death rate

(*a*) Death rate is the rate at which individuals of a certain age die.

(*b*) Note that death rates often vary with age with either the very young or the very old displaying the greatest death rates.

(*c*) Note additionally that population growth occurs when overall birth rates exceed overall death rates.

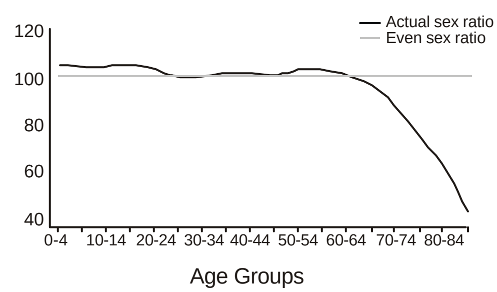
11. Sex ratio

(*a*) More often than not the rate at which a population may grow is dependent on the sex ratio in the population; the fewer females, the slower the rate of population growth.

(*b*) This, of course, is because uteruses are limiting and males often can inseminate more than one female.

(*d*) This generalization falls apart, however, when males are limited in their ability to inseminate more than one female, or when males contribute significantly to the raising of offspring.

(*e*) Figure shows sex ratios (New South Wales) as they vary with age (units on *y* axis are in living males per 100 females):



SURVIVORSHIP CURVES

12. Survivorship curves

(*a*) Observing age structure graphically can provide insights into a species' (or a population's) ecology. Survivorship curves graph cohort size against relative age.

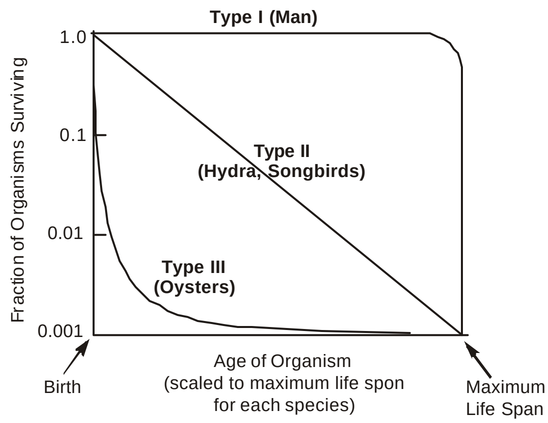
(*b*) **See Figure, Idealized survivorship curves.**

(*c*) The typical survivorship curve shows cohort size declining with age.

(*d*) There exist three general types of survivorship curves

- **Type I, II and III**

(*e*) Note in the following survivorship curves that the *y* axis is logarithmic!!!



Type I survivorship curves

(*a*) Because individuals tend to die exponentially due to accidents or predation, it often is a good strategy to reproduce relatively early in a life span rather than relatively late

  (*i*) That way individuals achieve reproduction while they still have a reasonable likelihood of being alive.

  (*ii*) This is assuming, of course, that the goal is a Darwinian one, i.e., maximizing one's reproductive output.

  (*iii*) Note that how such a strategy works is complicated if individual fecundity increases with age.

(*b*) Very often for a given species there will be some age at which individuals are maximally fecund. Species that combine maximum fecundity with early ages typically do so at the expense of their ability to survive long periods (i.e., this is an example of the principle of allocation).

(*c*) A survivorship curve of such individuals may display a relatively shallow slope while individuals are younger (i.e., maximally robust and maximally reproductive) but then show an abrupt increase in death rate at ages that are coincident to declines in fecundity.

(*d*) Humans, of course, have a type I survivorship curve; evolution makes us get married young and have lots of babies before a saber toothed tiger comes along and picks us off, i.e., →

Type II survivorship curves

(*a*) The simplest type of decline is exponential, i.e., the death rate for every cohort is the same.

(*b*) These survivorship curves graph as a straight line on semi-logarithmic graph paper (i.e., as presented in a typical survivorship curve).

(*c*) The individuals in populations that display a type II curve are those that both do not age and are born as fully fit as adults, e.g., hydr*a* Individuals are lost in these populations mostly to accidents and predation.

Type III survivorship curves

(*a*) The other side of the survivorship coin is the degree of investment in individual progeny. Some organisms invest a great deal in each offspring and those organisms are (ideally at least) rewarded with relatively high survivorship at early ages.

(*b*) Other organisms invest little in individual offspring, and display very low early-age survivorship (which they make up for by producing buckets of offspring).

(*c*) Organisms that produce large numbers of cheap progeny and which display minimal declines in fecundity with age, if they survive their youth, display type III survivorship curves. Examples include sea turtles and trees.

(*d*) That is, type III survivorship species have a very large rate of mortality when young, but should they survive their youth, they put significant energy into continued survival since the longer they survive, the more progeny they will produce.

LIFE HISTORIES

13. Life history

(*a*) "The traits that affect an organism's schedule of reproduction and survival (from birth through reproduction to death) make up its life history." The study of life history characteristics is the detailed study of those ecological and evolutionary parameters that impact on survivorship curves.

(*b*) "In many cases there are trade-offs between survival and traits such as clutch size (number of offspring per reproductive episode), frequency of reproduction, and investment in parental care. The traits that affect an organism's schedule of reproduction and death make up its life history. Of course, a particular life history pattern, like most characteristics of an organism, is the result of natural selection operating over evolutionary time."

(*c*) In other words, **the Darwinian goal is to maximize life time reproductive output**, and this can be achieved by having babies more rapidly or living longer, or some combination of the two, as well as by varying many additional details having to do with survival and reproduction.

14. Allocation of limited resources

(*a*) "Darwinian fitness is measured not by how many offspring are produced but by how many survive to produce their own offspring: Heritable characteristics of life history that result in the most reproductively successful descendants will become more common within the population. If we were to construct a hypothetical life history that would yield the greatest lifetime reproductive output, we might imagine a population of individuals that begin reproducing at an early age, have large clutch sizes, and reproduce many times in a lifetime. However, natural selection cannot maximize all these variables simultaneously, because organisms have a finite energy budget that mandates trade-offs. For example, the production of many offspring with little chance of survival may result in fewer offspring that can compete vigorously for limited resources in an already dense population."

(*b*) "The life history we observe in organisms represent a resolution of several conflicting demands. An important part of the study of life histories has been understanding the relationship between limited resources and competing functions: Time, energy, and nutrients that are used for one thing cannot be used for something else."

(*c*) "These issues can be phrased in terms of three basic questions:

(*i*) How often should an organism breed?

(*ii*) When should it begin to reproduce?

(*iii*) How many offspring should it produce during each reproductive episode?

(*d*) The way each population resolves these questions results in the integrated life history patterns we see in nature." (all one quote starting with (*c*) but broken up for clarity)

(*e*) "Many life history issues involve balancing the profit of immediate investment in offspring against the cost to future prospects of survival and reproduction. These issues can be summarized by three basic "decisions": when to begin reproducing, how often to breed, and how many offspring to produce during each reproductive episode. The various "choices" are integrated into the life history patterns we see in nature."

15. Semelparity (big bang)

(*a*) Organisms that produce one clutch of offspring (progeny) per life time are said to be semelparous (i.e., to display semelparity). The advantage of semelparity is that at the point of reproduction few if any resources need be devoted to survival past reproduction.

16. Iteroparity (repeated reproduction)

(*a*) Organisms that produce more than one clutch of offspring (progeny) per life time are said to be iteroparous (i.e., to display iteroparity). The advantage of iteroparity is that it allows organisms to display more than one statistical "shot" at producing a successful litter.

(*b*) "The critical factor in the evolutionary dilemma of big-bang versus repeated reproduction is the survival rate of the offspring. If their chance of survival is poor or inconsistent, repeated reproduction will be favored."

POPULATION GROWTH

17 Population growth

(*a*) The simplest case of population growth is that which occurs when there exist no limitations on growth within the environment. In such situations two things occur

(*i*) The population displays its intrinsic rate of increase

(*ii*) The population experiences exponential growth

18. Intrinsic rate of population increase (r_{max})

(*a*) The intrinsic rate of population increase is the rate of growth of a population when that population is growing under ideal conditions and without limits, i.e., as fast as it possibly can. This rate of growth implies that the difference between the birth rate and death rate experienced by a population is maximized.

(*b*) Note that the intrinsic rate of population increase is a characteristic of a population and not of its environment. Indeed, in most environments a population is not able to achieve this maximum rate of growth. However, a population that is not growing maximally can still experience exponential growth.

(*c*) "A population with a higher intrinsic rate of increase will grow faster than one with a lower rate of increase. The value of r_{max} for a population is influenced by life history features, such as age at the beginning of reproduction, the number of young produced, and how well the young survive."

19. Exponential growth

(*a*) Exponential growth simply means that a population's size at a given time is equal to the population's size at an earlier time, times some greater-than-one number.

(*b*) For example, if a population increased in size per unit time in the following manner: 1, 2, 4, 8, 16, 32, 64, 128, etc. (or, e.g., 1, 3, 9, 27..., or 1, 5, 25, 125, ..., etc. then the population is displaying exponential growth, each unit time the population is increasing by a factor of 2 (or 3 or 5 in the other examples; note that exponential growth is occurring so long as the rate of increase per unit time is greater than a factor of 1, e.g., 2 or 4 or 10 or 1.2, etc.

(*c*) When population size is graphed against time (e.g., generations) a population growing exponentially displays a J-shaped curve.

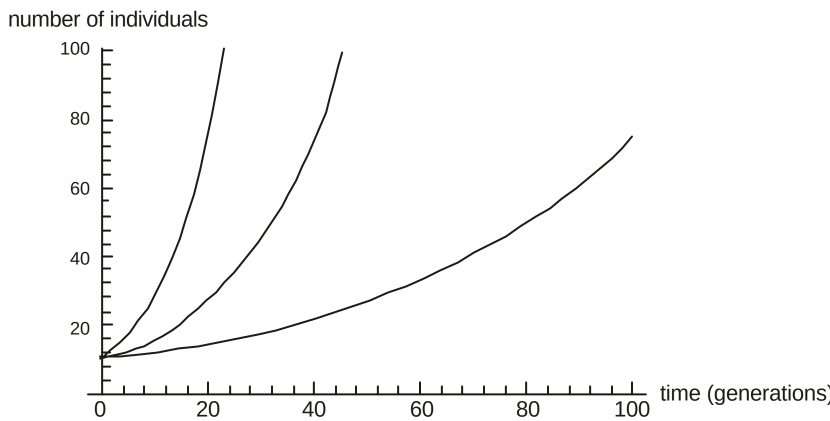
(*d*) Note differences in intrinsic rates of growth, in this J-shaped curves, that result in differences in rates of exponential growth (declining intrinsic growth rates are seen going from left to right in this graph):

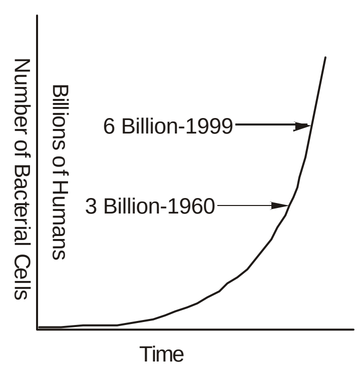
(*e*) [In a rich culture medium bacteria, grown under aerobic conditions, achieve a final concentration of 2-5 × 10^9 cells per ml in about 12-18 hours. Although plotted on a different time scale the human growth curve **looks the same**; the human population at similar points on the growth curve are shown.

(*f*) When population size is graphed against time (e.g., generations) a population growing exponentially displays a straight line curve when graphed on semi-logarithmic graph paper (for example, below is a graph of the exponential increase in the computer processing power available per dollar—note that on log-linear graph paper this curve is approximately a straight line):

(*g*) "The J-shaped curve of exponential growth is characteristic of populations that are introduced into a new or unfilled environment, or whose numbers have been drastically reduced by a catastrophic event and are rebounding."

(*h*) In other words, a population that is in an environment lacking limits will grow exponentially (indeed, a population that is capable of growing will tend to grow exponentially), and the rate at which growth will occur will be a function of r_{max} and the degree to which the environment matches the ideal environment in which an organism is capable of achieving r_{max}.





20. Limits on population growth

(*a*) Exponential growth cannot go on forever; sooner or later any population will run into limits in their environment

21. Carrying capacity (*K*)

(*a*) "Populations subsist on a finite amount of available resources, and as the population becomes more crowded, each individual has access to an increasingly smaller share. Ultimately, there is a limit to the number of individuals that can occupy a habitat.

Ecologists define carrying capacity as the maximum stable population size that a particular environment can support over a relatively long period of time. Carrying capacity, symbolized as K, is a property of the environment, and it varies over space and time with the abundance of limiting resources."

(*b*) In other words, for any given organism, there will be a maximum number of individuals that the environment can support without the environment being consequently degraded to the point where it can no longer support that number of individuals.

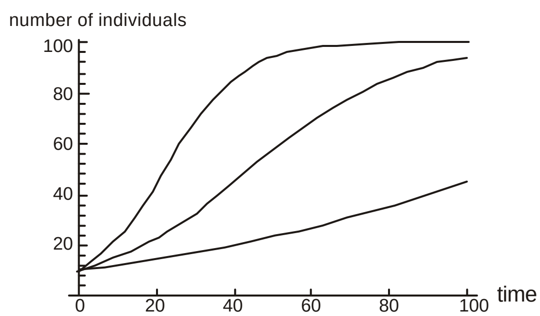
(*c*) Generally, as population size approaches carrying capacity, the amount of some key resource declines per capita to the point where individuals experience either a higher death rate or a lower fecundity; thus, as population size approaches carrying capacity, the rate of population growth declines towards zero.

22. Logistic growth

(*a*) Logistic growth is a mathematical description of population growth that employs two parameters, r_{max} and K, and two variables, N and t.

(*b*) The logistic growth curve is S-shaped.

(*c*) **See Figure: Population growth predicted by the logistic model.**



(*d*) That is, the population grows exponentially at a rate which is determined by r_{max} and the suitability of a given environment to an organism's needs until population size is sufficient that the limitations associated with the carrying capacity of the environment are approached.

(*e*) This slows the rate of population growth in a way such that the larger the population becomes, the slower its rate of growth; this slowing of the growth transforms the curve from a J-shaped one to an S-shaped one. Ultimately the rate of growth of the population reaches zero at the carrying capacity.

(*f*) "Because the rate at which a population grows changes with the density of organisms that are currently in the population, the logistic model is said to be density dependent." That is, population growth grows as population density approaches that dictated by an environment's carry capacity for that population.

(*g*) Note that populations do not typically display the idealized logistic growth seen with the model. One deviation from idealized logistic growth is delayed feedback; this can cause population size overshooting and, in fact, what is typically observed in real populations is not just effects of random events but also populations sizes which vary up and down around the carrying capacity rather than remaining invariant exactly at the carrying capacity.

23. *K*-selected populations (equilibrial populations)

(*a*) Idealized populations may be distinguished in terms of the logistic growth equation.

(*b*) For example, a species may bias its life history toward maximizing either r_{max} or K

(*c*) That is, some organisms are good at increasing their population size rapidly in environments which lack limits (e.g., weeds) while other species (e.g., gorillas) are good at maintaining population sizes at carrying capacity in environments that have limits.

(*d*) A species that is better at maintaining a population at carrying.

(*e*) capacity in a stable environment is said to be more *K*-selected.

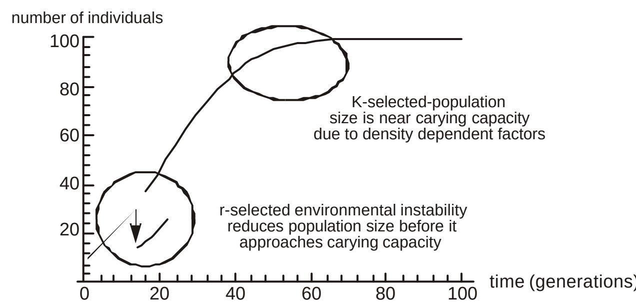
(*f*) A typical *K*-selected species is shown to the right →

24. *r*-selected populations (opportunistic populations)

(*a*) A species that is good at growing rapidly in, for example, disturbed environments, but is significantly less capable of maintaining its population at carrying capacity in undisturbed (i.e., stable) environments is termed *r*-selected.

25. *r* and *K* selection compared

(*a*) Few species are purely *r*- or *K*-selected; e.g., there certainly exist populations that are able to increase rapidly but may also thrive in mature ecosystems. “It has been difficult to demonstrate a direct relationship between population growth rate and specific life history characteristics. Increasingly, ecologists are recognizing that most populations show a mix of the traditional *r*-selected and *K*-selected characteristics; life history evolves in the context of a complex interplay of factors.”



(*b*) "Plants and animals whose young are subject to high mortality rates often produce large numbers of offspring. Thus, plants that colonize disturbed environments usually produce many small seeds, most of which will not reach a suitable environment. Small size might actually benefit such seeds if it enables them to be carried long distances... In other organisms, extra investment on the part of the parent greatly increases the offspring's change of survival."

	r **Unstable environment, density independent**	***K*** **Stable environment, density dependent interactions**
Organism size	Small	Large
Energy used to make each individual	Low	High
# Offspring produced	Many	Few
Timing of maturation	Early	Late (with much parental care)
Life expectancy	Short	Long
Lifetime reproductive events	One	More than one
Survivorship curve	Type III	Type I or II

POPULATION-LIMITING FACTORS

26. Density-dependent factors

(*a*) Density-dependent limits on population growth are ones that stem from intraspecific competition. Typically, the organisms best suited to compete with another organism are those from the same species. Thus, the actions of conspecifics can very precisely serve to limit the environment (e.g., eat preferred food, obtain preferred shelter, etc).

(*b*) Actions of that serve to limit the environment for conspecifics—e.g., eating, excreting wastes, using up non-food resources, taking up space, defending territories—are those that determine carrying capacity. They are referred to as *density dependent* because the greater the density of the *population*, the greater their effects. Density-dependent factors may exert their effect by reducing birth rates, increasing death rates, extending generation times, or by forcing the migration of conspecifics to new regions.

(*c*) "The impact of disease on a population can be density dependent if the transmission rate of the disease depends on a certain level of crowding in the population." "A death rate that rises as population density rises is said to be density dependent, as is a birth rate that falls with rising density. Density-dependent rates are an example of negative feedback. In contrast, a birth rate or death rate that does *not* change with population density is said to be density independent... Negative feedback prevents unlimited population growth."

(*d*) Predation can also be density dependent since predators often can switch prey preferences to match whatever prey organisms are most plentiful in a given environment. "Many predators, for example, exhibit switching behaviour: They begin to concentrate on a particularly common species of prey when it becomes energetically efficient to do so.

27. Density-independent factors

(*a*) Density-independent effects on population sizes (or structures) occur to the same extent regardless of population size. These can be things like sudden changes in the weather

(*b*) "Over the long term, many populations remain fairly stable in size and are presumably close to a carrying capacity that is determined by density-dependent factors. Superimposed on this general stability, however, are short-term fluctuations due to density-independent factors."

28. Community

(*a*) A community consists of all of the organisms living within a certain geographical area. These organisms include conspecifics as well as members of other species. These organisms interact with each other both directly and indirectly.

(*b*) Numerous (pessimists might say "endless") parameters affect what species are present and in what abundance

(*c*) "Simple generalizations can rarely explain why certain species commonly occur together in communities."

(*d*) "The distributions of most populations in communities are probably affected to some extent by both abiotic gradients and interactions [with other species]."

29. Co-evolution

(*a*) Not only do the abiotic and biotic components of an ecosystem impact on what species are present and in what abundance, but species also are modified by their interactions with other species

(*b*) Co-evolution represents the evolutionary modification of organisms in response to other organisms, particularly when two organisms are mutually modified in response to modifications displayed by the other, e.g.,

(*i*) a flower population better attracts certain insects which in turn evolve to better exploit the flower population.

(*ii*) faster rabbits select for faster coyotes which in turn select for faster rabbits.

COMMUNITY

COMMUNITY INTERACTIONS

1. Interspecific interactions

(*a*) Coevolution is one consequence of a more general category of ecology called interspecific interactions (between-species interactions). Previously, we considered intraspecific interactions, i.e., those between very similar organisms, conspecifics.

(*b*) Interspecific interactions range from those between fairly similar organisms to those between very dissimilar organisms.

(*c*) A key distinction between intraspecific and interspecific interactions is that the former but not the latter share a gene pool;

- (*i*) intraspecific interactions do not generally lead to the extinction of a species.
- (*ii*) In interspecific interactions, losers can go extinct.

(*d*) Interspecific interactions include symbioses and can be categorized as

- (*i*) Predation/parasitism (+/-)
- (*ii*) Competition (-/-)
- (*iii*) Commensalism (+/0)
- (*iv*) Mutualism (+/+)

2. Commensalism

(*a*) Commensalism is a relatively unexploited interspecific interaction. The reason for this has as much to do with its definition as anything, i.e., commensalism is a relationship in which one member gains but the other member neither gains nor loses; this places commensalism on a knife's edge between predation and mutualism.

(*b*) If the "unaffected" individual is indeed affected, even just a little, then the relationship can no longer, technically, be termed commensalisms. In the real world, it is essentially impossible to determine whether the "unaffected" member really is unaffected, so the concept is difficult to apply. Nevertheless, in absence of evidence for mutualism or predation then an assumption of commensalisms is a reasonable one.

3. Mutualism

(*a*) Mutualisms, while not necessarily as common as predation or interspecific competition, are still enormously common. This makes some sense since a mutualistic relationship is one in which both members gain. However, it is likely that most mutualistic relationships started out, in evolutionary time, as exploitative (+/-) relationships which somehow were co-opted into less exploitative relationships. Examples include everything from lichens, to bees and flowers, to mitochondria and the already lectured on eucaryotic cell.

PREDATION

4. Predation

(*a*) +/– interactions include

- (*i*) Predation
- (*ii*) Parasitism

(*iii*) Parasitoidism
(*iv*) Herbivory

(*b*) These interactions all involve
(*i*) one individual killing and then eating the other fully (predation)
(*ii*) not killing and then eating the other partially (parasitism and herbivory), or
(*iii*) letting one's offspring do the eating (parasitoidism).

(*c*) Note that an additional kind of + – interaction does not involve eating but instead is the stealing of some non-food a resource from one individual by the other: vines on trees, for example, or a cow bird's brood parasitism.

5. Defense against predation

(*a*) Prey organisms display numerous defenses against predation.

(*b*) That is, there exists a number of defenses against + / – – (as well as + / –) interactions:
(*i*) Secondary compounds (plants)
(*ii*) Nutritional deficiencies (plants)
(*iii*) Mechanical defenses (plants)
(*iv*) Production of poisons (animals)
(*v*) Mechanical defenses (animals)
(*vi*) Running away & hiding (animals)
(*vii*) Fighting back (mostly animals)
(*viii*) Cryptic coloration (mostly animals)
(*ix*) Batesian mimicry (animals)
(*x*) Müllerian mimicry (animals)
(*x*i) Immune systems (animals)

(*c*) [in order for a predator to obtain benefit from prey they have to encounter prey (i.e., be in close proximity), then detect prey (i.e., notice that they currently are in close proximity), then capture prey, then successfully consume the prey, and then successfully derive nutrient benefit from the prey, and minimally more benefit must be derived than the costs of capturing and consuming the prey – hence, it is to the potential prey's benefit, as an individual or as a population, to minimize their numbers so as to be rare and therefore rarely found by predators, to be cryptic in both coloration and behavior, to be capable of escaping if noticed, to be difficult to consume or to digest, and to not supply necessary nutrients or to be toxin to the predator in some manner].

6. Plant defenses against predation

(*a*) Of course, plant predators are called herbivores.

(*b*) Typically a plant (and other stationary organisms) will not manage to achieve complete avoidance of predation, but instead will limit their own predation to those organisms that possess appropriate morphological or biochemical adaptations.

(*c*) It is important to keep in mind that herbivores can be big (cows) as well as small (insects, fungi, bacteria) so more than one defense is typically necessary to defeat all possible predators.

(*d*) Of course, plants also tend to be eaten in pieces rather than as a whole organism, so anything a plant can do to spare part of the plant from being eaten can also be advantageous (this rule apparently is also true in terms of defenses against lawn mowers).

(*e*) Plant defenses against predation include

(*i*) Secondary compounds

(*ii*) Nutritional deficiencies

(*iii*) Mechanical defenses

7 Secondary compounds

(*a*) Secondary compounds are chemicals that plants produce that are distinct from the primary metabolism to some extent common to all plants. One role of secondary compounds are as defenses against predation, e.g., toxins.

(*b*) What is toxic to one herbivore may be useful to another; particularly humans take great advantage of plant secondary chemicals using them as drugs (both recreational and medicinal), spices, etc. Some animals (e.g., monarch butterflies) can actually incorporate these toxins into themselves to make themselves unpalatable to some of their own predators.

8 Nutritional deficiencies

(*a*) Plants additionally tend to lack certain nutrients (e.g., essential amino acids).

(*b*) Such nutritional deficiencies force predators to diversify what plants they consume, thus preventing herbivores from getting too good (specialized) at exploiting a particular plant species.

9. Mechanical defenses

(*a*) Anything a plant can do to keep a herbivore from reaching, biting, or deriving benefit from once a piece that has been removed can serve to protect the plant from being consumed.

(*b*) Thorns prevent larger things from comfortably eating a plant, while hairs and other small appendages can keep small things from reaching the plant.

(*c*) Plants also interfere with chewing by, essentially, being less than succulent, e.g.,. the shell of a nut or silica deposited in the leaves of grass.

(*d*) (between nutritional deficiencies, mechanical defenses, and secondary compounds one speaks of low forage quality and it is plants that represent low-quality forage that tend to accumulate when herbivore pressures are high, i.e., high animal to plant ratios).

10. Animal defenses against predation

(*a*) Animals are a little bit more versatile behaviorally when it comes to defending themselves against predation.

(*b*) For example, animals can

(*i*) Run and hide (particularly the latter aided by cryptic coloration)

(*ii*) Produce poisons that make them unpalatable

(*iii*) Employ morphological adaptations that interfere with consumption

(*iv*) Fight back using both morphological and chemical defenses (some plants, too, can fight back using, for example, actively sprayed chemical defenses)

(*v*) Not looking like prey (cryptic coloration)

11. Cryptic coloration

(*a*) Cryptic coloration is camouflage, the art of looking like something else, i.e., not hiding behind something but instead not being visible against appropriate backgrounds.

(*b*) ["Camouflage, called cryptic coloration, is the quintessential passive defense, making potential prey difficult to spot against its background. A camouflaged animal need only remain still on an appropriate substrate to avoid detection"].

12. Aposematic coloration

(*a*) A different approach is to taste bad (or be unpalatable for various other reasons) and to advertise this

(*b*) Aposematic coloration is how organisms advertise unpalatableness, at least visually (humans, or course, display a distinct bias in terms of sensory input hence we tend to notice the visual displays by animals much more so than, for example, the olfactic displays – notice that since birds display the same bias we often interpret these visual displays in terms strategies that interfere with predation by birds).

(*c*) For example, the black and yellow stripes on bees represent aposematic coloration, and it works!

(*d*) Aposematic coloration is so successful, in fact, that it gives rise to mimicry

(*i*) Batesian mimicry

(*ii*) Müllerian mimicry

13. Batesian mimicry

(*a*) Batesian mimicry is the tendency of palatable and otherwise succulent prey species to pretend to be unpalatable by looking like unpalatable species. This works to a point, but limits the size of the mimic's population since once mimics are sufficiently prevalent, predators will catch on to the mimicry.

(*b*) However, when their numbers are sufficiently few, the mimic gains from protection from predation while simultaneously not putting out the resources needed to achieve lack of palatability, etc.

14. Müllerian mimicry

(*a*) Mimicry works in everybody's favor when unpalatable species mimic each other (e.g., both wasps and bees sharing black and yellow aposematic coloration). Such mimicry increases the representation of lack of palatableness among potential prey associated with a given form of aposematic coloration.

(*b*) Note that both Batesian and Müllerian mimicry can occur simultaneously with the same aposematic coloration within the same communities (i.e., a group a similarly marked organisms, some of which are harmless and others which are not).

15. Predation and species diversity (keystone species)

(*a*) Another way that two directly competing species can achieve coexistence results from predation. A predator typically feeds on more than one species. By doing so, they serve to keep the populations of both species below the sizes one or both could attain in the absence of predation (i.e., below carrying capacity). This can allow both competing species (i.e., the prey) to coexist, especially if the weaker competing species happens to be better at escaping predation.

(*b*) Additionally, optimal foraging can result in prey caught and consumed as a function of their population densities such that predation maintains prey diversity by frequency-dependent effects in the same manner that frequency-dependent selection can maintain a balanced polymorphism.

(*c*) One can describe a predator whose presence has a profound impact on the species diversity of a given community as a *keystone species*.

COMPETITION BETWEEN SPECIES

16. Interspecific competition

(*a*) Interspecific competition represents a lose-lose interaction (–/–), that is, both species are less able to convert resources into progeny because the other species is laying claim to the same resources.

(*b*) Note that this is an unstable situation that will tend to select for either better means of acquiring the contested resources, or a switching to a different resource.

(*c*) Additionally, note that while a competing species may be more effective in exploiting any given resource, conspecifics will always be competing with any given individual for a larger variety of resources than will interspecifics.

(*d*) Thus, growth of a given species may be limited by both conspecifics (intraspecific competition/density-dependent factors) and interspecific competition (a density-independent factor).

(*e*) "Expression" of the costs of interspecfic competition include:
   (*i*) Competitive exclusion
   (*ii*) Resource partitioning
   (*iii*) Character displacement
   (*iv*) Fundamental vs. Realized Ecological Niche

17. Interference competition

Interspecific competition that involves actual interspecific fighting is termed interference competition.

18. Exploitative competition

Interspecific competition which involves no fighting but instead a co-usage of one or more resources is termed exploitative competition.

19. Competitive exclusion

(*a*) "Two species with similar requirements cannot coexist in the same community; one species would inevitably harvest resources and reproduce more efficiently, driving the other to local extinction. Even a slight reproductive advantage would eventually lead to the elimination of the inferior competitor and an increase in the density of the superior one". This is the competitive exclusion principle.

(*b*) Two populations with very similar needs, living sympatrically, will be in too great a competition with each other to coexist, unless both populations are the same species (in which case, of course, they wouldn't be two separate populations). Similarly, two populations can coexist if their needs sufficiently differ.

20. Resource partitioning

(*a*) Extinction of one of two populations living sympatrically and competing over too many resources is not the only possible outcome of interspecific competition. An alternative outcome is the evolution of a divergence of resource needs. Such a divergence is called resource partitioning, and is simply the ecological version of the idea that it is often easier to switch than it is to fight.

21. Character displacement

(*a*) Character displacement is presumably a consequence resource partitioning. "The tendency for characters to be more divergent in sympatric populations of two species than allopatric population of the same two species is called character displacement."

(*b*) That is, characters diverge presumably in response to interspecific competition, but do not diverge in populations not subject to the same interspecific competition.

(*c*) Thus, the character differs between the population undergoing interspecific competition and the population not undergoing interspecific competition.

22. Ecological niche

(*a*) What is being fought over in interspecific competition is various aspects of the ecological niche. A niche is the sum total of what an organism does in its environment, including all of the resources consumed.

23. Fundamental niche

(*a*) All of the resources a population could exploit under ideal conditions, where there exists no interspecific competition, is termed the fundamental niche of an organism. The fundamental niche basically represents as good as things can get for an organism. A population able to exploit its fundamental niche would be able to achieve its maximal population size.

24. Realized niche

(*a*) Nothing, of course, is perfect, and the fundamental niche represents perfection to the exploiting population. In the real world, populations do not have access to all of the resources they could possibly exploit. Such a limitation on resource acquisition is termed a realized niche, i.e., what resources a population can exploit in a real environment, particularly one in which interspecific competition occurs.

TROPHIC STRUCTURE

25. Trophic structure

Trophic structures are the feeding relationships within communities and therefore within ecosystems, that is, who's eating whom.

26. Trophic level

Trophic levels refer to how far removed from the original source of energy an organism is within a trophic structure.

27. Primary producer

The first trophic level is made up of the primary producers, the organisms that obtain from inorganic sources the energy that powers ecosystems. Primary producers typically are photosynthetic organisms. More generally, primary producers are autotrophs (i.e., they fix CO_2).

28. Consumers

Consumers are the heterotrophs, i.e., organisms that obtain their carbon from other organisms. The typical consumer is a chemoheterotroph that consumes other organisms or parts of other organisms to obtain their carbon and energy. In addition to the types of consumers listed below we can also speak of omnivores, i.e., consumers that eat at different trophic levels including consuming producers and detrivores, which are consumers that consume detritus which is the broken up remains of organisms].

29. Primary consumer (herbivore)

A primary consumer is a consumer that eats primary producers. Primary consumers are called **herbivores.**

30. Secondary consumers (carnivore)

Secondary consumers eat primary consumers.

31. Tertiary consumers

Tertiary consumers eat secondary consumers.

32. Decomposers

(*a*) Decomposers consume the waste given off by living organisms or the remains of dead organisms which they did not kill.

(*b*) "The organic material that composes the living organisms in an ecosystem is eventually recycled, broken down and returned to the abiotic environment in forms that can be used by plants. Decomposers, which feed on nonliving organic material, are key to this recycling process. The most important decomposers are bacteria and fungi, which first secrete enzymes that digest organic material and then absorb the breakdown products; some can even digest cellulose."

(*c*) "In fact, all heterotrophs, including humans, are decomposers in the sense that they break down organic material and release inorganic products, such as carbon dioxide and ammonia, to the environment."

33. Food chain

A simplification of the trophic structure of an ecosystem is the food chain. Food chains refer to the passage of nutrients and energy from a primary producer to a primary consumer to a secondary consumer, and soon.

34. Food web

(*a*) Far more realistic is the concept of food webs. Food webs are like food chains but more realistic, i.e., allowing for species to consume more than one other kind of species. In addition, food webs allow individual species to consume at more than one trophic level.

(*b*) For example, humans consume primary producers (e.g., soya beans), primary consumers (e.g., cows), and secondary (or higher) consumers (e.g., salmon).

(*c*) [*grazing food chains* have producers at base which the herbivores then graze on. While grazing food chains are important, in nature they are outnumbered by *detritus-based food chains*. In detritus-based food chains, decomposers are at the base of the food chain, and sustain the carnivores which feed on them. In terms of the weight (or biomass) of animals in many ecosystems, more of their body mass can be traced back to detritus than to living producers.

ECOLOGICAL SUCCESSION

35. Ecological succession

(*a*) One thing that limits the carrying capacity for many organisms is that the presence of these organisms essentially spoils the environment for their continued presence. Such organisms typically are ***r*-selected**, and essentially are good at finding environments they can exploit, exploiting those environments, then giving way to organisms which are better at hanging on in those environments.

(*b*) The exploitation of an environment by one population, followed by the exploitation by a second (third, etc.) population is termed ecological succession.

(*c*) "Many of the changes in community structure during succession may be induced by the organisms themselves. Direct biotic interactions may be involved, including *inhibition* of some species by others through exploitative competition, interference competition, or both. The presence of organisms also affects the abiotic environment by modifying local conditions. This may result in *facilitation*, in which the group of organisms representing one stage 'paves the way' for species typical of the next stage . . . Sometimes the changes that facilitate the development of a later stage actually make the environments unsuitable for the very species responsible for the changes."

(*d*) Ecological succession continues in a habitat until species, typically ***K*-selected,** that are good at nurturing their young within the same environment (as well as good at excluding other species) comes to dominate the environment, or until catastrophic change essentially wipes the slate clean, making an environment once again exploitable to the *r*-selected populations.

36. Primary succession

(*a*) Ecological succession typically occurs in fairly well-defined waves of succeeding organisms. When the environment being exploited is essentially lifeless—lacking in both living organisms and in their remains—then the first round of exploitation is termed primary succession.

(*b*) Primary succession occurs, for example, following volcanic or glacial destruction of an environment. The first organisms that exploit an otherwise lifeless terrain are termed primary successors. This is a fairly rare occurrence especially relative to the much-more familiar secondary succession that we observe in disturbed habitats all around us.

37. Secondary succession

(*a*) Secondary succession is succession that follows primary succession, i.e., of an environment that already contains life (or, at least, soil).

(*b*) "Because resource availability changes over the course of succession, different species compete better at different stages. Early stages are typically characterized by *r*-selected species that are good colonizers because of their high fecundity and excellent dispersal mechanisms. Many of these may be described as 'fugitive' or 'weedy' species that do not compete well in established communities, but maintain themselves by constantly colonizing newly disturbed areas before better competitors can become established in the same places."

38. Climax community

(*a*) The community within an ecosystem that exists following ecological succession is termed the climax community. A climax community is made up of organisms that are good at reproducing in the face of interspecific competition

(*b*) "At the climax stage, environmental conditions are such that the same species can continue to maintain themselves. For example, the [maple-beech] forest that is the climax stage of old-field succession [in much of Ohio] maintains the moist, shaded environment that allows offspring of these species to grow, while inhibiting most of the species typical of earlier stages of succession."

(*c*) Climax communities will remain in place until either the climate changes, a better competitor arrives, or the community is catastrophically disrupted, e.g., by fire or, more recently, by extensive logging;

ISLAND BIOGEOGRAPHY

1. Island biogeography

(*a*) In order for an ecosystem to go through succession, the organisms in each wave of succession must be available in the local environment. The farther an ecosystem is from a source of these organisms, the less likely these organisms will be present and therefore that succession will occur. The smaller an island is, the less likely that species will find their way to the island and the more likely that species present on the island will go extinct (due to smaller size and due to resultantly smaller populations, respectively).

(*b*) This can be seen most obviously on islands: the farther an island is from a source of organisms, the less likely the given organisms will find their way to the island. The flip side is that as a consequence of, if nothing else, random extinction, the smaller an ecosystem is, the less able it is to hold on to the species that it has. Thus, the farther an island or ecosystem is from other islands or ecosystems, and the smaller the island or ecosystem, the more impoverished of species either is likely to be.

(*c*) Application of these ideas to our environment is somewhat profound because they tell us that we can't go on destroying ecosystems forever without risking their very existence. In other words, eventually if we convert every last forest into farmland, housing tract, or parking lot, the remnants of ecosystems will be so small that they will be unable to sustain what species they start with, and ecosystems will be so far apart that they will be unable to reacquire species from similar ecosystems

(*d*) This essentially, ultimately represents a genetic bottlenecking of the entire world, and if the goal of humans is to survive past this environmental disaster of our own making, then the big losers will most definitely be ourselves.

FLOW OF ENERGY THROUGH ECOSYSTEMS

1. Ecosystem

(*a*) "An ecosystem consists of all the organisms living in a community as well as all the abiotic factors with which they interact."

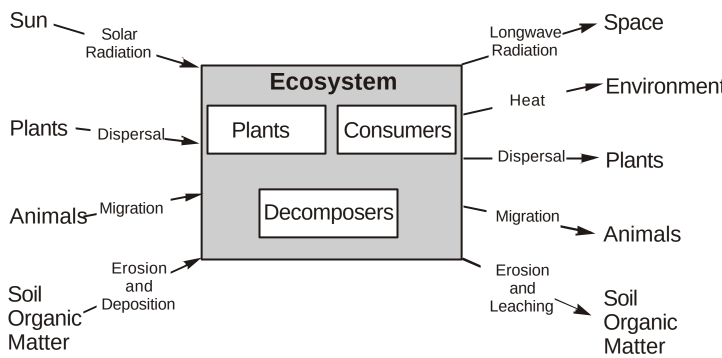
(*b*) Note that the boundaries of ecosystems are typically not arbitrarily defined, but instead are defined in some meaningful way: A pond, a field, a forest, etc.

(*c*) Ecosystems are typically understood in terms of

  (*i*) Energy flow through ecosystems

  (*ii*) Chemical cycling within (and through) ecosystems (*d*) Note that both involve the movement of "stuff" through both biotic and abiotic components of the ecosystem.

(*e*) "Ecosystems ecologists view ecosystems as energy machines and matter processors. By grouping the species in a community into trophic levels of feeding relationships, we can follow the transformation of energy in the whole ecosystem and map the movements of chemical elements as they are used by the biotic community."

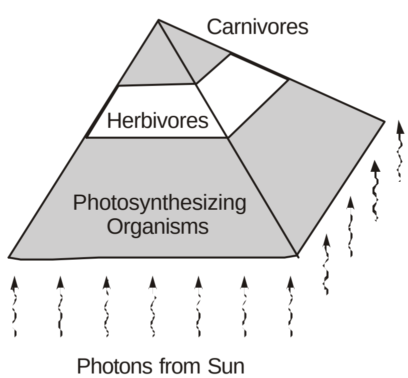


2. Energy flow

(*a*) Energy does not cycle through ecosystems but instead enters ecosystems and is used up within ecosystems. Ultimately, energy is lost from ecosystems primarily as waste heat, the most thermodynamically unavailable form of energy.

(*b*) "Energy enters most ecosystems in the form of sunlight. It is then converted to chemical energy by autotrophic organisms, passed to heterotrophs in the organic compounds of food, and dissipated in the form of heat . . . The movements of energy and matter through ecosystems are related because both occur by the transfer of substances through feeding relationships. However, because energy, unlike matter, cannot be recycled, an ecosystem must be powered by a continuous influx of new energy from an external source (the sun). Thus, energy flows through ecosystems, while matter cycles within them."

"Pyramid of Life"



(*c*) Note that energy flows through ecosystems mostly as bonds between carbon atoms and bonds between carbon and hydrogen atoms, e.g., as one finds in carbohydrates and lipids; consequently, within and between organisms the carbon cycle and the flow of energy are quite similar, at least until the two are decoupled in the course of cellular respiration (i.e., the separation of carbon atoms from their energy).

PRODUCTIVITY

3. Primary productivity

Only a small fraction of the sunlight striking the earth is converted to chemical energy by primary producers. That sunlight energy that is converted to chemical energy, over a given period, is termed primary productivity.

4. Gross primary productivity

Gross primary productivity is all of the light energy that is converted to chemical energy by producers.

5. Net primary productivity

Net primary productivity is all of the light energy that is converted to chemical energy and that is subsequently stored by the primary producer (i.e., the gross primary productivity minus that employed to run the primary producer's metabolism). The ratio of net primary productivity to gross primary productivity gives an indication of the cost of keeping the organism going, with large ratios indicative of relatively few costs (e.g., algae, ~50%) and smaller ratios associated with many costs (e.g., complex plants such as trees, ~10%).

6. Biomass

Net primary productivity is stored as biomass (dry mass of organisms).

7. Standing crop biomass

Standing crop biomass is another way of saying accumulated net primary productivity.

8. Limiting nutrient

(*a*) The productivity of an ecosystem is dependent on the primary productivity of the primary producers within that ecosystem. Other than sunlight, primary productivity is limited by nutrient availability.

(*b*) A limiting nutrient is that nutrient which is found in the lowest, relative concentrations such that an increase in this nutrient will increase primary productivity while a decrease in this nutrient will decrease primary productivity.

(*c*) Typically, either phosphorus or nitrogen serves as a limiting nutrient within a given ecosystem, though water availability can (and often does) also serve to limit the primary productivity of an ecosystem.

9. Secondary productivity

(*a*) "The rate at which an ecosystem's consumers convert the chemical energy of the food they eat into their own new biomass is called the secondary productivity." Note that secondary productivity is dependent, in part, on the efficiency of transfer of chemical energy between trophic levels. The transfer between trophic levels, however, is typically not highly efficient because of inefficiencies involved in energy transfers in general, and the fact that the consumer must use acquired energy to respire (i.e., keep their metabolism going, reproduce, repair themselves, etc).

(*b*) The more energy required to keep the consumer going (e.g., endotherms = "warm blooded" = more versus ectotherms = "cold blooded" = less), the less efficiently primary productivity will be converted to secondary productivity.

(*c*) "Of course, the energy contained in the feces is not lost from the ecosystem; it can still be consumed by decomposers. However, the energy used for respiration is lost from the ecosystem; thus, while solar radiation is the ultimate source of energy for most ecosystems, respiratory heat loss is the ultimate sink. This is why energy is said to flow through, not cycle within, ecosystems."

10. Trophic efficiency

(*a*) Trophic efficiency refers to the transfer of energy up trophic levels, e.g., the ratio of secondary productivity to primary productivity consumed.

(*b*) Trophic efficiencies generally range from 5% to 20%; that is, only 5% to 20% of primary producer biomass consumed is converted into new consumer biomass.

(*c*) Note that trophic inefficiencies arise note just due to the second law of thermodynamics but because of inefficiencies in digestion (i.e., not everything is assimilated but instead is pooped out); in addition, it is always important when looking at food pyramids to keep in mind that not everything at the lower trophic levels is eaten, i.e., there is a reason that much of the terrestrial world is green, animals do not consume all of the plant material; on the other hand, there is a reason that many aquatic environments are not quite as green, animals do consume most of the planktonic photosynthesizers within aquatic systems.

11. Pyramid of productivity

(*a*) A common way of illustrating ecological efficiency is via pyramids of productivity. In these, productivity consumed is compared to productivity acquired, going up trophic levels, e.g., each level represents a drop of net productivity of approximately 90% (95% to 80%).

(*b*) Note that this is the reason that eating "lower on the food chain" is more consistent with being a good world citizen than eating higher on the food chain, i.e., vegetarians make a substantially smaller per capita impact on our planet than do meat eaters.

(*c*) [A generalization exists among ecologists that on average, about 10% of the energy available in one trophic level will be passed on to the next; this is primarily due to the 3 reasons given above. Therefore, it is also reasonable to assume that in terms of biomass, each trophic level will weigh only about 10% of the level below it, and 10x as much as the level above it. It also seems, however, that every time I go to measure, test, or model this assumption I run into an inconsistency, so take this generalization with a big grain of salt. Still, it comes in useful in terms of human diet and feeding the world's population, consider this. If we all ate corn, there would be enough food for 10x as many of us as compared to a world where we all eat beef (or chicken, fish, pork, etc). Another way of looking at it is this. Every time you eat meat, you are taking food out of the mouths of 9 other people, who could be fed with the plant material that was fed to the animal you are eating.

12. Biomass pyramid

(*a*) Similar to the pyramid of productivity, pyramids can be constructed using biomass. Again, the variable associated with the primary producer is placed on the bottom with blocks associated with trophic levels stacked one upon the other. Just as with pyramids of productivity, biomass pyramids can show dramatically decreasing biomass with increasing trophic levels. However, this is not always the case and the reason for exceptions has to do with biomass pyramids being constructed from standing-crop biomass rather than from consumed-biomass data.

(*b*) Consequently, aquatic biomass pyramids can seemingly be upside down if net primary productivity does not accumulate in the ecosystem within primary producers (i.e., primary producers are eaten as fast as they grow/reproduce).

13. Pyramid of numbers

(*a*) Just as with productivity, total numbers of individual organisms tend to decline as one goes up trophic levels. All else held constant, this decline is a consequence of ecological efficiencies being less than 100%.

(*b*) A consequence of the pyramid of numbers is that top predator numbers tend to be small, thus making top predators both slow to evolve (also because they tend to be long lived and have long generation times) and relatively easy to drive to extinction.

CHEMICAL CYCLES

14. Biogeochemical cycles

(*a*) "Because nutrient cycles involve both biotic and abiotic components of ecosystems, they are also called biogeochemical cycles."

(*b*) [The inorganic nutrients cycle through more than the organisms... they also enter into the atmosphere, the oceans, and even rocks. Since these *chemicals* cycle through both the *biological* and the *geological* world, we call the overall cycles biogeochemical cycles. Each chemical has its own unique cycle, but all of the cycles do have some things in common. *Reservoirs* are those parts of the cycle where the chemical is held in large quantities for long periods of time. In *exchange pools*, on the other hand, the chemical is held for only a short time. The length of time a chemical is held in an exchange pool or a reservoir is termed its *residence* time. The oceans are a reservoir for water, while a cloud is an exchange pool. Water may reside in an ocean for thousands of years, but in a cloud for a few days at best. The biotic community includes all living organisms. This community may serve as an exchange pool (although for some chemicals like carbon, bound in a sequoia for a thousand years, it may seem more like a reservoir), and also serve to move chemicals from one stage of the cycle to another. For instance, the trees of the tropical rain forest bring water up from the forest floor to be evaporated into the atmosphere... The energy for most of the transportation of chemicals from one place to another is provided either by the sun or by the heat released from the mantle and core of the Earth.

15. The Carbon cycle

(*a*) The carbon cycle is an example of biogeochemical cycle in which the element (carbon) has a gaseous form, i.e., CO_2, carbon dioxide. Carbon dioxide is converted to organic forms of carbon in the Calvin cycle of primary producers. Organic carbon is converted back to carbon dioxide during respiration.

(*b*) Not all fixed carbon is converted back to CO_2 over medium-term time scales since some ultimately is buried as oil, coal, or limestone (the latter is calcium carbonate).

16. The Nitrogen cycle [ammonification, nitrogen assimilation, denitrification, nitrification, nitrogen fixing]

(*a*) The nitrogen cycle, like the carbon cycle, involves a gaseous form, i.e., N_2 or nitrogen gas.

(*b*) Nitrogen gas may be removed from the atmosphere, particularly by bacteria, in a process called **nitrogen fixing** [which is relatively expensive since nitrogen gas is quite stable].

(*c*) Nitrogen gas may be returned to the atmosphere, again particularly by bacteria, in a process called **denitrification** (a form of anaerobic respiration);

(*d*) More typically, bioavailable nitrogen is found as ammonium ion (NH_4^+), nitrate ion (NO_3^{2-}), and various organic, nitrogen-containing compounds (e.g., amino acids and nucleic acids).

(*e*) Nitrate and ammonium ion are converted back and forth between each other (and nitrite, NO_2^{2-}), also by various bacteria via processes termed **nitrification** and **ammonification.**

(*f*) The nitrogen cycle thus involves

- (*i*) **Nitrogen fixing**, the fixing of nitrogen from the atmosphere [typically by free-living or plant-associated nitrogen-fixing bacteria]
- (*ii*) **Assimilation**, the uptake of ammonium ion and nitrate ion from soil by plants and the uptake of organic nitrogen by animals from plants (amino acids, nucleic acids).
- (*iii*) **Ammonification**, the conversion of organic nitrogen back to ammonium ion by decom posers (nitrogenous waste) ($\blacktriangleright NH_4^+$); "The decomposition of organic nitrogen back to ammonium, a process called ammonification, is carried out mainly by bacterial and fungal decomposers."
- (*iv*) **Nitrification**, the various conversions of nitrogen within the soil from ammonium ion ($NH_4^+ \blacktriangleright NO_2^{2-} \blacktriangleright NO_3^{2-}$; note that this represents an oxidation of nitrogen); "Although plants can use ammonium directly, most of the ammonium in soil is used by certain aerobic bacteria as an energy source; their activity oxidizes ammonium to nitrite (NO_2^{2-}) and then to nitrate (NO_3^{2-})."
- (*v*) **Denitrification**, also by soil bacteria ($\blacktriangleright N_2$; note that this process involves the reduction of nitrogen); "Some bacteria can obtain the oxygen they need for metabolism from nitrate (NO_3^{2-}) rather than from O_2 under anaerobic conditions."

(*g*) [A portion of the nitrogen cycle as it occurs within fish tanks (here nitrification is a good thing and ammonification, the production and subsequent build up of ammonium ion, is a bad thing): The nitrogen cycle has some important practical considerations, as anyone who has ever set up a saltwater fish tank has found out. It takes several weeks to set up such a tank, because you must have sufficient numbers of nitrite and nitrate bacteria present to detoxify the ammonia produced by the fish and decomposers in the tank. Otherwise, the ammonia levels in the tank will build up and kill the fish. This is usually not a problem in freshwater tanks for two reasons. One, the pH in a freshwater tank is at a different level than in a saltwater tank. At the pH of a freshwater tank, ammonia is not as toxic. Second, there are more multicellular plant forms that can grow in freshwater, and these plants remove the ammonia from the water very efficiently. It is hard to get enough plants growing in a saltwater tank to detoxify the water in the same way.

17. The Phosphorus cycle

(*a*) Unlike the nitrogen and carbon cycles, the phosphorus cycle does not involve a gaseous phase. As a consequence, phosphorus tends to cycle more locally rather than entering into the world-wide cycling seen with nitrogen and carbon.

(*b*) The ultimate source of phosphorous is phosphate minerals that make up rocks.

(*c*) The form in which phosphorus is available is as the phosphate ion (PO_4^{3-})

(*d*) Phosphorous is lost from ecosystems by erosion; e.g., The Grand Canyon, an impressive example of erosion in action. Phosphorous can be gained by ecosystems, sometimes significantly, particularly via the movement of animals.

(*e*) "After producers incorporate phosphorus into biological molecules, it is transferred back to the soil by the excretion of phosphate by animals and by the action of decomposers on detritus."

(*f*) Note that phosphorus is transferred to (and between) terrestrial environments also by processes other than just bird pooping (i.e., guano) including the migration of various others animals such as salmon, which carry phosphorous from the sea back to their mother streams and on the way are eaten by such things as bears which, yes, do go on to poop in the woods:

(*g*) [Heterotrophs (animals) obtain their phosphorous from the plants they eat, although one type of heterotroph, the fungi, excel at taking up phosphorous and may form mutualistic symbiotic relationships with plant roots. These relationships are called *mycorrhizae*; the plant gets phosphate from the fungus and gives the fungus sugars in return.

BEHAVIOURAL ECOLOGY

(*a*) Animals typically display particular behaviors at different times of the day or times of the year. The mechanisms underlying these rhythmic behaviors may be categorized as endogenous or exogenous (coming from within the animal and coming from the animal's environment, respectively). Typically the exogenous signal is light (i.e., the stuff that comes from the sun).

(*b*) For example, a typical animal will be able to almost-display rhythmic behaviours at the appropriate times without exogenous signals (e.g., if deprived or light or changes in light) but will only not be able to display behaviors at appropriate times with high accuracy if deprived of the exogenous signals.

(*c*) Note that this endogenous-exogenous system allows animals to innately display appropriate behaviours at nearly appropriate times independently of fallible exogenous signals, but still adapt to changes in exogenous signals, e.g., as day lengths change with the seasons.

1. Kinesis

(*a*) Kinesis is a movement behavior such that movement randomly occurs given the presence of a stimulus; in practice, an organism will tend to settle down in a region that is preferred by tending to move particularly when not present in the preferred location. Kinesis is a mechanism of movement that involves activity only so long as a stimulus is present (or, alternatively, only when a signal is absent).

(*b*) For example, an animal might move only when the environment is in some way unfavorable; this movement does not occur in a specific direction but instead is randomly directed, with attainment and maintenance of the animal within a more favorable environment occurring simply because less movement occurs when the movement-associated stimulus is not present.

2. Taxis

Taxis, by contrast with kinesis, is directed movement either toward or away from a stimulus.

3. Migration

Migration is the regular (annual) movement of animals over long distances. Migrating animals find their way via one of three mechanisms

(*i*) Piloting (“map”)

(*ii*) Orientation (“compass”)

(*iii*) Navigation (“map” and “compass”)

4. Piloting

Piloting is the movement from one landmark to another such that terrain remains familiar throughout the migration. Because of the requirement that an animal have essentially memorized the directions for the entire trip (an internal map), piloting is typically employed only for relatively short trips (or trips made over well land-marked land, e.g., over a well-worn path).

5. Orientation

(*a*) Orientation involves straight-line travel in a direction that is globally oriented (e.g., flying by compass). Compasses are not necessarily artifacts (i.e., man-made devices) but may also be small, sensory magnets found within an animal’s head.

(*b*) Alternatively, many animals appear to orient using the position of the sun (or stars) and innate knowledge of the time of the day.

6. Navigation

(*a*) Navigation involves possessing both a map and a compass.

(*b*) Maps are not necessarily paper things, i.e., one can possess a "map" within one's head.

FINDING FOOD

7. Foraging (generalists, specialists)

(*a*) Foraging is the behaviour(s) an animal employs to feed. "Food habits are a fundamental part of an animal's niche and may be shaped in part by competition with other species."

(*b*) Animals may be categorized in terms of their foraging behaviours into generalists and specialists. **Specialist** tend to be better at acquiring specific kinds of food, employing morphological adaptations as well as behavioral adaptations and culture to maximize their yield of specific foods.

(*c*) **Generalists** are not as good at acquiring any particular kind of food, but generalists potentially have available to them many more kinds of food; "Generalists cannot be as efficient at securing any one type of food, but they have the advantage of having other options if a preferred food becomes unavailable."

8. Search image

(*a*) Generalists, too, can specialize in the acquisition of specific food stuffs, particularly by temporarily specializing. When specializing the generalist employs a specific search image which is a behavioral algorithm for catching/obtaining a certain kind of food. This search image will be employed, and even improved upon, until a decline in the abundance of that food stuff leads to literally diminishing returns; then, rather than suffering without adequate food supplies, the generalist can simply switch to a new food type and new search image.

9. Optimal foraging

(*a*) What makes one food type and search image preferable to another?

(*b*) Basically, ideally, an organism chooses to consume the food that is easiest to acquire on a per-unit-nutrient basis and in optimal foraging the benefits of a given forage essentially are optimized relative to costs. Thus, for example, slow, tasty, and abundant things are consumed preferentially to fast, rare, obnoxious things.

(*c*) Organisms that perform such a cost-benefit analysis are said to be optimizing their foraging.

(*d*) "Optimal foraging theory predicts that natural selection will favor animals that choose foraging strategies that maximize the differential between benefits and costs. Benefits are usually considered in terms of energy (calories) gained. However, other optimization criteria, such as specific nutrients, are sometimes more important than energy. Costs or tradeoffs associated with foraging consist of the energy needed to locate, catch, and eat food; the risk of being caught by a predator during feeding; and time taken away from other vital activities, such as searching for a mate."

(*e*) As a consequence of the complexity of the cost-benefit analysis of optimal foraging behavior, an organism does not necessarily do all necessary calculations in its head prior to subduing food, but instead has certain rule-of-thumb behavioral tendencies representing evolutionary algorithms defining what to eat under what circumstances; it is typically these rule-of-thumb behavioral tendencies that are optimized in optimal foraging behaviour.

10. Social behaviour

Social behaviour is interactions between two or more organisms, typically animals, usually conspecifics. Some animals are more social than others, with the minimal social behavior necessary between sexually reproducing animals being that associated with mating. "The complexity of behavior increases dramatically when interactions among individuals are considered. Aggression, courtship, cooperation, and even deception are part of the behavioural landscape of social behaviour. Social behaviour has both costs and benefits to members of those species that interact extensively."

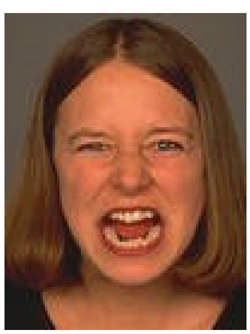
FIGHTING

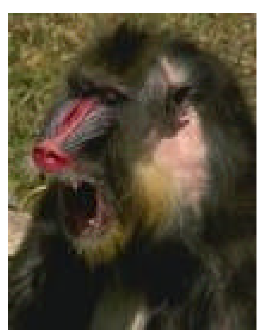
11. Agonistic behaviour

(*a*) Aggressive behaviour between conspecifics usually involves fighting over a limiting resource such as food, water, space, or mates. Depending on the importance of the resource as well as its scarcity, agonistic behavior can range from all-out fighting to the death to much safer ritualistic behavior.

(*b*) Animals typically lack action-at-a-distance weapons such as those possessed by humans (e.g., guns) so risk injury or even death whenever they engage in aggressive behaviour.

(*c*) Consequently, animals often avoid fighting unless there is a sure indication that they will win without incurring injury and if the resource is worth fighting over.





(*d*) Animals often possess sophisticated rituals in which they attempt to bluff their opponent into backing down, and animals also often have a good sense of when to retreat as losers from an otherwise hopeless, potentially injurious cause.

(*e*) Agonistic displays by a human female and a mandrill male:

12. Dominance hierarchies

(*a*) One way in which agonistic behavior is avoided is by knowing one's place in the scheme of things and then avoiding any behaviors that might be interpreted as threatening to those possessing a higher rank.

(*b*) Animals that are higher on dominance hierarchies risk injury to attain that status (and often must commit large amounts of energy to maintaining that status), but benefit by gaining preferred access to food or mates for themselves and also potentially for their offspring.

(*c*) Thus, a dominance hierarchy represents an institutionalized (though not necessarily completely static) snapshot of the results of previous agonistic behaviour, and are advantageously maintained by everyone to the extent that previous fighting need not be repeated.

13. Territoriality (home range)

(*a*) Another way that all-out fighting is avoided is by institutionalizing conflicts into territories (dominance hierarchies might also be considered to be territories, ones where social position is defended rather than space).

(*b*) A territorial individual will typically defend a specific area particularly against intrusion by **conspecifics**

- (*i*) **Conspecifics** are individuals that an individual is most directly in competition with, against which an individual possesses a reasonable chance of winning a fight, and with which one's mate might fool around.
- (*ii*) Territories that are not defended are instead called home ranges.

(*c*) Territories may be permanent or temporary, may be defended by one individual or many, and may be established to guard space, food, mates, etc.

(*d*) Territory owners are more likely to win fights against would-be trespassers; this is probably because the owner

- (*i*) Has more to lose and therefore is willing to risk more to win a fight (since the owner but not the trespasser has learned the territory)
- (*ii*) May be an older, more experienced fighter (since younger, less experienced fighters presumably are less likely to have acquired a territory)

(*e*) Note that territoriality represents an uneven partitioning of resources that can have the effect of minimizing the excursion of populations beyond an ecosystem's carrying capacity for that organism.

FINDING SEX

14. Courtship

(*a*) "In many animals, potential partners must go through a complex courtship interaction, unique to the species, before mating. This complex behaviour often consists of a series of fixed action patterns, each triggered by some action of the other partner and initiating, in turn, the other partner's next required behaviour. This sequence of events assures each animal not only that the other is not a threat, but also that the other animal's species, sex, and physiological condition [e.g., receptivity to mating] are all correct."

(*b*) Part of courtship behaviour can additionally involve some degree of assessment by one individual of the other individual.

(*c*) In addition to assuring that matings are successful in the sense that they produce viable offspring, an animal additionally is motivated to increase the likelihood of the success of offspring by finding, via courtship, mates that have the best genes or behaviors, i.e., animals, given a choice, like to "marry up".

15. Parental investment

(*a*) An animal that is destined to invest a lot of time and energy in the parenting of offspring would prefer to mate with individuals who bring more to the mating rather than less.

(*b*) Typically, especially given internal fertilization, the gender that invests the most in offspring is the female.

(*c*) This investment can come in the form of large gametes, internal development of the young, or raising the young following birth or hatching

- (*i*) Most females contribute to a least one of these parental investments.
- (*ii*) Many males do not (though, to be fair, there are many males out there that contribute to the sheltering and nourishment of females, the sheltering or internal development of young, and the raising of young).

(*d*) Sexual selection is the means by which a gender (typically males) either compete directly over a female or compete for a female's favorable attention; these battles in turn select for secondary sexual characteristics that aid in the fighting of battles over females or the attracting of females.

(*e*) In some species, e.g., humans, both parents often invest mightily in the raising of offspring and sexual selection consequently impacts directly on both genders.

16. Mating systems [promiscuous, monogamous, polygamous, polygyny, polyandry]

(*a*) An animal's mating system refers to how animals pair up for mating.

(*b*) Promiscuous mating systems exist particularly where one parent (e.g., the guy) does not participate at all in the raising of offspring whereas monogamous relationships occur particularly when two parents share the raising of children.

(*c*) Various mating-system types include:

(*i*) **Promiscuous** = low likelihood of subsequent mating with same individual

(*ii*) **Monogamous** = high likelihood of subsequent mating with one individual

(*iii*) **Polygamous** = high likelihood of subsequent mating with more than one individual

(*iv*) **Polygyny** = one male mates with several females

(*v*) **Polyandry** = one female mates with several males

(*d*) It is important to keep in mind that a mating system usually exists to serve some ultimate cause, i.e., enhancement of both male and female fitness.

COOPERATION

17. Altruism

Altruism is cooperative behavior in which the actor's Darwinian fitness is reduced by the behaviour. Particularly, this is when the actor's individual (as opposed to inclusive) fitness is reduced by the behavior

18. Cooperative behaviour

(*a*) Cooperative behaviours are acts that increase the Darwinian fitness of others. These same acts may or may not increase the Darwinian fitness of the actor, or may even decrease the fitness of the actor.

(*b*) Since natural selection favours individuals who increase their own fitness (i.e., not necessarily that of other's), it is not always obvious nor easy to understand either why cooperative behavior occurs or how it might have evolved. The evolution of cooperative behavior is typically considered to result as a consequence of either

(*i*) Kin selection

(*ii*) Reciprocal altruism

(*iii*) Group selection

19. Kin selection

(*a*) Kin selection is another way of saying that it pays to help those to whom we are most closely related

(*b*) Why?

(*i*) Individuals with which an individual is closely related share genes including genes that code for cooperative behaviour.

(*ii*) Increasing the Darwinian fitness of relatives therefore can serve to increase the Darwinian fitness associated with cooperative behavior.

(*c*) Note that key to kin selection is the ability to distinguish non-relatives from relatives, either by recognition of some kind or via correlates such as when relatively non-mobile individuals tend to be more closely related to individuals who are near to them than they are to individuals who are a greater distance from them.

(*d*) Kin selection essentially is cooperative behavior among kin (relatives) resulting in greater Darwinian fitness for these relatives in comparison to groups that do not mutually cooperate; the basis of kin selection is that relatives share genes and therefore that enhancing the fitness of a relative to some degree is equivalent to enhancing ones own Darwinian fitness (and, in particular, it enhances the inclusive fitness associated with ones genes/alleles).

(*e*) The most obvious form of kin selection is the caring of offspring by parents, i.e., it pays for parents to care for their offspring because their offspring share genes with them (that is, any allele that coded for not caring for otherwise helpless offspring would quickly go extinct).

20. Inclusive fitness

(*a*) Inclusive fitness is the idea that the fitness associated with an individual's genes is a function not just of the Darwinian fitness of the individual, but additionally the Darwinian fitness associated with the same alleles found in relatives.

(*b*) Thus, as far as your genes are concerned, your survival (and consequent reproduction) is no more important than the survival of two full siblings (i.e., brother or sister; with each you share half of your genes) or eight first cousins (with each you share 1/8 of your genes); note that we are implicitly assuming that all considered individuals have identical reproductive potentials, e.g., are of the same age and health, etc.

21. Coefficient of relatedness

(*a*) The coefficient of relatedness is the means by which these fractional-sharing-of-genes ideas are formalized.

(*b*) The coefficient of relatedness is the proportion of alleles in two individuals that are identical by decent (the calculation of which can get messy if inbreeding has occurred)

(*i*) For example, half of your genes came from your mom and, on average, each of your siblings shares half of these genes (since the same is true for your father, one-half * one-half + one-half * one-half = one-half, i.e., you share half of your genes with each full sibling).

22. Reciprocal altruism

(*a*) Reciprocal altruism is a means by which cooperative behaviour can evolve even between non-relatives. In reciprocal altruism, one individual performs a cooperative act in the (evolutionary) hope that individual who is the recipient of the act will cooperate in return.

(*b*) Reciprocal altruism likely requires a means by which individuals can distinguish reciprocators from those who refuse to cooperate in return.

23. Group selection

(*a*) Group selection is a means by which cooperative behaviour might evolve, though chances are that in the real world it makes little contribution except, perhaps, in the evolution of culturally learned behaviour that is cooperative

(*b*) The basic idea is that two groups are competing either over resources or directly fighting against each other; if in one group individuals cooperate whereas in the other they do not, then the overall fitness of the cooperating group will exceed that of the non-cooperating group, thus driving the latter, along with its non-cooperative behaviour, to extinction

(*c*) For example, humans even within large groups are very willing to put aside differences to fight against a common enemy

  (*i*) (which is why no change of significance is ever achieved by a government except during times of crisis; the flip side of this is that individuals who selfishly benefit from the status quo can always be expected to fight, with gusto, for their benefit from the way things are).

Practice Test Paper-I

1. The best source of Vitamin C among the following:
   (*a*) *Lycopersicum esculentum* (*b*) *Cirus medica*
   (*c*) *Capsicum annum* (*d*) *Phyllanthus emblica*

2. Pollution of big cities can be controlled to large extent by-
   (*a*) Wide roads and factories away from city
   (*b*) Cleanliness drive and proper use of pesticides
   (*c*) Proper sewage and proper exit of chemicals from factories
   (*d*) All of the above

3. The Ecological pyramid that is always upright
   (*a*) Pyramid of energy (*b*) Pyramid of biomass
   (*c*) Pyramid of number (*d*) None of the above

4. “Green house effect” with respect to global warming refers to-
   (*a*) Cooling & moist condition (*b*) Warming effect
   (*c*) Increased rainfall & greenery (*d*) Desertification

5. In India, Tropical rain forest occurs in-
   (*a*) Jammu and Kashmir (*b*) Andaman & Nicobar
   (*c*) Uttar Pradesh (*d*) Himachal Pradesh

6. Insectivorous plant generally grow in soil which is deficient in
   (*a*) Water (*b*) Nitrogen
   (*c*) Potassium (*d*) Calcium

7. Atomospheric ozone layer which protect us from UV-B & C is getting depleted most by addition of-
   (*a*) Chloro flurocarbon (*b*) Carbon monooxide
   (*c*) Carbon dioxide (*d*) Sulpur dioxide

8. A high BOD value in aquatic environment is indicative of-
   (*a*) A pollution free system
   (*b*) A highly polluted system due to excess of nutrients
   (*c*) A highly polluted system due to abundant heterotrophs
   (*d*) A highly pure water with abundance of autotrophs

9. In which of the following the maximum plant diversity is found-
   (*a*) Tropical evergreen forests
   (*b*) Tropical moist deciduous forests
   (*c*) Sub tropical mountain forests
   (*d*) Temperate moist forests

10. A term biotype means-
    (*a*) All individuals having same phenotype
    (*b*) All individuals having same genotype
    (*c*) All individual with different phenotype
    (*d*) All individuals with different genotype

11. Among the following environmental pollutants has the problem of biomagnifications-
    (*a*) SO_2 (*b*) NO_3
    (*c*) Hg fungicides (*d*) O_3 & CO_2

12. An increase in the atmospheric level of automobile exhaust gases does not lead to-
    (*a*) Pb Pollution (*b*) O_3 Pollution
    (*c*) Particulate air pollution (*d*) O_3 Pollution

13. The compound mainly responsible for pollution which caused the ill famed Bhopal gas tragedy was-
    (*a*) NH_4OH (*b*) CH_3NCO
    (*c*) CH_3NH_2O (*d*) $CHCl_3$

14. In recycling of mineral elements within an ecosystem, the responsible direct acing organism are called-
    (*a*) Decomposers (*b*) Producers
    (*c*) Primary consumers (*d*) Secondary consumers

15. Eutrophication of water bodies resulting to killing of fishes is mainly due to-
    (*a*) Non-availability of food
    (*b*) Non-availability of light
    (*c*) Non-availability of oxygen
    (*d*) Non-availability of essential minerals

16. The pyramid of biomass will be inverted in the ecosystem of-
    (*a*) Forests (*b*) Ponds
    (*c*) Grasslands (*d*) Drylands

17. Primary productivity at the climax stage of a succession is-
    (*a*) Higher then consumption (*b*) Lower then the consumption
    (*c*) Equal to consumption (*d*) Not related to consumption

18. UV radiations is injurious to plants because it-
    (*a*) Break phosphate bonds (*b*) Increases respiration
    (*c*) Causes dehydration (*d*) Causes genetic changes

19. The pyramid of number of a parasitic food chain in forest ecosystem is-
    (*a*) Always inverted
    (*d*) Always upright
    (*b*) Mixture of inverted & upright
    (*c*) Sometimes inverted and sometimes upright

20. The most stable ecosystem could be-
    (*a*) Ponds (*b*) Oceans
    (*c*) Desert (*d*) Forest

21. Air pollutant gases causing acid rain are-
    (*a*) CO_2 & Cl_2 (*b*) CO_2 & O_3
    (*c*) SO_2 & NO_x (*d*) CFC & CO_2

22. Plants that grows in saline water lodged habitat are called-
    (*a*) Xerophytes (*b*) Halophytes
    (*c*) Mangrooves (*d*) Mesophytes

23. Petro-crop plantation refers to-
    (*a*) Establishing gobar gas plant
    (*b*) Planting fast growing trees
    (*c*) Planting hydrocarbon rich plants
    (*d*) Recycling of waste

24. Which of the following is true climax according to monoclimax theory-
    (*a*) Edaphic climax (*c*) Climatic climax
    (*b*) Biotic climax (*d*) Physiographic climax

25. Ecotype is-
    (*a*) Genetically different but phenotypically similar
    (*b*) Genetically different but ecologically different individuals
    (*c*) Genetically adapted ecological race
    (*d*) Genetically & phenotypically dissimilar

26. Competition is the most severe between the two-
    (*a*) Closely related species growing in different niche
    (*b*) Closely related species growing in same habitat
    (*c*) Distantly related species growing in same habitat
    (*d*) Distantly related species growing in different niche

27. In ecological succession from pioneer to climax community, the biomass shall-
    (*a*) Decrease (*b*) No relation
    (*c*) Increase and then decrease (*d*) Increase continuously

28. Rate of storage of organic matter not used by heterotrophs is termed as-
    (*a*) Net productivity (*b*) Net primary productivity
    (*c*) Gross primary productivity (*d*) Secondary productivity

29. Abyssal zone in ocean has-
    (*a*) No sunlight but contains decomposers and consumers
    (*b*) No sunlight but contain producers
    (*c*) Sunlight and decomposers
    (*d*) Sunlight and producers

30. Climate of world is threatened by-
    (*a*) Increasing amount of atmospheric O_2
    (*b*) Decreasing amount of atmospheric O_2
    (*c*) Increasing amount of atmospheric CO_2
    (*d*) Decreasing amount of atmospheric CO_2

31. Among the following green house gases will absorb the light of wavelength-
    (*a*) 200 nm
    (*b*) 300 nm
    (*c*) 350 nm
    (*d*) 450 nm

32. The photochemical smog is produced by-
    (*a*) Nitrogen oxides
    (*b*) Hydrocarbons
    (*c*) Nitrogen oxides & hydrocarbons
    (*d*) Solar radiation on NO_X & hydrocarbon

33. Major aerosol pollutant in jet plane emission is-
    (*a*) SO_2
    (*b*) CO
    (*c*) Methane
    (*d*) Flurocarbon

34. Those species whose populations have been seriously depleted and whose ultimately security is not assured is known
    (*a*) Threatened species
    (*b*) Endangered species
    (*c*) Vulnerable species
    (*d*) Rare species

35. Wild life is destroyed most when-
    (*a*) There is lack of proper care
    (*b*) Mass scale hunting for foreign trade
    (*c*) Its natural habitat is destroyed
    (*d*) Natural calamity

36. Increased incidence of floods in plains of North India are due to-
    (*a*) Increased deforestation in catchment areas
    (*b*) Increase in incidence of rainfall
    (*c*) Silting of dams
    (*d*) More area under cultivation

37. The two major aspects of ecosystem are-structure and function. By function we mean-
    (*a*) The rate of biological energy flow i.e., the rate of production of respiration of community
    (*b*) Biological or ecological regulation including both regulation of organisms by environment and relation of environment by the organisms
    (*c*) The composition of biological community including species, numbers, biomass and life history
    (*d*) None of the above

38. Micro consumers are popularly known as-
(*a*) Primary consumer (*b*) Secondary consumer
(*c*) Tertiary consumer (*d*) Decomposers

39. Moss bags, epiphytic lichens and mosses have used for monitoring-
(*a*) Air pollution (*b*) Water pollution
(*c*) Oil pollution (*d*) Land pollution

40. The maximum primary productivity is seen in-
(*a*) Grasslands (*b*) Tropical rain forest
(*c*) Deserts (*d*) Mangroves

41. Ticks on cattle or cattle ergot feed on lice is an example of –
(*a*) Ammensalism (*b*) Commensalism
(*c*) Proto-cooperation (*d*) Mutualism

42. When mimic resembles a ferocious/ poisonous/distasteful organism for eg. Viceroy butterfly mimics monarch butterfly is –
(*a*) Aggressive mimicry (*b*) Conscious mimicry
(*c*) Protective mimicry (*d*) All of these

43. Early successful stages are tolerant of the harsh, abiotic condition in barren areas are characterized by-
(*a*) Weedy α-selected (*b*) Weedy r-selected
(*c*) Weedy γ-selected (*d*) Weedy k-selected

44. As ecosystem matures more γ-selected replace g-selected. During this species richness and total biomass increase. Under such condition productivity-
(*a*) Also Increase (*b*) remains unchanged
(*c*) Decreased (*d*) Random increase

45. Limitating factor in temperate and boreal forest is-
(*a*) Nutrients (*b*) Frost
(*c*) Oxygen (*d*) Sunlight

46. Limitating factor for plant growth in steppes and desert is-
(*a*) Nutrients (*b*) Water
(*c*) Oxygen (*d*) Sunlight

47. No succession is seen in Savannah grasslands –
(*a*) Regular fires (*b*) Paucity of Nutrients
(*c*) Low water availability (*d*) Low oxygen supply

48. Diversity between geographical areas within one overall large area-
(*a*) α- Diversity (*b*) β-diversity
(*c*) γ- Diversity (*d*) μ-diversity

49. The characteristic population growth curve of bacteria is-

(*a*) Straight (*b*) S shaped

(*c*) J shaped (*d*) Random

50. The maximum biodiversity will occur at-

(*a*) Poles (*b*) Deserts

(*c*) grasslands (*d*) Alpines

51. Chimpanzees have a relatively low birth rate. They take good care of their young, and most chimps live a long life. The chimp survivorship curve would look like

(*a*) a line that slopes gradually upward

(*b*) a relatively flat line that drops steeply at the end

(*c*) a line that drops steeply at first, then flattens out

(*d*) a line that slopes gradually downward

52. An oak tree produces thousands of acorns, but very few grow into mature oak trees. The oak tree exhibits a . . . survivorship curve.

(*a*) Type I (*b*) Type II

(*c*) Type III (*d*) Type I or II

53. In the models that describe population growth, r stands for

(*a*) population density

(*b*) carrying capacity

(*c*) total number of individuals in the population

(*d*) growth rate

54. When the per capita birth rate equals the per capita death rate

(*a*) a population grows rapidly

(*b*) the size of a population remains constant

(*c*) density-dependent limiting factors do not affect the population

(*d*) a population is in danger of extinction

55. A population would always grow exponentially

(*a*) if it were limited only by density-dependent factors

(*b*) until it reaches carrying capacity

(*c*) if there were no limiting factors

(*d*) if it showed logistic growth

56. A wildlife biologist is trying to predict what will happen to a bear population if bear hunting is banned. He had the equations all worked out but then realized that he had grossly underestimated the amount of food available to the bears. To make his predictions more accurate, he will have to go back to his equations and

(*a*) decrease N (*b*) increase N

(*c*) decrease K (*d*) increase K

57. A population that grows rapidly at first and then levels off at carrying capacity can be modeled
(*a*) by a logistic equation
(*b*) as delta N/ delta t equals B minus D
(*c*) as dN/dt = rN
(*d*) as being relatively unaffected by limiting factor

58. A population that is growing logistically
(*a*) grows fastest when density is lowest
(*b*) has a high intrinsic rate of increase
(*c*) grows fastest at an intermediate population density
(*d*) grows fastest as it approaches carrying capacity

59. Human population growth was slow and gradual for a long period, but it turned sharply upward
(*a*) after the development of agriculture, which decreased the death rate
(*b*) during the last half-century, when the birth rate increased
(*c*) as a result of the Black Death, which left more food for the survivors
(*d*) during the Industrial Revolution, when the death rate dropped

60. Which of the following is the most accurate comment on the Earth's carrying capacity for people?
(*a*) K is smaller now than it was a thousand years ago
(*b*) The human population is still a long way from K
(*c*) Our technology has allowed us to keep increasing K
(*d*) When it comes to humans, the concept of K is irrelevant

61. All of the organisms in a particular area make up a food chain.
(*a*) a population (*b*) a community
(*c*) a niche (*d*) an ecosystem

62. _______ views a community as a chance assemblage of organisms with similar abiotic needs.
(*a*) The niche
(*b*) The individualistic hypothesis
(*c*) Species richness
(*d*) Commensalism

63. Milkweed plants produce bad-tasting and poisonous compounds that deter most plant-eaters. But the caterpillars of Monarch butterflies are able to eat milkweed leaves without being harmed. In fact, the chemicals obtained from milkweed actually protect the Monarch from insect-eating birds. This example illustrates
(*a*) coevolution (*b*) competitive exclusion
(*c*) succession (*d*) mutualism

64. A bat locates insect prey in the dark by bouncing high-pitched sounds off them. One species of moth escapes predation by diving to the ground when it hears sonar of a particular bat species. This illustrates ____ between the bat and moth.
(*a*) mutualism
(*b*) competitive exclusion
(*c*) ecological succession
(*d*) coevolution

65. In terms of +, –, and 0, predation can be described as a _______ relationship.
(*a*) –/0
(*b*) +/0
(*c*) +/+
(*d*) +/–

66. Flounder look like the sea floor. This is an example of
(*a*) Müllerian mimicry
(*b*) aposomatic coloration.
(*c*) character displacement
(*d*) cryptic cloration

67. Which of the following describes mimicry?
(*a*) An insect's bright colors warn a predator that it tastes bad
(*b*) The mottled pattern on a fish looks like dead leaves on the bottom of a pond
(*c*) Two species of mice live in the same area and eat the same kinds of seeds
(*d*) A harmless frog resembles a poisonous frog

68. A tick has what type of relationship with a dog?
(*a*) agonistic
(*b*) competitive
(*c*) commensal
(*d*) parasitic

69. When goats were introduced to an island off the California coast, the goats lived in the same areas and ate the same plants as the native deer. The deer population dwindled, and the deer finally disappeared. This is an example of
(*a*) commensalism
(*b*) succession
(*c*) coevolution
(*d*) competitive exclusion

70. The niche of an animal is
(*a*) the number of individuals of the species the environment will support
(*b*) the same as its habitat
(*c*) the way the animal fits into its environment
(*d*) its den or nest

71. The resources a population actually uses describes its ________; while the resources it actually uses are its _________.
(*a*) realized niche; habitat
(*b*) realized niche; fundamental niche
(*c*) fundamental niche; realized niche
(*d*) habitat; ecosystem

72. Two species of cuckoo doves live in a group of islands off the coast of New Guinea. Of 33 islands, 14 have one species, 6 have the other, 13 have neither, and none has both. What might best explain this? The two species of birds could
(*a*) be on different trophic levels
(*b*) have similar niches

(*c*) have a mutualistic relationship
(*d*) have different niches

73. The relationship between species A and species B is described as commensalism. This means that
(*a*) both species suffer
(*b*) both species benefit
(*c*) one species benefits and the other species suffers
(*d*) one species benefits and the other species is unaffected

74. A lichen is actually composed of two organisms–a fungus and an alga. They depend on each other for survival. The most specific term that describes their relationship is
(*a*) parasitism (*b*) commensalism
(*c*) symbiosis (*d*) mutualism

75. In Paine's study of the intertidal zone on the coast of Washington State he found that
(*a*) competitive exclusion inevitably reduced species richness
(*b*) mutualism among prey species maintained species diversity
(*c*) the mussel Mytilus preyed on the sea star Pisaster
(*d*) the presence of a keystone predator maintained community diversity

76. Under which of the following circumstances would interspecific competition be most obvious?
(*a*) when resources are most abundant
(*b*) in the presence of a keystone predator
(*c*) when organisms have quite different ecological niches
(*d*) when a foreign organism is introduced to a community

77. Which of the following best illustrates ecological succession?
(*a*) A mouse eats seeds, and an owl eats the mouse
(*b*) Decomposition in soil releases nitrogen that plants can use
(*c*) Grass grows on a sand dune, then shrubs, and then trees
(*d*) Imported pheasants increase, while local quail disappear

78. After clear-cutting, timber companies cannot afford to wait for the long process of _____ to occur naturally; they plant trees right away.
(*a*) mutualism (*b*) succession
(*c*) coevolution (*d*) decomposition

79. The current view of succession is
(*a*) expressed by the equilibrial model
(*b*) that disturbance and nonequilibrium are inevitable
(*c*) that it ends once the climax community is established
(*d*) that it proceeds in a linear fashion

80. The . . . hypothesis contends that increased diversity is promoted when disturbances prevent competitive exclusion. The . . . hypothesis contend that increased diversity is promoted when disturbances result in the coexistence of several successional stages.
   (*a*) dynamic equilibrium . . .Wilson/MacArthur
   (*b*) Wilson and MacArthur. . . biogeography
   (*c*) aposomatic; cryptic
   (*d*) dynamic equilibrium . . .intermediate disturbance

81. An organism's trophic level refers to
   (*a*) the rate at which it uses energy
   (*b*) where it lives
   (*c*) what it eats
   (*d*) whether it is early or late in ecological succession

82. Which of the following is a primary producer?
   (*a*) detritivores
   (*b*) shrimp
   (*c*) poison ivy
   (*d*) lions

83. The main decomposers in an ecosystem are
   (*a*) bacteria and animals
   (*b*) plants and fungi
   (*c*) fungi and bacteria
   (*d*) bacteria and plants

84. The energy for nearly every organism in nearly every ecosystem ultimately comes from
   (*a*) minerals in the soil
   (*b*) the sun
   (*c*) heat from Earth
   (*d*) respiration

85. Which of the following equations is correct?
   (*a*) NPP equals GPP minus Respr
   (*b*) Respr equals NPP + GPP
   (*c*) GPP equals NPP– Respr
   (*d*) NPP equals GPP plus Respr

86. The relationship between biomass and primary productivity is that
   (*a*) biomass is the rate of primary productivity
   (*b*) biomass is the inverse of primary productivity
   (*c*) biomass is the natural log of primary productivity
   (*d*) primary productivity is the rate at which biomass is produced

87. When you eat an apple, you are a
   (*a*) primary consumer
   (*b*) tertiary consumer
   (*c*) primary producer
   (*d*) secondary consumer

88. Why is a diagram of energy flow from trophic level to trophic level shaped like a pyramid?
   (*a*) Organisms at each level store most of the energy and pass little on
   (*b*) There are more producers than primary consumers, and so on

(*c*) Organisms eventually die as they get older
(*d*) Most energy at each level is lost, leaving little for the next

89. In an ecosystem the _____ is always greater than the _____ .
(*a*) number of primary producers . . . number of primary consumers
(*b*) biomass of secondary consumers . . . biomass of primary producers
(*c*) energy used by primary consumers . . . energy used by secondary consumers
(*d*) biomass of primary producers . . . biomass of primary consumers

90. The biggest difference between the flow of energy and the flow of chemical nutrients in an ecosystem is that
(*a*) the amount of energy is much greater than the amount of nutrients
(*b*) energy is recycled, but nutrients are not
(*c*) organisms always need nutrients, but they don't always need energy
(*d*) nutrients are recycled, but energy is not

91. Which of the following statements is correct?
(*a*) Over land, evaporation exceeds transpiration and precipitation
(*b*) Over land, evaporation and transpiration exceed precipitation
(*c*) Over oceans, transpiration exceeds precipitation
(*d*) Over oceans, evaporation exceeds precipitation

92. An ecosystem is unlikely to be limited by the supply of ____ because it is obtained from the air.
(*a*) water (*b*) carbon
(*c*) phosphorus (*d*) calcium

93. Local conditions such as heavy rainfall or the removal of plants may limit the amount of nitrogen, phosphorus, or calcium available to a particular ecosystem, but the amount of carbon available to the system is seldom a problem. Why?
(*a*) Organisms do not need very much carbon
(*b*) Plants can make their own carbon using water and sunlight
(*c*) Plants are much better at absorbing carbon from the soil
(*d*) Many nutrients come from the soil, but carbon comes from the air

94. Bacteria are especially important in making ______ available to plants.
(*a*) water (*b*) nitrogen
(*c*) carbon (*d*) phosphorus

95. The direct product of nitrogen fixation is
(*a*) NH_4^+ (*b*) NO_2^-
(*c*) $NO_3.^-$ (*d*) NH_3

96. Nitrification is the conversion of
(*a*) NO_3^- into N_2 (*b*) N_2 to NH_3
(*c*) organic nitrogen into NH_4^+ (*d*) NH_4^+ into NO_3^-

97. The major source of nitrogen for most nonagricultural plants is
    (*a*) nitrates in the soil.
    (*b*) N_2 gas in the air.
    (*c*) proteins.
    (*d*) ammonium in the soil.

98. The phosphorus cycle lacks a(n) _____ component.
    (*a*) atmospheric
    (*b*) organic
    (*c*) mineral
    (*d*) aquatic

99. Ospreys and other top predators in food chains are most severely affected by pesticides such as DDT because
    (*a*) their systems are especially sensitive to chemicals.
    (*b*) of their rapid reproductive rates.
    (*c*) the pesticides become concentrated in their prey.
    (*d*) they cannot store the pesticides in their tissues.

100. Most endangered species are victims of
    (*a*) greenhouse warming.
    (*b*) habitat destruction.
    (*c*) overhunting.
    (*d*) competition with introduced species.

Practice Test Paper-II

1. Minimata disease is due to pollution by
   (*a*) Organic waste into drinking water
   (*b*) Oil spills in oceans
   (*c*) Industrial waste mercury into fishing water
   (*d*) Entry of Cadmium into drinking water

2. The maximum water pollution is caused by-
   (*a*) Detergents (*b*) Pesticides
   (*c*) Industrial wastes (*d*) Ammonia

3. Biogas consist of-
   (*a*) CH_4, SO_2 and H_2 (*b*) CO_2, Alcohol and H_2
   (*c*) CH_4, CO_2 and water (*d*) All of the above

4. The Ozone layer saves from lethal UV. It mainly absorbs-
   (*a*) UV-A (*b*) UV-B
   (*c*) UV-A & B (*d*) UV-A & C

5. A non harmful species copies a harmful and tasteless form, the type of mimicry shown is-
   (*a*) Bateson (*b*) Mullerian
   (*c*) Darwinian (*d*) Morganarian

6. Exotic weed which proved very harmful for forest and grassland is-
   (*a*) Eupatromia (*b*) Verbenia
   (*c*) Eichornia (*d*) Salvia

7. Latest news of conflicts between human and wild animals has happened due to-
   (*a*) Habitat destruction
   (*b*) Increased poaching
   (*c*) Increased conservation
   (*d*) Increased Human population

8. Biological magnification is maximum in human it proves that human is-
   (*a*) Top consumer in food chain
   (*b*) More susceptible
   (*c*) Major Pollutant
   (*d*) Most efficient in storage of reserve food

9. Benthic organism of lakes or sea are usually-
   (*a*) Producer (*b*) Herbivores
   (*c*) Carnivores (*d*) Decomposers

10. Among the following which is not an characteristic of r-Selected species-
    (*a*) Short maturation time
    (*b*) Short life span
    (*c*) Small size of offspring's
    (*d*) More then one time offspring production

11. In India most of plant flowers during spring or summer because-
    (*a*) It is breeding season for butterflies
    (*b*) More solar radiation are available
    (*c*) Fruit and seed setting must be complete before onset of monsoon
    (*d*) Environmental fluctuations are low

12. Total energy available for work at equilibrium is termed as-
    (*a*) Free energy (*b*) Entropy
    (*c*) Activation energy (*d*) Enthalpy

13. Drosophila shares more its genes with sister (75%) as compare to its daughter (50%) due to-
    (*a*) Eusocialbilty (*b*) Kin selection
    (*c*) Haploidy diploidy (*d*) Parthenogensis

14. The gradual mode of speciation in single lineage in which species diverge in spurts of relatively rapid change which result in increase in species is termed as-
    (*a*) Punctuated equilibrium (*b*) Adaptive radiation
    (*c*) Anagenesis (*d*) Cladogenesis

15. Profitability of prey for predator lies in its energy content and
    (*a*) Prey density (*b*) Palatability
    (*c*) Foraging time (*d*) prey availability

16. Net productivity of closed ecosystem is-
    (*a*) 0 (*b*) <0
    (*c*) >0 (*d*) $+1/-1$

17. Number of individual surviving to reproductive stage is termed as-
    (*a*) Fecundity (*b*) Net reproduction rate
    (*c*) Survivorship curve (*d*) Reproductive Mortality

18. Major source of green house gases are-
    (*a*) Burning of plants (*b*) Burning of fossil fuels
    (*c*) Respiration (*d*) Use of LPG

19. Global warming is due to-
    (*a*) Absorption of UV by Ozone (*b*) Absorption of IR by CO_2
    (*c*) Absorption of IR by ozone (*d*) Absorption of UV by CO_2

20. Soil in naturally growing vegetation is-
    (*a*) Acidic due to Bicarbonate in soil
    (*b*) Basic due to Bicarbonate in soil
    (*c*) Neutral
    (*d*) Acidic due to Sulphuric acid

21. Deepest enriched soil with nutrients is present at-
    (*a*) Tropical rain forests (*b*) Dry deciduous forests
    (*c*) Grasslands (*d*) Conifers

22. Maximum biodiversity occurs at-
    (*a*) Tropics (*b*) Equator
    (*c*) Temperate (*d*) Shooth

23. Rapid nutritional recycling takes place in-
    (*a*) Coral (*b*) Deserts
    (*c*) Grasslands (*d*) Oceans

24. When a marine fish is placed in fresh water, it dies becuase-
    (*a*) Entry of water and it floats (*b*) Exit of water and shrinks
    (*c*) Deficiency of salts (*d*) Deficiency of nutrients

25. In winter pollution rate enhances due to-
    (*a*) SPM (*b*) SO_2 and NO_2
    (*c*) Burning of fuels (*d*) Low temperature

26. Which is correct relationship between habitat disturbance and biodiversity-
    (*a*) Areas with no habitat disturbance tends to have high biodiversity
    (*b*) Areas with high habitat disturbance tends to have high biodiversity
    (*c*) Areas with moderate habitat disturbance tends to have high biodiversity
    (*d*) Areas with no habitat disturbance tends to have low biodiversity

27. The birds in tropics are generally smaller in size because of-
    (*a*) To increase surface area to volume ratio
    (*b*) To decrease surface area to volume ratio
    (*c*) For easy flight
    (*d*) Aestivation

28. In an pond ecosystem, net productivity by zooplankton is ‘p’ and biomass consumed by small fishes is 'c', then the ratio of c/p is termed as-
    (*a*) Assimilation efficiency (*b*) Net secondary productivity
    (*c*) Consumption efficiency (*d*) Conversion efficiency

29. For climax which statement is INCORRECT?
    (*a*) Number of perennial species increases
    (*b*) Dependency on detritious food chain increases
    (*c*) Vertical stratification of community increases
    (*d*) Exploitation competition is more then normal competition

30. At present, the relationship between human and monkey can be stated as
    (*a*) They both have common ancestors
    (*b*) Human have evolved from monkey
    (*c*) Both have very distinct phylogeny
    (*d*) Relationship can not be established

31. Each organism occupies a particular trophic level in a food chain. Moving from one trophic level to the nex involves an energy loss of about ...
    (*a*) 10% (*b*) 30%
    (*c*) 50% (*d*) 70%
    (*e*) 90%

32. The greatest amount of food per acre is produced in the ...
    (*a*) tundra (*b*) grassland
    (*c*) marine biome (*d*) rain forest

33. Predator populations and types of decomposers are biotic environmental factors. Which is an abiotic environmental factor?
    (*a*) common flora (*b*) availability of prey
    (*c*) presence of microbes (*d*) average precipitation

34. Which of these is a large reservoir of nitrogen that is unusable by most organisms?
    (*a*) soil (*b*) ocean
    (*c*) atmosphere (*d*) space

35. The concentration of which gas can be reduced by preventing forest depletion?
    (*a*) Oxygen (O_2) (*b*) Methane (CH_4)
    (*c*) Carbon dioxide (CO_2) (*d*) Nitrous oxide (N_2O)

36. What is the approximate increase in global surface temperatures in the past century?
    (*a*) 1.5°F (.8°C) (*b*) 5°F (2.8 °C)
    (*c*) 1°F (.5°C) (*d*) 2°F (1.1°C)

37. What the gas which contributes most to the Greenhouse Effect?
    (*a*) Methane(CH_4) (*b*) Carbon dioxide (CO_2)
    (*c*) All of the above (*d*) Nitrous oxide (N_2O)

38. What has been the approximate rise in sea level over the past century?
    (*a*) 14-16 inches (35-40 cm) (*b*) 10-12 inches (25-30 cm)
    (*c*) 2-4 inches (5-10 cm) (*d*) 6-8 inches (15-20 cm)

39. This type of biome (habitat) has very long cold winters, short warm summers and typically has acidic soils as a result of the cold temperatures and litter fall.
    (*a*) Desert (*b*) Tundra
    (*c*) Taiga (Coniferous forests) (*d*) Temperate forests

40. A population's role in the community or the resources it uses is called its _____?
    (*a*) Trophic structure (*b*) Niche
    (*c*) Community interaction (*d*) Habitat

41. Two species or populations are competing for the exact same resources, and one will eventually exclude the other. What is the technical term for this?
   (*a*) Predation (*b*) Competitive exclusion
   (*c*) Coevolution (*d*) Mutualism

42. Predators can influence the structure of a community because their removal from the community causes a catastrophic change in the composition and structure of the rest of the community. What are the predators called because of this?
   (*a*) Keystone species (*b*) Oppourtunists
   (*c*) Coevolutionists (*d*) Edge species

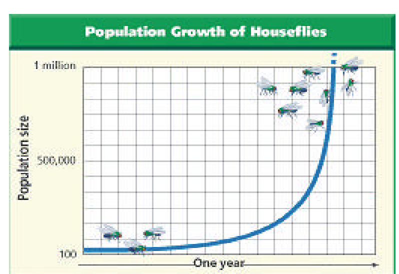
43. What is the single most important factor contributing to losing or creating endangered species?
   (*a*) air pollution (*b*) clearcut logging
   (*c*) habitat loss (*d*) water pollution

44. Which process is most capable of slowing global warming?
   (*a*) Decomposition (*b*) Respiration
   (*c*) Photosynthesis (*d*) Chemosynthesis

45. Why have top predators (consumers at the top of the food chain), such as the cheetah and the tiger, always had smaller populations than organisms lower in the food chain?
   (*a*) Hunted by humans (*b*) Low birth rate
   (*c*) Limited energy availability (*d*) None of the above

46. Which of these is NOT a characteristic of a rapid life-history organism?
   (*a*) rapid period of time until maturation
   (*b*) small body size
   (*c*) early reproduction age
   (*d*) long life span

47. Based on the data in the graph, which of these statements is true?
   (*a*) Growth of the housefly population begins to increase rapidly about 3/4 of the way through the first year
   (*b*) At the beginning of the year, there are no houseflies in the population
   (*c*) The population size shows a straight-line increase
   (*d*) All of the population will be dead at the end of one year

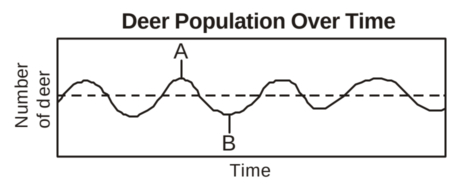


48. __________ is a density-dependent factor.
   (*a*) Competition (*b*) Temperature
   (*c*) Drought (*d*) Floods

49. Which of these is an explanation of why a population can fluctuate once it has reached carrying capacity?
   (*a*) All populations experience exponential growth once they reach carrying capacity
   (*b*) A population of organisms always grows rapidly once it reaches carrying capacity
   (*c*) Limiting factors can influence the number of organisms in a population once it reaches carrying capacity
   (*d*) The number of organisms decreases but never increases once it reaches carrying capacity

50. Ecosytem is mainly concerned with
   (a) energy flow and nutrient recycling (b) population
   (c) community (d) species

51. An environment's __________ is the number of organisms of a certain species that can be supported indefinitely.
   (*a*) exponential growth
   (*b*) stability
   (*c*) carrying capacity
   (*d*) density

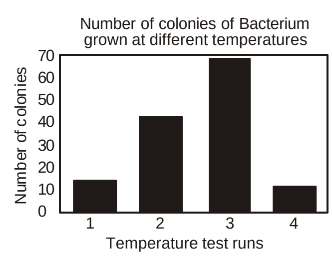


52. When is it possible for a population growth rate to be less than zero?
   (*a*) When the death rate is greater than the birthrate
   (*b*) The population growth rate can never be less than zero
   (*c*) When the birthrate is equal to the death rate
   (*d*) When the birthrate is greater than the death rate

53. What does the dotted line represent on this graph?
   (*a*) predation (*b*) carrying capacity
   (*c*) death rate (*d*) birth rate

54. The population distribution for a country shows that each age structure is about the same size. What type of population growth is this country experiencing?
   (*a*) zero growth (*b*) rapid growth
   (*c*) stable growth (*d*) slow growth

55. Based on the data in the graph, which of the colonies was least affected by temperature as a limiting factor?
   (*a*) 3
   (*b*) 4
   (*c*) 2
   (*d*) 1



56. Which of these is NOT a limiting factor to the growth of a population?
   (*a*) availability of food (*b*) increasing population of predators
   (*c*) introduction of disease (*d*) long-term abundance of space

57. Which of these equations represents zero population growth?
    (*a*) Birthrate – Death rate = 0
    (*b*) Birthrate – Death rate > 0
    (*c*) Birthrate + Death rate < 0
    (*d*) Birthrate + Death rate = 0

58. The population of a country is experiencing a slow doubling time. Which of these is true of that country?
    (*a*) It can also be categorized as a developing country
    (*b*) It has zero population growth
    (*c*) It will never double its population
    (*d*) It can also be categorized as a developed country

59. A population of rabbits experiences an increase over time. Which of these statements about that population is true?
    (*a*) The population may face increased competition due to resource depletion
    (*b*) The population my face decreased competition due to resource depletion
    (*c*) The population may experience exponential growth due to resource depletion
    (*d*) The population may experience straight-line growth due to resource depletion

60. An elephant is considered to have a slow life-history pattern. Which of these characteristics would be matched to an elephant?
    (*a*) unstable environment (*b*) long lifespan
    (*c*) reproduce early (*d*) mature quickly

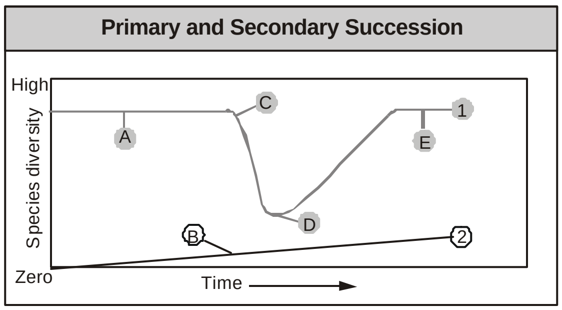
61. The portion of the shoreline that lies between the low tide line and the high tide line is called the __________.
    (*a*) intertidal zone (*b*) aphotic zone
    (*c*) wetlands (*d*) plankton

62. An organism with the ability to withstand changes to biotic and abiotic environmental factors is said to have __________.
    (*a*) tolerance (*b*) a pioneer community
    (*c*) limiting factors (*d*) secondary succession

63. Which of these biomes would you expect to find a coyote living in?
    (*a*) desert (*b*) taiga
    (*c*) tropical rain forest (*d*) tundra

64. Which of these statements is NOT true?
    (*a*) Secondary succession happens in areas where organisms had previously live(d)
    (*b*) Primary succession happens when communities of organisms populate otherwise barren land
    (*c*) Ecological change does not always equate with destruction
    (*d*) The process of succession resulting in a climax community always happens within one year

65. An undersea volcano in the Hawaiian Islands chain erupts, forming a new island in the Pacific Ocean. Over the course of time, which of these would most likely be the first species to survive on the new island?
   (*a*) lichens
   (*b*) grasses
   (*c*) mammals
   (*d*) birds



66. What does the lower line on the graph represent?
   (*a*) primary succession
   (*b*) secondary succession
   (*c*) a climax community
   (*d*) a limiting factor

67. Which of these is a characteristic of a grasslands biome?
   (*a*) Warm weather allows for year-round plant growing conditions
   (*b*) It contains an underground mat called sod
   (*c*) There are vast land areas with bare ground and no plants
   (*d*) It has a short plant-growing season

68. Which of these is a characteristic of a tropical rain forest?
   (*a*) populated with squirrels, bears, and deer
   (*b*) location close to the Equator
   (*c*) short, mild summers
   (*d*) relatively few trees per hectare

69. About how much annual precipitation does a taiga usually receive?
   (*a*) about 250-400 cm
   (*b*) no more than 50 cm
   (*c*) about 75-190 cm
   (*d*) no less than 300 cm

70. Which of these statements is true?
   (*a*) Deciduous forests are populated with broad-leaved hardwood trees that lose their foliage every year
   (*b*) Tropical rain forests are communities that occur in climates that have a defined dry season with rainfall totals less than 50 cm of rain per year
   (*c*) The soils in tundras usually have a large humus content
   (*d*) Grasslands are identified by their permanently frozen ground called permafrost

71. Which marine biome is characterized by deep water depths that never receive sunlight?

(*a*) a lake (*b*) a bog
(*c*) an estuary (*d*) an aphotic zone

72 Which of these statements about the amount of food production after 20 °C is true?

(*a*) Food production remains the same as temperatures increase beyond 20 °C
(*b*) Food production stops as temperatures increase beyond 20 °C
(*c*) Food production drops drastically as temperatures increase beyond 20 °C
(*d*) Food production continues to increase as temperatures increase beyond 20 °C

73. Which of these statements is true?

(*a*) In a pyramid of energy, only about 40% of the energy at one level is available for the next trophic level
(*b*) The law of conservation, which can be applied to the pyramid of energy, means that energy is constantly created and destroyed
(*c*) In a pyramid of numbers, the population size usually gets smaller as the trophic level increases
(*d*) In a pyramid of biomass, the weight of a lower trophic level is the same as the level above it

74. A relationship among organisms where one species benefits while the other species neither benefits nor is harmed is called __________.

(*a*) parasitism (*b*) predation
(*c*) mutualism (*d*) commensalism

75. What element is considered the building block of all the molecules of life?

(*a*) carbon (*b*) sodium
(*c*) magnesium (*d*) hydrogen

76. What is the difference between mutualism and parasitism?

(*a*) Mutualism means that one member of a species thrives at the expense of the member of the species. Parasitism means that one member of a species thrives at the expense of the member of the species
(*b*) Mutualism means that one member of a species benefits without harming or benefiting the member of another species. Parasitism means that both species' members benefit from the relationship
(*c*) Mutualism means both members of a species benefit from living together. Parasitism means that one member of a species thrives at the expense of the member of the species
(*d*) Mutualism mean that both members of a species benefit from living together. Parasitism means that one member of a species benefits without harming or benefiting the member of another species

77. Which of these is NOT an example of a terrestrial ecosystem?

(*a*) human skin (*b*) garden pot
(*c*) rotting log (*d*) volcano site

78. Which of the following statements about the biosphere is true?
(*a*) Earth's biosphere includes the portion of Earth within 1 mile of the surface
(*b*) Living things in Earth's biosphere are affected by nonliving things
(*c*) Ecologists never study animal in Earth's biosphere
(*d*) The physical environment of Earth's biosphere is the only factor in influencing living things

79. An organism which can produce its own food from simple raw materials and an energy source is a(n)
(*a*) autotroph
(*b*) producer
(*c*) both (*a*) and (*b*)
(*d*) neither (*a*) nor (*b*)

80. As energy is passed from one trophic level to the next, the amount of usable energy
(*a*) increases
(*b*) decreases
(*c*) remains constant
(*d*) is highly variable

81. A 'habitat' is:
(*a*) A place to buy furniture and furnishings
(*b*) The same as an ecosystem
(*c*) A particular area inhabited by plants and animals
(*d*) The number of different organisms living in a specific area

82. How an organism is suited to live in a particular place is called:
(*a*) Competition
(*b*) Adaptation
(*c*) Addition
(*d*) Participation

83. 'Biodiversity' is described as:
(*a*) The range of different species in an environment
(*b*) The seasonal and daily changes in an environment
(*c*) The way species differ from one another
(*d*) The influence of physical factors on an environment

84. Which of these is a correct food chain?
(*a*) Fish→chips→peas
(*b*) Man→cow→grass
(*c*) Cow→farm→supermarket
(*d*) Grass→cow→man

85. The arrows in a food chain show:
(*a*) Who eats who
(*b*) The route of food to the shops
(*c*) The movement of energy between organisms
(*d*) Where you need to go to get a meal

86. All the energy in a food chain originates from:
(*a*) A plant
(*b*) The farmer
(*c*) The Sun
(*d*) An electric socket

87. In the 1960's myxomatosis was 'accidentally' released killing approximately 90% of rabbits in the UK. What happened in the food chain below? Carrots→rabbits→foxes
   (*a*) The number of carrots increased
   (*b*) The number of foxes increased
   (*c*) The number of carrots decreased and the number of foxes increased
   (*d*) The number of carrots increased and the number of foxes decreased

88. Rabbits are important grazers, maintaining some important grassland habitats. If another catastrophe were to reduce rabbit populations what would happen?
   (*a*) Important grassland butterflies would be lost
   (*b*) There would be more grass for the surviving rabbits
   (*c*) The grassland would be invaded by trees and shrubs
   (*d*) All of the above

89. A food web:
   (*a*) Is made by a spider
   (*b*) Shows how feeding relationships are interlinked
   (*c*) Shows the number of organisms in a habitat
   (*d*) Only shows important animals

90. Which of these are **not** competed for by plants?
   (*a*) Light (*b*) Minerals
   (*c*) Warmth (*d*) Water

91. Weeds compete with crops for resources. Farmers can get rid of weeds by using:
   (*a*) Insecticide (*b*) Fungicide
   (*c*) Herbicide (*d*) Rodenticide

92. Which of the following statements about pesticides is true?
   (*a*) Spraying pesticides only affects the farmer's crops
   (*b*) There do not affect food chains
   (*c*) Without pesticides farmers could not grow crops
   (*d*) Pesticides can end up in rivers and streams

93. Many pesticides are stored in an animal's body fat. If a pesticide got into a lake, which organism would have the highest level? microscopic plant→micro animal→fish →osprey
   (*a*) Osprey (*b*) Fish
   (c) Microscopic animals (d) Microscopic plants

94. What do farmers using modern farming techniques rely on to ensure maximum crop yields?
   (*a*) Pesticides (*b*) Fertilisers
   (*c*) Pesticides and fertilisers (*d*) Large machinery

95. Fertilisers can be washed into rivers by the rain. This can cause:
   (*a*) Bioaccumulation (*b*) Eutrophication
   (*c*) Biodegradation (*d*) Spontaneous combustion

96. Organic food is supposed to be better for you because:
    (*a*) It relies on chemicals to improve the flavour
    (*b*) It is more expensive to buy
    (*c*) It is all grown in glasshouses, keeping it clean of environmental pollutants
    (*d*) It is grown without the use of artificial fertilisers and pesticides

97. The biggest impacts are made on the environment by:
    (*a*) The migration of organisms (*b*) Predation
    (*c*) Human interference (*d*) Competition

98. Sustainable development is:
    (*a*) New building work to maintain jobs
    (*b*) Just a phrase used by environmentalists
    (*c*) Typical 21st century farming methods
    (*d*) Improving the lives of today's people, without damaging the quality of life of future generations

99. Farming crises and food scares arise because:
    (*a*) Animals are dirty
    (*b*) Some people don't cook their food properly
    (*c*) Man has interfered too much with natural food production
    (*d*) We eat too much fast food

100. The Rio declaration on the Environment and development and Agenda 21 encouraged people to:
    (*a*) Act local, think global
    (*b*) Act global, think local
    (*c*) Act as we are, think as we do
    (*d*) Not worry, the earth will go on forever

7

Biodiversity and Taxonomy

BIODIVERSITY

Biodiversity is defined as 'the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems'. India is one of 12 megadiversity countries of the world. The innumerable life forms harbored by the forests, deserts, mountains, other land, air and oceans provide food, fodder, fuel, medicine, textiles etc. There are innumerable species, the potential of which is not as yet known. It would therefore be prudent to not only conserve the species we already have information about, but also species we have not yet identified and described from economic point of view. *Taxus baccata*, a tree found in the Sub-Himalayan regions, once believe to be of no value is now considered to be effective in the treatment of certain types of cancer. The diversity of genes, species and ecosystem is a valuable resource that can be tapped as human needs and demands change, the still more basic reasons for conservation are the moral, cultural and religious values.

Biodiversity has direct consumptive value in agriculture, medicine and industry. Approximately 80000 edible plants have been used at one time or another in human history, of which only about 150 have even been cultivated on a large scale. Today a mere 10 to 20 species provide 80%–90% food requirements of the world. The indirect values imply the functions performed by biodiversity which are not of any direct use such as ecological processes etc. In India, many rural communities particularly the tribals obtain considerable part of their daily food from the wild plants. Some examples are: *Ceropegia bubosa* in Central India and Western Ghats. At one time, nearly all medicines were derived from biological resources. Even today they remain vital and as much as 67%–70% of modern medicine are derived from natural products. In developing countries, a large majority of the people rely on traditional medicines for their primary health care, most of which involve the use of plant extracts.

- **Genetic Biodiversity:** Genetic variation within species both among living organisms and the ecological complex in which they occur. eg., the genetic diversity in rabbit population.

- **Species Biodiversity**: Full range of species on earth.
- **Community and ecosystem diversity:** On wider scale, biodiversity includes variation in biological community in which species live, the ecosystem in which community exists and interactions among the levels. Eg., diversity across the landscape of entire region.
- **α-Diversity:** Number of species in a single community, used to compare number of species in different ecosystem types.
- **β-Diversity:** Degree to which species composition changes along the environmental gradient. Eg., **β**-diversity will be low if same species occupy the whole mountain and high if species changes at successive higher elevations.
- **γ-Diversity:** It applies to larger geographical scales and defined as rate at which additional species are encountered as geographical replacements within a habitat types in different localities.

MAJOR BIODIVERSITY THREATS

Habitat destruction, overexploitation, pollution, and species introduction are the major causes of biodiversity loss in India. Other factors included fires, which adversely affect regeneration in some cases, and such natural calamities as droughts, diseases, cyclones, and floods. Habitat destruction, decimation of species, and the fragmentation of large contiguous populations into isolated, small, and scattered ones has rendered them increasingly vulnerable to inbreeding depression, high infant mortality, and susceptibility to environmental stochasticity and, in the long run, possibly to extinction.

This erosion of biodiversity is largely due to habitat loss caused by the expansion of various development projects such as mines, dams, and road and canal construction. Habitat loss leads to the fragmentation of continuous stretches of land and consequently fragments wildlife populations inhabiting them. These small populations are increasingly vulnerable to inbreeding depression, high infant mortality, susceptibility to environmental stochasticity, and, in the long run, possibly to extinction. Apart from the primary loss of habitats, there are numerous other problems contributing to the loss and endangered status of several plant and animal species. Habitat degradation such as changes in forest composition and quality can in turn lead to declines in primary food species for wildlife. Poaching is another insidious threat that has emerged in recent years as one of the primary reasons for extinction of species such as the tiger. Poaching pressures, however, are unevenly distributed since certain selected species are more heavily targeted than others. Population pressures and concomitant increases in the collection of fuelwood and fodder, and grazing in forests by local communities also take their toll on the forests and consequently its biodiversity. Other minor factors include fires, which adversely affect regeneration in some cases, and natural calamities like droughts, diseases, cyclones, and landslides.

India's contribution to agro-biodiversity has been impressive. India stands seventh in the world as far as the number of species contributed to agriculture and animal husbandry is concerned. In qualitative terms too, the contribution has been significant, as it has contributed such useful animal species as water buffalo and camel and plant species such as rice and sugarcane. India has also been a secondary centre of domestication for animal species such as horse and goat, and such plant species as potato and maize. Animal species, which are reported to be threatened in India, have been listed in Table 9.1.

Taxa2	India			World	Percentage of India to the word
	Species	Endemic species	Threatened species		
Protista	25772			312592	8.242
Mollusca2	50702	9672		665352	7.62
Arthropoda2	683892	16214 (Insects)2		9879492	6.902
Other Invertebrates	283292			871212	9.562
Protochordata2	119			1062	5.652
Pisces	25462		4	217232	11.72
Amphibia2	092	1102	32	51502	4.062
Reptilia2	4562	142	162	58172	7.842
Aves2	1232	692	732	90262	13.662
Mamalia2	3902	382	752	46292	8.42

India has 47 000 species of flowering and non-flowering plants representing about 12% of the recorded world's flora. Out of 47 000 species of plants, 5 150 are endemic and 2532 species are found in the Himalayas and adjoining regions and 1 782 in the peninsular India. India is also rich in the number of endemic faunal species it possesses, while its record in agro-biodiversity is very impressive as well. There are 166 crop species an numerous wild relatives of domesticated animals. Overall India ranks seventh in terms of contribution to world agriculture.

STATUS OF BIODIVERSITY IN INDIA

India occupies only 2.4% of the world's land area but its contribution to the world's biodiversity is approximately 8% of the total number of species, which is estimated to be 1.75 million. Of these, 126 188 have been described in India. The species recorded includes flowering plants (angiosperms), mammals, fish, birds, reptiles, and amphibians, constitute 17.3% of the total whereas nearly 60% of India's bio-wealth is contributed by fungi and insects. Such a distribution is similar to that found in the tropics and the subtropics. Biogeographically, India is situated at the tri-junction of three realms namely Afro-tropical, Indo-Malayan and Paleo-Arctic realms, and therefore, has characteristic elements from each of them. This assemblage of three distinct realms probably is a fact which is believed to partly account for its rich and unique in biological diversity. Based on the available data, India ranks tenth in the world and fourth in Asia in plant diversity, and ranks tenth in the number of endemic species of higher vertebrates in the world. There are 10 biogeographical zones in India. They can be classified as under:

The Biogeographic classification of India (Rodgers and Pawar 1990)

- **Trans-Himalayas.** An extension of the Tibetan plateau, harboring high-altitude cold desert in Laddakh (J&K) and Lahaul Spiti (H.P) comprising 5.7 % of the country's landmass.
- **Himalayas.** The entire mountain chain running from north-western to northeastern India, comprising a diverse range of biotic provinces and biomes, 7.2 % of the country's landmass.

- **Desert.** The extremely arid area west of the Aravalli hill range, comprising both the salty desert of Gujarat and the sand desert of Rajasthan. 6.9% of the country's landmass.
- **Semi-arid.** The zone between the desert and the Deccan plateau, including the Aravalli hill range. 15.6 % of the country's landmass.
- **Western ghats.** The hill ranges and plains running along the western coastline, south of the Tapti river, covering an extremely diverse range of biotic provinces and biomes. 5.8% of the country's landmass.
- **Deccan peninsula.** The largest of the zones, covering much of the southern and southcentral plateau with a predominantly deciduous vegetation. 4.3 % of the country's landmass.
- **Gangetic plain.** Defined by the Ganges river system, these plains are relatively homogenous. 11% of the country's landmass.
- **North-east India.** The plains and non- Himalayan hill ranges of northeastern India, with a wide variation of vegetation. 5.2% of the country's landmass.
- **Islands.** The Andaman and Nicobar Islands in the Bay of Bengal, with a highly diverse set of biomes. 0.03% of the country's landmass.
- **Coasts.** A large coastline distributed both to the west and east, with distinct differences between the two; Lakshadeep islands are included in this with the percent area being negligible.

Forest type2	Distribution	% of forest area
Tropical forests2		
Tropical wet evergreen2	North East and South, Andaman and Nicobar island2	5.82
Tropical semi evergreen2	South and East2	2.52
Tropical moist deciduous2	Central and East2	30.32
Tropica littoral and swamp2	Along the coast2	0.92
Tropical dry deciduous2	West and Central2	38.2
Tropical thorn2	West and Central2	6.72
Tropical dry evergreen2	Central and South2	0.12
Subtropical forests2		
Subtropical broad leaved hill forests2	South2	0.42
Subtropical pine2	Sub-Himalayan tract2	5.02
Subtropical dry evergreen2	North-East and South2	0.2
Temperate forests2		
Montane wet temperate2	Himalaya and Nilgiris (in Western Ghats)2	2.02
Himalayan moist temperate2	Temperate areas of Himalays2	3.42
Himalayan dry temperate2	Dry temperate areas of Himalayas2	0.2
Sub-alpine and alpine forests2		
Sub-alpine2	Himalaya2	4.32
Moist alpine shrub2	Himalaya2	4.32
Dry alpine shrub2	Himalaya2	4.32

Apart from the biogeographic classifications described above ecosystems can also be demarcated on the basis of purely geographical or geological features like mountains, islands, valleys, plateaux, oceans; on the basis of vegetative cover like forests, grasslands, mangroves and deserts; on the basis of climatic conditions like arid and semi-arid areas, permanently snow-bound areas, high rainfall areas; on the basis of soil characteristic and other such criteria. In some descriptions the biomes/ecosystems are clubbed together into very general habitat classifications. The main natural habitat types are:

1. Forests

The forest cover of the country is placed at 633 397 sq km according to the forest survey of India assessment (1997). This presents 19.27% of India's total geographical areas. India is endowed with diverse forest types ranging from the Tropical wet evergreen forests in North-Eastern to the Tropical thorn forests in the Central and Western India.

2. Grasslands

In India the spread of grassland and shrubland is put at 12% of the total landmass while the planning commission (1989) and Grasslands and Fodder research Institute, Jhansi gives an estimate of about 3.7 to 3.9%. The diversity of grasslands in India is high ranging from semi-arid pastures of the western part of the Deccan peninsula, the humid, semi-waterlogged tall grassland of the Terai belt, the rolling shola grasslands of the western ghat hilltops, and the high-altitude alpine pastures of the Himalayas.

3. Wetlands

Wetlands cover 3% of the Indian landmass, or nearly 100 000 sq. Km. Wetlands in India harbor a vast variety of life forms that are a part of the complex food of these transitional ecosystems. About 320 species of birds are associated with the Indian Wetlands. Apart from birds, the wetlands support a diverse population of plants and animals including 150 species of amphibians. Wetlands are the habitat of some of the world's endangered and threatened flora and fauna. The Western and Central flock of Siberian crane, one of the most endangered cranes in the world, uses Keoladeo as its winter site. The brown antlered deer (*Cervus eldi eldi*) or 'sangai' is found only in *phumadis* (floating landmasses) of Lok Tak Lake. Gahirmatha beach is a major breeding site of olive ridley turtles. Chilka is the habitat of many threatened species such as green sea turtle, Hawksbill turtle, dugong, and blackbuck.

4. Mangroves

Government of India estimated mangrove cover of 674 000 ha, which is about 7% of the world's mangrove. Mangroves are salt-tolerant ecosystems in tropical and subtropical regions. These ecosystems are largely characterized by assemblage of unrelated tree genera that share the common ability to grow in saline tidal zone. India harbours some of the best mangroves swamps in the world, located in the alluvial deltas of Ganga, Mahanadi, Godavari, Krishna, and Cauveri rivers and on the Andaman and Nicobar group of Islands. The largest stretch of mangroves in the country lies in the Sunderbans in West Bengal covering an area of about 4,200 sq. km. The predominant mangroves species are *Avicennia officinalis, Excoecaria agallocha, Heritiera fomes, Bruguiera parviflora, Ceriops decandra, Rhizophora mucronata* and *Xylocarpus granatum*. Mangroves also harbour a number of molluscs, polychaetes and honeybees. The Indian mangroves are host to 105 species of fish, 20 kinds of shellfish, and 229 crustacean species. The Royal Bengal tiger is found in the Sunderban mangroves. Different species of monkeys, otters, deer, fishing cats, snakes and wild pigs are common. A total of 117 species of migratory and residential birds have been reported. The most common birds are flamingos, storks, sea eagles, kites, kingfishers, sandpipers, bulbuls, and whistlers.

5. Coral reefs

Accurate estimates of coral reef extent in the world are not available. A rough estimate puts it at 600 000 sq Km (Smith 1978) out of which 60% occurs in the Indian Ocean region and most of it in south-east Asia. The coral reef cover in Indian waters is roughly estimated upto 19,000 sq. Km (Wafar 1992). Indian reefs belong to the following categories:

1. PalkBay and Gulf of Mannar : Fringing
2. Gulf of Kachchh : Fringing, Patchy
3. Andaman and Nicobar Islands : Fringing
4. Lakshadeep Islands : Atolls
5. Central West coast : Patchy

The diversity of the Indian coral reefs is very impressive with about 200 coral species belonging to 71 genera. The richest being Andaman and Nicobar Islands which alone harbors 179 species.

6. Deserts

In India, deserts extend over about 2% of the landmass. Three kinds of deserts are noticeable in India:

1. The sand desert of western Rajasthan and neighbouring areas.
2. The vast salt desert of Gujarat
3. The high-altitude cold desert of Jammu and Kashmir and Himachal Pradesh.

Desert fauna in India is also quite diverse, with about 1200 sp. of animals reported from Thar region of which 440 are vertebrates and 755 are invertebrates. Desert fox, Desert cat, Houbara Bustard and some Sandgrouse species are restricted to the Thar area (Rodgers and Pawar 1988). In the remote part of Great Rann, Gujarat lies the nesting ground of Flamingoes and the only known population of Asiatic wild ass.

The cold deserts in India cover a vast area of 109 990 sq. Km, about 87,780 sq. km in Laddakh (Jammu and Kashmir) and 22,210 sq. Km in Lahaul -Spiti (Himachal Pradesh). The diversity of the high altitude cold deserts has been studied only recently with many insect species being endemic. Interestingly the cold desert harbors *Kiang* a close relative of the Indian wild ass found the Rann of Kachchh. Other distinctive animals include Snow leopard, Yak, Tibetan antelope, Ibex, Blue sheep, Tibetan gazelle, Woolly hare etc.

BIODIVERSITY HOTSPOTS

In order to concentrate resources on those areas that are most vulnerable, conservationists have identified certain areas as biodiversity “hotspots.” The term was first used by British ecologist Norman Myers in 1988 to designate areas in which there is a disproportionate number of endemic species (species that are found nowhere else) and which are losing habitat at a high rate. In a February 2000 article in *Nature*, Myers and other ecologists identified **25** “hotspots” that together comprise only **1.4 percent** of the Earth’s surface yet **contain 44 percent of all species of higher plants and 35 percent of all land vertebrate species.**

Hotspots are defined according to their plant vegetation. According to Myers's definition, a hotspot has to contain **at least 0.5 percent of the world's 300,000 plant species as endemics**. Plants are important because vegetation is what determines the primary productivity of an ecosystem. Most, but not all, of the hotspots are in tropical areas; many are in developing countries where populations rely on species-rich ecosystems for food, firewood, cropland, and income from timber. In Madagascar, for example, about 85 percent of the plants and animals are found nowhere else in the world

Biodiversity hotspots are areas that are unusually rich in species, most of which are endemic, and are under a constant threat of being overexploited. Among the 25 hot spots in the world, two are found in India. These are two distinct areas: the **Eastern Himalayas and the Western Ghats** and are also depicted in the National forest vegetation map of India.

1. Eastern Himalayas

Phytogeographically, the Eastern Himalayas forms a distinct floral region and comprises Nepal, Bhutan, neighbouring states of east and north-east India, and a contiguous sector Yunnan province in south western China. In the whole of Eastern Himalayas, there are an estimated 9000 plant species, with 3500 (i.e. 39%) of them being endemic. In India's sector of the area, there occur some 5800 plant species, roughly 2000 (i.e. 36%) of them being endemic. At least 55 flowering plants endemic to this area are recognized as rare, for example, the pitcher plant ***(Nepenthes khasiana)***. The area has long been recognized as a rich centre of primitive flowering plants and the area is recognized as '***Cradle of Speciation'.***

Species of several families of monocotyledons, Orchidaceae, Zingiberaceae and Arecaceae abound in the area. Gymnosperms and pteridophytes (ferns) are also well represented in the area. The area is also rich in wild relatives of plants of economic significance, e.g., rice, banana, citrus, ginger, chilli, jute and sugarcane. The region is regarded as the **centre of origin** and diversification of five palms of commercial importance namely, c**oconut, arecanut, palmyra palm, sugar palm and wild date palm.** Tea (*Thea sinensis*) is reported to be in cultivation in this region for the last 40,000 years. Many wild and allied species of tea, the leaves of which are used as substitute of tea, are found growing in the North East in the natural habitats. The **'taxol'** plant *Taxus wallichiana* is sparsely distributed in the region and has come under red data category due to its over exploitation for extraction of a drug effectively used against cancer.

As regards faunal diversity, 63% of the genera of land mammals in India are know from this area. During the last four decades, two new mammals have been discovered from the region: **Golden Langur from Assam – Bhutan region, and Namdapha flying squirrel from Arunachal Pradesh** indicating the species richness of the region. The area is also a **rich centre of avian diversity – more than 60%** of the Indian birds are recorded in the North East. The region also has two endemic genera of lizards, and 35 endemic reptilian species, including two turtle. Of the 204 Indian amphibians, at least 68 species are known from North East, 20 of which are endemic. From Namdapha National Park itself, a new genus of mammal, a new subspecies of bird, 6 new species of amphibia, four new species of fish, at least 15 new species of beetles and 6 new species of flies have been discovered.

2. Western ghats

The Western Ghats region is considered as one of the most important biogeographic zones of India, as it is one of the richest centres of endemism. Due to varied topography and micro-climatic regimes, some areas within the region are considered to be active zones of speciation.

The region has 490 arborescent taxa, of which as many as 308 are endemics this endemism of tree species shows a distinct trend, being the highest (43%) in 8N-10°30'N location and declining to 11% in 16N - 16°30'N location. About 1 500 endemic species of dicotyledonous plants are reported from the Western Ghats. 245 species of orchids belonging to 75 genera are found here, of which 112 species in 10 genera are endemic to the region.

As regards the fauna, as many as 315 species of vertebrates belonging to 22 genera are endemic, these include 12 species of mammals, 13 species of birds, 89 species of reptiles, 87 species of amphibians and 104 species of fish. The extent of endemism is high in amphibian and reptiles. There occur 117 species of amphibians in the region, of which 89 species (i.e. 76%) are endemic. Of the 165 species of reptiles found in Western Ghats, 88 species are endemic. Many of the endemics and other species are listed as threatened. Nearly 235 species of endemic flowering plants are considered endangered. Rare fauna of the region includes: **Lion Tailed Macaque, Nilgiri Langur, Nilgiri Tahr, Flying Squirrel, and Malabar Gray Hornbill.**

Response

The Ministry of Environment and Forests (MoEF) is the nodal agency in the Government of India for planning, promotion, coordination, and overseeing the implementation of the environmental and forestry programmes. The MoEF is also the focal point for implementation of the Convention on Biological Diversity. The mandates of the Ministry interalia include survey of flora, fauna, forests and wildlife, and conservation of natural resources. These objectives are supported by legislative and regulatory measures. A number of institutions affiliated with the Ministry are involved in the work related to various aspects of biological diversity. Survey and inventorization of the floral and faunal resources are carried out by the Botanical Survey of India (BSI) established in 1890, and the Zoological Survey of animals species have been recorded by the BSI and ZSI respectively. The Survey organizations have published over the years, documents on flora and fauna at country, state and in some cases district levels and for selected ecosystems. Besides, extensive reports on inventories of resources indicating level of biodiversity in selected areas have also been brought out. The Surveys have also published **Red Data Books** (Originally printed by International council for conservation of nature and natural resources) on endangered species. The voucher specimens are preserved in Central National Herbarium (CNH) of BSI and National Zoological Collection (NZC) of ZSI. The Forest Survey of India publishes every three years, a State of Forest in India report based on remote sensing and ground truth data.

CONSERVATION STRATEGICS

Existing policy response In situ conservation (within natural habitat)

India has a network of 85 national parks and 448 sanctuaries, covering 4.2% of the its land area [MoEF 1998]. This number has progressively increased over the last twenty-five years. Areas having significant biodiversity value are declared national parks or sanctuaries under the Wild Life (Protection) Act of 1972 (henceforth referred to as WL Act), as amended in 1991. Before this act, national parks and sanctuaries were being set up but under various state or area specific acts.

With the coming of this act, all areas notified under any other act became parks or sanctuaries notified under this act, Under the WL Act, **national parks** are given a higher level of protection and no human use activity is permitted within them: The act specifies that: "*No person shall destroy, exploit or remove any wild life from a National Park or destroy or* *damage the habitat of any wild animal or deprive any wild animal of its habitat within such National Park except under and in accordance with a permit granted by the Chief Wild Life Warden and no such permit shall be granted unless the State Government, being satisfied that such destruction, exploitation or removal of wild life from the National Park is necessary for the improvement and better management of wild life therein, authorises the issue of such permit.*" [Section 35(6) of the Act]. Also, no private land holding or right is allowed within a national park.

Sanctuaries are accorded a lesser level of protection, and grazing and some community or individual rights can be permitted. Under the WL Act, national parks are fully protected from all human disturbance and, consequently, correspond to the revised category Ia (Scientific Reserves) of the IUCN categorisation system for protected areas. A sanctuary, where grazing and various other rights can be permitted, corresponds to IUCN category IV Habitat and Wildlife Management Area).

Some important measures taken are as follows

- A programme entitled **"Eco-development"** for in situ conservation of biological diversity involving local communities has been initiated in recent years. The concept of eco-development integrates the ecological and economic parameters for sustained conservation of ecosystems by involving the local communities with the maintenance of earmarked regions surrounding protected areas. The economic needs of the local communities are taken care of under this programme through provision of alternative sources of income and a steady availability of forest and related produce. To conserve the respective ecosystems, a **Biosphere Reserve Programme** is being implemented. Twelve biodiversity rich areas of the country have been designated as Biosphere Reserves (Table 9.5) applying the diversity and genetic integrity of plants, animals and microorganisms in their totality as part of the natural ecosystems, so as to ensure their self-perpetuation and unhindered evolution of the living resources.
- Programmes have also been launched for scientific management and wise use of fragile ecosystem. Specific programmes for management and conservation of wetlands, mangroves, and coral reef systems are also being implemented. 21 wetlands, 15 mangrove areas and 4 coral reef areas have been identified for management. National and sub-national level committees oversee and guide these programme to ensure strong policy and strategic support.
- Six internationally significant wetlands of India have been declared as "**Ramsar Sites**" under the Ramsar Convention. To focus attention on urban wetlands threatened by pollution and other anthropogenic activities, State Governments were requested to identify lakes that could be include the National Lake Conservation Plan. The activities of the NLCP include formulation of perspective plans for conservation based on resource survey using remote sensing technology and GIS studies on biodiversity and related ecological matters, prevention of pollution from point and non-point sources, treatment of catchment, desilting and weed control.
- Wild Life Protection Act is in the final stage of revision and provisions have been made for conservation reserves and com- munity reserves to allow restrictive use to make it more people oriented. Presently Biodiversity Act which is in the final stage, has got the component of National Biodiversity Authority to control access to genetic resources form international community. There will also be State Biodiversity Boards to control access to domestic consumers. Under the World Heritage Convention, five

natural sites have been declared as "**World Heritage Sites**", the name of which are under:

1. The Tura Range in Gora Hills of Meghalaya is a gene sanctuary for preserving the rich native diversity of wild Citrus and Musa species.
2. Sanctuaries for rhododendrons and orchids have been established in Sikkim.
3. Large mammal species targeted protection based on the perception of threat to them have been under implementation.

- **Project Tiger.** A potential example of an highly endangered species is the Indian Tiger (*Panthera tigris*) The fall and rise in the number of Tiger's in India is an index of the extent and nature of conservation efforts. It is estimated that India had about 40 000 tigers in 1900, and the number declined to a mere about 1 800 in 1972. Hence, Project Tiger was launched in 1973 with the following objectives:
- To ensure maintenance of available population of Tigers in India for scientific, economic, aesthetic, cultural and ecological value
- To preserve, for all times, the areas of such biological importance as a national heritage for the benefit, education and enjoyment of the people
- At present there are 25 Tiger Reserves spreading over in 14 states and covering an area of about 33 875 sq km and the Tiger population has more than doubled now due to a total ban on hunting and trading tiger products at national and international levels and the implementation of habitat improvement and anti-poaching measures (MoEF 2000)
- **Project Elephant** was launched in 1991-92 to assist States having free ranging population of wild elephants to ensure long term survival of identified viable populations of elephants in their natural habitats. Major activities of Project Elephant are:
- Ecological restoration of existing natural habitats and migratory routes of elephants. Development of scientific and planned management for conservation of elephants habitats and value population of wild Asiatic elephants in India
- Promotion of measures for mitigation of man-elephant conflict in crucial habitats and moderating pressures of human and domestic stock activities in crucial elephant habitats
- Strengthening of measures for protection of wild elephants from poachers and unnatural caused of death. Research on Project Elephant management related issues Public education and awareness programmes
  - Eco-development
  - Veterinary care
- Rhinos have been given special attention in selected sanctuaries and national parks in the North East and North-west India. All these programmes, though focussed on a single species, have a wider impact as they conserve habitats and a variety of other species in those habitats. The Ministry of Environment and Forests constituted the National Afforestation and Eco-development Board (NAEB) in August 1992. National Afforestation and Eco-development Board has evolved specific schemes for promoting afforestation and management strategies, which help the states in developing specific afforestation and management strategies and eco-development packages for augmenting biomass production through a participatory planning process of Joint Forest Management and microplanning.

Ex-situ conservation (outside natural habitats)

To complement in situ conservation, attention has been paid to ex-situ conservation measures. According to currently available survey, Central Government and State Government together run and manage 33 Botanical Gardens. Universities have their own botanical gardens. There are 275 zoos, deer parks, safari parks, aquaria etc. A Central Zoo Authority was set up to secure better management of zoos. A scheme entitled Assistance to Botanic Gardens provides one-time assistance to botanic gardens to strengthen and institute measure for ex-situ conservation of threatened and endangered species in their respective regions.

- Maximum biodiversity among vertebrates: Pisces (osteochythes/bony fishes)
- Maximum biodiversity among invertebrates: Arthropods (insecta)
- Maximum biodiversity occurs in: tropics (5° to 25° North South)
- Countries with maximum biodiversity: Brazil, Columbia, China
- In India maximum biodiversity occurs along Western Ghats.
- Wild life which become extinct in near past: Dodo (Mauritus/1680), Yellow headed Macaw (Jamaica/1765), Stellar sea cow (Bering sea /1767) and many Australian animals like Wallabies, Tasmanian emus, Tasmanian Tiger, Rat Kangaroo etc.
- Red Data book which have list of Threatened organism is published by Union of Nature and Natural resources (IUCN)

Threatened Species

The **Number of Threatened Species** for include "all full species categorized at the global level as Critically Endangered, Endangered or Vulnerable." Subspecies, introduced species, species whose status is insufficiently known, and species whose status has not been assessed are excluded.

Threatened species are classified in one of 3 categories:

1. Critically Endangered: includes species facing an extremely high risk of extinction in the wild in the immediate future.
2. Endangered: includes species that are not "Critically Endangered" but are facing a very high risk of extinction in the wild in the near future
3. Vulnerable: includes species facing a high risk of extinction in the wild in the medium-term future. For each threat category, five criteria A-E are used to classify species in one of the three categories mentioned above:
   - A- Declining population
   - B- Small population and decline or fluctuation
   - C- Small population size and decline
   - D- Very small population/very restricted distribution
   - E- Quantitative analysis (e.g. Population Viability Analysis)

DNA FINGERPRINTING

On some human chromosomes, a short sequence of DNA has been repeated a number of times. In any particular chromosomes the repeat number may vary from one to thirty repeats. Since these repeat regions are usually bounded by specific restriction enzyme sites, it is possible to cut out the segment of the chromosome containing this **variable number of tandem repeats** or **VNTR's**, run the total DNA on a gel, and identify the VNTR's by hybridization with a probe specific for the DNA sequence of the repeat. VNTR occurs in minisatellite DNA concentrated around Telomere

It is widely known that each individual has a DNA profile as unique as a fingerprint. Actually, over 99% of all 3 billion nucleotides in human DNA, which we inherit from each parent, are identical among all individuals. However, for every 1000 nucleotides that we inherit there is 1 site of variation or polymorphism, in the population. These DNA polymorphisms change the length of the DNA fragments produced by the digestion of restriction enzymes. The resulting fragments are called restriction fragments length polymorphisms (RFLP's—"riflips"). Gel electrophoresis can be used to separate and determine the size of the RFLPs. The exact number and size of fragments produced by a specific restriction enzyme digestion varies from individual to individual. The fundamental techniques involved in genetic fingerprinting were discovered in 1984 by Alec J. Jeffreys.

Steps to Producing a Genetic Fingerprint

- The first step is to obtain a sample of DNA from such substances as blood, semen, hair roots, or saliva. *Using newly developed biochemical techniques to multiply the amount of DNA present, researchers can work with as small a sample as one hair root.*
- The individual cells from the sample are split open, and the DNA is separated from the rest of the cellular debris.
- The DNA is then treated with specialized proteins called restriction enzymes, which cleave the DNA into smaller fragments by cutting at specific sites. *Since the minisatellites from any two individuals have different compositions, they are cleaved at different sites, producing fragments of different lengths.*
- The DNA fragments are then applied to one end of a thin, jellylike substance called an agarose gel, and an electric current is passed through the gel. *The negatively charged DNA fragments will migrate across the surface of the gel in response to the current, with the smaller, more mobile pieces traveling farther. The DNA is thus separated into individual bands, with the fragments in each one progressively smaller in size.*
- Because the gel cannot be easily handled, a thin nylon membrane is laid over its surface and covered by a layer of paper towels. As the towels draw moisture from the gel, the DNA is transferred onto the surface of the nylon membrane, a process called blotting.
- The DNA bands are still invisible to the eye, and there are too many to be useful. Therefore, a solution of the radioactive probes made from minisatellites is washed over the surface of the membrane.
- If any of the probes have the same composition as a part of a DNA fragment, they will bind to it. *The probes will ingnore the vast majority of the hundreds of bands present and will bind anywhere from 6 to 20.*
- To see the pattern of bands, the researchers place a sheet of photographic film on top of the membrane.
- The radioactive labels will expose the film, ultimately producing a pattern of thick-and-thin dark bands.
- This pattern of bars is the GENETIC FINGERPRINT.

Varied Applications of DNA Fingerprinting

The likelihood that two individuals—other than identical twins—will have the same genetic fingerprint varies from about one in 800,000 to about one in 1 billion, depending on the number of probes that are used in the test. By comparison, the probability that two individuals will have the same conventional fingerprint is also about one in 1 billion. But the genetic fingerprint has many other advantages over conventional fingerprints.

- It is unusual for police to find a high-quality fingerprint at a crime scene, but much more likely that they will find blood or semen. Furthermore, only a microscopically small sample is required for a positive identification.
- No relationship exists between the conventional fingerprints of parents and children, but the genetic fingerprints are closely related because the child receives half of her or his genetic information from each parent. Thus, half the bands int he child's genetic fingerprint come from the mother, and half from the father. This similarity can be used to establish paternity (or maternity) with a much higher degree of certainity than is possible with other techniques, such as a blood test.

SYSTEMATICS

Systematics is the study of relationships between organisms. It includes all relationships between organisms in an attempt to identify patterns in their similarities. Systematics includes those areas of biology concerned primarily with similarities and differences between organisms. It includes disciplines such as evolution, phylogeny, comparative anatomy, comparative physiology, comparative biochemistry, comparative embryology, comparative ethology, paleontology, taxonomy, and classification. The object of systematics is the uncovering of genetic relationships that will shed light on the evolution, or phylogeny, of the organisms being compared.

Terms

- **Phylogeny** is the evolutionary history of a group of organisms.
- The science concerned with the reconstruction of phylogenies is **systematics**. Systematics includes any biological discipline involved in comparisons between organisms.
- **Taxonomy** is the science of naming and classification of organisms based on their genetic (evolutionary) relationships. Taxonomy is very much a field of systematics in that it is based on phylogeny and comparisons between organisms and groups of organisms. It is the science of arranging living things into groups reflecting their relationships.
- **Classification** is the actual practice of placing animals into these groups.
- **Nomenclature** is the collection of rules and procedures of assigning names to the groups.

CLASSIFICATION

There are between 1.4×10^6 (known as of 1992) and 100×10^6 (maximum estimate) species alive on the planet today. With this many organisms we must have a filing, or classification, system so we can keep track of the species, their relationships, and what we know about them.

In biology, we use a classification system based on genetic relationships. The system reflects the evolution of the organisms classified. For example, consider cats, tigers, humans, flies, oaks, and pneumonia bacteria. We would use systematic biology, including anatomy, behaviour, physiology, and biochemistry to group these organisms accord to their degree of kinship. We use physical similarity as our index to kinship and assume that similar organisms are ore close related than dissimilar ones. We can construct a simple phylogeny, or phylogenetic tree, showing the relationships between these 6 organisms using our current knowledge of their appearance and cell biology. The resulting diagram is a cladogram in which the vertical axis is time and the branching points show the time of the most recent common ancestor between two groups. We will build the cladogram in class beginning with cats and tigers because they seem to be the most closely related of any pair of organisms in the collection. We then arrange other organisms on the cladogram according to how closely related to cats they seem to be.

The classification system proposed in 1758 by Carl Linnaeus reflects these evolutionary relationships and is the system used by all biologists today. In its original form it included 7 categories (ranks) but we have added many more. Each if the world's known organisms is positioned in a hierarchy of categories with other organisms to which it is related. Thus, those with very recent common ancestors (and little time to diverge) are grouped closely together and those with more remote ancestors are placed in different groups.

The most closely related are placed in the same **species**. The species is the most restrictive and least inclusive category. Membership in the same species means the organisms share a very recent common ancestry and have had very little time to diverge, hence they are very much alike. All humans belong to the same species, *(Homo sapiens*) and while we are not identical, we are very much alike.

At the other end of the hierarchy is the **kingdom**. This category is the most inclusive and least restrictive. To belong to the same kingdom as another organism does not require recent common ancestry, genetic commonality, or very much similarity. Humans and jellyfish belong to the same kingdom (Animalia).

For example, a Linneaen classification of a human would be as follows.

A **category** is a level in the following hierarchy. Kingdom and order are categories.

A **taxon** (plural: taxa) is a unit in any category. Reptilia, Homo, and Annelida are taxa.

Linnaean Classification of Humans

Superkingdom: **Eukaryota** (+ Plantae, Fungi, Protoctista)

Kingdom: **Animalia** (+ Cnidaria, Annelida, Mollusca, Arthropoda, etc)

Phylum: **Chordata** (+ Cephalochordata, Urochordata)

Subphylum: **Vertebrata** (+ Osteichthyes, Aves, Reptilia, etc)

Class: **Mammalia** (+ Carnivora, Rodentia, Perissodactyla, etc)

Order: **Primata** (+ Hominidae, Pongidae, etc)

Family: **Homiinidae** (+ Homo, Australopithecus, Zinjanthopus, etc)

Genus: **Homo** (+ H. *habilis, H. erectus*, etc)

Species ***Homo sapiens***

Of these categories, only the **species** is real and exists in nature. The others are artificial constructs we make for our own convenience and are not unambiguously identifiable in nature. A species, at least in sexually reproducing organisms, is defined as being a group of potentially interbreeding individuals that cannot interbreed with individuals outside the group.

Nomenclature: Every species, when it is first described by a taxonomist, is assigned a binomial name. This name consists of the generic name, which is always capitalized, and the specific epithet, which is not. Thus our species is ***Homo sapiens***. When written the scientific name is placed in a different type font, usually italics, than the rest of the text that accompanies it. The scientific name is unique and no other organism in the kingdom can have it.

PHYLOGENY

One concern in this series of lectures is with phylogeny, how it is reconstructed, and how our knowledge of it is incorporated into our classification of organisms.

Our understanding of phylogeny is based in part on **fossils**. A fossil is any preserved remnant of an organism that lived in the past. Most organisms die without leaving a trace but occasionally (rarely) some aspect of the organism may be preserved for great lengths of time, sometimes millions of years. Fossils may be actual hard parts of former organisms, they may be casts of organisms or their parts, they may be preserved artifacts made by the organism such as burrows or footprints or fecal pellets. Many fossils are not the actual parts of the original organism but replacements that have been mineralized.

The fossil record is very incomplete for a number of reasons. The discovery of a fossil by a paleontologist is the culmination of a series of improbably events. First, very few organisms die under circumstances that make fossilization likely. Relatively few individuals become fossils to start with. Second, the fossils must survive millions of years of geologic events such as erosion, vulcanism, pressure, faulting, orogenies (mountain building episodes), earthquakes etc and remain intact. Thirdly, the fossil must occur I or be moved by some force to a location at or near the ground surface where it has a chance of being found. Finally, the fossil must be noticed by someone who recognizes it as being worthy of attention. All of these steps are improbable.

Dating: For fossils to be useful in constructing phylogenies we must have some idea of their age. We use **relative and absolute dating.**

Relative dating. Most fossils are formed in sediments laid down in water. These sediments become sedimentary rock which then may be lifted above the water to become dry land during mountain building episodes. The sediments, and the fossils are laid down in chronological order, with the oldest in the lower layers or strata, and the youngest in the upper strata. Simply knowing the level of a stratum of a fossil gives information about its age relative to other fossils in associated strata.

We also have methods of absolute dating whereby we can put actual ages, in years, on fossils. Most absolute dating methods rely on known rates of radioactive decay whereby a radioactive isotope decays to a stable isotope. Carbon 14, for example, has a radioactive decay rate such that it takes 5,600 years for half of it to decay to nitrogen.

^{14}C and ^{12}C are taken up by living organisms in the ratio present in the environment. Let this initial ratio be X. Once the organism dies the ^{14}C begins to decay at its known rate. In 5600 years the ratio will be X/2, in 11,200 years it will be x/4 and so on. By measuring the amount of ^{14}C remaining in carboniferous fossils and comparing the ratio with that originally present.

Because of its relatively short half life ^{14}C is useful only for times less than about 50,000 years. After that time there is not enough ^{14}C left to measure accurately. Carbon 14 consequently is very useful in studies of recent human prehistory. Other isotopes, such as potassium-argon are used for longer time ranges. Potassium 40 has a half life of 1.3 billion years.

Macroevolution is evolution above the species level. It is the evolution of higher taxonomic categories such as genera, families, orders, classes and phyla. Does it occur by the same mechanisms as microevolution but over larger periods of time?

Evidence for Phylogeny

For the first 200 years of the study of biology, physical (anatomical) similarity was the basis for almost construction of phylogenies and classifications. Early biologists relied on anatomic similarities, fossil similarities, and embryological similarities (all of which are anatomic) to determine which organisms were closely and which distantly related. Our early understanding of evolution was based on anatomy.

Recently, however, new and powerful sources of evidence have been provided by molecular biology and biochemistry. We can now look amino acid sequences of proteins or at the genes encoding those proteins for similarities or differences. This is almost like having the answers at the back of the book. We have struggled mightily to discover the true genetic relationships between organisms using anatomy and now we can verify our ideas with an independent and very powerful new set of data. Neither method is infallible and we should continue to use both and check the results of each against the other.

The new molecular techniques are based on the assumption that closely related organisms should have proteins with very similar amino acid sequences or, even better, genes with the same or similar base sequences. This follows the same reasoning developed earlier. The more time that has elapsed since the last common ancestor, the more time there has been for differences to develop.

Protein sequences. As you know, the amino acid sequence of a polypeptide is determined genetically in that it is encoded in the nucleotide sequence of the gene. Genes undergo point mutations reqularly and, if the mutations have no discernable effect on the protein, will persist in the genome indefinitely. Thus, nucleotide sequences would be expected to change at time passes and point mutations accumulate. Comparison of the primary structures of the same protein from different organisms can tell us how similar the genes for that protein are in the two organisms. from that we can deduce how much change has taken place since the two organisms shared their last common ancestor.

Cytochrome c, for example, is a polypeptide of 104 amino acids present in all anaerobic organisms in association with an electron carrier in the electron transport chain on the mitochondrial cristae. Its amino acid sequence has been determined for a wide variety of representative organisms.

If you were asked use anatomic characteristics to arrange a rhesus monkey, tuna fish, rattlesnake, chimpanzee, and dog according to how closely related to humans each is, you would probably produce the following: chimp, monkey, dog, snake, fish and this is exactly the arrangement biologists have agreed upon for centuries.

The following data are from amino acid sequencing studies of cytochrome c.

Humans and chimpanzees have identical cytochrome c molecules. All 104 amino acids are the same.

Humans and rhesus monkey have a difference of 1 amino acid out of 104.

Humans and dogs have 13 different amino acids.

Humans and snake have 20 different amino acids.

Humans and tuna fish have 30 different amino acids.

A phylogeny made using cytochrome c is identical to the traditional one using anatomy.

DNA Hybridization It is now possible to compare the genes of two organisms directly to see how similar their nucleotide sequences are. One technique for doing this is DNA hybridization. In this method we look, not at the gene product (protein) but at the gene itself.

DNA from two organisms of interest is removed and heated to cause the 2 strands to separate into complementary strands. The single stranded DNA from the two species is mixed and allowed to cool so that double stranded DNA will reform. The new double strands are hybrids. That is they are composed of one strand from each species. How tightly the two strands bond to each other is a measure of how similar their nucleotide sequences are. if they are perfect complements, with no different nucleotides, they will bond perfectly at all base pairs for the entire length. if they differ they will not find partners for all their bases. The more different they are, the poorer the match and the looser the bonding. The hybrid molecules can be heated to cause them to separate again. The amount of heat needed to separate them is proportional to the tightness of the bonding between them. If the nucleotide sequences are identical then more heat will be required. The more different they are, the less the heat that will be needed.

If we construct our phylogeny correctly, using only homology and no analogy, the resulting taxa are monophyletic, meaning they have one common ancestor. If we slip up and include some analogy, as in our tuna example, the resulting group is polyphyletic, since there are many unrelated ancestors. Tuna, sharks, ichthyosaurs, and porpoises do not have a single common ancestor. A group is polyphyletic if its members are derived from 2 or more ancestors that are not common to all.

Sometimes we create polyphyletic groups knowing we are probably doing so but we lack enough information to make monophyletic groups. The Protoctista, for example, is recognized as a polyphyletic group of many very different organisms that have little in common other than their unicellularity. As we learn more about these organisms we gradually remove them from the Protoctista and place them in monophyletic groups. green algae, brown algae, red algae, diatoms, flagellates, ciliates, amoebas, others

BIOLOGICAL NOMENCLATURE

Botanical nomenclature is about naming plants. Bear in mind that plant names refer to abstract entities – the collection of all plants (past, present, and future) that belong to the same group. As you will recall, taxonomy is about grouping. Botanical nomenclature is about applying names to taxonomic groups.

Scientific names of plants reflect the taxonomic group to which the plant belongs. One must first decide on the groups to be recognized; only then does one start to be concerned about assigning an appropriate name to the plant.

Scientific names are never misleading. No matter where you are, every plants has only one correct name. *so long as its taxonomic treatment is not in dispute.* This last is a major reservation, but we can ignore it for now. The universality of scientific names means that even English speaking people can find out what species grow in China or Saudi Arabia by reading a technical flora of these countries. Not only are the names the same, they are always written in the Latin alphabet (which is the same alphabet as these notes).

Pronunciation. There is as little point about wo rrying over the ‘correct’ pronunciation of scientific names as there is in worrying over which is the correct pronunciation of English words. It may be difficult to recognize a scientific name if it is spoken by someone from another part of the world but one can always recognize it when it is written out. In this, scientific names are no different from other words. Think how hard it can be to understand different versions of English. Nevertheless, it is advantageous to use the same pronunciation as the other people you work with. Just be prepared to modify your pronunciation if you move to another part of the world.

Taxonomy refers to forming groups. Plants that belong to the same group have the same name. The taxonomic decisions concerning how a group is to be treated (what goes in the group, what rank it should be recognized as) MUST be made before it can be assigned a name. It does not matter how you decide what its affinities are (unless, of course, you want others to support and use your treatment), but you must make these decisions before you can decide on an appropriate name for the group. So remember, **taxonomy first**.

If people are going to communicate around the world, there needs to be an internationally accepted system of nomenclature. Creating such a system was not, and is not, an easy task. It was not until 1930 that agreement was reached on an International Code had become standard around 1753. There were, however, many areas where there was widespread agreement in practice, with some of the practices dating back to before Linnaeus. For reasons that you will learn later, Linnaeus is taken as the starting point for botanical nomenclature. Let's consider for a moment some of the areas of agreement that existed before there was formal agreement on an **International Code of Botanical Nomenclature.**

The International Code of Botanical Nomenclature

Principles of Botanical Nomenclature

There are six principles that guide decisions concerning the Code.

Uniqueness Principle (Principle IV): The uniqueness principle states that there is only one correct name for a particular taxonomic group within a given taxonomic treatment. It is the central principle upon which all the remainder of the code is based. If people disagree on the taxonomic treatment, they will consider different names to be correct but, within any treatment, each taxonomic group has only one correct name.

Type Principle (Principle II): The type principle states, "The application of names of taxonomic groups is determined by means of nomenclatural types". For vascular plants such as grasses, a nomenclatural type is a herbarium specimen that has been deposited in a herbarium. A nomenclatural type anchors the meaning of a name. If there is an argument as to what kind of plant the author of a name meant by a particular name, one examines the type specimen. No matter what taxonomic treatment is followed, the name must be used in a sense that includes its type specimen. If, as occasionally happens, the author of a new name provides a description that does not match the type specimen, it is the type specimen, not the description, that determines what kind of plant is called by the name in question.

Adherence to the type principle did not become mandatory until 1958. Prior to that time, when taxonomists published a new name they frequently simply listed several different specimens that exemplified what they meant by the name, without identifying any particular specimen as the 'top dog' among the examples. All the designated specimens, including their duplicates, are referred to as *syntypes*: nomenclatural types of a single name, all of which were equally important. This became a problem if later taxonomists decided that there are two or more taxa among the specimens listed. When this happens, it became necessary to determine which of the specimens listed belongs with the original name.

To prevent such situations arising, the rules for designating a type specimen were made more explicit. Since 1990 it has been necessary to identify the exact specimen that is to be the nomenclatural type of the taxon, and the herbarium in which the specimen is located. Between 1958 and 1990 it was enough to specify who collected the specimen, where it was collected, the date on which it was collected, and the collection number it was given, if any. The problem was that, if the collector made several duplicate specimens, each of the duplicates is a *syntype*. In most instances this is not a problem, but occasionally the supposed duplicates turn out to belong to different species. Requiring that an author state exactly which of the specimens is to be regarded as the nomenclatural type helps prevent even this kind of problem. If possible, the accession number of the type should be specified as well as the name of the herbarium in which it is located, but many older herbaria do not give their specimens accession numbers.

There are several different kinds of type specimen, but the most important are holotypes, lectotypes, neotypes, and epitypes. The next most important are isotypes, syntypes, and paratypes. The first four kinds of type refer to specimens that are, unequivocally, the nomenclatural type of a name. A *holotype* is a specimen that has been designated the nomenclatural type of a name by the person creating the name. If the person who originally published a particular name did not designate a holotype, a later taxonomist may select a specimen to serve as the nomenclatural type. This specimen then becomes what is called the *lectotype* of the name. If the holotype or lectotype is destroyed or lost, a new type specimen can be selected. Such replacement types are called *neotypes.*

An *epitype* is a specimen selected to be the nomenclatural type of name for which there is a holotype, lectotype, or neotype available. Why would it be necessary to select another specimen as a nomenclatural type? Sometimes the holotype, lectotype, or neotype simply does not show the features that are needed to determine, unequivocally, to which of two taxa it belongs. In such a case, it cannot be used to fix the meaning of a name. In such situations, another specimen can be selected as the 'anchoring' specimen; it is this specimen that is the *epitype.*

Priority Principle (Principle III): This principle states, in essence, that if a taxonomic group has been given two or more names, the correct name is the first name that meets the *Code's* standards for publication. Basically, this means that the priority of a name dates from the time that it was first published and made known to other botanists. Writing the name in a letter (or Email) to a colleague does not count, nor do notes made on herbarium sheets.

Taxonomic groups may end up with two or more names for several reasons. The most common reason is taxonomic disagreement, about which the *Code* says nothing. Sometimes, the person publishing a later name is simply unaware that the group has already been named. In other cases, two (or more) names were given to different looking specimens of what was later treated as a single group. Whatever the reason, the priority principle states that only the first name validly and legitimately published for a particular taxonomic group is correct.

In determining priority, the date that matters is the date on which the material was actually mailed to other institutions; this is not always the same as the year on the cover of a book or journal.

***RETROACTIVITY PRINCIPLE* (*PRINCIPLE* VI):** This principle states, "The Rules of nomenclature are retroactive unless expressly limited". The Retroactivity Principle means that anyone proposing a change in the *Code* needs to consider the effect that the proposed change will have on names published in a wide range of literature and over a considerable period of time. This is an intimidating requirement. It is why all proposed changes to the Code undergo committee scrutiny before being voted on. If the committee has a problem with a proposed change, one of its members will get in touch with the person proposing the change. The committee member may point out unforeseen consequences of the proposed change. Alternatively, he or she may suggest examples that will make a stronger case for the change, or suggest modifications that will avoid some undesirable consequences.

All proposals to change the *Code* are published in *Taxon*, but they remain proposals until they are voted on at the next International Botanical Congress.

PRINCIPLES 1 and V: The other two principles are straightforward. Principle I states that botanical nomenclature is independent of zoological and bacteriological nomenclature. If an organism is considered to be a plant, then it must be named in accordance with the *Botanical Code.* If it is considered a bacterium, it must be named according to the *Bacteriological Code.* Principle V states that scientific names are to treated as if they were Latin, regardless of their derivation.

Other Key Provisions of the Code

1 Any changes in the Code should be designed to increase the stability of plant nomenclature. No one likes name changes, not even the taxonomists that propose them.

2. Every plant belongs to a species, every species to a genus, every genus to a family, every family to an order, every order to a class, every class to a division (also called a phylum nowadays - a concession to the greater number of zoologists in the world). This is the taxonomic hierarchy. Note that the Code *assumes* the existence of species. It does NOT state what constitutes a species, let alone discuss whether species are real. The Code also *requires* that plant diversity be summarized in a hierarchical structure. Again, it is not a question of whether such a structure really exists. The fact that the Code assumes the existence of species and a hierarchical structure does not mean that that the assumptions are correct, merely that, in naming plants (and the zoological code is similar in this regard), one must act as if species are real and nature is hierarchical. Many people object to this, but no one has provided a persuasive argument for dropping the system.

PUBLISHING SCIENTIFIC NAMES

Before a name, even a name that has a Latin form, can be accepted as a scientific name, it must satisfy several criteria. Some of these have to do with its form, others with how its existence and meaning are made known to others.

Form

Principle V states that a scientific name must be treated as if it were Latin, but the Articles 16-28 of the *Code* also specify what form the name must take. I have summarized them in the table below.

Family names must be formed by combining a generic name with the suffix –aceae, but there are eight exceptions to this rule. Each of the eight exceptional names was almost universally used, and used in the same sense, throughout the world when the first edition of the *Code* was prepared and so, in accordance with the overriding goal of achieving nomenclatural stability, it was agreed that they would continue to be used. The eight names are Gramineae

(Grass Family, alternative *Poaceae*) *Palmae* (Palm Family, alternatively *Arecaceae*), *Cruciferae* (Mustard Family, alternatively *Brassicaceae*), *Leguminosae* (Pea family, alternatively *Fabaceae*), *Guttiferae* (St. John's Wort Family, alternatively *Clusiaceae*), *Umbelliferae* (Carrot Family, alternatively *Apiaceae*), *Labiatae* (Mint Family, alternatively *Lamiaceae*), and *Compositae* (Daisy Family, alternatively *Asteraceae*).

Rank	**Ending**	**Examples**
Division (Phylum)	-phyta	Pinophyta, Magnoliophyta
Class	-opsida	Pinopsida, Liliopsida, Magnoliopsida
Order	-ales	Pinales, Liliales, Magnoliales
Family	-aceae	Pinaceae, Liliaceae, Magnoliaceae
Tribe	-eae	Pineae, Lilieae, Magnolieae
Genus	A noun	*Pinus*, *Lilium*, *Magnolia*
Species	Depends	*Pinus flexilis*,*Lilium grandiflorum*, *Magnolia grandiflora*
Variety	Depends	*Pinus flexilis* var. *humilus*
Form	Depends	

The name of a species is ALWAYS a binomial. 'Grandiflora' is not the name of a species. It has to be combined with a generic name to form the name of a species, as in *Magnolia grandiflora*. The word 'grandiflora' is what we call the specific epithet. It states which species of *Magnolia* is under discussion. Specific epithets are often adjectives that describe some attribute of the plant (it helps to learn a little Latin - 'grandiflora' means large flowered), but may refer to the habitat of a species (pratensis -of fields, lacustris - of lakes, saxicola - of rocky places), the place where the species occurs (chinensis, europaea, canadensis), or a person that is somehow connected to the species (the connection may be remote) - wrightii (referring a single, male person named Wright), wrightiae (referring to a single female person named Wright), wrightorum (refering to 2 or more people, one of whom - and possibly only 1 out of a 100 - was male) or wrightarum (referring to 2 or more people with not even one male among them - the Romans were sexist).

Technically speaking, subspecies is a higher rank than variety. A subspecies may include several varieties. In practice, most taxonomists nowadays use one rank or the other, but not both. Europeans tend to use subspecies and expect subspecies to occupy somewhat different areas whereas Americans use variety to denote plants that are different from the plants first put in the species. In practice, the two ranks are used almost interchangeably.

Writing Scientific Names

In North America it is customary to write names at the rank of genus and below in italics or some other font that sets them apart from the rest of the text. The most recent edition of the Code recommends that all scientific names, no matter what their rank, be in a different font from the rest of the text. Either practice makes it easy to scan for taxonomic information.

The names of all ranks from subgenus up must be capitalized. In most instances, the specific epithet – and epithets for lower rankings, must not be capitalized. There are some exceptions to this rule, cases where it is permissible, but not required, to capitalize the specific or varietal epithet, but you need to be careful. Personally I recommend always using lower case for epithets (names distinguishing species and lower ranks). That way one is never wrong.

Authorities

- You will notice that scientific names are often followed by a word or a capital letter and a period, or one or more unintelligible (to the uninitiated) sets of letters. To join the initiated, read on.
- The letters and/or words that follow a scientific name (sometimes they may be within a name – more on that later) are a shorthand reference to the name of the person or person that first gave a name to the entity involved and, in some instances, to the person of persons who first treated it at the rank being used. This is probably easier to understand through some examples. Consider *Oryzopsis exigua* Thurber
- Note that only the first two words are italicized. This means you are looking at the name of a species. 'Thurber' is the last name of the person who first gave a name to this species – and the name he gave to it is the one shown. Consider "*Oryzopsis asperifolia* Michx."
- Again, you are looking at the name of a species in the genus *Oryzopsis*. This species was first named by a fellow whose name is abbreviated to Michx. The period tells you that his name has been abbreviated. His full name was Michaux. To whom do you think "L." refers to in "*Triticum aestivum* L."? "*Dichanthelium lanuginosum* (Elliott) Gould"
- The name is *Dichanthelium lanuginosum*. As you immediately recognize (because the name is a binomial), the entity being named is being treated as a species. The first person to give a name to this species was a chap whose last name was Elliott, but he named it *Panicum lanuginsoum*. An inner circle of initiates could tell you that Elliott refers to Walter Elliott, who lived from 1803 to 1887, in eastern North America (There is a book called Authors of Plant Names that provides such insight).
- "Gould" stands for Frank W. Gould came along later and decided that, although Elliott was right in describing the species, he should have put it in a different genus, the genus *Dichanthelium*. Elliott's name is in parentheses to show that he was the first person to say "Aha, these plants are different"' Gould's name is outside the parentheses because he said, yes, Elliott was right - these plants are different – but they should be included in the genus *Dichanthelium*, not *Panicum* Consider "*Distichlis spicata* (L.) Greene
- Linnaeus [L. stands for Linnaeus] first described the entity, but as *Uniola spicata*, not *Distichlis spicata*. Greene was the first person to say no, these plants should be in *Distichlis* and then publish the combination "*Distichlis spicata*". Linnaeus gets credit for being the first person to describe the entity, Green for being the person to give it the name shown.

- Most journals, and consequently many professors, ask that you cite the authorities for a name when it is first used. It is a rather meaningless exercise. It is meant to say "I am using this name in the sense that it was used by Greene (in the last example)", but really you are probably using it in the sense that it is used in some flora – or based on what your boss told you. The 1999 Congress encouraged editors to be more rational about when it was useful to cite authorities and when not, but I suspect that most journals will continue to require them for some time to come.

PROPOSING A NEW NAME OR NEW COMBINATION

If you have to publish a new name or combination, the Code requires that you follow certain rules (which it calls articles). The key requirements are that:

1. The new name or combination be published in a normal botanical outlet (not the Herald Journal or Statesman), copies of which are sent to at least two botanical institutions.
2. If the name is for a new taxon, the distinguishing characteristics of the taxon, and preferably a full description, must be given *in Latin* and a holotype specified.
3. If the name is simply a new combination, perhaps reflecting the transfer of a species from one genus to another or its demotion to a subspecies, there must be a clear and complete reference to the place where the original name was first published.

Practice Test Paper-I

1. Different groups of seaweeds can generally be distinguished on the basis of
   (*a*) color.
   (*b*) size.
   (*c*) whether they have true leaves, stems, and roots.
   (*d*) whether they are autotrophic or heterotrophic.

2. Which of the following are protozoans?
   (*a*) diatoms, flagellates, amoebas, and ciliates
   (*b*) apicomplexans, flagellates, amoebas, and ciliates
   (*c*) amoebas, actinomycetes, ciliates, and flagellates
   (*d*) flagellates, ciliates, cyanobacteria, and apicomplexans

3. In general, how do algae and protozoans differ?
   (*a*) Protozoans can move, and algae cannot.
   (*b*) Algae are free-living, and protozoans are parasitic.
   (*c*) Protozoans are autotrophic, and algae are heterotrophic.
   (*d*) Algae are photosynthetic, and almost all protozoans are heterotrophic.

4. Most biologists agree that seaweeds are protists, even though most other protists are microscopic unicellular creatures. Some biologists think that at least some seaweeds should be considered plants, not protists. Which of the following would support the latter position?
   (*a*) Certain seaweeds contain several kinds of specialized cells.
   (*b*) Certain seaweeds undergo sexual and asexual reproduction.
   (*c*) Certain seaweeds are found to be prokaryotic.
   (*d*) Certain seaweeds have very complex cells.

5. Protozoans called choanoflagellates live in small clusters. They look very much like choanocytes, special feeding cells found in sponges, which are simple animals. Why might biologists find choanoflagellates of great evolutionary interest?
   (*a*) They show how the very first organisms might have lived.
   (*b*) They might show how the first heterotrophs lived.
   (*c*) offer hint about origin of multicellular organism
   (*d*) They suggest what the first eukaryotes might have been like.

6. Which of the following is not evidence for the role of endosymbiosis in the origin of eukaryotes?
   (*a*) Chloroplasts have their own DNA.
   (*b*) The inner membrane of a chloroplast is similar to prokaryotic membranes.
   (*c*) Mitochondria and chloroplast both are surrounded by two membranes.
   (*d*) The DNA in the eukaryotic nucleus codes for some enzymes in mitochondria.

7. Protists are a diverse group of organisms that include
   (*a*) plants. (*b*) algae.
   (*c*) protozoans. (*d*) b and c

8. Among the following which statement is NOT a part of principles of current code adopted by XII International Botanical Congress in Leningrad (1975).
   (*a*) Botanical nomenclature is independent of Zoological nomenclature
   (*b*) The application of names is determined by means of nomenclature types
   (*c*) The nomenclature of taxonomic group is based upon priority of publication
   (*d*) Scientific names of taxonomic group are treated as Italics regardless of their derivation.

9. Different hybrid forms of the same parentage are designated as-
   (*a*) Apomicts (*b*) Nothomorphs
   (*c*) Race (*d*) Variety

10. According to current code for Botanical Nomenclature, the names of class must ends with-
    (*a*) –opsida (*b*) –idae
    (*c*) –ales (*d*) –aceae

11. A specimen or element selected by a competent worker form the original material studied by the author to serve as a substitute for the holotype if the latter was not designated in the original publication or is lost or destroyed-
    (*a*) Lectotype (*b*) Neotype
    (*c*) Isotype (*d*) Paratype

12. Which technique is routinely used among plants for establishing genetic relationship-
    (*a*) Amino acid sequence (*b*) Serological investigation
    (*c*) Iso-enzyme profiling (*d*) Chromosome morphology

13. Numerical taxonomy is also referred as –
    (*a*) Statistical taxonomy (*b*) Phenetics
    (*c*) Computer aided taxonomy (*d*) All

14. Which is NOT a characteristic of numerical taxonomy-
    (*a*) The greater the content of information in taxa of classification and the more character on which it is based, the better is classification
    (*b*) Every character is of equal weight in creating natural taxa.
    (*c*) Classification is based on percentage (%) similarity coefficient for each OTU.
    (*d*) Phylogenetic inferences cannot be made form the taxonomic structure of a group and from character correlation.

15. Which technique is not utilized during DNA profiling-
    (*a*) Restriction digestion (*b*) Electrophoresis
    (*c*) Southern blotting (*d*) RFLP

16. For DNA fingerprinting the region of DNA used for study are the non-coding regions of chromosome known as-
   (*a*) VNTR (*b*) RFLP
   (*c*) RAPD (*d*) All

17. Which is major factor contributing to loss of biodiversity?
   (*a*) Habitat loss and fragmentation
   (*b*) Introduced species
   (*c*) Over exploitation of Plants and Animals
   (*d*) Industrial agriculture and forestry

18. An International treaty designated to protect wildlife from being threatened by international trade was set up in 1975, it is known as-
   (*a*) WTO (*b*) IUCN
   (*c*) CITES (*d*) FAO

19. The diploid generation of the plant life cycle always
   (*a*) produces spores.
   (*b*) is called the gametophyte
   (*c*) is larger and more conspicuous than the haploid stage
   (*d*) develops from a spore

20. The diploid sporophyte stage is dominant in the life cycles of all of the following except
   (*a*) a pine tree (*b*) a dandelion.
   (*c*) a rose bush (*d*) a moss

21. Land plants arose during the
   (*a*) Ordovician (*b*) Jurassic
   (*c*) Cambrian (*d*) Carboniferous

22. Most bryophytes, such as mosses, differ from all other plants in that they
   (*a*) do not produce flowers (*b*) have cones but no seeds
   (*c*) have flagellated sperm (*d*) lack vascular tissue

23. Deep in the tropical rain forest, a botanist discovered an unusual plant with highly developed vascular tissue, stomata, flagellated sperm, cone-like reproductive structures bearing seeds, and an alternation of generations life cycle. He was very excited about this discovery because it would be rather unusual for a plant to have both
   (*a*) highly developed vascular tissue and flagellated sperm
   (*b*) vascular tissue and alternation of generations
   (*c*) seeds and flagellated sperm
   (*d*) alternation of generations and seeds

24. The Ozone layer saves from lethal UV. It mainly absorbs-
   (*a*) UV-A (*b*) UV-B
   (*c*) UV-A & B (*d*) UV-B & C

25. Besides nomenclature of plants in wild, ICBN also gives binomial names for-
    (*a*) Bacteria & Fungus (*b*) Fungus
    (*c*) Fungus & cultivated plants (*d*) Cultivated plant

26. __________ are not native to a particular area, and can upset the balance of the ecosystem.
    (*a*) Exotic species (*b*) Ultraviolet waves
    (*c*) Decomposers (*d*) Reintroduction programs

27. What is the difference between a threatened species and an endangered species?
    (*a*) A threatened species means that the population is likely to become endangered An endangered species has population numbers so low that it is likely to become extinct
    (*b*) A threatened species is already extinct. An endangered species means that the population's numbers have increased greatly over the last 5 years
    (*c*) A threatened species means that the population is likely to become endangered. An endangered species is already extinct
    (*d*) A threatened species and an endangered species are the same thing

28. Which of these programs is used to preserve a species facing extinction?
    (*a*) edge effects (*b*) sustainable use
    (*c*) natural resources (*d*) captive breeding

29. What does this figure illustrate?
    (*a*) habitat fragmentation
    (*b*) biodiversity
    (*c*) extinction
    (*d*) edge effect

30. The maximum biodiversity in India occurs at-
    (*a*) Western Himalayas (*b*) North East Himalayas
    (*c*) Western Ghats (*d*) Eastern Ghats

31. In which kingdom would you classify the archaea and nitrogen-fixing organisms, if the five-kingdom system of classification is used?
    (*a*) plantae (*b*) fungi
    (*c*) protista (*d*) monera

32. Plants reproducing by spores such as mosses and ferns are grouped under the general term
    (*a*) Cryptogams (*b*) bryophytes
    (*c*) sporophytes (*d*) thallophytes

33. Which one of the following pairs of plants are not seed producers?
    (*a*) *fern* and *Funaria* (*b*) *Ficus* and *Chlamydomonas*
    (*c*) *Punica* and *Pinus* (*d*) *Funaria* and *Ficus*

34. According to botanical nomenclature, which are not allowed-
(*a*) Synonyms (*b*) Antonyms
(*c*) Tautonyms (*d*) Isonyms

35. The original specimen submitted by author himself is termed as-
(*a*) Holotype (*b*) Paratype
(*c*) Lectoype (*d*) Isotype

36. Phenetic classification is based on
(*a*) the ancestral lineage of existing organisms
(*b*) observable characteristics of existing organisms
(*c*) dendrograms based on DNA characteristics
(*d*) sexual characteristics

37. Which of the following is Spermatophyte?
(*a*) Bryophyte (*b*) Pteridophyte
(*c*) Thallophyte (*d*) Gymnosperm

38. The National herbarium in our country is located in-
(*a*) Bombay (*b*) Calcutta
(*c*) Chennai (*d*) Delhi

39. All of the following are reasonable hypotheses for the high diversity observed in tropical rain forest except
(*a*) Habitat heterogeneity
(*b*) Climatic variability
(*c*) Niche specialization and resource partitioning
(*d*) Population interaction and coevolution

40. Research on the nothern spotted owl indicates that
(*a*) owl population will stabilize if an adequate number of immature forest source habitats can be preserved
(*b*) metapopulations must be more closely spaced to compensate for the owl's limited flight capacity
(*c*) setting aside marginal habitat encourages dispersion of owls into areas where reproductive success is unlikely
(*d*) the current owl population is too small to disperse into source habitats

41. A population of strictly monogamous swans consists of 40 males and 10 females. The effective population size for this population is
(*a*) 50 (*b*) 40
(*c*) 20 (*d*) 10

42. Which of the following conditions is the most likely indicator of a metapopulation's long-term survival?
(*a*) The population is not subdivided into subpropulations
(*b*) Regular and extensire movement of individuals among patches makes the subpopulations function essential as a single unit.

(*c*) Source and sinks all contain subpopulations
(*d*) All subpopulations are connected by corridors

43. The applications of ecological principles to return a degraded ecosystem to its natural state is characteristic of
(*a*) bioremediation
(*b*) restoration ecology
(*c*) landscape ecology
(*d*) conservation ecology

44. ––––––––––––– is the unit of evolution
(*a*) species (*b*) individual
(*c*) community (*d*) population

45. Not all species contribute equally to the integrity of an ecological community, with limited time and resources, it would be most reasonable to focus conservation efforts on
(*a*) the large vertebrates (*b*) keystone species
(*c*) primary producers (*d*) exotic species

46. Populations with low effective sizes are susceptible to all of the following problems except
(*a*) inbreeding
(*b*) genetic drift
(*c*) bottlenecking
(*d*) adaptive radiation

47. Which of the following errors would result in an underestimate of a specie's MVP?
(*a*) underestimating the maximum age of reproduction
(*b*) underestimating the average birth rate
(*c*) overestimating the death rate
(*d*) overestimating the average fecundity

48. European zebra mussels, accidentally released into lake Erie in 1988, quickly displaced native mussel species. This threat to biodiversity is an example of
(*a*) Metapopulation expansion
(*b*) exotic introduction
(*c*) habitat fragmentation
(*d*) over exploitation

49. Which of these ecosystems has the lowest primary productivity per square meter?
(*a*) a salt marsh (*b*) an open sea
(*c*) a coral reef (*d*) a grassland

50. The part of chromosome used for DNA fingerprinting is-
(*a*) Microsatellite (*b*) Minisatellite
(*c*) Tandem satellite (*d*) Macrosatellite

51. International code for botanical nomenclature is not applicable to-
    (*a*) Gymonosperms (*b*) Bryphytes
    (*c*) Algae (*d*) Cultivated plants

52. A system of classification in which a large number of traits are considered is-
    (*a*) Artificial system (*b*) Natural system
    (*c*) Phylogenetic system (*d*) Synthetic system

53. Western blotting is technique for hybridization of-
    (*a*) Antigen-Antibody (*b*) DNA-cDNA
    (*c*) Polyamines (*d*) Monosaccharides

54. A group of plants or animals with similar traits of any rank is-
    (*a*) Species (*b*) Genus
    (*c*) Order (*d*) Taxon

55. Basic unit or smaller taxon of taxonomy is-
    (*a*) Species (*b*) Genus
    (*c*) Family (*d*) Variety

56. Sequence of taxonomic categories is-
    (*a*) Class-Phylum-Tribe-Order-Family-Genus-Species
    (*b*) Division-Class-Family-Tribe-Order-Genus-Species
    (*c*) Division-Class-Order-Family-Tribe–Genus–Species
    (*d*) Phylum-Order-Class-Tribe-Family–Genus–Species

57. In which kingdom would you classify the archaea and nitrogen-fixing organisms, if the five-kingdom system of classification is used?
    (*a*) plantae (*b*) fungi
    (*c*) protista (*d*) monera

58. Western blotting is technique for hybridization of-
    (*a*) Antigen-Antibody (*b*) DNA-cDNA
    (*c*) Polyamines (*d*) Monosaccharides

59. Basic unit or smaller taxon of taxonomy is-
    (*a*) Species (*b*) Genus
    (*c*) Family (*d*) Variety

60. Rhinoceros are found at-
    (*a*) Kaziranga (*b*) Nandan Kanan
    (*c*) Runn of Kutch (*d*) Nilgiri hills

61. Besides nomenclature of plants in wild, ICBN also gives binomial names for-
    (*a*) Bacteria & Fungus (*b*) Fungus
    (*c*) Fungus & cultivated plants (*d*) Cultivated plants

62. The characteristic type of inflorescence of the Genus Euphorbia is
    (*a*) Capitulum (*b*) Catkin
    (*c*) Cyathium (*d*) Panicle

63. The heat that radiates back to the earth from the greenhouse gases results in
    (*a*) additional global warming (*b*) thermal inversion
    (*c*) eutrophication (*d*) smog

64. Eutrophication is a kind of
    (*a*) water pollution (*b*) air pollution
    (*c*) land pollution (*d*) noise pollution

65. The root cause of Loss of biodiversity is-
    (*a*) Habitat destruction (*b*) Increasing Population
    (*c*) Overexploitation (*d*) Pollution

66. Cryopreservation is method mostly applied for conservation of-
    (*a*) Recalcitrant seeds (*b*) Orthodox seeds
    (*c*) Any germplasm (*d*) Animal embryo

67. The best cryopreservant for cryo preservation is-
    (*a*) Liquid Nitrogen (*b*) Dimethyl sulphoxide
    (*c*) Solid Co_2 (*d*) Glycerol

68. Some species of rotifers consist solely of females. Their method of reproduction is described as
    (*a*) fragmentation (*b*) asexual
    (*c*) sperm-stealing (*d*) parthenogenesis

69. Members of the phylum Mollusca are recognized on the basis of
    (*a*) segmentation
    (*b*) trochophore larva
    (*c*) the presence of a foot, visceral mass, and mantle
    (*d*) water vascular system

70. Cephalopods are the only mollusks
    (*a*) without a mantle (*b*) with a closed circulatory system
    (*c*) that reproduce sexually (*d*) that have segmented bodies

71. A marine biologist dredged up a small animal from the bottom of the ocean. It was uniformly segmented, with short, stiff appendages and soft, flexible skin. It had a complete digestive system and an open circulatory system, but no skeleton. Based on this description, this animal sounds most like
    (*a*) a lancelet (*b*) a crustacean
    (*c*) a mollusk (*d*) a roundworm

72. Phylum _____ includes the largest number of species.
    (*a*) Mollusca (*b*) Arthropoda
    (*c*) Annelida (*d*) Chordata

73. The key to the diversity and success of the arthropods is/are
(*a*) their trochophore larvae
(*b*) their high reproductive rate
(*c*) an open circulatory system
(*d*) jointed appendages

74. Among the following, which is NOT an endangered animal-
(*a*) Asiatic Lion (*Panthera leo persica*)
(*b*) Asiatic Tiger (*Panthera tigris*)
(*c*) Indian wild ass (*Equus heniunus khur*)
(*d*) Rhesus Monkey (*Maccaca mulatta*)

75. Chilka lake harbors high biodiversity of-
(*a*) Pisces
(*b*) Aves
(*c*) Reptiles
(*d*) Mammals

76. Cause of diversity loss in small population is-
(*a*) Founder effect
(*b*) A demographic bottleneck
(*c*) Inbreeding and genetic drift
(*d*) All of the above

77. Extinction rate is high at-
(*a*) Main lands
(*b*) Large islands
(*c*) Small islands near mainlands
(*d*) Small island far from mainlands

78. Among the following ex-situ conservation method for biodiversity conservation is-
(*a*) Biosphere reserve
(*b*) National park
(*c*) Gene bank
(*d*) Historical landscape

79. Among the following phenomenon, which does NOT support the increase in biodiversity-?
(*a*) Niche specialization
(*b*) Habitat/Resource partitioning
(*c*) Habitat fragmentation
(*d*) Mass extinction

80. Among the following, which is NOT a characteristic of extinction prone species-
(*a*) low reproduction rate and specialized feeding habits
(*b*) large in size and feed at high trophic level
(*c*) Fixed migratory pattern or Specialized nesting or breeding areas
(*d*) Early sexual maturity and short life span

81. Several categories of risk of species extinction have been defined. A species can be determined as vulnerable if there is considered to be-
(*a*) 10% probability of extinction within 100 years
(*b*) If the probability is 20% within 20 years or 10 generations
(*c*) If within 5 years or two generations the risk of extinction is atleast 50 %
(*d*) If the probability is 100% of extinction within 50 generation or 100 years

82. Habitat may be adversely affected by human influence by-
(*a*) Urban and Industrial development (*b*) Pollution
(*c*) Tourism (*d*) All of the above

83. In India, the maximum threat of imminent extinction is at-
(*a*) Western Ghats (*b*) Western Himalayas
(*c*) Sundervan (*d*) Thar Desert

84. The hot spot of biodiversity in India are-
(*a*) North and West Himalayas (*b*) Western Ghat and N E Himalayas
(*c*) Andaman and Nicobar Islands (*d*) Sundervan and N.E. Himalayas

85. Among the following, which is best used for biodiversity characterization-
(*a*) Shanon-weaver Index (*b*) Sociability Index
(*c*) Vitality Index (*d*) All of the above

86. The single greatest current threat to biodiversity
(*a*) greenhouse warming (*b*) the introduction of exotics
(*c*) overhunting (*d*) habitat destruction

87. Species diversity tends to decrease with
(*a*) increased habitat heterogeneity (*b*) increased distance from the poles
(*c*) increased ocean depth (*d*) increased fragmentation

88. Which of the following factors does not play a role in increased biodiversity?
(*a*) Complex population interactions
(*b*) The introduction of exotic species
(*c*) A higher degree of habitat heterogeneity
(*d*) Narrower niches

89. Biodiversity hot spots are
(*a*) distributed evenly throughout the biosphere
(*b*) regions where there is the potential for high levels of extinction.
(*c*) the same for all groups of organisms
(*d*) regions where thermophilic species thrive

90. The metapopulation of a species found in a particular environment
(*a*) is the source population
(*b*) consists of all the populations of a particular guild
(*c*) consists of all the subpopulations of that species
(*d*) is the population's Minimum Viable Potential

91. In a(n) ________ habitat natality exceeds mortality and in a(n) ______ habitat mortality exceeds natality.
(*a*) fragmented. . .hot spot
(*b*) tropical. . .polar
(*c*) In both tropical and polar environments there may be regions where with differing rates of mortality and natality.
(*d*) natural . . .source
(*e*) source. . .sink

92. Which of the follow does not apply to a population with a low effective population size?
    (*a*) Genetic drift
    (*b*) Increased genetic diversity
    (*c*) Reduced heterozygosity
    (*d*) Increased homozygosity
    (*e*) Inbreeding

93. Species that have a disproportionately large impact on the maintenance of an ecosystems biodiversity are referred to as
    (*a*) exotics
    (*b*) primary producer
    (*c*) archaea
    (*d*) keystone species

94. A landscape
    (*a*) consists of metapopulations.
    (*b*) is all of the populations found in the same environment
    (*c*) is composed of the trees and flowers that are planted around human dwellings
    (*d*) is composed of interacting ecosystems

95. Edge species
    (*a*) decrease biodiversity
    (*b*) only exist in areas that have been altered by humans
    (*c*) require the unique homogenous edge environment
    (*d*) may require conditions found in both of the bordering ecosystems

96. The zoned reserve concept of landscape management calls for
    (*a*) many small, interconnected nature preserves
    (*b*) protected areas to be surrounded by transitional areas
    (*c*) bioremediation
    (*d*) assisting the movement of individuals from a source to a sink population

97. You have been asked to participate in the cleanup of an oil spill. You dislike the feel of oil on your hands, so you volunteer to culture Pseudomonas. The aspect of the cleanup that you are participating in is
    (*a*) biodiversity maintenance
    (*b*) preservationism
    (*c*) bioremediation
    (*d*) biophilia

98. A type of agriculture that involves rotating a crop such as avocados with a leguminous crop such as alfalfa is an example of
    (*a*) landscape management
    (*b*) biodiversity maintenance
    (*c*) maintaining genetic variation
    (*d*) sustainable agriculture

99. According to botanical nomenclature, which are not allowed-
    (*a*) Synonyms
    (*b*) Antonyms
    (*c*) Tautonyms
    (*d*) Isonyms

100. The original specimen submitted by author himself is termed as-
    (*a*) Holotype
    (*b*) Paratype
    (*c*) Lectoype
    (*d*) Isotype

Practice Test Paper-II

1. The maximum biodiversity in world occurs in-
   (*a*) At equator (*b*) In tropics
   (*c*) Temperate (*d*) Deserts

2. Phenetic classification is based on
   (*a*) the ancestral lineage of existing organisms
   (*b*) observable characteristics of existing organisms
   (*c*) dendrograms based on DNA characteristics
   (*d*) sexual characteristics

3. The National herbarium in our country is located in-
   (*a*) Bombay (*b*) Calcutta
   (*c*) Chennai (*d*) Delhi

4. Two population A & B could freely interbreed in but cannot exchange the genetic material are termed as-
   (*a*) Biological Species (*b*) Taxonomic Species.
   (*c*) Ecotype (*d*) Biotype

5. In India maximum biodiversity occurs in-
   (*a*) Western ghats (*b*) Eastern Ghats
   (*c*) Western Himalayas (*d*) All

6. Among the following, which is not endangered species-
   (*a*) *Nepenthes khasiana* (*b*) *Tecomela undulata*
   (*c*) *Taxus bacata* (*d*) *Comphiphora wightii*

7. Taxonomic Species could be precisely defined on basis of Failure of-
   (*a*) Inbreeding (*b*) Gene Exchange
   (*c*) Morphology (*d*) Physiology

8. For classification of angiosperms floral characters are preferred over vegetative characters because-
   (*a*) Reproductive axis shows a large degree of prominent variations
   (*b*) Floral characters show less variation then vegetative traits
   (*c*) Shape of flower is diagnostic feature in many families
   (*d*) It is more handy to study floral features then vegetative characters

9. Phylogenetic system differs from a natural system in its stress on-
   (*a*) Anatomical details (*b*) Physiological details
   (*c*) Morphological traits (*d*) Origin and evolutionary trends

10. A species characterized by only morphological traits is-
    (*a*) Biospecies (*b*) Morphospecies
    (*c*) Taxonomic species (*d*) Sibling species

11. Among the following, which is not in-situ conservation-
    (*a*) Biosphere reserve
    (*b*) Gene bank
    (*c*) National Park
    (*d*) Sanctuary

12. In the artificial system of classification
    (*a*) Large number of characters are taken into consideration
    (*b*) Correlated characters are more important
    (*c*) Physiological characters are relied upon
    (*d*) One or few morphological character are considered

13. Species is-
    (*a*) Group of individuals occurring in geographical area
    (*b*) Population of one type
    (*c*) Population or populations of individuals with similar genotypic and phenotypic traits
    (*d*) Population or populations of interbreeding individuals

14. Lectotype is-
    (*a*) Duplicate of holotype
    (*b*) Specimen described along with holotype
    (*c*) Specimen cited by author without making one holotype
    (*d*) Specimen selected from original material for nomenclature type when there is no holotype

15. Neotype is-
    (*a*) Nomenclature type from the original material
    (*b*) Nomenclature type when the original material is missing
    (*c*) One of the two or more specimens cited by the author
    (*d*) New species discovered by a scientist

16. Related species which are reproductively isolated but morphologically similar are called-
    (*a*) Allopatric
    (*b*) Sympatric
    (*c*) Sibling
    (*d*) Morphospecies

17. The part of chromosome used for DNA fingerprinting is-
    (*a*) Microsatellite
    (*b*) Minisatellite
    (*c*) Tandem satellite
    (*d*) Macrosatellite

18. International code for botanical nomenclature is not applicable to-
    (*a*) Gymonosperms
    (*b*) Bryophytes
    (*c*) Algae
    (*d*) Cultivated plants

19. DNA fingerprinting involves hybridization of-
    (*a*) Constant number of tandem repeats
    (*b*) Variable number of dispersed repeats
    (*c*) Constant number of dispersed repeats
    (*d*) Variable number of Tandem repeats

20. A system of classification in which a large number of traits are considered is-
    (*a*) Artificial system (*b*) Natural system
    (*c*) Phylogenetic system (*d*) Synthetic system

21. Western blotting is technique for hybridization of-
    (*a*) Antigen-Antibody (*b*) DNA-cDNA
    (*c*) Polyamines (*d*) Monosaccharides

22. A group of plants or animals with similar traits of any rank is-
    (*a*) Species (*b*) Genus
    (*c*) Order (*d*) Taxon

23. Layer of Atmosphere possessing zone is-
    (*a*) Stratosphere (*b*) Mesosphere
    (*c*) Ionosphere (*d*) Troposphere

24. The closest algal relatives of land plants are
    (*a*) chrysophytes. (*b*) psilophytes.
    (*c*) charophytes. (*d*) rhodophytes.

25. Which of the following is not a homology shared by land plants and their closest living algal relatives?
    (*a*) thylakoid arrangement
    (*b*) cell wall composition
    (*c*) the presence of cuticle on the surface of leaves
    (*d*) the presence of chlorophyll b and beta-carotene

26. The innovation that was essential to the survival of bryophytes on land was
    (*a*) freedom from water to reproduce.
    (*b*) the embryophyte condition
    (*c*) vascular tissue.
    (*d*) chlorophylla.

27. During the Carboniferous period, forests consisting mainly of ____ produced vast quantities of organic matter, which was buried and later turned into coal.
    (*a*) early angiosperms
    (*b*) ferns and other seedless plants
    (*c*) gymnosperms
    (*d*) gymnosperms and early angiosperms

28. All heterosporous plants produce
    (*a*) megaspores that develop into female gametophytes and microspores that develop into male gametophytes
    (*b*) megaspores that bear antheridia and microspores that bear archegonia
    (*c*) spores that produce both archegonia and antheridia
    (*d*) seeds

29. Ferns and mosses are mostly limited to moist environments because
    (*a*) their pollen is carried by water
    (*b*) they lack a cuticle and stomata
    (*c*) they lack vascular tissue
    (*d*) they have swimming sperm

30. All seed plants
    (*a*) produce flowers
    (*b*) are heterosporous
    (*c*) produce antheridia and archegonia on the same gametophyte
    (*d*) exhibit a dominant gametophyte generation

31. In seed plants the ______ is surrounded by ________.
    (*a*) Nucellus . . . integuments
    (*b*) ovule . . . microspores
    (*c*) integument . . . a seed
    (*d*) microsporangium . . . a megasporangium

32. An explorer found a plant that had roots, stems, and leaves. It had no flowers but produced seeds. This plant sounds like a(n)
    (*a*) fern (*b*) bryophyte
    (*c*) angiosperm (*d*) gymnosperm

33. Gymnosperms were most abundant during the
    (*a*) Paleozoic (*b*) Precambrian
    (*c*) Cenozoic (*d*) Mesozoic

34. When you look at a pine or apple tree, the plant you see is
    (*a*) haploid sporophyte (*b*) diploid sporophyte
    (*c*) haploid gametophyte (*d*) diploid gametophyte

35. Conifers usually
    (*a*) bear cones that produce both microspores and megaspores
    (*b*) have pollen that is transported by water
    (*c*) bear both male and female cones on the same tree
    (*d*) shed their leaves in the fall

36. Which of the following best describes how fertilization occurs in a conifer?
    (*a*) A sperm cell swims through a film of moisture to fertilize the egg
    (*b*) A pollen grain carried by wind carries a sperm that fertilizes the egg
    (*c*) A sperm cell carried by wind fertilizes the egg
    (*d*) A pollen grain swims through a film of moisture to fertilize the egg

37. Angiosperms are different from all other plants because only they have
    (*a*) a vascular system
    (*b*) flowers

(*c*) a life cycle that involves alternation of generations
(*d*) seeds

38. Most species of plants are
(*a*) non-seedbearing plants (*b*) angiosperms
(*c*) gymnosperms (*d*) ginkgophytes

39. Unlike most angiosperms, grasses are pollinated by wind. As a consequence, some unnecessary parts of grass flowers have almost disappeared. Which of the following parts would you expect to be most reduced in a grass flower?
(*a*) stamens (*b*) petals
(*c*) anthers (*d*) carpels

40. The portion of the flower that receives the pollen is the
(*a*) style (*b*) ovary
(*c*) anther (*d*) stigma

41. A fruit is a mature
(*a*) seed (*b*) pollen grain
(*c*) bulb (*d*) ovary

42. In a flowering plant, meiosis occurs within the _____, producing a spore that develops into a female gametophyte.
(*a*) ovule (*b*) seed
(*c*) stamen (*d*) anther

43. The pollen tube releases two sperm cells into the embryo sac. The result of this is the
(*a*) union of the two sperm nuclei to form a zygote
(*b*) union of one sperm nucleus with the egg nucleus while the other sperm nucleus unites with the nuclei of the center cell forming a triploid nucleus
(*c*) union of one sperm nucleus with the egg nucleus and the disintegration of the other sperm nucleus
(*d*) fusion of both sperm nuclei with the egg nucleus and the formation of a triploid zygote

44. The triploid nucleus of the embryo sac develops into the
(*a*) embryo (*b*) endosperm
(*c*) fruit (*d*) carpel

45. Some plants have evolved to attract specific animals. The animal receives a meal that it does not have to compete for, and the plant is assured that its pollen will not be wasted on plants of different species. Through time, the plant gets better at attracting the animal and increases its reproductive success as a result. Simultaneously, the animal improves its feeding on a specific plant and increases its reproductive success as a result. This scenario is an example of
(*a*) coevolution (*b*) mutualism
(*c*) diversifying selection (*d*) commensalism

46. It has been proposed that plants, by _________, may have been responsible for global ________ during the Paleozoic.
   (*a*) increasing atmospheric CO_2 concentration . . . warming
   (*b*) increasing atmospheric CO_2 concentration. . . cooling
   (*c*) reducing atmospheric CO_2 concentration. . . warming
   (*d*) reducing atmospheric CO_2 concentration. . . cooling

47. The body of a fungus (with the exception of yeast) consists of threadlike ____ , which form a network called a ____.
   (*a*) mycelia . . . dikaryon
   (*b*) hyphae . . . chytrid
   (*c*) mycelia . . . hypha
   (*d*) hyphae . . . mycelium

48. The hyphae of parasitic fungi that are modified to penetrate and absorb nutrients from host tissue are called
   (*a*) haustoria (*b*) asci
   (*c*) basidiocarps (*d*) septa

49 .Which of the following is a difference between plants and fungi?
   (*a*) Plants have diploid and haploid phases, and fungi only have haploid stages
   (*b*) Fungi have cell walls
   (*c*) Fungi are heterotrophic and plants are autotrophic
   (*d*) Plants produce spores

50. The asexual spores produced by members of the division Ascomycota are called
   (*a*) conidia (*b*) lichens
   (*c*) asci (*d*) mycorrhizae

51. From the human perspective, which of the following kinds of fungi would be considered the least useful or beneficial?
   (*a*) mycorrhizal fungus (*b*) yeast
   (*c*) rust (*d*) decomposer

52. Where and when does fertilization occur in the mushroom life cycle?
   (*a*) underground, as a mycelium begins to spread
   (*b*) on the surface of the ground, when a basidiospore germinates
   (*c*) in a mushroom, when nuclei of a dikaryotic cell fuse
   (*d*) underground, when hyphae of different mating types fuse

53. Fungi are classified on the basis of
   (*a*) their source of food
   (*b*) whether they form molds
   (*c*) their sexual stage
   (*d*) their commercial use

54. Lichens are
    (*a*) a mutualistic association of fungi and plant roots
    (*b*) predatory fungi
    (*c*) the sexual stage of deuteromycetes
    (*d*) a symbiotic association of photosynthesizers and fungi

55. Molecular evidence suggests that fungi
    (*a*) are a polyphyletic group
    (*b*) and animals have a common ancestor
    (*c*) are more closely related to the kingdom Monera than any other kingdom
    (*d*) evolved from plants

56. A graduate student found an organism in a pond and thinks it is a freshwater sponge. The postdoctoral student thinks it looks more like an aquatic fungus. How can they decide whether it is an animal or a fungus?
    (*a*) see if it reproduces sexually
    (*b*) figure out whether it is autotrophic or heterotrophic
    (*c*) look for cell walls under a microscope
    (*d*) determine whether it is unicellular or multicellular

57. All animals can trace their lineages to a common ancestor that lived in the
    (*a*) Precambrian (*b*) Jurassic
    (*c*) Pliocene (*d*) Devonian

58. Animals probably evolved from colonial protists. How do animals differ from these protist ancestors?
    (*a*) The protists were prokaryotic
    (*b*) Animals have more specialized cells
    (*c*) The protists were heterotrophic
    (*d*) The protists were autotrophic

59. Which of the following animals does not have a body cavity?
    (*a*) flatworm (*b*) ant
    (*c*) mouse (*d*) earthworm

60. Unlike other animals sponges
    (*a*) are unicellular
    (*b*) possess cell walls
    (*c*) lack true tissues
    (*d*) exhibit bilateral symmetry

61. Which of the following is associated with bilateral symmetry?
    (*a*) a sessile lifestyle
    (*b*) cephalization
    (*c*) all bilaterally symmetrical animals are parazoans
    (*d*) none have a mesoderm

62. How do cnidarians and ctenophores differ from all other eumetazoans?
    (*a*) Cnidarians and ctenophores have no nervous tissue
    (*b*) Cnidarians and ctenophores have a gastrovascular cavity; other eumetazoans do not
    (*c*) Cnidarians and ctenophores have mesoderm, other eumetazoans do not
    (*d*) Cnidarians and ctenophores are radially symmetrical

63. Ectoderm can give rise to _______; mesoderm can give rise to ______; endoderm can give rise to _________.
    (*a*) Muscle . . . liver . . . the central nervous system
    (*b*) the lining of the digestive tract . . . muscle . . . lungs
    (*c*) the central nervous system . . . liver . . . lungs
    (*d*) muscle . . . liver . . . lungs

64. Which of the following is evidence that the extant phylum that is most closely related to chordates is Echinodermata?
    (*a*) They are both coelomates
    (*b*) They are both deuterostomes
    (*c*) The mature forms of both phyla exhibit bilateral symmetry
    (*d*) They are both triploblastic

65. Zoologists have placed chordates and echinoderms on one major branch of the animal phylogenetic tree, and mollusks, annelids, and arthropods on another major branch. Which of the following is one of the bases for this separation into two branches?
    (*a*) whether the animals have a skeleton
    (*b*) type of symmetry
    (*c*) whether the animals have a body cavity
    (*d*) how the body cavity is formed

66. Which of the following is not a difference between protostomes and deuterostomes?
    (*a*) the presence of a body cavity
    (*b*) Protostomes are schizocoelous and deuterostomes are enterocoelous.
    (*c*) the fate of the blastopore
    (*d*) the cleavage plane of the embryo

67. All of the following are true of the phylum Platyhelminthes, except:
    (*a*) they are dorsoventrally flattened
    (*b*) they are all parasitic
    (*c*) they are bilaterally symmetrical
    (*d*) all of the classes of Platyhelminthes discussed in the text have members that can reproduce sexually

68. The main cause, which leads to increase in biodiversity is-
    (*a*) Unchanged environment (*b*) Habitat uniformity
    (*c*) Natural selection (*d*) Mutation

69. Numerical taxonomy includes-
    (*a*) Chemo taxonomy
    (*b*) Statistical taxonomy
    (*c*) Comparative taxonomy
    (d) Phylogenetic taxonomy

70. A place is designated as hot spot of biodiversity if it covers-
    (*a*) 0.5 % endemic species of total plant species
    (*b*) 1 % endemic species of total plant species
    (*c*) 1.8 % endemic species of total plant species
    (*d*) 22 % endemic species of total plant species

71. The number of ovules present in the ovary of Asteraceae is
    (*a*) one
    (*b*) two
    (*c*) four
    (*d*) many

72. Which of the following statement(s) is/are false?
(i) 6 orders and 14 families are classified under the series Heteromerae
(ii) Natural system of classification does not attempt at bringing out phylogenetic relationship
(iii) Darwin published his theory of evolution through the book "Origin of Species" in 1856
(iv) Bicarpellatae has 4 orders and 24 families
    (*a*) (i) and (iv)
    (*b*) (i), (ii) and (iii)
    (*c*) (i) and (iii)
    (*d*) (ii) and (iv)

73. The first step in the technique of protoplasmic fusion is the
    (*a*) hybridization
    (*b*) collection of somatic cells
    (*c*) isolation of protoplasts
    (*d*) selection and isolation of somatic cells

74. Biological concept of species was given by-
    (*a*) Meyer
    (*b*) John ray
    (*c*) Carlos Linneus
    (*d*) Dobzzanky

75. Among the following, which is not mangrove plant-
    (*a*) Avicennia officinalis
    (*b*) xcoecaria agallocha
    (*c*) Heritiera fomes
    (*d*) Sueda fruticosa

76. Project Elephant was launched in 1991-92. Major activities of Project Elephant are:
    (*a*) Ecological restoration of existing natural habitats and migratory routes of elephants
    (*b*) Promotion of measures for mitigation of man-elephant conflict
    (*c*) Eco-development
    (*d*) ALL

77. Paeonia is separated from Ranunculaceae and placed in paenaceae on the basis of-
    (*a*) Embryology
    (*b*) Anatomy
    (*c*) Cytology
    (*d*) Chemotaxonomy

78. Natural selection
 (*a*) usually leads to adaptation
 (*b*) is the process whereby organisms who are "best fit" survive and leave more offspring
 (*c*) favors those organisms that are better able to survive and reproduce in a particular environment
 (*d*) All of these statements are correct

79. Which statement most clearly contradicts Lamarck's hypothesis that acquired characteristics are inherited?
 (*a*) The cactus plant spread very rapidly when introduced into Australia
 (*b*) Most zebras can fun faster than lions, and their offspring also run faster than lions
 (*c*) Bacteria which are resistant to penicillin have been discovered
 (*d*) The seeds from a pine tree that was bent by the wind grew into tall, straight trees in a sheltered valley

80. Which of the following observations or assumptions was NOT part of Darwin's theory of natural selection?
 (*a*) Traits are inherited as discrete units called genes
 (*b*) Evolution occurs over long periods of time
 (*c*) Populations produce more offspring than their environment can support
 (*d*) Organisms compete for limited resources

81. Which of the following are the main ideas that Darwin advanced in his works?
 (*a*) species change over time
 (*b*) living species have arisen from earlier life forms
 (*c*) the earth is approximately 6,000 years old and is unchanging
 (*d*) both a and b are correct answers

82. Which of the following is the best measure of the "fitness" of an organism?
 (*a*) reproductive success (*b*) strength
 (*c*) life span (*d*) geographic range

83. Biodiversity hot spots are mainly located
 (*a*) at equator
 (*b*) in temperate regions
 (*c*) between tropics
 (*d*) in artic region.

84. Which of these organisms population was threatened by DDT prior to it being banned in 1972?
 (*a*) brown pelican
 (*b*) ginkgo tree
 (*c*) black-footed ferret
 (*d*) gray wolf

85. Cyclosporine is a drug that is used to help organ transplant patients fight off rejection of their new organs. What organism was used to help isolate this drug?
(*a*) soil fungus (*b*) plant
(*c*) bacterium (*d*) protist

86. A species that no longer exists in the wild but is protected by humans is said to live in ________.
(*a*) an island (*b*) captivity
(*c*) a corridor (*d*) reintroduction

87. When the last member of a particular species dies, the species is said to be __________.
(*a*) isolated (*b*) diversified
(*c*) endangered (*d*) extinct

88. Which of these is NOT usually considered a threat to biodiversity?
(*a*) preservation of habitats (*b*) acid precipitation
(*c*) and pollution (*d*) use of pesticides

89. What is sustainable use?
(*a*) Protected strips of land that allow organisms to migrate from one wilderness area to another
(*b*) The study of methods to help protect biodiversity
(*c*) The ability to use natural resources in a way that helps people and protects the ecosystem
(*d*) A law that makes it illegal to do harm to species that are listed as endangered or threatened

90. Which of these statements is true?
(*a*) Biodiversity tends to increase as you get closer to the equator
(*b*) Cold climates have greater amounts of biodiversity than warm climates
(*c*) Tropical regions of Earth contain very few of the world's land species
(*d*) Coral reefs tend to be less biologically diverse than temperate deciduous forests

91. Kingdom protista includes-
(*a*) Slime moulds (*b*) Archaebacteria
(*c*) Cyanobacteria (*d*) Diatoms

92. Benthic organism of lakes or sea are usually-
(*a*) Producer (*b*) Herbivores
(*c*) Carnivores (*d*) Decomposers

93. The largest family of flowering plants is
(*a*) Fabaceae (*b*) Musaceae
(*c*) Composotae (*d*) Asteraceae

94. Biodiversity means-
(*a*) Species richness (*b*) Polymorphism
(*c*) Habitat diversity (*d*) All of the above

95. Earth's maximum biodiversity is confined in-
   (*a*) Equator
   (*b*) Tropics
   (*c*) Temperate
   (*d*) Tundra

96. The maximum plant diversity occurs in-
   (*a*) Brazil
   (*b*) China
   (*c*) India
   (*d*) Colombia

97. Among the following animal group which are highly diverse-
   (*a*) Arthropod
   (*b*) Mollusk
   (*c*) Pisces
   (*d*) Aves

98. The formation and usage of named for cultivated plants is governed by-
   (*a*) ICBN
   (*b*) ICZN
   (*c*) INCP
   (*d*) None

99. Among the following which rule was NOT part of Paris code decided in first international Botanical Congress-
   (*a*) Linnaeus as starting point for all plant nomenclature
   (*b*) The rule of priority as fundamental
   (*c*) The requirement for Valid and effective publication
   (*d*) Each species named should be based on herbarium specimen (Type)

100. The first book written by Carlos Linnaeus, "The Father of Taxonomy" was-
   (*a*) Species Plantarum
   (*b*) Genera Plantarum
   (*c*) Origin of Species
   (*d*) Phoenix

Model Test Paper – 1

PART – A

1. If a pendulum with a time period 'T' is placed on moon then its time period will-
   (*a*) Increase (*b*) Decrease
   (*c*) Unchanged (*d*) Infinity

2. When the canon is fired, it will move-
   (*a*) Front (*b*) Back
   (*c*) Randomly (*d*) not moves

3. Soldiers are not allowed to pass in synchronized march over a bridge because-
   (*a*) It produces more noise
   (*b*) Bridge may break due to resonance
   (*c*) Uniform force distribution will break the bridge
   (*d*) Center of mass of bridge will increase

4. If the cylinder of mass 'm' and radius 'r' is transformed into disc with radius '2r', then its moment of inertia will be-
   (*a*) 2 (*b*) 4
   (*c*) 1/2 (*d*) 1/4

5. On putting a thin water film over a glass plate it becomes more transparent to light because-
   (*a*) Lesser would be reflection
   (*b*) Lesser will be refraction
   (*c*) Trapped air increase transparency
   (*d*) It does not happens

6. For equilibrium reaction the value for Delta G will be
   (*a*) Zero (*b*) Negative
   (*c*) Positive (*d*) Infinity

7. The tetrahedral geometry of carbon is best explained by-
   (*a*) Monochoro methane (*b*) Dichloro methane
   (*c*) Choloroform (*d*) Carbon tetrachloride

8. About Haber's process for ammonia production, the false statement is-
   (*a*) It is second order reaction
   (*b*) Slow at room temperature
   (*c*) High pressure is required
   (*d*) Al_2O_3 is used as catalyst

9. On increasing the NaCl into water it boiling point decreases because-
   (*a*) Due to more energetic molecules
   (*b*) Weak H-bonding
   (*c*) More collision between molecules
   (*d*) Activation energy is decreased

10. The necessary condition for reaction to be spontaneous is-
    (*a*) H – ve & S + ve (*b*) H – ve & S – ve
    (*c*) H + ve & S + ve (*d*) H – ve & S + ve

11. Moon does not have atmospheric gases-
    (*a*) Gravity is not sufficient to hold gases
    (*b*) Speed of rotation is very high
    (*c*) Water and plants are absent
    (*d*) Absence of sheathing ozone layer

12. Earth is slightly inclined on its axes, if axis of rotation is made perpendicular then major effect will be on-
    (*a*) Day & night (*b*) Seasons
    (*c*) Tides of ocean (*d*) Rotation of earth

13. The magnetic field around earth is a result of -
    (*a*) Structure of earth crust (*b*) Plate faults
    (*c*) Motion of liquid mantle (*d*) Motion in liquefied core

14. Which of them is a result of process of sedimentation-
    (*a*) Coal (*b*) $CaCO_3$
    (*c*) Igneous rocks (*d*) Granite

15. Among the following which radioisotope is routinely used for determination of age of fossils-
    (*a*) P 32 (*b*) S 35
    (*c*) C 14 (*d*) O 18

16. Convert the binary number 1101.101 into decimal number-
    (*a*) 13.625 (*b*) 13.5
    (*c*) 13.62 (*d*) 13.26

17. Which of them is not programming language-
    (*a*) BASIC (*b*) COBOL
    (*c*) PASCAL (*d*) LOTOUS

18. The clock speed in computer is usually measured in-
    (*a*) Bytes (*b*) Seconds
    (*c*) Hertz (*d*) RAM

19. Bug, in computer terminology means-
    (*a*) Logical error (*b*) Syntax error
    (*c*) Organism effecting computer (*d*) High level Programming

20. Consider the following programme and write the result that will print at end of program-

```
If A=4 and B=5
Do While A =/= 0
If  A >= B
A=A–B
Else
B=B-A
EndIf
PRINT A, B
```

    (*a*) 0, 0 (*b*) 0, 1
    (*c*) 1, 1 (*d*) 1, 0

21. If there is double bond between A & T and triple bond between GC, then which sequence will be most stable at higher temperature-
    (*a*) ATTGTACCAAA (*b*) AATTATATATA
    (*c*) AGCAGAGAGTT (*d*) AGGCCGGCCCTA

22. If a tall pea plant is crossed with pure dwarf pea plant, all F_1 progenies were tall, in subsequent generation after selfing of F_1 generation progeny, the ratio of tall to dwarf plant will be-
    (*a*) 1:1 (*b*) 1:2:1
    (*c*) 3:1 (*d*) All tall

23. White blood cells (WBC) have major function as-
    (*a*) Defensive role (*b*) Respiration
    (*c*) Tumor suppressor (*d*) Phagocytosis of cell debris

24. Rules stating that as we move toward the polar region from tropics the size of organism increases-
    (*a*) Allen's rule (*b*) Bergman's rule
    (*c*) Fischer rule (*d*) Copes rule

25. During photosynthesis evolution of oxygen is from-
    (*a*) Water (*b*) CO_2
    (*c*) Glucose (*d*) Chlorophyll

26. Maximum numbers of lines producing symmetrical planes from a regular hexagon-
    (*a*) 3 (*b*) 4
    (*c*) 6 (*d*) 8

27. If P=(1,2), Q=(–2, –10) & R=(1, m) and PQ+QR = Minimum, then the value of 'm' will be-
    (*a*) + 6 (*b*) – 6
    (*c*) + 8 (*d*) – 8

28. Twenty-Five student participate in competition, marks obtained by first two students are 6 & 10. Each subsequent student gains an average of preceding students, then the marks obtained by the 100 student will be-
    (*a*) 6 (*b*) 8
    (*c*) 10 (*d*) 16

29. How many boxes of size 2 × 2 × 4 can be fitted in a box of size 11 × 8 × 20-
    (*a*) 100 (*b*) 110
    (*c*) 120 (*d*) 220

30. Integration of below mentioned equation would be-

$$\frac{d}{dx}e^{x}\sin^{2}\theta+\frac{d}{dx}e^{x}\sin^{2}(\theta-\pi/2)$$

    (*a*) $2e^{x}(\sin\theta - \cos\theta)$ (*b*) $2e^{x}(\sin\theta)$
    (*c*) $2e^{x}(\cos\theta)$ (*d*) $e^{x}(\sin\theta - \cos\theta)$

PART-B

1. In Human number of linkage groups present in male is:
    (*a*) 21 (*b*) 22
    (*c*) 23 (*d*) 24

2. Holiday junction is observed during:
    (*a*) Mitosis (*b*) Interphase
    (*c*) Recombination (*d*) DNA Repair

3. Layer of Atmosphere possessing ozone is-
    (*a*) Stratosphere (*b*) Mesosphere
    (*c*) Ionosphere (*d*) Troposphere

4. The Ozone layer saves from lethal UV. It mainly absorbs-
    (*a*) UV-A &B (*b*) UV-B
    (*c*) UV-B & C (*d*) UV-A & C

5. Major hot spot of biodiversity in India are-
    (*a*) Andaman & western ghats
    (*b*) Eastern Ghats & Western Himalayas
    (*c*) Western ghats & N.E Himalayas
    (*d*) North East and Western Himalayas

6. In humans, XX males and XY Females are rare, such rare sexes are due to-
   (*a*) Deletion of X chromosome
   (*b*) Deletion of Y chromosome
   (*c*) XY translocation
   (*d*) Duplication of X chromosomes

7. The major difference in PS-I and PS-II found in Chloroplast are-
   (*a*) Position on lamellae (*b*) Chlorophyll a
   (*c*) Position of electron carriers (*d*) Energy harvesting

8. Testosterone hormone necessary for spermatogenesis is secreted by-
   (*a*) Leydig cells (*b*) Sertoli cells
   (*c*) Spermatozoa (*d*) Cowpers gland

9. The major site of attack by HIV-virus on immune system is-
   (*a*) MHC (*b*) B- Lymphocytes
   (*c*) T- Lymphocytes (*d*) Macrophages

10. Rarely there is occurrence of gill clefts in higher animals, this shows-
    (*a*) They may be useful for that organism
    (*b*) Ancestral returns of that character
    (*c*) Favorable mutation in organism
    (*d*) Retrogressive Evolution

11. A single base pair mutation occurs in strand CATTACCG, its complementary strand had a sequence GTTATGGC. It means mutation has changed base pair-
    (*a*) $A \rightarrow T$ (*b*) $T \rightarrow T$
    (*c*) $T \rightarrow A$ (*d*) $A \rightarrow A$

12. Crossing over occurs during-
    (*a*) Mitotic Metaphase (*b*) Meiotic Metaphase
    (*c*) Mitotic Prophase (*d*) Meiotic Prophase

13. Maize has 10 pairs of chromosome, what will be number of chromosome and chromatids at Metaphase II-
    (*a*) 10 & 10 (*b*) 10 & 20
    (*c*) 20 & 40 (*d*) 5 & 10

14. In plants IAA causes cell elongation due to-
    (*a*) Increase in pH of Apoplast
    (*b*) Increase in pH of cytoplasm
    (*c*) Decrease in pH of Apoplast
    (*d*) Increase in pH of cytoplasm

15. In bacteria site of respiration is-
    (*a*) Glogi bodies (*b*) Cytoplasm
    (*c*) Endoplasmic reticulum (*d*) Microsomes

16. In human females there is inactivation of one X chromosomes for dosage compensation due to-
    (*a*) Methylation (*b*) Acetylation
    (*c*) Phosphorylation (*d*) Formylation

17. Type of proofreading activity by DNA polymerase I in E. COLI is-
    (*a*) $5' - 3'$ exonuclease
    (*b*) $5' - 3'$ endonuclease
    (*c*) $3' - 5'$ exonuclease
    (*d*) $3' - 5'$ endonuclease

18. Fungus used for commercial production of citric acid is-
    (*a*) Neurospora (*b*) Penicillum
    (*c*) Aspergillus (*d*) Sacchromyces

19. Wild Ass are found at-
    (*a*) Kaziranga (*b*) Nandan Kanan
    (*c*) Runn of Kutch (*d*) Nilgiri hills

20. Rifampicin resistant mutants of *E. Coli* were obtained in an experiment which of following is most likely to undergo mutation-
    (*a*) Aminoacyl t-RNA synthetase
    (*b*) Beta subunit of RNA Polymerase
    (*c*) Sigma factor of RNA polymerase
    (*d*) Alpha Subunit of RNA polymerase

21. Induction of β-galactosidase activity by IPTG is result of-
    (*a*) Stimulation of *lac* repressor function
    (*b*) IPTG binding to *lac* operon & inducing transcription
    (*c*) IPTG binding to *lac I* gene product and inhibiting its activity
    (*d*) Inhibition of b galactosidase degradation

22. Set of genes that are originate by gene duplication are known as-
    (*a*) Paralogues (*b*) Homologues
    (*c*) Orthologues (*d*) Epilogues

23. Mammalian promoters sequence is located-
    (*a*) at about 20 bp upstream of translational start site
    (*b*) at about 20 bp upstream of transcriptional start site
    (*c*) downstream of coding sequence
    (*d*) within coding sequence

24. *Agrobacterium rhizogenes* causes-
    (*a*) Crown gall (*b*) Nodules
    (*c*) Hairy root (*d*) Pustles

25. Which of the following technique would you use to separate molecules based upon their size-
   (*a*) Gel Exclusion chromatography
   (*b*) Antibody affinity chromatography
   (*c*) Ion Exchange chromatography
   (*d*) Isoelectric Focusing

26. Which part of translational modification of proteins does not occur in lumen of ER-
   (*a*) Glycosylation
   (*b*) Ubiquitnation
   (*c*) Conformation folding & formation of quaternary structure
   (*d*) Formation of Disulphide bonds

27. Short Day (Long night) plants flowers when-
   (*a*) night > critical dark period
   (*b*) dark period interrupted by flash of light
   (*c*) night < critical dark period
   (*d*) night < critical dark period & day length is interrupted by dark period

28. In eukaryotes which is not secondary messenger-
   (*a*) 1,2 diacyl glycerol (DAG) (*b*) 3′-5′ Cyclic AMP
   (*c*) Inositol 1,4,5 triphosphate (*d*) Cyclins

29. If a girl born with sickle cell anemia, what must be true for parents-
   (*a*) Only father has sickle cell an emia
   (*b*) Only mother carried sickle cell an emia
   (*c*) Only mother had sickle cell an emia
   (*d*) Both parents carried sickle cell an emia

30. Michelis Menten hypothesis-
   (*a*) Enables to calculate iso-electric point of enzymes
   (*b*) Postulates all enzymes are proteins
   (*c*) States that rate of a enzymatic reaction may be independent of substrate concentration
   (*d*) Postulates formation of enzyme substrate complex

31. The half life of radium is 1600, the fraction of sample after 6400 years would be-
   (*a*) 1/4 (*b*) 1/16
   (*c*) 1/8 (*d*) 1/2

32. Which enzyme doesn't require primer-
   (*a*) RNA dependent DNA polymerase
   (*b*) DNA dependent DNA polymerase
   (*c*) DNA dependent RNA polymerase
   (*d*) Taq DNA polymerase

33. Human cytotoxic T-cells have following phenotype-
(a) CD_4^+ CD_8^+ CD_3^+
(b) CD_4^+ CD_8^- CD_3^+
(c) CD_4^- CD_8^- CD_3^+
(d) CD_4^- CD_8^+ CD_3^+

34. Live vaccine is –
(a) Low dose of infectious bacteria administered as prophylactic
(b) A dose of bacterium strain in a modified form which retains immunogenecity but is not pathogenic
(c) A low dose of toxin produced by bacterium
(d) A sample of cells from a patient who recovered recently from disease

35. B form of DNA is characterized by-
(a) Rare form of DNA bases
(b) Left handed helix
(c) Helical turn having 2 bases per turn
(d) Major and minor grooves that allows molecules interacting with DNA

36. Genes for color blindness are located on-
(a) X-Chromosome
(b) Y-chromosomes
(c) Both
(d) None of these

37. Photochemical smog always contains-
(a) Ozone
(b) Methane
(c) CO
(d) None of these

38. Mycorrhiza works as-
(a) Modified root
(b) A root hair in adverse condition
(c) Vegetative propagation
(d) Mechanical support

39. Development of fruit without fertilization is-
(a) Parthenocarpy
(b) Pathenogenesis
(c) Sporogamy
(d) Autogamy

40. Linkage decreases the frequency of –
(a) Hybrid
(b) Dominant allele
(c) Recessive allele
(d) both b and c

41. The bacteria which convert ammonium salts into nitrite is-
(a) Nitrobacter
(b) Nitrosomonas
(c) Azobacter
(d) none of these

42. The transfer of genetic material form one bacterium to another by virus is-
(a) Transduction
(b) Translation
(c) Conjugatiuon
(d) Transformation

43. Penicillin inhibits bacterial multiplication because-
(a) It checks spindle formation
(b) It destroys chromatin
(c) It inhibits cell wall formation
(d) It checks RNA synthesis

44. In photosynthesis, light energy is utilized in-
    (*a*) Converting ATP into ADP
    (*b*) CO_2 change into carbohydrate
    (*c*) ADP converting into ATP
    (*d*) All of these

45. The plasma membrane of intestine is highly folded into microvilli. The main function of Microvilli is-
    (*a*) To Secrete digestive enzymes
    (*b*) To help in blood circulation
    (*c*) To increase its absorptive surface
    (*d*) For ageing of worn out cells

46. The structure formed where two adjacent membrane are thickened with disc shaped adhesive material in between and tonofibrils radiating out from adhesive region is-
    (*a*) Gap junction (*b*) Tight junctions
    (*c*) Desmosomes (*d*) Plasmodesmata

47. How you can separate Gram + ve bacteria from Gram –ve bacteria-
    (*a*) Presence of Techoic Acid (*b*) Absence of periplasmic Space
    (*c*) Exotoxin Produced (*d*) All of the above

48. The process of sneezing of phagocytes between the endothelial cells of blood vessels and reaching to damaged area is known as-
    (*a*) Margination (*b*) Metastasis
    (*c*) Diapedesis (*d*) Angiobiosis

49. In humans cell recognition molecules are-
    (*a*) HLA (*b*) B-cells
    (*c*) T-Cells (*d*) Immunoglobins

50. Cancers cell are monoclonal, are characterized by uncontrolled growth, invasion of other tissues and dissemination to other tissues. The phenomenon of invasion to other tissues is termed as-
    (*a*) Angiobiogenesis (*b*) Metastasis
    (*c*) Diapedesis (*d*) Transformation

51. Environmental control of sex determination is seen in-
    (*a*) Melandrium (*b*) Drosophila
    (*c*) Bonelia (*d*) Apes indica

52. Dosage compensation in case of drossophila is due to-
    (*a*) Methylation (*b*) Acetylation
    (*c*) Hyper activation (*d*) Heterochromatization

53. During respiration in yeast the end product is-
    (*a*) Water and CO_2 (*b*) CO_2, alcohol and energy
    (*c*) H_2S, $C_6H_{12}O_6$ and energy (*d*) Water and CO_2

54. When the earth originated, there was a large amount of methane and other hydrocarbons but now in the present atmosphere, it is replaced by-
(*a*) Hydrogen (*b*) Oxygen
(*c*) Coal (*d*) CO_2

55. The chromatin is made up of repitative units known-
(*a*) Chromosomes (*b*) Chromonemata
(*c*) Nucleosomes (*d*) Nucleotides

56. In Down's Syndrome the number of chromosomes in somatic cell is-
(*a*) 45 (*b*) 47
(*c*) 22 (*d*) 24

57. Among the following which do not bring variation at Individual level-
(*a*) Gene mutation
(*b*) Fertilization
(*c*) Meiosis and Crossing over
(*d*) Chromosome aberration and Hybridizations

58. Natural selection will not operate if-
(*a*) Population is isolated and small
(*b*) Mutating population
(*c*) Random matting population
(*d*) Large population

59. Which is best experimental demonstration to prove natural selection-
(*a*) Lederberg's replica replicating
(*b*) Kettelwell's Industrial metabolism
(*c*) Pastuer's Swann nech exp.
(*d*) Urey millers exp.

60. Which is **false** about stabilizing selection-
(*a*) Constant or unchanging environment
(*b*) Introduces heterozygosity
(*c*) Favours average
(*d*) It tends to arrest variance & environmental changes

61. Which hormone is identical and interchangeable and present in all animals is-
(*a*) Thyroid (*b*) Adrenalin
(*c*) Somatotropin (*d*) Insulin

62. Birds & mammals forms are generally larger size in colder region as compare to warmer region. This is-
(*a*) Allens rule (*b*) Cope's rule
(*c*) Bergman's rule (*d*) Dollo's Law

63. The relationship in which one is benefited without other being harmed is-
    (*a*) Ammensalism (*b*) Commensalism
    (*c*) Proto-cooperation (*d*) Mutualism

64. When mimic resembles a ferocious/ poisonous/distasteful organism for eg. Viceroy butterfly mimics monarch butterfly is –
    (*a*) Aggressive mimicry (*b*) Conscious mimicry
    (*c*) Protective mimicry (*d*) All of these

65. Phylogenetic relationship can be more precisely established by comparing-
    (*a*) Amino acid sequence (*b*) DNA
    (*c*) r-RNA (*d*) m-RNA

66. In a sample from an African population, the frequency of L^M and L^N alleles were 0.78 and 0.22 resp. What are expected frequency of MN phenotypes-
    (*a*) 0.8 (*b*) 0.02
    (*c*) 0.34 (*d*) 0.016

67. Changes in the seasons are caused by:
    (*a*) the tilt of Earth's axis toward or away from the sun.
    (*b*) annual cycles of temperature and rainfall.
    (*c*) variation in the distance between Earth and the sun.
    (*d*) an annual cycle in the sun's energy output.

68. Pelvic girdle and hind limbs in python are example of-
    (*a*) Analogous organ (*b*) Homologous organ
    (*c*) Vestigial organ (*d*) Paralogous organ

69. For muscles the major source of energy is-
    (*a*) ATP (*b*) Phosphocreatin
    (*c*) GTP (*d*) Lactic Acid

70. Early successful stages are tolerant of the harsh, abiotic condition in barren areas are characterized by-
    (*a*) Weedy a-selected (*b*) Weedy r-selected
    (*c*) Weedy g-selected (*d*) Weedy k-selected

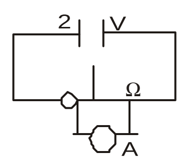
Model Test Paper – 2

PART – A

1. If the pendulum with the time period 't' is placed in the space then its time period will
   (*a*) Increase (*b*) Decrease
   (*c*) Zero (*d*) Infiniti

2. If the ball is thrown with the intial velococity of 100 m/s with angle of 45 0, then what would be ratio of its maximum height to maxim distance is-
   (*a*) 1/2 (*b*) 1/2
   (*c*) 3/4 (*d*) 1

3. The current flowing in the circuit will be-
   (*a*) 0.25 A (*b*) 0.5 A
   (*c*) 0.75 A (*d*) 1.0 A



4. The lens used to correct the myopia is-
   (*a*) Concave (*b*) Convex
   (*c*) Concavo-convex (*d*) Convexo-concave

5. A body of mass ‘m’ goes round a horizontal circle of radius ‘r’. The work done will be-
   (*a*) mv^2/r (*b*) mv/r^2
   (*c*) mgh (*d*) Zero

6. pH of 10^{-8} M HCl will be -
   (*a*) 6 (*b*) 8
   (*c*) 6.92 (*d*) 7.08

7. The ground state electronic configuration of iron is [Ar] $3d^6 4S^2$. The electronic configuration of ferric ion will be-
   (*a*) [Ar] $3d^6 4S^0$. (*b*) [Ar] $3d^4 4S^2$.
   (*c*) [Ar] $3d^5 4S^0$. (*d*) [Ar] $3d^3 4S^2$.

8. Among the following one that is not aromatic-
   (*a*) cyclohexadienyl cation
   (*b*) cycloheptatrienyl cation
   (*c*) cyclopentadienyl cation
   (*d*) cyclopropyl cation

9. How much litre of 1.2 Molar solution be added to one litre of 0.6M Nacl to make it 0.75 molar
   (*a*) 0.30 lit (*b*) 0.33 lit
   (*c*) 0.36 lit (*d*) 0.15 lit

10. The BLACK is coded KCALB, then the white will be-
   (*a*) TIEHW (*b*) HTWIE
   (*c*) ETIHW (*d*) ETHIW

11. Solve the following quadratic equation:
   $3x^2 + 2x - 1 = 0$
   (*a*) –2/3 (*b*) 3/2
   (*c*) 1/2 (*d*) –1/3

12. A litre of helium at 2 atmospheric pressure and 27° C is heated until both pressure and volume are doubled . The final temperature of gas will be-
   (*a*) 108° C (*b*) 927° C
   (*c*) 1000° C (*d*) 1200° C

13. One machine can do work in 10 minutes and a second can do in 15 min, how many minutes will both machines working together simultaneously take to do work-
   (*a*) 8 (*b*) 9
   (*c*) 6 (*d*) 5

14. If any side of triangle is doubled, the area of new triangle is k times of the old one, K is equal to-
   (*a*) 2 (*b*) 4
   (*c*) 3 (*d*) $\sqrt{2}$

15. What is the probability of getting to consecutive kings from a peck of playing cards-
   (*a*) 1/52 × 1/53 (*b*) 4/52 × 4/51
   (*c*) 1/13 × 1/12 (*d*) 4/52 × 3/51

16. Normal life span of RBC is -
   (*a*) 4 hours (*b*) 4 months
   (*c*) 4 years (*d*) Immortal

17. Which one of the following animals do not have milk producing mammary glands-
   (*a*) Bat (*b*) Dolphins
   (*c*) Platypus (*d*) Sea Horse

18. A common feature of haemoglobin and chlorophyll is-
   (*a*) They are porphyrin derivative
   (*b*) They are oxygen carrier
   (*c*) Both help in electron transport chain
   (*d*) Both are proteins

19. AIDS virus attacks-
    (*a*) T-helpers cells (*b*) B-cells
    (*c*) Neutrophils (*d*) Lymphocytes

20. All living beings have self regulatory mechanism to maintain steady state and this is called as-
    (*a*) Homeostasis (*b*) Osmosis
    (*c*) Phagocytosis (*d*) Parabiosis

21. The ozone layer lies in-
    (*a*) Troposphere (*b*) Stratosphere
    (*c*) Tropopause (*d*) Mesophere

22. Seasonal variation is due to-
    (*a*) Rotation of earth
    (*b*) Revolution of earth
    (*c*) Inclination of earth on its axis
    (*d*) Gravitational pull of moon

23. Main cause of earthquakes is disturbances in-
    (*a*) Earth crust (*b*) upper mantle
    (*c*) Lower mantle (*d*) Inner core

24. The planet having maximum density is-
    (*a*) Mercury (*b*) Jupiter
    (*c*) Pluto (*d*) Earth

25. Computers directly understand which language-
    (*a*) Machine language (*b*) C
    (*c*) Oracle (*d*) BASIC

26. Which among the following is not physical component of CPU-
    (*a*) RAM (*b*) CU
    (*c*) ALU (*d*) VDU

27. Binary equivalent of 15.5 is-
    (*a*) 1111.101 (*b*) 1001.1
    (*c*) 1111.1 (*d*) 1111.01

28. India's latest super computer is-
    (*a*) Paran 1000 (*b*) Param 10000
    (*c*) Param Padam (*d*) Param Infiniti

29. The difference between the GMT and place 'A' which is 82 ½ 0 E of GM line will be-
    (*a*) + 3 ½ hours (*b*) – 3 ½ hours
    (*c*) + 5 ½ hours (*d*) – 5 ½ hours

30. What would be the output of the following program-

```
A=10  B= 20  I= 0
WHILE  I < 5
I=I+1
A=A+2
B=B+2
STOP
PRINT A,B
```

(*a*) 18, 28 (*b*) 20, 30
(*c*) 22, 32 (*d*) 16, 26

PART – B

1. Which of the following organelle is involved in photorespiration-
(*a*) Peroxisomes (*b*) Ribosomes
(*c*) Glyoxysomes (*d*) Dictyosomes

2. In which phase of cell cycle the drug colchine exerts its effect-
(*a*) G_1 (*b*) G_2
(*c*) S (*d*) M

3. Seed storage protein of legumes are deficient in-
(*a*) Threonoine (*b*) Methionine
(*c*) Lysine (*d*) glycine

4. A hormone that controls closure of stomata in response to water stress is-
(*a*) Abscissic acid (*b*) Gibberlin
(*c*) Proline (*d*) Ethylene

5. The process by which a cell secrete macromolecules by fusing a transport vesicle to plasma membrane is called
(*a*) Pinocytosis (*b*) Phagocytosis
(*c*) Endocytosis (*d*) Exocytosis

6. When a cell is expends energy to move a solute across its membrane against a concentration gradient, the process is called as-
(*a*) Diffusion (*b*) Osmosis
(*c*) Facillitated Diffusion (*d*) Active transport

7. The CO_2 acceptor in C_4 plants is-
(*a*) 3-phosphoglyceric acid (*b*) Ribulose bis phosphate
(*c*) Phospho enol pyruvic acid (*d*) Xylulose 5 phosphate

8. Light harvesting complex II is located in the-
(*a*) Thylakoid lumen (*b*) Stroma
(*c*) Thylakoid membrane (*d*) Outer membrane of chloroplast

9. The maximum frequency of recombination of genes at two loci is-
   (*a*) 25 % (*b*) 50 %
   (*c*) 75 % (*d*) 100 %

10. Symbiotic association between fungi and roots of higher plant is known as-
    (*a*) Mycorrhyiza (*b*) Lichen
    (*c*) Collaroid (*d*) Epiphytic roots

11. A known uncoupler of electron transport chain and oxidative phosphorylation is-
    (*a*) Dinitrophenol (*b*) Ancymidol
    (*c*) Triaconotol (*d*) Hexaacamzol

12. Production of transgenic cotton resistant to lepidodenteron insect utilizing bacillus thuringeneisis is due to-
    (*a*) α-endotoxin (*b*) α-endotoxin
    (*c*) α-exotoxin (*d*) δ-exotoxin

13. A group of interconnected food chains is called as-
    (*a*) Pyramid of number (*b*) Complex food chain
    (*c*) Food web (*d*) Food cycle

14. Among the following phyla, one evolutionarily closest to phylum chordata is-
    (*a*) Annelida (*b*) Arthopoda
    (*c*) Echinodermata (*d*) Onchycophora

15. Human originated in epoch known as-
    (*a*) Pleistocene (*b*) Pliocene
    (*c*) Miocene (*d*) Holocene

16. The order Anura, Urodela, Apoda belongs the class-
    (*a*) Amphibian (*b*) Reptilian
    (*c*) Mammalian (*d*) Pisces

17. The condition albinism in man is linked to deficiency of the enzyme-
    (*a*) Glucose-6-phosphate dehydrogenase
    (*b*) Arginase
    (*c*) Tyrosinase
    (*d*) Xanthin oxidase

18. Which among the following is not universal stop codon-
    (*a*) UAA (*b*) UGA
    (*c*) UAC (*d*) UAG

19. The body temperature of following groups of animals occurs in order-
    (*a*) Protheria>metatheria>Eutheria>Aves
    (*b*) Aves>Eutheria>Metatheria>Prototheria
    (*c*) Eutheria>Aves>Metatheria>Prototheria
    (*d*) Metatheria>Eutheria>Aves>Prototheria

20. If you are asked to clone a man from a single cell and you are provided with the following cells, which one would you will choose-
    (*a*) Sperm (*b*) Erythrocyte
    (*c*) Lymphocyte (*d*) Kidney fibroblast

21. The number of complementarity determining region(s) present in human kappa chain are-
    (*a*) 1 (*b*) 2
    (*c*) 3 (*d*) 4

22. Transfer RNA genes are transcribed by-
    (*a*) RNA polymerase I (*b*) RNA polymerase II
    (*c*) RNA polymerase III (*d*) RNA dependent RNA pol

23. Shine-Dalgarno sequences are associated with-
    (*a*) Transcription (*b*) Translation
    (*c*) Replication (*d*) Recombination

24. Gonadotropin releasing factor is synthesized by-
    (*a*) Anterior Pituatory (*b*) Hypothalamus
    (*c*) Adrenal (*d*) Thymus

25. In Eukaryotic cell, DNA synthesis occurs during the phase of cell cycle-
    (*a*) G1 Phase (*b*) G2 Phase
    (*c*) S phase (*d*) M phase

26. The combination of closely related genetic markers which tends to transmitted as unit to the next generation is called-
    (*a*) Allotype (*b*) Haplotype
    (*c*) Karyotype (*d*) Isotype

27. The hormone epinephrine is involved in-
    (*a*) Red blood cell synthesis (*b*) Stress response
    (*c*) Control of blood sugar level (*d*) Control of metabolic rate

28. The vector responsible for the spread of filiaris is-
    (*a*) Anopheles (*b*) Culex
    (*c*) Ades (*d*) Sand fly

29. The following of the four is not a secondary messanger-
    (*a*) ATP (*b*) Inositol 1,4,5 triphosphate
    (*c*) Ca^{++} (*d*) c-AMP

30. Early pregnancy dtection test detects the presence of whoch one of the following hormone-
    (*a*) Human chronic hormone (*b*) Lutenizing hormone
    (*c*) Follicle stimulating hormone (*d*) Estrogen

31. Selective transfer of which of the following antibodies are responsible for passive humoral immunity in infants-
(*a*) IgA (*b*) IgM
(*c*) IgG (*d*) IgE

32. The animal that most recently extinct from India is-
(*a*) Asiatic Lion (*b*) Dodo
(*c*) Asiatic Cheetah (*d*) Golden Langaur

33. Which of the following anti-tumor agent act by impairing the de novo purine synthesis-
(*a*) Cytosine arabinoside (*b*) 5-flurouracil
(*c*) Methotrexate (*d*) Hydroxyurea

34. Which one of the following has a quaternary structure-
(*a*) α-chymotrypsin (*b*) Haemoglobin
(*c*) Insulin (*d*) Myoglobin

35. Which one of the following is conservative substitution-
(*a*) Val to Ile (*b*) Asp to Pro
(*c*) Lys to Leu (*d*) Trp to Ala

36. Phospholipids are involved in all except one of the following-
(*a*) Cell to cell recognition
(*b*) Signal transduction
(*c*) Surfactant function in lungs
(*d*) Mediator of hypersensitivity

37. Insulin dependent diabetes mellitus is associated with-
(*a*) High level of insulin
(*b*) Severe weight gain
(*c*) Destruction of b-cells of pancreas
(*d*) Mutation of insulin

38. The Z-DNA helix -
(*a*) Has fewer base pair turn then B-DNA
(*b*) Is favoured by alternate GC base pairs
(*c*) Tends to found at 3'ends of genes
(*d*) Is the most common conformation of DNA

39. How many energy bonds are expended in formation of peptide bond-
(*a*) 2 (*b*) 4
(*c*) 3 (*d*) 6

40. Receptors for steroid hormones are found-
(*a*) On cell membrane (*b*) In cytoplasm
(*c*) In mitochondria (*d*) On ribosomes

41. Endonuclease is an enzyme that hydrolyzes-
    (*a*) A nucleotide at 3' ends of oligonucleotides
    (*b*) A phosphodisester bond located in the interior of a polynucleotide
    (*c*) A nucleotide from either termini of an oligonucleotide
    (*d*) A peptide bond located in the interior of polypeptide

42. The Km of enzyme is-
    (*a*) One half of the V max
    (*b*) A dissociation constant
    (*c*) Substrate concentration that gives max velocity
    (*d*) Substrate concentration that gives half-maximum velocity

43. The class of immunoglobin most abundant in body secretion-
    (*a*) Ig M (*b*) Ig G
    (*c*) Ig A (*d*) Ig E

44. One of the following participates in phagocytic activity-
    (*a*) Neutrophils (*b*) Mast cells
    (*c*) T-Cells (*d*) Thrombocytes

45. Operons-
    (*a*) Are approximately uniform in size
    (*b*) Do not bind protein
    (*c*) Are found in all eukaryotic genes
    (*d*) Are Shorter in lower eukaryotes then higher ones

46. RNA is very susceptible to hydrolysis in alkali because-
    (*a*) It contains uracil in its structure
    (*b*) Its 2′-OH group participates in intramolecular cleavage of phosphodiester backbone
    (*c*) Cleavage occurs in the glycosylic bonds of purine bases
    (*d*) Cleavage occurs in the glycosylic bonds of pyramidine bases

47. T_4 polynucleotide kinase is used for-
    (*a*) Labeling 3′ ends of DNA
    (*b*) Labeling 5′ ends of DNA
    (*c*) Creating blunt ends of DNA
    (*d*) Dephosphorylation of DNA

48. A plasmid cloning vector should contain all of the following except-
    (*a*) Origin of replication (*b*) Inducible promoter
    (*c*) Selectable marker gene (*d*) Multiple cloning sites

49. Enzymes used in “cycle sequencing” of DNA is-
    (*a*) T_7 DNA polymerase (*b*) T_4 DNA polymerase
    (*c*) Klenow DNA polymerase (*d*) Taq DNA polymerase

50. Viral replication within cells is inhibited by-
(*a*) IL-4 (*b*) IL-1
(*c*) IFN-α (*d*) TNF-α

51. Holoandric inheritance is shown by-
(*a*) X-chromosomes (*b*) Y-chromosomes
(*c*) Autosomes (*d*) Allosomes

52. Lesch-Nyann Syndrome is due to defect in-
(*a*) Recessive X-chromosomes (*b*) Dominant X-chromosome
(*c*) Autosomes (*d*) Y-chromosomes

53. Selection of African tribes is more of heterozygous gene for RBC is due to-
(*a*) Severe malaria (*b*) Environment unstability
(*c*) More cases of Sickle cell anemia
(*d*) both a&c

54. Molecular clock of evolution could be traced on basis of-
(*a*) Comparison of Short arm of 16-S RNA
(*b*) Substitution in amoniacids of polypeptide due to mutation
(*c*) DNA fingerprinting
(*d*) Fossil study

55. Phylogenetic relationship can be more precisely established by comparing-
(*a*) Amino acid sequence (*b*) DNA
(*c*) r-RNA (*d*) m-RNA

56. The Typical Medelian dihybrid test cross ratio is-
(*a*) 9:3:3:1 (*b*) 1:1:1:1
(*c*) 9:7 (*d*) 1:2:1

57. Extra nuclear genetic material is present in-
(*a*) Ribosome (*b*) Centriole
(*c*) Plastids (*d*) Golgi

58. Dosage compensation in human is achieved by-
(*a*) Methylation (*b*) Acetylation
(*c*) Hyperactivation (*d*) Silencing

59. Energy obtained by oxidation of 1 g of protein is -
(*a*) 9 K cal (*b*) 4.5 K cal
(*c*) 18 K cal (*d*) 12 K cal

60. Among the following the progenitors of mammals were-
(*a*) Aves (*b*) Pisces
(*c*) Amphibians (*d*) Reptiles

61. Abrupt change in gene frequency in isolated population is termed as-
(*a*) Adaptive radiation (*b*) Allopatric speciation
(*c*) Random drift (*d*) Mutation

62. Main cause of loss of Biodiversity is-
(*a*) Pollution (*b*) Population explosion
(*c*) Habitat destruction (*d*) Over exploitation

63. Which radioisotope is used for estimating age of rocks-
(*a*) U^{238} & K^{40} (*b*) U^{235} & C^{14}
(*c*) U^{238} & H^{3} (*d*) C^{14} & H^{3}

64. What is main cause of evolution of new species-
(*a*) Natural selection (*b*) Competition
(*c*) Mutation (*d*) Hybridization

65. Competitive exclusion principle operates in-
(*a*) Distantly related species (*b*) Closely related sps.
(*c*) Species in overlapping niche (*d*) Shortage of nutrition

66. The new type designated when original type is missing-
(*a*) Co-type (*b*) Syntype
(*c*) Neotype (*d*) Lectotype

67. Inversion when chromosomes are not involved is termed as-
(*a*) Pericentric (*b*) Paracentric
(*c*) Allocentric (*d*) Autocentric

68. In a sample from an African population, the frequency of LM and LN alleles were 0.78 and 0.22 resp. What are expected frequency of MN phenotypes-
(*a*) 0.8 (*b*) 0.02
(*c*) 0.34 (*d*) 0.016

69. Ozone layer is severely depleted at-
(*a*) Equator (*b*) Tropics
(*c*) Poles (*d*) Temperate

70. The anionic charge of phosphodiester bond of DNA in prokaryotes is balanced by-
(*a*) Polyamines (*b*) H-NS
(*c*) H-L (*d*) Histone

Model Test Paper – 3

PART – A

1. What is the fundamental unit on which natural selection acts:
   (*a*) Species (*b*) Individual
   (*c*) Population (*d*) Gene

2. In a paddy field, which of the following organism can serve as a bio-fertlizer
   (*a*) N_2- Fixing Cynobacteria
   (*b*) Methane producing bacteria
   (*c*) Nitrifying bacteria
   (*d*) Photosynthetic bacteria

3. A regular hexagon is inscribed in a circle of diameter (*d*) What is the perimeter (i.e. sum of the sides) of the hexagon?
   (*a*) 3d (*b*) 6d
   (*c*) $3\pi d$ (*d*) $(\pi/3)d$

4. The software that forms the web is called:
   (*a*) TCP/ IP (*b*) html
   (*c*) URL (*d*) www

5. The octal integer 777 when converted to binary becomes
   (*a*) 100000000 (*b*) 111111111
   (*c*) 11111110 (*d*) 111111

6. Consider the following truth table.

P	Q	P<Q	P≠Q
3	3	0	0
4	5	A	B

   The value of A and B will be-
   (*a*) 0,0 (*b*) 0,1
   (*c*) 1,0 (*d*) 1,1

7. An atomic orbital having the quantum no. n = 1 and l = 1 will have the shape of:
   (*a*) ellipsoId (*b*) dumb-bell
   (*c*) cone (*d*) sphere

8. H–C–H bond angle in CH_4 is 109.5° due to lone pair repulsion. The H–O–H angle in H_2O will:
   (*a*) remain the same (*b*) decrease
   (*c*) increase (*d*) become 1800

9. 19 girls and 9 boys are asked to stand in a circle. In an such arrangement, it is always the case that there are:
   (*a*) 2 boys standing next to each other
   (*b*) 2 girls standing next to each other
   (*c*) 3 boys standing next to each other
   (*d*) 4 girls standing next to each other

10. The number $(10^n - 1)$ is divisible by 11 for
    (*a*) all values of n
    (*b*) odd values of n
    (*c*) even values of n
    (*d*) n = multiple of 11

11. If $\log\sqrt{8^x} = 3\frac{1}{3}$ then value of x is
    (*a*) 32 (*b*) 30
    (*c*) 42 (*d*) 2

12. At any time t, the rate of change in the no. of decaying nuclei is A times. the no. of nuclei present where A is the decay constant. The time at which 2/3 of the originally present nuclei would have decayed is:
    (*a*) ln $2/\lambda$ (*b*) λ. ln 3
    (*c*) ln $3/2\,\lambda$ (*d*) λ. ln 2

13. Global warming is due to which of the following?
    (*a*) Green house gases absorb both visible and infrared radiation
    (*b*) Infrared radiation is observed by green house gases whereas visible radiation is not
    (*c*) Infrared radiation is not observed by green hosue gases whereas visible radiation is
    (*d*) Earth is slowly corning closer to the sun

14. Jupiter's mass is mostly made up of:
    (*a*) Helium (*b*) Argon
    (*c*) Hydrogen (*d*) Xenon

15. The southwest monsoon occurs over major parts of India in the months from June to September. The main cause of the monsoon:
    (*a*) The land is cooler than the sea
    (*b*) The centrifugal force deflects the wind
    (*c*) The land is warmer than the sea
    (*d*) Wind blows from North-east to south-west

16. Which of the following chemical groups is the most Hydrophobic?
    (*a*) $CH_2 - CO_2$
    (*b*) $CH_2 - CH_2 - NH_3$
    (*c*) Histidine
    (*d*) Phenyl alanine

17. A ball of mass 10 gm moving at 10 m/sec collide completely in elastically with another ball of mass 10 gms which is at the rest. After the collision which of the following is true?
    (*a*) The combination will be at rest
    (*b*) The combination will get cooled
    (*c*) The combination will have a kinetic energy of 0.5 Joule
    (*d*) The combination will move at 5m/sec.

18. Consider the following programe segment:
    N = 20
    If N >10 then N = N – 1
    If N = 10 then N = 20
    If N < 10 then N = N + 1
    If N = 0 then STOP
    If each step in this program takes 1 second, then the total time for the program to run will be:
    (*a*) 10 seconds (*b*) 20 seconds
    (*c*) 100 seconds (*d*) Infinite

19. Viruses can disable computers. A computer virus can be transmitted one machine to another if:
    (*a*) they are used to run similar application
    (*b*) they are used by same programmes
    (*c*) floppy disks are exchanged between different computer
    (*d*) they use different operating system

20. The aim of galvanising the iron is to :
    (*a*) give it a better look
    (*b*) protect it from rusting
    (*c*) increase its hardness
    (*d*) make it more elastic

21. Silver halides are used in photo-graphic plates because they are:
    (*a*) Oxidised in air
    (*b*) colourless
    (*c*) easily soluble in hypo solution
    (*d*) readily reduced by light

22. A body will radiate heat
    (*a*) at all finite temperature
    (*b*) when heated and then allowed to cool
    (*c*) when its temperature is higher than surroundings
    (*d*) when its temperature is above 0°C

23. The activity of a radioisotope falls to 12.5% in 90 days. The half life of radio isotopeis
    (*a*) 260 days (*b*) 265 days
    (*c*) 270 days (*d*) 268.2 days

24. Heavy water (Deuterium, D_2O) is usually prepared from:
    (*a*) heavy hydrogen (*b*) sea water only
    (*c*) river water only (*d*) ordinary water

25. Hydrogen bomb is based on the phenomenon of:
    (*a*) nuclear fusion (*b*) nuclear fission
    (*c*) nuclear reaction (*d*) none

26. During the earthquake most damage is seen on earth crust because earth crust is-
    (*a*) Rigid (*b*) Brittle
    (*c*) Enelastic (*d*) Molten

27. A certain planet is revolving in a fixed orbit. If the radius of its orbit in increased four times then its mean surface temperature will decrease-
    (*a*) 1 (*b*) 2
    (*c*) 4 (*d*) 16

28. Charge density is more at poles because-
    (*a*) Magnetic field is parallel to poles
    (*b*) Magnetic field is parallel to equator
    (*c*) Magnetic field is perpendicular to poles
    (*d*) Magnetic field is perpendicular to equator

29. If an object absorbs green part of white light, then its color will be-
    (*a*) Blue (*b*) Yellow
    (*c*) Green (*d*) Purple

30. $n \xrightarrow{\text{lmit/ t}} \infty \left[2 + \frac{1}{n}\right]$ equals to
    (*a*) $\sqrt{e}$ (*b*) e
    (*c*) e^2 (*d*) e^3

PART – B

1. A homozygous Rh positive man (RR) marries an Rh negative (rr) woman. Their first child is normal, but their second child has hemolytic disease (Rh disease). The first child did not have hemolytic disease because-
   (*a*) the child was heterozygous
   (*b*) the child lacked Rh antigen
   (*c*) The mother had a previous blood transfusion that protected the child against antibodies
   (*d*) Ant-Rh antibodies were not induced in the mother until the delivery of first child.

2. Which of the following organelles has protein-phospholipid membrane, energy conversion enzymes, and ribosomes similar to that found in bacteria-
   (*a*) Lysosome (*b*) Mitochondria
   (*c*) Peroxisomes (*d*) Rough ER

3. Which of the following take place during the anaphase of mitosis in an animal cell-
   (*a*) Kinetochore microtubule elongate to push chromosomes towards the metaphase plate
   (*b*) Sister chromatid remains attached to each other at the centromere and move towards the poles as a unit
   (*c*) The contractile ring completes the process of cytokinesis
   (*d*) Polar microtubules elongate and slide to push the spindle poles apart.

4. Members of which of the following groups cannot generate their own ATP-
   (*a*) Lichens (*b*) Diatoms
   (*c*) Viruses (*d*) Protozoa

5. The complementary RNA sequence for GATCAA is
   (*a*) CTAGTT (*b*) CUAGUU
   (*c*) AGCTGG (*d*) AGCUGG

6. Which of the following would best demonstrate that the genomes of differentiated cell are genetically equivalent?
   (*a*) Isolation and culture of blastomeres of two or four-celled embros
   (*b*) Isolation and culture of the nuclei in the presence of cells from which they have been removed
   (*c*) Isolation and fusion of two different somatic cell types
   (*d*) Injection of a nucleus isolated from an adult cell into an egg from which nucleus has been removed.

7. All of the following mechanisms has been shown experimentally to contribute to the formation of cancer cell EXCEPT
   (*a*) Abnormally high energy reserves in cancer cell that cause them to divide quickly
   (*b*) Mutations that cause excess proliferation of growth factor of cancer cells.

(*c*) Mutations that reduced the need for growth factor in cancer cells
(*d*) Mutation that inactivate genes that normally inhibit cell division.

8. Which of the following statement is LEAST likely to be true of mutations in a diploid organism such as fruit fly-
   (*a*) Some loci are more mutable than others
   (*b*) Some mutation can affect the activity of several genes.
   (*c*) Some mutations can have lethal effects
   (*d*) Most somatic mutations markedly alter the organisms phenotype.

9. The addition of colchicine to a culture of actively dividing flagellated eukaryotic cells inhibit all of the following EXCEPT-
   (*a*) Movement of the flagella
   (*b*) Growth of the flagella
   (*c*) Formation of microtubular cytoskeleton
   (*d*) Polymerization of tubulin

10. In enzyme mediated reaction, enzyme molecules are capable of all the following EXCEPT-
   (*a*) altering the equilibrium of the chemical reaction
   (*b*) decreasing the activation energy of the reactions.
   (*c*) increasing the rate of reaction
   (*d*) binding of molecules other then substrate molecules

11. The cDNA fragment that includes the ricin gene is 5.7 kilobases. If the entire fragment codes for the ricin polypeptide, the approximate number of amino acids in the polypeptide would be-
   (*a*) 17,100 (*b*) 5,700
   (*c*) 2,500 (*d*) 1,900

12. Member of which of the following classes of macromolecules are known to exhibit enzyme like (catalytic) properties
   I. RNA
   II. Glycoprotein
   III. Lipoprotein
   IV. Polysaccharides
   (*a*) II and III (*b*) I and II
   (*c*) I, II and III (*d*) All the four

13. Which of the following statement is NOT characteristic of all viruses with DNA genomes?
   (*a*) Replication occurs only in a living cell
   (*b*) Replication involves the translation on cellular ribosomes
   (*c*) The viral nucleocapsid is surrounded by a lipid envelope
   (*d*) The viral genome is surrounded by a protein

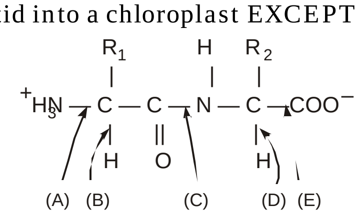
14. In the presence of a fixed concentration of a competitive inhibitor, which of the following would best characterized an enzyme catalyzed reaction when the concentration of the substrate is increased?
   (*a*) The Km increases
   (*b*) The inhibition decreases
   (*c*) The maximal rate of reaction (Vmax) increases
   (*d*) The maximal rate of reaction (Vmax) decreases

15. Biological oxidation of glucose resulting in which of the following metabolic end product would yield the largest number of ATP molecules?
   (*a*) $CH_3CHOHCOOH$ (*b*) $CH_3COCOOH$
   (*c*) $CO_2 + N_2 + H_2O$ (*d*) $CO_2 + H_2O$

16. The distribution of transmembrane proteins in the plane of cell membrane can be visualized by which of the following?
   (*a*) Thin section electron microscopy
   (*b*) Freeze fracture electron microscopy
   (*c*) Ultraviolet spectroscopy
   (*d*) SDS-gel electrophoresis

17. Plasmodesmata most closely resembles which of following in animal cells
   (*a*) Desmosomes (*b*) Gap junction
   (*c*) Basal laminae (*d*) Tight junction

18. All of the following occur during maturation of a proplastid into a chloroplast EXCEPT
   (*a*) an increase in size
   (*b*) an increase in the number of grana
   (*c*) the bleaching of chlorophyll
   (*d*) the synthesis of pigments



19. A peptidase hydrolyzes peptide bonds in small proteins. In the dipeptide shown above, which bond would be hydrolyzed?
   (*a*) A or E (*b*) B
   (*c*) C (*d*) D

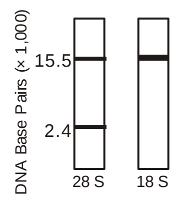
20. All of the following cellular events involve actin filaments EXCEPT
   (*a*) Amoeboid movement
   (*b*) Cytoplasmic streaming
   (*c*) Contraction of smooth muscles
   (*d*) Flagellar movement in bacteria

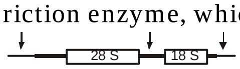
21. Eukaryotic and prokaryotic cells share all the following EXCEPT
   (*a*) ribosome dependent proteins synthesis
   (*b*) ATP synthesis linked to a protein gradient
   (*c*) a selectively permeable membrane
   (*d*) a cytoskeleton of tubulin

22. In E. coli, induction of the lactose operon occurs when allolactose binds to
    (*a*) galactosidase (*b*) lac mRNA
    (*c*) the operator (*d*) the repressor

23. Synthesis and processing of eukaryotic messenger RNA includes all of the following EXCEPT
    (*a*) formation of a ribonucleoprotein complex
    (*b*) formation of a short region of RNA-DNA duplex
    (*c*) Addition of polyuridine at the 3'end
    (*d*) ligation of exons

24. The autoradiogram above (after the electrophoresis and southern blotting) shows human DNA digested with a specific restriction enzyme and probed with labelled rRNA. In the autoradiogram on the left, the probe was 28S rRNA; at the right, the probe was 18S rRNA. If the arrows in the following maps locate the recognition site of the restriction enzyme, which map best explains the results shown above-



    (*a*) 

    (*b*) 

    (*c*) 

    (*d*) 

25. During which of the following stages of the cell cycle will a diploid cell contains twice the amount of DNA found in a gamete?
    (*a*) Prophase (*b*) Entire S phase
    (*c*) Entire G1 phase (*d*) Entire G2 phase

26. With respect to human height, the production of short individuals by two average sized parents is best explained by-
    (*a*) mutation (*b*) Polygenic inheritance
    (*c*) Epistasis (*d*) Discontinous variation

27. At which of the following trophic levels is the greatest amount of free energy available-
    (*a*) Producers (*b*) Herbivores
    (*c*) Top consumers (*d*) Decomposers

28. A balanced polymorphism may be maintained by all of the following EXCEPT
    (*a*) Natural selection
    (*b*) Directional selection
    (*c*) Heterozygote advantage
    (*d*) Use of multiple niches

29. A severe winter storm kills many chickadees. An investigation comparing the body size of dead birds with that of survivors reveals that the dead birds include mainly the largest and smallest members of the population. The winter storm exemplifies
    (*a*) Stabalizing selection (*b*) Directional selection
    (*c*) Balancing selection (*d*) Kin selection

30. All of the following may be true of a population with a stable age distribution EXCEPT
   (*a*) The number of organism is changing at a constant rate
   (*b*) Age specific births and death rates are not changing over time
   (*c*) Population size increasing
   (*d*) The proportions of organisms in each class are changing

31. Larger islands may have greater species diversity than smaller islands because larger islands
   (*a*) are in tropics
   (*b*) are farther from continents than smaller islands are
   (*c*) have more habitat than smaller islands do
   (*d*) have no reproductive isolation among their populations

32. Two if the premises that form the basis if Darwin's concept of natural selection are
   (*a*) Ecotype and race
   (*b*) heritability and fitness
   (*c*) Uniformitarianism and catatrophism
   (*d*) geographic and reproductive isolation

33. In an ecosystem, fixed carbon has accumulate in the form of organic matter derived from dead plants and animals. Which of the following is the best explanation for this observation?
   (*a*) Decomposer activity has been low
   (*b*) Producers have been utilizing sunlight inadequately
   (*c*) There have been insufficient numbers of secondary consumers
   (*d*) Nitrogen has been cycled, but carbon has not

34. Which of the following is a density-independent factor that could limit a population of high altitude butterflies?
   (*a*) A late spring snow storm
   (*b*) Scarcity of oviposition sires
   (*c*) Predation
   (*d*) Parasitism

35. One summer the moose population of national park was unusually high, and park naturalist noticed signs of malnutrition among the adults. The wolf population was fairly low, near 20. That winter for first time in many years, a substantial number of seemingly healthy adult mouse as well as calves and crippled animals were killed and eaten by wolves. This description is part of a general situation in which the wolf and moose populations-
   (*a*) Are maintained in a stable equilibrium from year to year
   (*b*) Are simultaneously becoming extinct
   (*c*) Fluctuate out of phase with each other
   (*d*) Fluctuate independently of each other

36. A prime factor promoting the adaptive radiation of Darwin's finces on the Galapagos Islands was the
    (*a*) Variety of available and suitable habitats
    (*b*) High predation pressure
    (*c*) Genetic uniformity of the original invading populations of birds
    (*d*) Presence of warblers and true wood peckers on the islands

37. All of the following are adaptations that permit the camel to be active by day in the desert EXCEPT
    (*a*) Thick fur
    (*b*) Hyperthermia
    (*c*) Elongated nasal cavity
    (*d*) Water storage in hump

38. Among the following ecological relationships below which is most different from other three?
    (*a*) Fungal mycelia around the algal cells in lichens
    (*b*) Algal cells embedded in coral tissues
    (*c*) Salmonella in the human gut
    (*d*) Cellulose digesting protozoa in a termite gut

39. Niches of two coexisting species of pond snails of the same genus are likely to be similar, but not identical, because of which of the following?
    I. Closely related species use similar resources
    II. Competitive interactions exist between these species
    III. Unlimited resources are available
    (*a*) I only
    (*b*) II only
    (*c*) I and II only
    (*d*) I and III only

40. In which of the following habitats would one expect to find the highest diversity of vascular plants?
    (*a*) Salt marsh
    (*b*) Spruce-Fir forest
    (*c*) Small islands
    (*d*) Prairie-forest ecotone

41. In deep-sea hydrothermal vents near the Galapagos Islands, bacteria obtain energy by oxidizing hydrogen sulphide released from the vents. Giant tube worms, which lack mouth and digestive systems, harbor the bacteria in their tissues and use them as a source of organic molecules. Clams obtain energy by filtering bacteria directly from the water, and numerous crabs and octopi feed on clams. In this unique ecosystem, the bacteria are playing the role of
    (*a*) Primary producers
    (*b*) Primary consumers
    (*c*) Tertiary consumers
    (*d*) Decomposers

42. Which of the following would be considered to be natural populations in pond?
    (*a*) All individuals of the genus Rana
    (*b*) All the individuals of species Rana tigerina
    (*c*) All the organisms of any two species affecting each other ecologically
    (*d*) All the adults of any one species

43. The massive adaptation radiation of insects over the world is most likely related to the
    (*a*) World wide increase in species diversity in the Cambrian period
    (*b*) evolution of the land flora by the middle of Paleozoic era
    (*c*) human alteration of the environment in the Pleistocene epoch
    (*d*) environmental stability of the seas over all of geological time

44. One group of ecologist has suggested that producers are limited by competion for resources, primary consumers (herbivores) are limited by predation, and secondary consumers (carnivores) are limited by food. If this was true, at which of the following trophic levels would one expect to find substantial evidence for competitive exclusion?
    (*a*) Producers only
    (*b*) Herbivores only
    (*c*) Carnivores only
    (*d*) Producers and carnivores

45. Which of the following statements is most likely correct concerning the Hardy-Weinberg equilibrium in natural populations?
    (*a*) It occurs infrequently in small populations from natural communities
    (*b*) It occurs in founding populations, but not in established populations
    (*c*) It occurs in populations from late successional communities, but not from early successional communities
    (*d*) It occurs on small islands, but on large islands.

46. Under some circumstances a population can split into two or more species without the existence of geographic barriers. All of the following genetically determined behavior could provide conditions leading to speciation except-
    (*a*) Selection of a specific host fruit for completion of life cycle by a fruit fly
    (*b*) Association of courtship with a particular habitat type in a sparrow
    (*c*) Choice of a butterfly of the time of day to breed
    (*d*) Selection of prey types by a wide ranging hawk

47. If the alleles 'A' and 'a' conform to Hardy-Weinberg expectations, and if the frequency of 'a' is 0.3, which of the following is the most common genotype in the population
    (*a*) A (*b*) Aa
    (*c*) AA (*d*) aa

48. The theory of punctuated equilibrium argues that
    (*a*) Speciation and morphological divergence are weakly associated
    (*b*) Selective forces act throughout a species life time
    (*c*) Major morphological changes are separated by long periods of morphological statis
    (*d*) Speciation rates are not related to evolutionary rates

49. Which of the following is true of a selectively neutral gene that is a mutant allele at a locus-
    (*a*) Its effect on fitness are different from those of more frequent allele that leads to normal phenotype
    (*b*) It reaches high frequencies because of state of balanced polymorphism
    (*c*) It confers neither reproductive advantage nor disadvantage on the individual
    (*d*) Its expression is masked by the normal allele

50. Which of the following is a post zygotic isolating mechanism in speciation?
    (*a*) Isolation by hybrid sterility
    (*b*) Seasonal isolation
    (*c*) Behavioural isolation
    (*d*) Geographical isolation

51. The phenomenon of genetic drift is most likely to occur in populations that
    (*a*) Are allopatric
    (*b*) Are undergoing gene flow
    (*c*) Are small and interbred
    (*d*) Have great reproductive potential

52. The resemblance of body structures and mode of life of some species of Australian marsupials to certain species of placental mammals is an example of
    (*a*) Convergent evolution
    (*b*) Punctuated equilibrium
    (*c*) Sequential evolution
    (*d*) Polymorphism

53. If one compares the primary structure of the protein cytochrome c in organisms that are separated in evolutionary time, e.g, humans and yeast, one discovers that
    (*a*) Hydrophilic amino acids are usually substituted fro hydrophobic amino acids
    (*b*) The overall primary and tertiary structure of molecule is quite different
    (*c*) The proteins have evolved different functions
    (*d*) Considerable sequences similarity exist between the two proteins

54. Which of the following genotypes would produce the greatest variety of gametes of the alleles assorted independently?
    (*a*) aaBBCcDd (*b*) aabbCCDD
    (*c*) AaBbCCDd (*d*) AABBCCDD

55. Which of the following is most likely to reduce competition in sympatric, closely related species
    (*a*) Darwinian fitness
    (*b*) Kin selection
    (*c*) Niche overlap
    (*d*) Character displacement

56. It is now thought that the atmosphere of the primitive Earth was composed largely of carbon dioxide, nitrogen, and water vapor. The composition of certain iron-containing minerals suggest that the carbon dioxide began to be replaced by oxygen about 2 billion years ago. Which of the following is the best explanation for the change in atmospheric composition?
   (*a*) Ozone produced in the upper atmosphere by UV light broke down to oxygen
   (*b*) Minerals such as iron oxide released oxygen into atmosphere
   (*c*) Oxygen was present in volcanic gases and slowly accumulated with time
   (*d*) Photosynthesis was established in primitive bacteria

57. The amino acids in the amino acid sequence of the polypeptide chain of human proteins differs from those of chimpanzee by approximately what percent?
   (*a*) 99% (*b*) 49%
   (*c*) 9% (*d*) 1%

58. An evolutionary benefit of sexual reproduction is that
   (*a*) It provides a mechanism of genetic recombination.
   (*b*) It requires a lower level of resource investment than asexual does
   (*c*) The offspring will resemble their parents genetically
   (*d*) The reproductive success rates are less variable than for asexual reproduction

59. The unit of life in which biological evolution actually occurs is usually considered to be the
   (*a*) Whole organism (*b*) Population
   (*c*) Species (*d*) Community

60. It has been proposed that mitochondria and chloroplast evolved from certain bacteria that existed as endo-symbiotic organism in early cells. Which of the following will best support this hypothesis-?
   (*a*) Both organelles contain DNA molecule
   (*b*) Both organelles have microtubules
   (*c*) Both organelles lacks mRNA
   (*d*) Only chloroplast can synthesize some proteins

61. Which of following plant hormones hasten the apple ripening?
   (*a*) Auxins (*b*) Gibberellin
   (*c*) Abscisic acid (*d*) Ethylene

62. All if the following are responses of the vertebrate egg to fusion with the male gamete EXCEPT
   (*a*) Completion of maturation (meiotic division)
   (*b*) Loss of the ability to undergo mitosis
   (*c*) Transient elevation of intracellular free calcium
   (*d*) Fusion of male and female pronuclei

63. Which of the following is secreted principally by the corpus luteum of the human ovary?
    (*a*) Luteinizing hormone
    (*b*) Follicle stimulating hormone
    (*c*) Gondotropin releasing factor and estrogen
    (*d*) Progesterone

64. Blood fibrinogen is converted into fibrin during
    (*a*) Immune response (*b*) Oxygen transport
    (*c*) Glucose regulation (*d*) Clot formation

65. All of the following are found in vertebrate smooth muscles EXCEPT
    (*a*) Sarcomeres (*b*) Thin filaments
    (*c*) Thick filaments (*d*) Tropomyosin

66. A vitamin that has an important role in the formation of collagen fibres and prevention of scurvy is
    (*a*) Thiamin (*b*) Riboflavin
    (*c*) Ascorbic acid (*d*) Tocopherol

67. In mammals, which of the following are produced after rearrangement of DNA sequence in specific cells?
    (*a*) Hemoglobins (*b*) Actins
    (*c*) Antibodies (*d*) Trypsins

68. In a cross between a pure bred, red-eyed female fruit fly and a white-eyed male, what percent of the male offspring will have white eyes? (white eyes are X-linked, recessive)
    (*a*) 100% (*b*) 75%
    (*c*) 50% (*d*) 0%

69. Hemophilia in humans is due to an X-chromosome mutation. What will be the results of mating between a normal (non-carrier) female and a hemophilac male?
    (*a*) Half of daughters are normal and half of sons are hemophilic.
    (*b*) All sons are normal and all daughters are carriers.
    (*c*) Half of sons are normal and half are hemophilic; all daughters are carriers.
    (*d*) Half of daughters are hemophilic and half of daughters are carriers; all sons are normal.

70. Two unlinked loci effect mouse hair color. AA or Aa mice are agouti. Mice with genotype aa are albino because all pigment production is blocked, regardless of the phenotype at the second locus. At the second locus, the B allele (agouti coat) is dominant to the b allele (black coat). What would be the result of a cross between two agouti mice of genotype AaBb?
    (*a*) 4 agouti: 4 black: 8 albino
    (*b*) 9 agouti: 3 black: 3 albino: 1 grey
    (*c*) 9 agouti: 3 black: 4 albino
    (*d*) 8 agouti: 4 black: 4 albino

Model Test Paper – 4

PART-A

1. Three numbers x, y, z are in geometric progression. If the sum of the three numbers is 26 and the largest of the three number is 9 times that of the small number, then the values of largest number is-
   (*a*) 20 (*b*) 18.
   (*c*) 15 (*d*) 10

2. An electric beam can deflect-
   (*a*) X-rays (*b*) α-rays
   (*c*) γ-rays (*d*) neutron beam

3. The half life of the first order reaction is 60 sec. After the first three minutes the percentage of reactant remaining is-
   (*a*) 7.5 % (*b*) 15 %
   (*c*) 25 % (*d*) 12.5 %

4. Aspirin is chemically-
   (*a*) Methyl benzoate (*b*) Ethyl salicate
   (*c*) Acetyl salicylic acid (*d*) o-hydorxybenzoic acid

5. Phosphorus normally exhibits a covalency of-
   (*a*) +3 and +5 (*b*) +1 and +3
   (*c*) +2 and +3 (*d*) +3 and +4

6. The reaction of ethanol, with a series of inorganic acid is studied. What is order of reactivity of halogens acid with ethanol-
   (*a*) HCl>HBr>HI (*b*) HI>HBr>HCl
   (*c*) HBr>HI>HCl (*d*) HBr>HCl>HI

7. A beam of monochromatic blue light of wavelength 4200 Å in air travels in water (refractive index = 4/3). Its wavelength in water will be-
   (*a*) 2800 Å (*b*) 5600 Å
   (*c*) 3150 Å (*d*) 4200 Å

8. Which of the following has the highest percentage of ionic character in its bonding-
   (*a*) Licl (*b*) $BeCl_2$
   (*c*) CsF (*d*) CsCl

9. When the temperature of a chemical reaction is increased, there is increase in the-
   (*a*) Enthalpy (*b*) Entropy
   (*c*) Free energy (*d*) Heat capacity

10. If the six amino acids in succession form a hexapeptide, the resulting structure will have-
   (*a*) Six peptide bond and six Ca atoms
   (*b*) Five peptide bond and six Ca atoms
   (*c*) Five peptide bond and five Ca atoms
   (*d*) Six peptide bond and five Ca atoms

11. For the following algolrithm, what is value of x on completion of the code-

```
    x=0
    i=0
    j=10
do while i<10
    x=i+j
    i=i+1
    j=j–1
end do
```

   (*a*) 100 (*b*) 135
   (*c*) 0 (*d*) 9

12. The geometry and the type of hybrid orbital present around the centre in BF_3 is
   (*a*) linear, sp (*b*) trigonal planner, sp^2
   (*c*) tetrahedral, sp^3 (*d*) pyramidal, sp^3

13. The electronic configuration of an element is 1s2, 2s2, 2p6, 3s2, 3P6, 3d5, and 4s1. This represent its
   (*a*) Excited state (*b*) Ground state
   (*c*) Cationic form (*d*) Anionic form

14. In bioinformatics BLAST means
   (*a*) Basic Local Alignment Search Tool
   (*b*) Bioinformatics Local Alignment Search Test
   (*c*) Biological Logarithmic Alignment Search Tool
   (*d*) Basic Local Alignment Software Throughput

15. Potassium permanganate is a/an – agent
   (*a*) reducing (*b*) alkylating
   (*c*) oxidizing (*d*) None

16. Unit for the measure of conductance is
    (*a*) volt (*b*) mho
    (*c*) amp (*d*) ohm

17. Which of the following is coldest?
    (*a*) North pole (*b*) Siberia
    (*c*) Liquid nitrogen (*d*) Dry ice

18. Which one of the five choices makes the best comparison? LIVED is to DEVIL as 6323 is to
    (*a*) 2336 (*b*) 6232
    (*c*) 3326 (*d*) 3236

19. Which number should come next?
    144 : 12 1 : 100 : 81 : 64 : ?
    (*a*) 17 (*b*) 19
    (*c*) 36 (*d*) 49

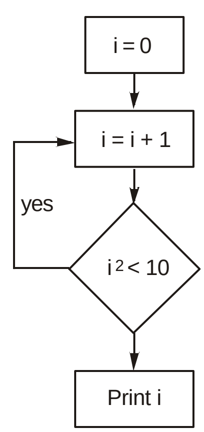
20. From a garden two girls collect 25 flowers. Hema collects four times as many as Jaya did How many flowers did Jaya collect?
    (*a*) 4 (*b*) 5
    (*c*) 8 (*d*) 10

21. A boy is 4 years old and his sister is three times as old as he is. When the boy is 12 years old, how old will his sister be?
    (*a*) 16 (*b*) 20
    (*c*) 24 (*d*) 36

22. In a Redox reaction involving two molecules
    (a) both lose electrons
    (b) one molecule loses electron and is reduced while the other gains electrons
    (c) one molecule loses electrons and is oxidized while the other gains electrons
    (d) one molecule gains electrons and is oxidized while the other loses electrons

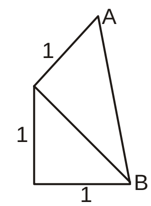
23. Which of the following compounds would you expect to be most soluble in water?
    (a) $CH_3–CH_2–OH$
    (b) $CH_2–CH_2–CH_2–CH_2–OH$
    (c) $CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–OH$
    (d) $CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–OH$

24. What would be the output of following program
    (*a*) 2
    (*b*) 3
    (*c*) 4
    (*d*) 5

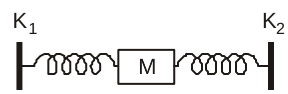


25. If an integer occupies five character in its binary form. The number of characters required for its decimal form will be-
    (*a*) 1 (*b*) 2
    (*c*) 3 (*d*) 4

26. The distance between point A and B will be-
    (*a*) $\sqrt{2}$
    (*b*) 3
    (*c*) $3\sqrt{3}$
    (*d*) $\sqrt{3}$



27. A wooden box of mass M is suspended between two springs having spring constant K1 and K2. Both springs are fixed to walls. If the wooden block is displaced along (+) X-axis then the time period for oscillation will be-
    (*a*) $T = 2\pi\sqrt{m/k1 + k2}$
    (*b*) $T = 2\pi\sqrt{m(k1/k2)\ g}$
    (*c*) $T = 2\pi\sqrt{m(k1 - k2)^2/g}$
    (*d*) $T = 2\pi\sqrt{(k1 - k2)/m}$



28. A satellite is revolving around an planet with orbital radius R. If mean density of planet is r and universal gravitational constant is G. Then the orbital velocity will depend on-
    (*a*) G & r (*b*) r & R
    (*c*) G, R & r (*d*) only on R

29. Given $y = a^x . \dfrac{dy}{dx} =$
    (*a*) xa^{x-1} (*b*) $1/a^x$
    (*c*) $a^x \ln a$ (*d*) None of the above

30. Recently Govt. of India has allowed mixing of alcohol in petrol. What is the amount of alcohol permitted for mixing in petrol?
    (*a*) 2.5% (*b*) 10 – 15%
    (*c*) 10% (*d*) 5%

PART – B

1. One of the parents of a cross has a mutation in its mitochondria. In that cross, that parent is taken as a male. During segregation of F_2 progenies that mutation is found in
    (*a*) one-third of the progenies
    (*b*) none of the progenies
    (*c*) all the progenies
    (*d*) fifty percent of the progenies

2. When a fresh-water protozoan possessing a contractile vacuole, is placed in a glass containing marine water, the vacuole will
   (*a*) Increase in number (*b*) Disappear
   (*c*) Increase in size (*d*) Decrease in size

3. One of the following is a very unique feature of the mammalian body:
   (*a*) Homeothermy
   (*b*) Presence of diaphragm
   (*c*) Four chambered heart
   (*d*) Rib cage

4. Chemically hormones are
   (*a*) Biogenic amines only
   (*b*) Proteins, steroids and biogenic amines
   (*c*) Proteins only
   (*d*) Steroids only

5. Which one of the following pairs is not correctly matched?
   (*a*) Vitamin B12 - Pernicious anaemia
   (*b*) Vitamin B6 - Loss of appetite
   (*c*) Vitamin B1 - Beri-beri
   (*d*) Vitamin B2 - Pellagra

6. Duodenum has characteristic Brunner's glands which secrete two hormones called
   (*a*) Kinase, estrogen
   (*b*) Secretin, cholecystokinin
   (*c*) Prolactin, parathormone
   (*d*) Estradiol, progesterone

7. Mast cells of connective tissue contain
   (*a*) Vasopressin and relaxin (*b*) Heparin and histamine
   (*c*) Heparin and calcitonin (*d*) Serotonin and melanin

8. Cancer cells are more easily damaged by radiation than normal cells because they are
   (*a*) Starved of mutation (*b*) Undergoing rapid division
   (*c*) Different in structure (*d*) Non-dividing

9. ATPase enzyme needed for muscle contraction is located in
   (*a*) Actinin (*b*) Troponin
   (*c*) Myosin (*d*) Actin

10. Which one of the following pairs is not correctly matched?
    (*a*) Streptomyces - Antibiotic
    (*b*) Serratia - Drug addiction
    (*c*) Spirulina - Single cell protein
    (*d*) Rhizobium - Biofertilizer

11. A free living nitrogen-fixing cyanobacterium which can also form symbiotic association with the water fern Azolla is
    (*a*) Tolypothrix (*b*) Chlorella
    (*c*) Nostoc (*d*) Anabaena

12. In the ABO system of blood groups, if both antigens are present but no antibody, the blood group of the individual would be
    (*a*) B (*b*) O
    (*c*) AB (*d*) A

13. Which one of the following pairs correctly matches a hormone with a disease resulting from its deficiency?
    (*a*) Luteinizing hormone - Failure of ovulation
    (*b*) Insulin- Diabetes insipidus
    (*c*) Thyroxine - Tetany
    (*d*) Parathyroid hormone - Diabetes mellitus

14. In a mutational event, when adenine is replaced by guanine, it is a case of
    (*a*) Frame shift mutation (*b*) Transcription
    (*c*) Transition (*d*) Transversion

15. Which of the following hormones is not a secretion product of human placenta?
    (*a*) Human chorionic gonadotropin
    (*b*) Prolactin
    (*c*) Estrogen
    (*d*) Progesterone

16. You are required to draw blood from a patient and to keep it in a test tube for analysis of blood corpuscles and plasma. You are also provided with the following four types of test tubes. Which of them will you not use for the purpose?
    (*a*) Test tube containing calcium bicarbonate
    (*b*) Chilled test tube
    (*c*) Test tube containing heparin
    (*d*) Test tube containing sodium oxalate

17. What is a keystone species?
    (*a*) A species which makes up only a small proportion of the total biomass of a community, yet has a huge impact on the community's organisation and survival
    (*b*) A common species that has plenty of biomass, yet has a fairly low impact on the community's organization
    (*c*) A rare species that has minimal impact on the biomass and on other species in the community
    (*d*) A dominant species that constitutes a large proportion of the biomass and which affects many other species

18. DNA fingerprinting refers to
    (*a*) Molecular analysis of profiles of DNA samples
    (*b*) Analysis of DNA samples using imprinting devices
    (*c*) Techniques used for molecular analysis of different specimens of DNA
    (*d*) Techniques used for identification of fingerprints of individuals

19. Flagella of prokaryotic and eukaryotic cells differ in
    (*a*) Type of movement and placement in cell
    (*b*) Location in cell and mode of functioning
    (*c*) Microtubular organization and type of movement
    (*d*) Microtubular organization and function

20. The animals with bilateral symmetry in young stage, and radial pentamerous symmetry in the adult stage, belong to the phylum
    (*a*) Annelida (*b*) Mollusca
    (*c*) Cnidaria (*d*) Echinodermata

21. Lack of independent assortment of two genes A and B in fruit fly Drosophila is due to
    (*a*) Repulsion (*b*) Recombination
    (*c*) Linkage (*d*) Crossing over

22. In your opinion, which is the most effective way to conserve the plant diversity of an area?
    (*a*) By tissue culture method
    (*b*) By creating biosphere reserve
    (*c*) By creating botanical garden
    (*d*) By developing seed bank

23. Which of the following is expected to have the highest value (gm/m2/yr) in a grassland ecosystem?
    (*a*) Secondary Production
    (*b*) Tertiary Production
    (*c*) Gross Production (GP)
    (*d*) Net Production (NP)

24. If by radiation all nitrogenase enzymes are inactivated, then there will be no
    (*a*) Fixation of nitrogen in legumes
    (*b*) Fixation of atmospheric nitrogen
    (*c*) Conversion from nitrate to nitrite in legumes
    (*d*) Conversion from ammonium to nitrate in soil

25. Age of fossils in the past was generally determined by radio-carbon method and other methods involving radioactive elements found in the rocks. More precise methods, which were used recently and led to the revision of the evolutionary periods for different groups of organisms, includes
    (*a*) Study of carbohydrates/proteins in fossils
    (*b*) Study of the conditions of fossilization

(*c*) Electron spin resonance (ESR) and fossil DNA
(*d*) Study of carbohydrates/proteins in rock

26. What kind of evidence suggested that man is more closely related with chimpanzee than with other hominoid apes?
(*a*) Evidence from DNA from sex chromosomes only
(*b*) Comparison of chromosomes morphology only
(*c*) Evidence from fossil remains, and the fossil mitochondrial DNA alone
(*d*) Evidence from DNA extracted from sex chromosomes, autosomes and mitochondria

27. An ecosystem which can be easily damaged but can recover after some time if damaging effect stops will be having
(*a*) Low stability and high resilience
(*b*) High stability and low resilience
(*c*) Low stability and low resilience
(*d*) High stability and high resilience

28. During transcription, if the nucleotide sequence of the DNA strand that is being coded is ATACG then the nucleotide sequence in the mRNA would be
(*a*) TATGC (*b*) TCTGG
(*c*) UAUGC (*d*) UATGC

29. Extranuclear inheritance is a consequence of presence of genes in
(*a*) Mitochondria and chloroplasts
(*b*) Endoplasmic reticulum and mitochondria
(*c*) Ribosomes and chloroplast
(*d*) Lysosomes and ribosomes

30. Viruses that infect bacteria, multiply and cause their lysis, are called
(*a*) Lysozymes (*b*) Lipolytic
(*c*) Lytic (*d*) Lysogenic

31. The recessive genes located on X-chromosome in humans are always
(*a*) Lethal
(*b*) Sub-lethal
(*c*) Expressed in males
(*d*) Expressed in females

32. In C_3 plants, the first stable product of photosynthesis during the dark reaction is
(*a*) Malic acid
(*b*) Oxaloacetic acid
(*c*) 3-phosphoglyceric acid
(*d*) Phosphoglyceraldehyde

33. Crossing over that results in genetic recombination in higher organisms occurs between
    (*a*) Sister chromatids of a bivalent
    (*b*) Non-sister chromatids of a bivalent
    (*c*) Two daughter nuclei
    (*d*) Two different bivalents

34. Which of the following statements is not true for retroviruses?
    (*a*) DNA is not present at any stage in the life cycle of retroviruses
    (*b*) Retroviruses carry gene for RNA-dependent DNA polymerase
    (*c*) The genetic material in mature retroviruses is RNA
    (*d*) Retroviruses are causative agents for certain kinds of cancer in man

35. Restriction endonucleases
    (*a*) Aare present in mammalian cells for degradation of DNA when the cell dies
    (*b*) Are used in genetic engineering for ligating two DNA molecules
    (*c*) Are used for in vitro DNA synthesis
    (*d*) Sre synthesized by bacteria as part of their defense mechanism

36. In glycolysis, during oxidation electrons are removed by
    (*a*) ATP
    (*b*) glyceraldehyde-3-phosphate
    (*c*) NAD+
    (*d*) molecular oxygen

37. Phenetic classification of organisms is based on
    (*a*) Observable characteristics of existing organisms
    (*b*) The ancestral lineage of existing organisms
    (*c*) Dendrogram based on DNA characteristics
    (*d*) Sexual characteristics

38. The Ti plasmid, is often used for making transgenic plants. This plasmid is found in
    (*a*) Azotobacter
    (*b*) Rhizobium of the roots of leguminous plants
    (*c*) Agrobacterium
    (*d*) Yeast as a 2 μm plasmid

39. In a plant, red fruit (R) is dominant over yellow fruit (r) and tallness (T) is dominant over shortness (t). If a plant with RRTt genotype is crossed with a plant that is rrtt,
    (*a*) 25% will be tall with red fruit
    (*b*) 50% will be tall with red fruit
    (*c*) 75% will be tall with red fruit
    (*d*) All the offspring will be tall with red fruit

40. Which one of the following precedes re-formation of the nuclear envelope during M phase of the cell cycle?
    (*a*) Decondensation from chromosomes, and reassembly of the nuclear lamina
    (*b*) Transcription from chromosomes, and reassembly of the nuclear lamina
    (*c*) Formation of the contractile ring, and formation of the phragmoplast
    (*d*) Formation of the contractile ring, and transcription from chromosomes

41. A normal woman, whose father was colour-blind is married to a normal man. The sons would be
    (*a*) 75% colour-blind
    (*b*) 50% colour-blind
    (*c*) All normal
    (*d*) All colour-blind

42. In the amino acid GLY, the Cα atom is connected to one carboxyl group, one amino group and two hydrogen bonds. The H-Cα-H bond angle is likely to be close to-
    (*a*) 1800 (*b*) 900
    (*c*) 109.50 (*d*) 1200

43. In which of the following structure, you are likely to see non-watson crick base pairs-
    (*a*) B-DNA (*b*) A-DNA
    (*c*) Z-DNA (*d*) t-RNA

44. In the structure of ideal Watson -crick B-DNA
    (*a*) Base pairs are perpendicular to the helix axis
    (*b*) Base pairs are parallel to the helix axis
    (*c*) Base pairs are inclined with respect of the helix axis
    (*d*) Hydrogen bond between bases are perpendicular to the helix axis

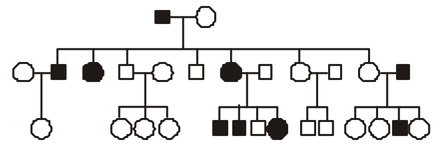
45. If the side R groups of alternate aminoacids along a polypeptide strand points in opposite direction then the secondary structure of polypeptide stretch should be-
    (*a*) α-helix (*b*) 310 -helix
    (*c*) β-strand (*d*) Random coil

46. The peptide ITVNGKTY can take up the following three structures-
    A. all 8 amino acids are in α-helix conformation
    B. all 8 amino acids are in β-helix conformation
    C. all 8 amino acids are in 310-helix conformation

    Arrange the structure in decreasing order of their N to terminal distances-
    (*a*) ABC (*b*) BCA
    (*c*) CAB (*d*) BAC (changed)

47. The phospholipids which form a membrane bilayer are-
    (*a*) Completely non-polar molecules
    (*b*) Completely polar groups
    (*c*) Ampipathic molecules with polar head group and hydrophobic tail
    (*d*) None of the above

48. In the pedigree above, circles denotes females, squares denote males, and shaded figures denote individual expressing a specific trait. Which of the following is most probable mode of inheritance of this trait?



(*a*) Simple Mendelian dominant
(*b*) Simple Mendelian recessive
(*c*) Codominant relationship of a single pair of alleles
(*d*) X-linked dominant transmission

49. Catabolite repression in *E. coli* bacteria, involving the catabolite activator protein (CAP), is actually a type of positive regulation, because
(*a*) cAMP-CAP helps RNA polymerase to initiate transcription
(*b*) cAMP-CAP prevents RNA polymerase from initiating transcription
(*c*) Glucose stimulates the production of cAMP
(*d*) Glucose binds CAP and inactivates it

50. The rate at which a DNA fragment moves in an electrophoretic gel is primarily a function of the fragment's
(*a*) Length
(*b*) Double helical structure
(*c*) Degree of methylation
(*d*) Adenine content

51. Mitochondria and chloroplast carry out oxidative phosphorylation and photo phospho -rylation, respectively, by means of
(*a*) Conformational coupling
(*b*) Chemiosmotic coupling
(*c*) High energy intermediate coupling
(*d*) Sliding filaments

52. C_4 plants, by decreasing photorespiration and efficiency carrying out photosynthesis, can
(*a*) Decrease stomatal openings and thereby reduce the water loss.
(*b*) Decrease stomatal opening and thereby reduce the leaf temperature
(*c*) Increase stomatal opening and thereby increase water loss
(*d*) Increase stomatal opening and thereby increase transpiration rates

53. Which of the following adaptation appeared for first time in the common ancestor of the mammals, birds, and modern reptiles?
(*a*) Membranous lungs
(*b*) Internal nostrils
(*c*) Tetrapod limbs
(*d*) Amniotic eggs

54. Intron-free genes can be obtained through:
(*a*) Inverse-transcription
(*b*) Direct transcription

(*c*) Reverse transcription
(*d*) Sequence transcription

55. According to inducible operon concept, an operator gene combines with:
(*a*) Inducer gene to switch on transcription
(*b*) Regulator protein to switch off transcription
(*c*) Regulator gene to switch off transcription
(*d*) Regulator protein to switch on transcription

56. The peptide, Gly - lie - Met - Lys -Glu - Phe, upon treatment with Trysin produces:
(*a*) Gly-Ile-Met+ Lys-Glu-Phe
(*b*) Gly-Ile-Met-Lys+Glu-Phe
(*c*) Gly- lie + Met-Lys-Glu-Phe
(*d*) All of the above

57. Ouabain inhibits the Na+/K+ pump by:
(*a*) Binding toNa^+- binding site
(*b*) Binding to K^+- binding site
(*c*) Binding to ATP binding site
(*d*) None

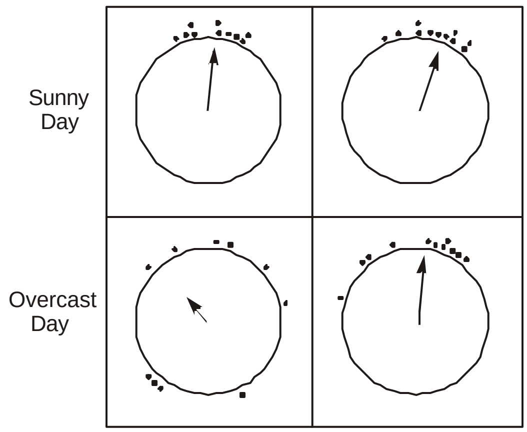
58. When [S] = KM, the velocity of an enzyme catalyzed reaction is about:
(*a*) $0.1 \times V_{max}$
(*b*) $0.2 \times V_{max}$
(*c*) $0.3 \times V_{max}$
(*d*) $0.5 \times V_{max}$

59. Many enzymes require cofactors to function. Many of these cofactors are vitamins. Which of the following statements is NOT true?
(*a*) Fe, Zn, Cu, Mg, Mn, K, Ni, and Mo are classified as vitamins
(*b*) Humans have lost the ability to synthesize vitamins
(*c*) Vitamins are modified by the body to form coenzymes
(*d*) There are 2 classes of vitamins: water-soluble and fat-soluble

60. The first antibody synthesized by the fetus:
(*a*) IgG
(*b*) IgA
(*c*) IgM
(*d*) IgE

61. Multimeric forms may contain a secretary component:
(*a*) Ig A &IgD
(*b*) IgD & IgG
(*c*) IgG & IgE
(*d*) IgA & IgM

62. In the diagram above, the centre of each circle represents the location at which homing pigeons were released. The top of each circle is the homeward direction, each dot represents the direction taken by the one bird, and the arrows represents the statistical average if the chosen directions. The bird in left-hand circle were equipped with the magnets that prevented them from detecting the Earth's magnetic field. This experiment demonstrated that homing pigeons



(*a*) can navigate only on sunny days
(*b*) can use either the sun or earth's magnetic field as navigational aids
(*c*) use only the sun as a compass for navigation
(*d*) lose navigational ability when magnet are attached to them

63. Two populations of land snails have been effectively isolated from each other for a long period. According to the biological species concept, which of the following would demonstrate that the two populations have become separate species?
(*a*) The two populations behave differently when subjected to same dose of pesticides
(*b*) Sterile hybrids are produced when member of the two populations are experimentally mated
(*c*) DNA nucleotide sequence are different between two populations
(*d*) The two populations have different electrophoretic pattern of proteins

64. Behaviour by an individual that confers evolutionary benefits to a recipient at no evolutionary cost to donor because the recipient delivers benefits to the donor at some later time and behavior by an individual that increases the fitness of recipients but lowers the fitness of donor are termed as
(*a*) Reciprocity and Altruism
(*b*) Cooperation and Spite
(*c*) Nepotism and Kin selection
(*d*) Symbiosis and Predation

65. The birds in tropics are generally smaller in size because of-
    (*a*) To increase surface area to volume ratio
    (*b*) To decrease surface area to volume ratio
    (*c*) For easy flight
    (*d*) Aestivation

66. In an pond ecosystem, net productivity by zooplankton is ‘p’ and biomass consumed by small fishes is ‘c’, then the ratio of c/p is termed as-
    (*a*) Assimilation efficiency
    (*b*) Net secondary productivity
    (*c*) Consumption efficiency
    (*d*) Conversion efficiency

67. For climax which statement is INCORRECT?
    (*a*) Number of perennial species increases
    (*b*) Dependency on detritious food chain increases
    (*c*) Vertical stratification of community increases
    (*d*) Exploitation competition is more then normal competition

68. At present, the relationship between human and monkey can be stated as
    (*a*) They both have common ancestors
    (*b*) Human have evolved from monkey
    (*c*) Both have very distinct phylogeny
    (*d*) Relationship can not be established

69. Most of new species are formed by the process of -
    (*a*) Anagenesis (*b*) Cladogenesis
    (*c*) Sympatric speciation (*d*) Phylogenetic evolution

70. First organism evolved on earth were-
    (*a*) Aerobic heterotrophs
    (*b*) Anaerobic heterotrophs
    (*c*) Aerobic autotrophs
    (*d*) Anaerobic autrotrophs

MODEL TEST PAPER – 5

PART – A

1. Three students are picked at random from a school having a total of 1000 students. The probability that these three students will have identical date and month of their birth is:

   (*a*) 3/1000 (*b*) 3/365

   (*c*) $1/(365)^2$ (*d*) $1/(365)^3$

2. In how many different ways can six players be arranged in a line such that two of them, Ajit and Mukherjee, are never together?

   (*a*) 120 (*b*) 240

   (*c*) 360 (*d*) 480

3. A and B together can do a piece of work in 12 days, which B and C together can do in 16 days. After A has been working at it for 5 days and B for 7 days, C finishes in 13 days. In how many days C alone will do the work.

   (*a*) 16 (*c*) 24

   (*c*) 36 (*d*) 48

4. A spherical body moves with a uniform angular velocity w around a circular path of radius r. Which one of the following statements is correct?

   (*a*) The body has no acceleration

   (*b*) The body has a radial acceleration directed directed towards the centre of the path

   (*c*) The body has a radial acceleration directed away from the centre of the path

   (*d*) The body has an acceleration tangential to its path

5. Consider the following geological phenomea:
   1. Development of a fault
   2. Movement along a fault
   3. Impact produced by volcanic eruption
   4. Folding of rocks

   Which of the above cause earthquakes?

(*a*) 1, 2 and 3 (*b*) 2 and 4
(*c*) 1, 3 and 4 (*d*) 1, 2, 3 and 4

6. Two cars X and Y start from two places A and B respectively which are 700 km apart at 9 a.m. Both the cars run at an average speed of 60 km/hr. Car X stops at 10 a.m. and again starts at 11 a.m. while the other car Y continues to run without stopping. When do the two cars cross each other?
   (*a*) 2 : 40 p.m. (*b*) 3 : 20 p.m.
   (*c*) 4 : 10 p.m (*d*) 4 : 20 p.m.

7. Nine different letters are to be dropped in three different letter boxes. In how many different ways can this be done?
   (*a*) 27 (*b*) 39
   (*c*) 93 (*d*) 69

8. A person stands at the middle point of a wooden ladder which starts slipping between a vertical wall and the floor of a room, while continuing to remain in a vertical plane. The path traced by a person standing at the middle point of the slipping ladder is
   (*a*) A straight line (*b*) An elliptical path
   (*c*) A circular path (*d*) A parabolic path

9. How many 3 digit numbers can be formed with the digits 2, 3, 5, 7 and 9 if the digits are not repeated
   (*a*) 60 (*b*) 90
   (*c*) 210 (*d*) 405

10. Param Padma, which was in news recently, is
    (*a*) A new Civilian Award instituted by the Government of India
    (*b*) The name of supercomputer developed by India
    (*c*) The name given to a proposed network of canals linking northern and southern rivers of India
    (*d*) A software programme to facilitate e-governance in Madhya Pradesh

11. A weightless rubber balloon is filled with 200 cc of water. Its weight in water is equal to
    (*a*) 2 g (*b*) 200 mg
    (*c*) 200 microgram (*d*) Zero

12. Consider the following statements:
    1. Smart Card is a plastic card with an embedded microchip.
    2. Digital technology is primarily used with new physical communication medium such as satellite and fibre optics transmission.
    3. A digitial library is a collection of documents in an organized electronic form available on the Internet only.

    Which of the statements given above is /are correct?
    (*a*) 3 only (*b*) 1 and 2
    (*c*) 2 and 3 (*d*) 1, 2 and 3

13. Consider the following statements:
    1. Femur is the longest bone in the human body.
    2. Cholera is a disease caused by bacteria.
    3. 'Athlete's foot' is a disease caused by virus.

    Which of the statements given above are correct?
    (*a*) 1 and 2 (*b*) 2 and 3
    (*c*) 1 and 3 (*d*) 1, 2 and 3

14. Salts of which of the following elements provide colours to fireworks?
    (*a*) Zinc and Sulphur
    (*b*) Potassium and mercury
    (*c*) Strontium and barium
    (*d*) Chromium and nickel

15. Match List-I (Biosphere Reserves) with List-II (States) and select the correct answer using the codes given below the Lists:

List-I (Biosphere Reserves)	List-II (States)
A. Similipal	1. Sikkim
B. Dehong Deband	2. Uttaranchal
C. Nokrek	3. ArunachalPradesh
D. Kanchenjunga	4. Orissa
	5. Meghalya

    (*a*) ABCD – 1354 (*b*) ABCD – 4521
    (*c*) ABCD – 1524 (*d*) ABCD – 4351

16. In which organ of the human body are the lymphocyte cells formed?
    (*a*) Liver (*b*) Long bone
    (*c*) Pancreas (*d*) Spleen

17. Which one of the following statements is correct?
    (*a*) Cirrus clouds are composed of ice crystals
    (*b*) Cirrus clouds exhibit a flat base and have the appearance of rising domes
    (*c*) Cumulus clouds are white and thin, and form delicate patches and give a fibrous and feathery appearance
    (*d*) Cumulus clouds are classified as high clouds

18. Which one of the following statements is not correct?
    (*a*) Gulfs with narrow fronts and wider rears experience high tides
    (*b*) Tidal currents take place when a gulf is connected with the open sea by a narrow channel
    (*c*) Tidal bore occurs when a tide enters the narrow and shallow estuary of a river
    (*d*) The tidal nature of the mouth of the river Hooggly is of crucial importance to Kolkata as port

19. A car is running on a road at uniform speed of 60 km/hr. The net resultant force on the car is:
    (*a*) Driving force in the direction of car's motion
    (*b*) Resistance force in the direction of car's motion
    (*c*) An inclined force
    (*d*) Equal to zero

20. Jupiter's mass is mostly made up of:
    (*a*) Helium (*b*) Argon
    (*c*) Hydrogen (*d*) Xenon

21. The southwest monsoon occurs over major parts of India in the months from June to September. The main cause of the monsoon:
    (*a*) The land is cooler than the sea
    (*b*) The centrifugal force deflects the wind
    (*c*) The land is warmer than the sea
    (*d*) Wind blows from North-east to south-west

22. Nitric acid does not react with :
    (*a*) Copper (*b*) Silver
    (*c*) Iron (*d*) Gold

23. Silver halides are used in photo-graphic plates because they are:
    (*a*) Oxidised in air
    (*b*) Colourless
    (*c*) Easily soluble in hypo solution
    (*d*) Readily reduced by light

24. The theory of ionization was given by
    (*a*) Rutherford (*b*) Cavendish
    (*c*) Arrhenius (*d*) Faraday

25. Heavy water (Deuterium, D_2O)is usually prepared from:
    (*a*) Heavy hydrogen (*b*) Sea water only
    (*c*) River water only (*d*) Ordinary water

26. A number of images of a candle flame can be seen in a thick mirror. The brightest image is
    (*a*) First (*b*) Second
    (*c*) Third (*d*) Last

27. Hydrogen bomb is based on the phenomenon of:
    (*a*) Nuclear fusion
    (*b*) Nuclear fission
    (*c*) Nuclear reaction
    (*d*) None of the above

28. Sound is transmitted by longitudinal waves of compression and rarefaction through an elastic medium. What might the quality of sound be when the listener is at a great distance from the source as compared to being very close?
   (*a*) The high-frequency component will be reduced
   (*b*) The low frequency component will be reduced
   (*c*) All frequencies will be reduced to the same extent
   (*d*) There will be no difference

29. Viruses can disable computers. A computer virus can be transmitted one machine to another if:
   (*a*) They are used to run similar application
   (*b*) They are used by same programme
   (*c*) Floppy disks are exchanged between different computer
   (*d*) They use different operating system

30. An atomic orbital having the quantum no. n=1 and l=1 will have the shape of:
   (*a*) Ellipsoid (*b*) Dumb-bell
   (*c*) Cone (*d*) Sphere

PART – B

1. When CO_2 concentration in blood increases, breathing becomes
   (*a*) Shallower and slow
   (*b*) There is no effect on breathing
   (*c*) Slow and deep
   (*d*) Faster and deeper

2. Certain characteristic demographic features of developing countries are
   (*a*) High fertility, low or rapidly falling mortality rate, rapid population growth and a very young age distribution
   (*b*) High fertility, high density, rapidly rising mortality rate and a very young age distribution
   (*c*) High infant mortality, low fertility, uneven population growth and a very young age distribution
   (*d*) High mortality, high density, uneven population growth and a very old age distribution

3. Which one of the following is not correctly matched?
   (*a*) *Glossina palpalis* - Sleeping sickness
   (*b*) *Culex pipiens* - Filariasis
   (*c*) *Aedes aegypti* - Yellow fever
   (*d*) *Anopheles culifacies* - leishmaniasis

4. A major component of gobar gas is
   (*a*) Ammonia (*b*) Methane
   (*c*) Ethane (*d*) Butane

5. Angiosperms have dominated the land flora primarily because of their
   (*a*) Power of adaptability in diverse habitat
   (*b*) property of producing large number of seeds
   (*c*) nature of self pollination
   (*d*) domestication by man

6. An ovule which becomes curved so that the nucellus and embryo sac lie at right angles to the funicle is
   (*a*) Hemitropous (*b*) Campylotropous
   (*c*) Anatropous (*d*) Orthotropous

7. Ovulation in the human female normally takes place during the menstrual cycle
   (*a*) at the mid secretory phase
   (*b*) just before the end of the secretory phase
   (*c*) at the beginning of the proliferative phase
   (*d*) At the end of the proliferative phase

8. Injury to vagus nerve in humans is not likely to affect
   (*a*) Tongue movements
   (*b*) gastrointestinal movements
   (*c*) pancreatic secretion
   (*d*) cardiac movements

9. The cardiac pacemaker in a patient fails to function normally. The doctors find that an artificial pacemaker is to be grafted in him. It is likely that it will be grafted at the site of
   (*a*) Atrioventricular bundle
   (*b*) Purkinje system
   (*c*) Sinuatrial node
   (*d*) Atrioventricular node

10. Blood analysis of a patient reveals an unusually high quantity of carboxyhaemoglobin content. Which of the following conclusions is most likely to be correct? The patient has been inhaling polluted air containing unusually high content of
   (*a*) Carbon disulphide (*b*) Chloroform
   (*c*) Carbon dioxide (*d*) Carbon monoxide

11. In which one of the following enzymes, is copper necessarily associated as an activator?
   (*a*) Carbonic anhydrase (*b*) Tryptophanase
   (*c*) Lactic dehydrogenase (*d*) Tyrosinase

12. In Arthropoda, head and thorax are often fused to form cephalothorax, but in which one of the following classes, is the body divided into head, thorax and abdomen?
   (*a*) Insecta
   (*b*) Myriapoda
   (*c*) Crustacea
   (*d*) Arachnida and Crustacea

13. Which one of the following is the correct matching of a vitamin, its nature and its deficiency disease?
    (*a*) Vitamin A - Fat -soluble - Night blindness
    (*b*) Vitamin K - Fat -soluble - Beri -beri
    (*c*) Vitamin A - Fat -soluble - Beri -beri
    (*d*) Vitamin K - Water -soluble - Pellagra

14. In 1984, the Bhopal gas tragedy took place because methyl isocyanate
    (*a*) reacted with DDT
    (*b*) reacted with ammonia
    (*c*) reacted with CO_2
    (*d*) Reacted with water

15. Lead concentration in blood is considered alarming if it is
    (*a*) 20 μg/100 ml (*b*) 30 μg/100 ml
    (*c*) 4 – 6 μg/100 ml (*d*) 10 μg/100 ml

16. Anthesis is a phenomenon which refers to
    (*a*) Reception of pollen by stigma
    (*b*) Formation of pollen
    (*c*) Development of anther
    (*d*) Opening of flower bud

17. One set of a plant was grown at 12 hours day and 12 hours night period cycles and it flowered while in the other set night phase was interrupted by flash of light and it did not produce flower. Under which one of the following categories will you place this plant?
    (*a*) Long day
    (*b*) Darkness neutral
    (*c*) Day neutral
    (*d*) Short day

18. In which one of the following pairs is the specific characteristic of a soil not correctly matched?
    (*a*) Laterite - Contains aluminium compound
    (*b*) Terra rossa - most suitable for roses
    (*c*) Chernozems - Richest soil in the world
    (*d*) Black soil - Rich in calcium carbonate

19. In a longitudinal section of a root, starting from the tip upward, the four zones occur in the following order:
    (*a*) Root cap, cell division, cell enlargement, cell maturation
    (*b*) Root cap, cell division, cell maturation, cell enlargement
    (*c*) Cell division, cell enlargement, cell maturation, root cap
    (*d*) Cell division, cell maturation, cell enlargement, root cap

20. Presence of gills in the tadpole of frog indicates that
    (*a*) fishes were amphibious in the past
    (*b*) fishes evolved from frog -like ancestors
    (*c*) frogs will have gills in future
    (*d*) Frogs evolved from gilled ancestors

21. Which one of the following hormones is a modified amino acid?
    (*a*) Epinephrine (*b*) Progesterone
    (*c*) Prostaglandin (*d*) Estrogen

22. In the resting state of the neutral membrane, diffusion due to concentration gradients, if allowed, would drive
    (*a*) K^+ into the cell (*b*) K^+ and Na^+ out of the cell
    (*c*) Na^+ into the cell (*d*) Na^+ out of the cell

23. The maximum growth rate occurs in
    (*a*) Stationary phase (*b*) Senescent phase
    (*c*) Lag phase (*d*) Exponential phase

24. Diversification in plant life appeared
    (*a*) Due to long periods of evolutionary changes
    (*b*) Due to abrupt mutations
    (*c*) Suddenly on earth
    (*d*) By seed dispersal

25. The technique of obtaining large number of plantlets by tissue culture method is called
    (*a*) Plantlet culture (*b*) Organ culture
    (*c*) Micropropagation (*d*) Macropropagation

26. Cell elongation in internodal regions of the green plants takes place due to
    (*a*) Indole acetic acid (*b*) Cytokinins
    (*c*) Gibberellins (*d*) Ethylene

27. The most abundant element present in the plants is
    (*a*) Carbon (*b*) Nitrogen
    (*c*) Manganese (*d*) Iron

28. Photosynthetically active radiation (PAR) represents the following range of wavelength:
    (*a*) 500 – 600 nm (*b*) 450 – 950 nm
    (*c*) 340 – 450 nm (*d*) 400 – 700 nm

29. A terrestrial animal must be able to
    (*a*) excrete large amounts of water in urine
    (*b*) conserve water
    (*c*) actively pump salts out through the skin
    (*d*) excrete large amounts of salts in urine

30. A male human is heterozygous for autosomal genes A and B and is also hemizygous for hemophilic gene h. What proportion of his sperms will be abh?
    (*a*) 1/8 (*b*) 1 /32
    (*c*) 1 /16 (*d*) 1 /4

31. Edible part of mango is
    (*a*) Endocarp (*b*) Receptacle
    (*c*) Epicarp (*d*) Mesocarp

32. In chloroplasts, chlorophyll is present in the
    (*a*) Outer membrane (*b*) Inner membrane
    (*c*) Thylakoids (*d*) Stroma

33. Dough kept overnight in warm weather becomes soft and spongy because of
    (*a*) Absorption of carbon dioxide from atmosphere
    (*b*) Fermentation
    (*c*) Cohesion
    (*d*) Osmosis

34. In the somatic cell cycle
    (*a*) In G1 phase DNA content is double the amount of DNA present in the original cell
    (*b*) DNA replication takes place in S-phase
    (*c*) A short interphase is followed by a long mitotic phase
    (*d*) G2 phase follows mitotic phase

35. A nutritionally wild type organism, which does not require any additional growth supplement is known as
    (*a*) Phenotype (*b*) Holotype
    (*c*) Auxotroph (*d*) Prototroph

36. Which of the following propagates through leaf-tip?
    (*a*) Walking fern (*b*) Sprout-leaf plant
    (*c*) Marchantia (*d*) Moss

37. Common indicator organism of water pollution is
    (*a*) *Lemna pancicostata*
    (*b*) *Eichhornia crassipes*
    (*c*) *Escherichia coli*
    (*d*) *Entamoeba histolytica*

38. ELISA is used to detect viruses, where
    (*a*) DNA-probes are required
    (*b*) Southern blotting is done
    (*c*) Allkaline phosphatase is the key reagent
    (*d*) Catalase is the key reagent

39. If you are provided with root-tips of onion in your class and are asked to count the chromosomes, which of the following stages can you most conveniently look into?
    (*a*) Metaphase (*b*) Telophase
    (*c*) Anaphase (*d*) Prophase

40. When a diploid female plant is crossed with a tetraploid male, the ploidy of endosperm cells in the resulting seed is
    (*a*) Tetraploidy (*b*) Pentaploidy
    (*c*) Diploidy (*d*) Triploidy

41. India's wheat yield revolution in the 1960s was possible primarily due to
    (*a*) Hybrid seeds
    (*b*) Increased chlorophyll content
    (*c*) Mutations resulting in plant height reduction
    (*d*) Quantitative trait mutations

42. The most likely reason for the development of resistance against pesticides in insects damaging a crop is
    (*a*) Random mutations
    (*b*) Genetic recombination
    (*c*) Directed mutations
    (*d*) Acquired heritable changes

43. The following ratio is generally constant for a given species:
    (*a*) A + G/ C + T
    (*b*) T + C/ G + A
    (*c*) G + C /A + T
    (*d*) A + C /T + G

44. A self-fertilizing trihybrid plant forms
    (*a*) 8 different gametes and 64 different zygotes
    (*b*) 4 different gametes and 16 different zygotes
    (*c*) 8 different gametes and 16 different zygotes
    (*d*) 8 different gametes and 32 different zygotes

45. Lichens are well known combination of an alga and a fungus where fungus has
    (*a*) A saprophytic relationship with the alga
    (*b*) An epiphytic relationship with the alga
    (*c*) A parasitic relationship with the alga
    (*d*) A symbiotic relationship with the alga

46. In oogamy, fertilization involves
    (*a*) A small non-motile female gamete and a large motile male gamete
    (*b*) A large non-motile female gamete and a small motile male gamete
    (*c*) A large non-motile female gamete and a small non-motile male gamete
    (*d*) A large motile female gamete and a small non-motile male gamete)

47. Which one of the following is a living fossil?
    (*a*) Cycas (*b*) Moss
    (*c*) Saccharomyces (*d*) Spirogyra

48. In which one of the following habitats does the diurnal temperature of soil surface vary most?
    (*a*) Shrub land (*b*) Forest
    (*c*) Desert (*d*) Grassland

49. Which form of RNA has a structure resembling clover leaf?
    (*a*) rRNA (*b*) hnRNA
    (*c*) mRNA (*d*) tRNA

50. The telomeres of eukaryotic chromosomes consist of short sequences of
    (*a*) Thymine rich repeats
    (*b*) Cytosine rich repeats
    (*c*) Adenine rich repeats
    (*d*) Guanine rich repeats

51. After a mutation at a genetic locus the character of an organism changes due to the change in
    (*a*) Protein structure
    (*b*) DNA replication
    (*c*) Protein synthesis pattern
    (*d*) RNA transcription pattern

52. During replication of a bacterial chromosome DNA synthesis starts from a replication origin site and
    (*a*) RNA primers are involved
    (*b*) Is facilitated by telomerase
    (*c*) Moves in one direction of the site
    (*d*) Moves in bi-directional way

53. Plants adapted to low light intensity have
    (*a*) Larger photosynthetic unit size than the sun plants
    (*b*) Higher rate of CO_2 fixation than the sun plants
    (*c*) More extended root system
    (*d*) leaves modified to spines

54. According to Oparin, which one of the following was not present in the primitive atmosphere of the earth?
    (*a*) Methane (*b*) Oxygen
    (*c*) Hydrogen (*d*) Water vapour

55. The richest sources of vitamin B12 are
    (*a*) Goat's liver and Spirulina (*b*) Chocolate and green gram
    (*c*) Rice and hen's egg (*d*) Carrot and chicken's breast

56. The most thoroughly studied of the known bacteria - plant interactions is the
    (*a*) Cyanobacterial symbiosis with some aquatic ferns
    (*b*) Gall formation on certain angiosperms by Agrobacterium
    (*c*) Nodulation of Sesbania stems by nitrogen fixing bacteria
    (*d*) Plant growth stimulation by phosphate-solubilising bacteria

57. In transgenics, expression of transgene in target tissue is determined by
    (*a*) Enhancer (*b*) Transgene
    (*c*) Promoter (*d*) Reporter

58. The Ramachandran map is relevant in the study of
    (*a*) DNA structures
    (*b*) RNA structures
    (*c*) Protein structures
    (*d*) Carbohydrate structures

59. Which one of the following pairs refers to paralagous proteins?
    (*a*) Rat myoglobin and rat hemoglobin
    (*b*) Rat myoglobin and mouse myoglobin
    (*c*) Rat myoglobin and mouse hemoglobin
    (*d*) Rat myoglobin and rat cytochrome

60. t-RNAs in eukaryotes are transcribed by
    (*a*) RNA polymerase II
    (*b*) RNA polymerase I
    (*c*) RNA polymerase III
    (*d*) Reverse transcriptase

61. Which technique will be most appropriate to purify dCTP from a mixture of dCTP, dCDP and dCMP?
    (*a*) Anion exchange chromatography
    (*b*) Cation exchange chromatography
    (*c*) Gel filtration chromatography
    (*d*) Hydrophobic interaction chromatography

62. Which enzyme breaks down cAMP to AMP?
    (*a*) Adenylyl cyclase
    (*b*) Phosphodiesterase
    (*c*) 5′ nucleotidase
    (*d*) cAMP-dependent protein kinase

63. Of the following ecological relationships, which one is the most different from the other three?
    (*a*) Algae embedded in coral tissues
    (*b*) *Salmonella* in human. gastric tract
    (*c*) Cellulolytic bacteria in a termite gut
    (*d*) Pollen-collecting bees visiting flowers.

64. Wild type *E. coli* was plated on a Rifampicin containing medium and incubated at 37°C. Majority of the cells died; however, some colonies appeared after a few days. What is the most likely explanation for this observation?
   (*a*) Degradation of Rifampicin
   (*b*) Mutation in DNA polymerase III
   (*c*) Efflux of Rifampicin
   (*d*) Mutation in the β subunit of RNA polymerase

65. Human genomic DNA is digested into fragments approximately 1 kb in size, denatured and then renatured. Which of the following statements is true?
   (*a*) All fragments will renature at the same rate
   (*b*) Fragments composed largely of repetitive DNA sequences will renature fastest
   (*c*) Fragments composed largely of non-repetitive DNA sequences will renature fastest
   (*d*) Fragments with high A:T content will renature fastest

66. When an infectious agent was analyzed chemically, it was found to contain nitrogen and sulfur but not phosphorous. It is likely to be a
   (*a*) Bacterium (*b*) Virus
   (*c*) Mycoplasma (*d*) Prion

67. Which of the following hormones does **not** act by a second messenger system?
   (*a*) Glucagon (*b*) Epinephrine
   (*c*) Luteinizing hormone (*d*) Aldosterone

68. Two-dimensional gel electrophoresis carries out protein separation based on
   (*a*) Mass and hydrophobicity
   (*b*) Mass
   (*c*) Charge and mass properties
   (*d*) Disulphide bonding

69. About 1 % individuals in a population suffer from a genetic disorder. The cause was traced to such individuals being homozygous recessive for a single locus with two alleles. The elder of the two children of a family (where both the parents are normal suffers from the disorder, while the younger one is normal). What is the probability that the third child of the family will be a normal daughter?
   (*a*) 49.5% (*b*) 12.5%
   (*c*) 37.5% (*d*) 25%

70. A red-flowered tall parent plant (P1) was crossed to a true breeding red-flowered dwarf plant (P2) and half of the progenies obtained was red & tall and the other half red & dwarf. In the next generation, half of all these progenies segregated only for flower colour and the other half segregated only for height. The genotype of the P1 is
   (*a*) Heterozygous for color & height
   (*b*) Homozygous for color; heterozygous for height
   (*c*) Heterozygous for color; homozygous for height
   (*d*) Homozygous for color; homozygous for height

Model Test Paper – 6

PART – A

1. Between 00:30 hrs on 1st January, 1801 to 23:30 hrs on 31st December 2000, how many times did the sun rise in Bangalore?
   (*a*) 73000 (*b*) 73050
   (*c*) 73049 (*d*) 73051

2. A mammalian cell line grows as a monolayer in a cell culture. Individual cells are disc-shaped, with a diameter of 1 micrometer. A colony made up of a single, dense layer of such cells is one centimeter in diameter. What is the approximate number of cells at the periphery of the colony
   (*a*) 31400 (*b*) 314159
   (*c*) 3143 (*d*) 10000

3. Let us designate the four hydrogen in the methane molecule as H_A, H_B, H_C and H_D. Imagine a plane passing through the central carbon, H_A and H_B and another plane passing through the central carbon, H_C and H_D. what is the angle between two planes-
   (*a*) 0° (*b*) 90°
   (*c*) 109.47° (*d*) 120°

4. The oxygen consumption of a rat and a lobster were measured first after 1 hour at 30°C and then after 1 hour at 15 °C. Which of the following lobster best describes the change in oxygen consumption from 30 °C to 15 °C ?
   (*a*) Increased in rat and decreased lobster
   (*b*) Decreased in rat and increased in lobster
   (*c*) Increased in rat and unchanged in lobster
   (*d*) Decreased in rat and unchanged in lobster

5. The structures of enantiomers are
   (*a*) Superimposable on each other
   (*b*) Mirror images of each other
   (*c*) Related by a 2-fold symmetry
   (*d*) Exactly the same

6. A solid object dropped from the top of a building takes 2 seconds to reach the ground. What is the best approximation for the height of the building in meters?
   (*a*) 10 (*b*) 20
   (*c*) 40 (*d*) 80

7. The density of deuterated water is
   (*a*) Twice that of ordinary water
   (*b*) Less than that of ordinary water
   (*c*) Same as that of ordinary water
   (*d*) Slightly greater than that of ordinary water

8. At the melting temperature of ice (0 °C) which statement is true?
   (*a*) The molar free energy difference between ice and water is zero
   (*b*) The entropy difference between ice and water is zero
   (*c*) Addition of salt will decrease the free energy of the solid phase more than that of the liquid phase
   (*d*) The mole fraction of ice at 0 °C is 1

9. The weights of fish in a pond are observed to be normally distributed, with a mean weight of 10 kg and a standard deviation of 1 kg. What proportion of fish will be heavier than 12 kg at a 95% confidence level?
   (*a*) About 95% (*b*) About 33.3%
   (*c*) About 5% (*d*) About 2.5%

10. Consider the equation px2+qx+r = 0. If rp = q^2/ 4 then how many real solutions of this equation are possible?
    (*a*) 0 (*b*) 1
    (*c*) 2 (*d*) Infinite

11. The female of a species of insects lays about 300 eggs in June-July. Half of them hatch successfully (equal proportion of males and females) by October. Forty percent, of the larvae form pupae by January, and adults emerge from one third of the pupae by March. Mating takes place during May, and 20% of the adult insects manage to mate successfully. Thereafter, all the adults die after the females have laid eggs in June-July. There are no sex specific differences in survival, mortality, successful completion of developmental stages and mating success. If 10 fertilized females are released in a very large enclosure in June-July 2001, how many eggs are likely to be laid during June-July 2005?
    (*a*) 48000 (*b*) 6000
    (*c*) 36000 (*d*) 24000

12. Which of the following is a post-zygotic isolating mechanism in speciation
    (*a*) Behavioural isolation
    (*b*) Seasonal isolation
    (*c*) Fertilisation failure
    (*d*) Hybrid sterility

13. If the pH of the parietal cells in the stomach is 7 and that of the lumen of the stomach is 1, then against what concentration difference do the parietal cells pump out protons?
    (*a*) 1,000,000 (*b*) 6
    (*c*) 60 (*d*) 700,000

14. One of the angles between the diagonals of a rectangle is 60°. The lengths of the sides of the rectangle are in the ratio
    (*a*) 1: 6 (*b*) 1: $\sqrt{2}$
    (*c*) 1:.$\sqrt{3}$ (*d*) 1:$\sqrt{6}$

15. Apart from the 20 naturally occurring amino acids, 700 'unnatural' amino acids have been reported in the literature. If all the 720 were to be accommodated in the genetic code, what is the minimum number of bases needed in a codon?
    (*a*) 4 (*b*) 5
    (*c*) 6 (*d*) 7

16. A stream is free of pollutants within a few miles downstream of a point at which it is being contaminated by a small amount of sewage. This is most likely the result of
    (*a*) Eutrophication (*b*) Decomposition
    (*c*) Photosynthesis (*d*) Succession

17. Computers directly understand which language-
    (*a*) Assembly language (*b*) Machine language
    (*c*) BASIC (*d*) High level language

18. Which among the following is a programming language-
    (*a*) SQL (*b*) Oracle
    (*c*) Sybase (*d*) LOGO

19. Which among the Following is Data base management system-
    (*a*) MS-Word (*b*) MS-Excel
    (*c*) MS-Access (*d*) MS-PowerPoint

20. The out come following equation would be-
    $n \to \infty$ (1+ 2/n)n
    (*a*) e2 (*b*) e
    (*c*) e2 + 1 (*d*) e2 – 1

21. f(x) = ax2 + bx + C
    g(x) = px2 + q + r
    f(x).g(x) = 0
    If a, b, c & p, q, r = real, then
    (*a*) $\sqrt{}$b2 – 4ac = 0 & $\sqrt{}$P2 – 4pr = 0
    (*b*) $\sqrt{}$b2 – 2ac = 0
    (*c*) b2 – 4ac = 0 & P2 – 4pr = 0
    (*d*) $\sqrt{}$P2 – 4pr = 0

22. Which is the correct statement for a collapsing star-
    (*a*) Its gravitational force will decrease
    (*b*) It will stop emitting light
    (*c*) Its density increases
    (*d*) No changes in internal pressure are seen

23. Our sun is a Young star. It will turn into_______ after 500 million years as
    (*a*) White dwarf (*c*) Red giant
    (*b*) Neutron star (*d*) Black hole

24. An air bus take off from London to Paris departs at 4:00 PM Monday. When it crosses the Prime Meridian what will be time and Day
    (*a*) 4:00 PM Sunday (*b*) 4:00 PM Tuesday
    (*c*) 4:00 PM Monday (*d*) 4:00 AM Sunday

25. Geological time scale is-
    (*a*) Sequence of geological events in different ages of past
    (*b*) Division of geological event in 24 hours
    (*c*) Period of formation of earth divided into million of years
    (*d*) Sequence of geological events not measured in exact time period.

26. The surface of earth where life is possible is termed as-
    (*a*) Lithosphere (*b*) Biosphere
    (*c*) Ecosystem (*d*) Hydrosphere

27. Fill the values of x and y in |xy| for Decimal number 9 in Binary codes-
    (*a*) x = 0, y = 0 (*b*) x = 0, y = 0
    (*c*) x = 1, y = 1 (*d*) x = 1, y = 0

28. Bug, in computer terminology means-
    (*a*) Logical error
    (*b*) Syntax error
    (*c*) Organism effecting computer
    (*d*) High level Programming

29. Consider the following programme and write the result that will print at end of program-

```
Do While A =/= 0
    If A >= B
    A = A–B
Else
    B = B–A
EndIf
    PRINT A, B
```

    (*a*) 0, 0 (*b*) 0, 1
    (*c*) 1, 1 (*d*) 1, 0

30. If there is double bond between A & T and triple bond between GC, then which sequence will be most stable at higher temperature-
   (*a*) ATTGTACCAAA (*b*) AATTATATATA
   (*c*) AGCAGAGAGTT (*d*) AGGCCGGCCCTA

PART – B

1. A synthetic peptide has the sequence $(Ala)_{10}$ and forms a right handed a helical structure. Its molecular weight is
   (*a*) 890 (*b*) 728
   (*c*) 1000 (*d*) 710
2. The most abundant protein in human blood is
   (*a*) Transferrin (*b*) Albumin
   (*c*) γ globulin (*d*) Hemoglobin
3. Consider three polypeptides of 15 residues each. They adopt distinct conformations corresponding to right-handed α-helical structure, left-handed α-helical structure and single strand of a β-sheet structure. Considering the shortest distance between the first and the last residues as the length of the structure, which one of the following statements is true?
   (*a*) Right-handed a-helical structure is longest
   (*b*) Left-handed a-helical structure is longest
   (*c*) β-strand structure is longest
   (*d*) All the three polypeptides have identical length
4. The absorption spectrum of a protein solution will always show a maximum at
   (*a*) 190 nm (*b*) 260 nm
   (*c*) 280 nm (*d*) 340 nm
5. Long term reflex actions such as cycling and swimming are controlled by
   (*a*) Cerebellum (*b*) Spinal cord
   (*c*) Hypothalamus (*d*) Cerebrum
6. HIV replicates its genome using unique mechanisms. Which of the following statements about HIV is **not** correct?
   (*a*) HIV is an enveloped RNA virus
   (*b*) The virion contains an RNA dependent DNA polymerase
   (*c*) A DNA copy of the HIV genome integrates into host cell DNA
   (*d*) Virion contains an RNA dependent RNA polymerase
7. A mutation that inactivates a trans-acting regulatory gene of a positively controlled operon would lead to
   (*a*) Hyper-expression of the operon
   (*b*) Expression of the operon is shut off
   (*c*) Constitutive expression
   (*d*) Delayed expression, comparable to that of the wild type at later stages of growth

8. The coenzyme involved in oxidative decarboxylation is
   (*a*) Thiamine pyrophosphate (*b*) Biotin
   (*c*) Nicotinamide Adenine Dinucleotide
   (*d*) Pyridoxal phosphate

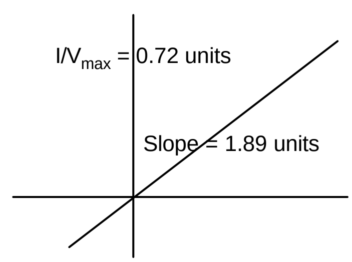
9. The term "zygotic induction" refers to
   (*a*) Embryogenesis of the fertilized egg
   (*b*) Process of fertilization
   (*c*) Prophage induction in a F^- (F minus) recipient bacteria after *Hfr* strain mediated conjugation
   (*d*) Prophage entering the lytic cycle after UV irradiation of a lysogen

10. Which of the following is common to both fatty acid synthesis and degradation?
   (*a*) The oxidation/reduction reactions occur between the α and the β carbons of the fatty acid
   (*b*) The biochemical nature of the reductant/oxidant
   (*c*) The intracellular location of the metabolic pathways
   (*d*) The nature of the two carbon unit

11. The colour of flowers of an annual species of plants is controlled by a single locus with two alleles R and r, and the genotypes RR, Rr and IT are red, pink and white respectively. A large number of seeds from individuals with pink flowers were collected and planted on an island, where, because of absence of pollinators, only self-pollination is possible. What will be the most likely outcome after 25 years?
   (*a*) About 50% plants with red flowers, 50% with white flowers
   (*b*) Almost 100% plants with pink flowers
   (*c*) Red, pink and white flowered plants in a ratio of 1:2: 1
   (*d*) Red, pink and white flowered plants in equal proportion

12. The fermentation of glucose by yeast normally yields
   (*a*) Lactic acid, CO_2 and 2 ATP
   (*b*) Ethanol, CO_2 and 36 ATP
   (*c*) Ethanol, CO_2 and 2 ATP
   (*d*) CO_2, H_2O and 36 ATP

13. The Km of the enzyme for the substrate that gives the following Lineweaver-Burk plot is



   (*a*) 3.646
   (*b*) 0.734
   (*c*) 2.625
   (*d*) 1.361

14. The synthesis of DNA was shown to be template dependent and semi-conservative. This would predict that
   (*a*) No organism can have a single-stranded genome
   (*b*) RNA cannot serve as the genome of any organism

(*c*) All single stranded genomes would be synthesized via a double-stranded intermediate

(*d*) Template-independent DNA polymerases do not exist in nature

15. Phage P1 lysate was raised on an *E. coli* strain with a genotype *Tn* 10, A^-, B^-, C^-, D^- and used to transduce a wild type strain of *E. coli.* Transductants were selected on tetracycline (based on *Tn* 10*)* and then checked for the transfer of the remaining markers. Fifteen percent of the transductants were B^- and C^-, 40% were D^- but all of them were A^+. Assuming that all of the markers were on one side of *Tn* 10, the order of the markers is
    (*a*) *Tn 10,* A, B, C and D
    (*b*) *Tn 10,* A, C, Band D
    (*c*) *Tn 10,* D, A, Band C
    (*d*) *Tn 10,* D, B, C and A

16. 'Kin selection' is
    (*a*) The mating of relatives
    (*b*) The recognition of relatives in societal groups
    (*c*) A process of keeping young females while forcing young males out
    (*d*) A behavior that increases the survivorship of an individual's relatives

17. A laboratory-synthesized protein has an amino acid sequence same as that of human lysozyme but with all chiral residues in D-configuration. Which one of the following statements is false?
    (*a*) Such a protein will never fold into a compact shape
    (*b*) This protein will have left-handed α-helical regions in the places of right-handed α-helical regions in the natural lysozyme
    (*c*) This protein will not be functional with the natural substrates
    (*d*) This protein could form crystals

18. Which one of the following genes is defective in patients suffering from severe combined immunodeficiency syndrome (SCID)?
    (*a*) Cystic fibrosis transmembrane conductor (CFTR)
    (*b*) Adenosine deaminase
    (*c*) Ribonucleotide reductase
    (*d*) α2-microglobulin

19. Helium and Deuterium have the same
    (*a*) Number of protons
    (*b*) Protons to neutrons ratio
    (*c*) Number of electrons
    (*d*) Atomic mass

20. Which of the following compounds is an end product of β-oxidation
    (*a*) Pyruvic acid (*b*) Acetyl CoA
    (*c*) Oxaloacetate (*d*) Alanine

21. Non-polar amino acids are found mostly
    (*a*) In the core of the protein
    (*b*) On the surface of the protein
    (*c*) In α-helices
    (*d*) In no specific regions

22. Which one of the following amino acids is most hydrophilic?
    (*a*) Glycine (*b*) Serine
    (*c*) Arginine (*d*) Cysteine

23. Fatty acids yield more energy per mole than carbohydrates and proteins. This is because they
    (*a*) Have larger molecular weight
    (*b*) Are more non-polar
    (*c*) Are more reduced
    (*d*) Have more carbon atoms for CO_2 production

24. The relative viscosity of a protein solution is affected by
    (*a*) Temperature, shape and molecular weight
    (*b*) Temperature and molecular weight
    (*c*) Molecular weight and shape
    (*d*) Temperature and shape

25. Which of the following statements regarding signaling is not true?
    (*a*) Steroid hormone-intracellular receptor complex binds to the regulatory sequence of certain genes
    (*b*) Chaperone proteins bind to the intracellular receptors in the absence of hormone ligands
    (*c*) Vitamin D acts via intracellular receptors
    (*d*) Intracellular receptors activate gene expression in the absence of ligand

26. In animals, ritualized contests with little risk of serious injury or death to participants within the species lead to
    (*a*) Stable dominance hierarchy
    (*b*) Biological altruism
    (*c*) Instinctive behavior
    (*d*) Spread of recessive genes

27. The residue histidine can act as a ligand for the heme iron in proteins such as myoglobin because
    (*a*) Histidine side chain has a pKa close to pH 5.0
    (*b*) One of the nitrogens has a lone pair of electn;ms available for coordination
    (*c*) The aromatic ring of the histidine can act favorably with the heme iron
    (*d*) Five membered rings have a favorable dipolar interactions with ferrous or ferric Ions

28. Conversion of Testosterone to Estrogen is mediated by
    (*a*) Aromatase
    (*b*) 5-α reductase
    (*c*) 3-β-hydroxy-steroid dehydrogenase
    (*d*) Desmolase

29. Which of the following is degraded upon treatment with RNase A?
    (*a*) DNA-RNA duplex
    (*b*) RNA-RNA duplex
    (*c*) Single stranded RNA
    (*d*) DNA-RNA duplex, RNA-RNA duplex and single stranded RNA

30. Which one of the following statements with respect to Testosterone is **not** true?
    (*a*) Testosterone receptor mutant is embryonic lethal
    (*b*) Testosterone receptor is essential for male reproduction
    (*c*) Testosterone is produced in female rats
    (*d*) Testosterone is not essential for fetal growth

31. In the genome of a eukaryotic organism, if all the four bases occur randomly, then which amino acid pair will occur least frequently in its proteome?
    (*a*) Methionine and Tryptophan
    (*b*) Arginine and Serine
    (*c*) Proline and Tryptophan
    (*d*) Glycine and Methionine

32. Carboxypeptidase Y has the following kinetic parameters for a series of substrates. At very low substrate concentration, which of these substrates would be hydrolyzed most quickly?

	Substrate	$\mathbf{K_{cat}}$ $\mathbf{(s^{-1})}$	$\mathbf{K_m}$ **(M)**
(*a*)	Ala-He-Asp	2×10^{-1}	$3 \times 1\ 0^{-2}$
(*b*)	Ala-Pro-Arg	5×10^{-3}	2×10^{-6}
(*c*)	Ala-Val-Gin	5×10^{-2}	4×10^{-3}
(*d*)	Ala-Ile-Lys	5×10^{-1}	1×10^{-5}

33. Some cells divide by budding. After budding, you have a mother cell and a daughter cell. If the mother cell cannot bud any more, the increase in cell number as a function of time will be
    (*a*) Exponential (*b*) Linear
    (*c*) Logarithmic (*d*) Hyperbolic

34. Histones, proteins that playa role in packaging DNA, are characterized by a
    (*a*) High pI
    (*b*) Low pI
    (*c*) pI at 7
    (*d*) Hydrophobic surfaces

35. Ketone bodies are formed due to
   (*a*) Breakdown in the p-oxidation pathway which would produce an excess of acetyl CoA
   (*b*) Inhibition of fatty acid activation and transport
   (*c*) Channelisation of oxaloacetate from the citric acid cycle to gluconeogenesis
   (*d*) Inhibition of cAMP production

36. Ribozymes are known to catalyze reactions on
   (*a*) Phosphorus centers but not carbon centers
   (*b*) Carbon centers but not phosphorus centers
   (*c*) Both carbon and phosphorus centers
   (*d*) Neither carbon nor phosphorus centers

37. Topological winding number (T_w) of two DNA strands in a covalently closed circular plasmid is 200. If the value of writhe (W_r) for the plasmid is zero, the linking number (L_k) is
   (*a*) –100 (*b*) 200
   (*c*) 100 (*d*) –200

38. Administration of Estrogen to adult male rats results in
   (*a*) Decreased Testosterone production
   (*b*) Decreased Luteinizing hormone and Testosterone production
   (*c*) Increased Estrogen secretion in the testis
   (*d*) None of the above

39. What is the [S] for the enzyme-catalyzed reaction which has an initial velocity of 12.62 mole/litre/min, and the maximum velocity of 21.85 mole/litre/min, and a Michaelis-Menten constant of 3.88 mole/liter?
   (*a*) 2.51 mole/litre (*b*) 5.30 mole/litre
   (*c*) 0.24 mole/litre (*d*) 4.31 mole/litre

40. When nonsense mutations occur in the reading frame of mRNA, protein synthesis gets terminated at the nonsense mutation to deliver a truncated polypeptide. However, in certain bacterial strains, this does not phappen; these bacterial cells are able to synthesize full-length polypeptide. This phenomenon is due to
   (*a*) Compensatory frame shift mutation that occurs elsewhere in the mRNA
   (*b*) Involvement of suppressor tRNAs
   (*c*) Polypeptide splicing at the broken point
   (*d*) Post-transcriptional editing of the nonsense mutation

41. The sediment at the bottom of a lake contains small proportions of deuterium and ^{13}C, the stable isotopes of hydrogen and carbon respectively. The methane produced by the methanogenic bacteria from the lake is subjected to complete combustion in air, which contains a small proportion of 170, to produce CO_2 and H_2O. How many distinct species of CO_2 and H_2O (i.e., compounds differing only in the atomic weights of the constituent atoms) will be formed?
   (*a*) 2 of CO_2 and 3 of H_2O
   (*b*) 4 of CO_2 and 4 of H_2O

(*c*) 6 of CO_2 and 6 of H_2O
(*d*) 3 of CO_2 and 2 of H_2O

42. The phenomenon of genetic drift is most likely to occur in populations that are
(*a*) Small and inbred
(*b*) Undergoing gene flow
(*c*) Allopatric
(*d*) Large and panmictic

43. A DNA polymerase isolated from a novel bacterium was found to incorporate many errors during DNA synthesis. Which of the following activities would you predict to be missing from this enzyme?
(*a*) 3′ to 5′ exonuclease activity
(*b*) RNA primase activity
(*c*) 5′ to 3′ exonuclease activity
(*d*) 5′ to 3′ endonuclease activity

44. When a mutation produces the first copy of a new, advantageous allele within a population of 'wild-types', the initial spread of this new allele through the population will be faster if it is
(*a*) Dominant to the wild-type
(*b*) Recessive to the wild-type
(*c*) Co-dominant with the wild-type
(*d*) Semi dominant with the wild-type

45. The peptide, Ala-Arg-Gln-Met-Thr-Trp-Lys-Val, is treated with cyanogen bromide to produce
(*a*) Ala-Arg-Gln-Met + Thr-Trp-Lys-Val
(*b*) Ala-Arg-Gln-Met-Thr-Trp + Lys-Val
(*c*) Ala-Arg + Gln-Met-Thr-Trp-Lys-Val
(*d*) Ala-Arg-Gln + Met-Thr-Trp-Lys-Val

46. Which of the following antibiotics is inactivated by neomycin phosphotransferase?
(*a*) Ampicillin (*b*) Chloramphenicol
(*c*) Spectinomycin (*d*) Kanamycin

47. Transmembrane domains of proteins are typically
(*a*) β sheets (*b*) α helical
(*c*) random coils (*d*) unstructured

48. Isozymes can be characterized by
(*a*) The different chemical reactions that they catalyze
(*b*) The differences in their elution profile from a size-exclusion column
(*c*) Differences in their amino acid sequences
(*d*) All of the above

49. The absorbance of 0.02mM ATP solution at 260nm with a cuvette having a path length of 0.5 cm is 0.154. Therefore, the molar absorption coefficient of ATP is
(*a*) 15400 (*b*) 7700
(*c*) 770 (*d*) 1540

50. Using standard 20 amino acids, how many tripeptide sequences can be designed with at least one glycyl residue in every sequence?
(*a*) 40 (*b*) 4000
(*c*) 800 (*d*) 8000

51. N-linked Glycosylation can occur in a protein containing the amino acid sequence
(*a*) Asn- Thr- Thr-Gly (*b*) Asn-Asn-Asn-Gly
(*c*) Glu-Asn- Thr-Gly (*d*) Ser-Ser-Ser-Gly.

52. Introns are released as lariats during splicing of
(*a*) Pre-mRNA transcripts and Group II intron containing transcripts
(*b*) Pre-mRNA transcripts only
(*c*) Group I intron containing transcripts
(*d*) tRN A precursors

53. Two cysteine residues in a protein form a disulfide bond. Which one of the following statements is false?
(*a*) The shortest distance between the two residues will be between the sulfur atoms of each residue
(*b*) Disulfide formation is normally favored at pH5 compared to pH8
(*c*) Neither of the sulfur atoms involved in the disulfide bridge can be protonated
(*d*) Disulfide bond formation decreases the conformational entropy of the unfolded state of the protein

54. Urea is a water soluble product of nitrogen metabolism. How many hydrogen bonds can it form with water molecule
(*a*) 3 (*b*) 4
(*c*) 6 (*d*) 2

55. Two identical twin adults look alike and they have been brought up in the same environment. If a crime has been committed by one of them, which test will identify the criminal with more certainty?
(*a*) DNA finger printing
(*b*) Blood group testing
(*c*) Finger print testing
(*d*) Serotyping

56. Membrane protein biogenesis initiates in the following compartment.
(*a*) Rough endoplasmic reticulum
(*b*) Golgi
(*c*) Smooth endoplasmic reticulum
(*d*) Endosomes

57. What is the number of hydrogen bonds in a double helical B-DNA structure of 100 base pairs with 20 adenines and 10 thymines in one of the two strands?
    (*a*) 200 (*b*) 230
    (*c*) 270 (*d*) 300

58. Which one of the following amino acids has chirality at the side chain?
    (*a*) Threonine (*b*) Cysteine
    (*c*) Valine (*d*) Proline

59. Which amino acid substitution will **not** result in a change in the mass spectrum of a peptide.
    (*a*) Arg to Lys (*b*) Ser to Thr
    (*c*) Ile to Leu (*d*) Asn to Met

60. In species with two sexes, "males" are defined by which of the following characters?
    (*a*) Males have brighter colouration than females
    (*b*) Males have smaller gametes compared to females
    (*c*) Males are larger than females
    (*d*) Males defend territories while females brood the eggs

61. Virally infected cells can be killed directly by
    (*a*) B cells (*b*) Basophils
    (*c*) NK cells (*d*) Eosinophils

62. Which one of the following [^{3}H] precursors can be used to monitor biosynthesis of DNA in activated lymphocytes in culture?
    (*a*) Thymidine tri-phosphate
    (*b*) Thymidine di-phosphate
    (*c*) Deoxythymidine tri-phosphate
    (*d*) Thymidine

63. Actin filaments are involved in all of the following except
    (*a*) Amoeboid movement
    (*b*) Cytoplasmic streaming
    (*c*) Contraction of smooth muscles
    (*d*) Flagellar movement in bacteria

64. The Hardy-Weinberg Law describes
    (*a*) Genotype frequencies of a population when evolutionary forces are not acting
    (*b*) How sexual reproduction would change the relative gene frequencies in a population
    (*c*) How mutations occur and balance each other
    (*d*) Genotype frequencies of a population when evolutionary forces are acting

65. The receptor for which of the following hormones is a transcription factor?
    (*a*) Insulin (*b*) Glucagon
    (*c*) Estradiol (*d*) Adrenalin

66. You would expect a cell with an extensive Golgi apparatus to
    (*a*) Synthesize large amounts of ATP
    (*b*) Secrete large amounts of protein
    (*c*) Synthesize large amounts of steroids
    (*d*) Synthesize excess phospholipids

67. Radioactive iodine can be incorporated into
    (*a*) Serine (*b*) Threonine
    (*c*) Tyrosine (*d*) Leucine

68. A Graafian follicle is
    (*a*) An immature developing follicle
    (*b*) A mature follicle ready to ovulate
    (*c*) A follicle undergoing apoptosis
    (*d*) Ovulated follicle

69. Which one of the following techniques was used in elucidation of the Watson-Crick double helical model of DNA?
    (*a*) Entirely by theoretical calculations and by using Chargaff's rule without performing any experiment.
    (*b*) X-ray diffraction by single crystals
    (*c*) X-ray diffraction by quasi crystals
    (*d*) X-ray diffraction by fibers

70. Which one of the following interactions between the side chains of amino acids in a protein structure is most favourable?
    (*a*) Asp – Glu (*b*) Arg – Lys
    (*c*) Lys – Val (*d*) Trp – Phe

Model Test Paper – 7

PART-A

1. In a substitution nucleophilic first order reaction (SN1) the stereochemical outcome is
   (*a*) Raemisation
   (*b*) Inversion of configuration
   (*c*) Retention of configuration
   (*d*) Difficult to predict

2. When irradiated with ultraviolet light Chlorine (Cl_2) reacts with tetrachloroethylene. But under similar condition when Oxygen (O_2) is vigorously bubbled through the solution the reaction
   (*a*) becomes more violent
   (*b*) does not get affected
   (*c*) slows down
   (*d*) stops

3. Which of the following compounds is optically inactive?
   (*a*) Lactic acid (*b*) 2-Methyl propionic acid
   (*c*) Tartaric acid (*d*) Butyric acid

4. Addition of excess bromine (Br_2) to 1,4-pentadine will yield
   (*a*) Only 4,5 dibromo 1-pentene
   (*b*) Only 1,2,4,5-tetra bromo pentene
   (*c*) Mixture of (*a*) and (*b*)
   (*d*) There will be no reaction

5. If you want to synthesize 1-Phenyl ethanol from phenyl magnesium bromide you will have to add
   (*a*) Water to it (*b*) Formaldehyde to it
   (*c*) Acetaldehyde to it (*d*) Acetone to it

6. When you will treat phenol with dilute HNO_3 at 20 °C, you will get
   (*a*) Only ortho nitro phenol
   (*b*) Only para nitro phenol
   (*c*) Mix1ure of ortho and para nitro phenol
   (*d*) Only 2,4,6 trinitro phenol

7. Soaps are
   (*a*) Esters of fatty acids
   (*b*) Metal salts of fatty acids
   (*c*) Glyceryl esters of fatty acids
   (*d*) Salts of fatty acids with organic bases

8. Natural rubber is a polymer of
   (*a*) Butadiene (*b*) Isoprene
   (*c*) Chloroprene (*d*) Nesprene

9. Ethylene when treated with dilute alkaline $KMnO_4$ forms
   (*a*) Ethyl alcohol (*b*) Ethylene glycol
   (*c*) Acetaldehyde (*d*) Ethane

10. EDTA is used as
    (*a*) Oxidized agent (*b*) Reducing agent
    (*c*) Chelating agent (*d*) Alkylating agent

11. Linkage present in cellulose molecule is
    (*a*) $\beta\,(1 \rightarrow 4)$ (*b*) $\alpha\,(1 \rightarrow 4)$
    (*c*) $\alpha\,(1 \rightarrow 6)$ (*d*) both (*b*) and (*c*)

12. Blocking action of enzyme through blocking its active site is
    (*a*) Allosteric inhibition (*b*) Feedback inhibition
    (*c*) Competitive inhibition (*d*) Non-competitive inhibition

13. Which one of the following is without coenzyme activity ?
    (*a*) Vitamin E (*b*) Thiamine
    (*c*) Biotin (*d*) Riboflavin

14. Active transport
    (*a*) Releases energy (*b*) Require energy
    (*c*) Produces energy (*d*) Produces toxic material

15. Correct sequence of stages in cell cycle is
    (*a*) G1, S, G2, M (*b*) G1, G2, S, M
    (c) M, S, G1, G2 (*d*) G1, G2, M, S

16. 0.1 M acetic acid is mixed with 02 M sodium acetate. Give that pKa of Acetic acid is 4.76, the pH of the mixture will be nearly
    (*a*) 4.5 (*b*) 5.0
    (c) 5.5 (*d*) 6.0

17. The scalar product of two vectors (u, u2, u3) (V1, V2, V3) =

(*a*) u1V1 + u2V2 + u3V3 (*b*) u1 v2 + u2v1 + U3V3

(*c*) u3v1, + U2V2 + u1v3 (*d*) u3v2 + u2v1 + u1v2

18. The determinant of a singular matrix

(*a*) Is equal to 0 (b) Is greater than 0

(*c*) Is less than 0

(*d*) Can be either greater than, equal to or less than 0

19. If the differential equation is stiff

(*a*) It should be solved by Gear's method

(*b*) Enters method

(*c*) 2nd order Rung-Kutta method

(*d*) Cannot be solved

20. The path of a projectile

(*a*) is parabola (*b*) is hyperbola

(*e*) is straight line (*d*) depends on the angle of throw

21. The probability of a man hitting a target is ¼. The number of times he must fire so that the probability of his hitting the target at least once is greater than 2/3 is

(*a*) 2 (*b*) 3

(*c*) 4 (*d*) Infinity

22. The number of spectral lines emitted by atomic hydrogen excited to the nth energy level is

(*a*) n(n + 1)/2 (*b*) n(n – 1)/2

(*c*) $n^2/2$ (*d*) n(n – 1)

23. A piece of ice slides down at 45° incline in twice the time if it takes to slide down a frictionless 45° incline. The coefficient of friction between the ice and the incline it

(*a*) 2 (*b*) 1/2

(*c*) 1/4 (*d*) 2 ½

24. A bucket of water is hung from a spring balance. A piece of iron is suspended into the water without touching the sides from an independent support. The reading on the spring balance will

(*a*) increase

(*b*) decrease

(*c*) not change]

(*d*) decrease with depth of immersion of iron piece

25. Which is not an programming language-

(*a*) BASIC (*b*) C

(*c*) MS-WORD (*d*) LOGO

26. Number of values that can be stored in 8 bits are-
(*a*) 8 (*b*) 16
(*c*) 64 (*d*) 256

27. If 11×11=100. Then which statement is correct-
(*a*) Left hand side is binary and right is octal
(*b*) Left hand side is binary and right is ternary
(*c*) Left hand side is hexadecimal and right is octal
(*d*) Left hand side is binary and right is also binary

28. Consider the following truth table.

P	Q	P<Q	P≠Q
3	3	0	0
4	5	A	B

The value of A and B will be-
(*a*) 0, 0 (*b*) 0, 1
(*c*) 1, 0 (*d*) 1, 1

29. A certain planet is revolving in a fixed orbit. If the radius of its orbit in increased four times then its mean surface temperature will decrease-
(*a*) 1 (*b*) 2
(*c*) 4 (*d*) 16

30. Charge density is more at poles because-
(*a*) Magnetic field is parallel to poles
(*b*) Magnetic field is parallel to equator
(*c*) Magnetic field is perpendicular to poles
(*d*) Magnetic field is perpendicular to equator

PART – B

1. Viroids differ from viruses in being
(*a*) Naked ANA molecules only
(*b*) Naked DNA molecules only
(*c*) Naked DNA packaged with viral genomes.
(*d*) Satellite ANA packaged with visual genome

2. A virus can be made radioactive by
(*a*) culturing the virus in a medium of ^{32}P
(*b*) culturing the viruses on a medium of potato, dextrose and ^{32}P
(*c*) providing ^{32}P to virus when they are about to attack the bacteria
(*d*) providing ^{32}P to a bacterium which have been infected by a virus

3. A short length of double stranded DNA molecule contains 120 adenine and 120 cytosine bases. The total number of nucleotides in this DNA fragment is
   (*a*) 60 (*b*) 120
   (*c*) 240 (*d*) 480

4. Besides having C, H, O which of these may also contain N, S & P ?
   (*a*) Protein (*b*) Fat
   (*c*) Carbohydrate (*d*) Vitamins

5. Which of the following element plays an important role in nitrogen fixation?
   (*a*) Manganese (*b*) Molybdenum
   (*c*) Zinc (*d*) Copper

6. Specificity of an enzyme depends upon
   (*a*) Active site (*b*) Linear sequence
   (c) Km (*d*) Turn over number

7. Sulphur containing Amino acid is
   (*a*) Valine (*b*) Leucine
   (*c*) Methionine (*d*) Histidine

8. Viruses are
   (*a*) Cellular organisms
   (*b*) Non-cellular organisms
   (*c*) Unicellular organisms
   (*d*) Cellular without wall

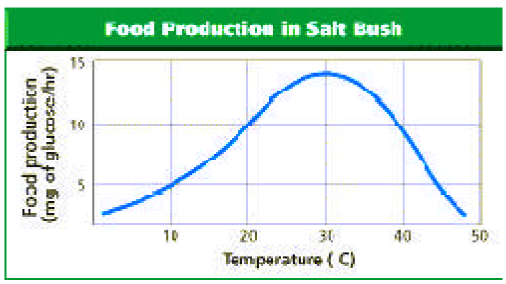
9. Which of the following does not contain both DNA and RNA ?
   (*a*) Yeast (*b*) Bacteria
   (*c*) Mycoplasma (*d*) Virus

10. Sodium Dodecyl Sulphate (SDS) is used while separating proteins by polyacrylanide gel electrophoresis because
    (*a*) It helps in solubilization of proteins thereby making it easier to separate
    (*b*) It binds to proteins and confers uniform negative charge density thereby making them move during electrophoresis
    (*c*) Decreases the surface tension of the buffer used for electrophoresis
    (*d*) Stabilizes the proteins

11. Absorption of UV radiation by proteins and nucleic acids is due to transition of Electrons between the
    (*a*) Vibrational energy levels
    (*b*) Rotational energy levels
    (*c*) Nuclear energy levels
    (*d*) Electronic energy levels

12. Which of these statements is true?
   (*a*) In a pyramid of numbers, the population size usually gets smaller as the trophic level increases.
   (*b*) In a pyramid of biomass, the weight of a lower trophic level is the same as the level above it.
   (*c*) In a pyramid of energy, only about 40% of the energy at one level is available for the next trophic level.
   (*d*) The law of conservation, which can be applied to the pyramid of energy, means that energy is constantly created and destroyed.

13. Which of these statements about the amount of food production after 20° C is true?
   (*a*) Food production stops as temperatures increase beyond 20° C.
   (*b*) Food production continues to increase as temperatures increase beyond 20° C.
   (*c*) Food production drops drastically as temperatures increase beyond 20° C.
   (*d*) Food production remains the same as temperatures increase beyond 20° C.

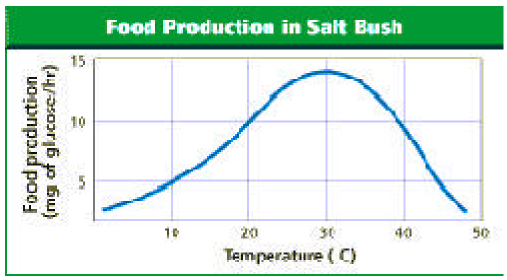


14. Which of these organisms breaks down and releases nutrients from other dead organisms?
   (*a*) Producers (*b*) Decomposers
   (*c*) Herbivores (*d*) Carnivores

15. Which of these is NOT an example of a terrestrial ecosystem?
   (*a*) Volcano site (*b*) Garden plot
   (c) Rotting log (*d*) Human skin

16. What is the difference between mutualism and parasitism?
   (*a*) Mutualism means that one member of a species thrives at the expense of the member of the species. Parasitism means that one member of a species thrives at the expense of the member of the species.
   (*b*) Mutualism means that one member of a species benefits without harming or benefiting the member of another species. Parasitism means that both species' members benefit from the relationship.
   (*c*) Mutualism mean that both members of a species benefit from living together. Parasitism means that one member of a species benefits without harming or benefiting the member of another species.
   (*d*) Mutualism means both members of a species benefit from living together. Parasitism means that one member of a species thrives at the expense of the member of the species.

17. Based on the data in the graph, which of the following statements is true?
   (*a*) There is no food production happens at 10° C.
   (*b*) Food production is the smallest at about 20° C.
   (*c*) Food production is the greatest at about 30° C.
   (*d*) Food production at 40° C is about 5 mg of glucose per hour.



18. Which of these organisms uses light energy to manufacture food for itself?
   (*a*) A heterotroph
   (*b*) An autotroph
   (*c*) A carnivore
   (*d*) An omnivore

19. Which of the following statements about the biosphere is true?
   (*a*) Ecologists never study animal in Earth's biosphere.
   (*b*) The physical environment of Earth's biosphere is the only factor in influencing living things.
   (*c*) Living things in Earth's biosphere are affected by nonliving things.
   (*d*) Earth's biosphere includes the portion of Earth within 1 mile of the surface.

20. A relationship among organisms where one species benefits while the other species neither benefits nor is harmed is called __________.
   (*a*) Mutualism
   (*b*) Predation
   (*c*) Parasitism
   (*d*) Commensalism

21. A DNA solution of 100μM concentration when placed in a cuvette of path length 1 cm gave an absorbency of 0.66. The extinction coefficient of DNA is-
   (*a*) 6.6×10^3 (*b*) 0.66×10^3
   (*c*) 1.5×10^{-4} (d) 6.6×10^{-3}

22. Trace of a matrix is
   (*a*) Some of the elements in the main diagonal
   (*b*) Some of the elements in all the diagonals
   (*c*) Value of determinant
   (*d*) None of the above

23. Formation of alpha helix in proteins is promoted by
    (*a*) Glutamic acid, arginine and leucine
    (*b*) Valine, leucine and phenylalanine
    (*c*) Proline, glycine and aspartic acid
    (*d*) Asparagine and serine

24. The major Source of stability of the DNA Double helix structure is
    (*a*) Hydrogen bonding between bases
    (*b*) Screening of phosphate changes by counter ions
    (*c*) Stacking interaction of neighboring basis
    (*d*) Solvation of phosphates

25. Urea acts as a protein denaturant because it binds to the
    (*a*) Charged residues of proteins
    (*b*) Hydrophobic residues of proteins
    (*e*) Peptide groups of proteins
    (*d*) CH_2 group of the protein backbone

26. In Nuclear Magnetic Resonance Spectroscopy the resonance phenomenon is observed after subjecting the nucleus under Question by one of the following electromagnetic radiations.
    (*a*) Infrared (*b*) X-rays
    (*c*) Radio frequency (*d*) Microwaves

27. Thermodynamics dictate that entropy, a measure of disorder in a system increase with every spontaneous process. Living system is highly ordered as well as spontaneous. This means that
    (*a*) Thermodynamics does not apply to living systems
    (*b*) Living systems increase the entropy of the surroundings
    (*c*) Living systems decrease the entropy of their surroundings
    (*d*) Living systems are not really ordered systems

28. Highly cooperative binding of a ligand to multiple binding sites on a macromolecule is best demonstrated by
    (*a*) Adair equation (*b*) Hill Plot
    (*c*) Lineweaver-Burk Plot (*d*) Arrhenius Plot

29. A hybridoma cell secreting mouse monoclonal antibodies can be generated by
    (*a*) Fusing spleen cells from immune mice with any cell from that mice
    (*b*) Culturing B cells in the presence of B cell growth factors
    (*c*) By transforming splenic B cells from an immune mouse with Epstein Barr virus
    (*d*) By fusing spleen cells from an immune mice with an appropriate plasmacytoma cell line

30. A virus is growing inside a B cell. The Viral antigens
    (*a*) Cannot be presented to T cells under that condition
    (*b*) Will be presented to T cells in association with MHC-I molecule

(*c*) Can be presented to T cells in association with both MHC-I and MHC-II molecules
(*d*) The virus has to use that B cell before any antigen presentation can take place

31. Super antigens stimulate
(*a*) Only T cells by binding to TCA in the absence of antigen presenting cells
(*b*) Can stimulate T, B and any other type of cells
(*c*) Only T cells by binding to the Vβ domain of T cells receptor and the MHC-II molecule an antigen presenting cells
(*d*) Only T cells by binding to CD_2 molecules

32. For developing a candidate vaccine for malaria
(*a*) We should identify several T cell and B cell epitopes which can elicit protective response in a large population
(*b*) We should identify only few T cell epitopes of the parasite
(*c*) We should identify only few B cell epitopes of the parasite
(*d*) We should identify epitopes which can induce antibody response in the host

33. In a chemical reaction, transition-state species have free energies
(*a*) Lower than either the reactants or the products
(*b*) Higher than either the reactants or the product
(*c*) Lower than the reactants, but higher than the products
(*d*) Higher than the reactants, but lower than the products

34. More free energy is released during the citric acid cycle than during glycolysis, but only 1 mole of ATP is produced for each mole of acetyl CoA that enters the cycle. What happens to most of tile remaining free energy that is produced duril1g the citric acid cycle?
(*a*) It is used to synthesize GTP
(*b*) It is used to reduce electron carriers
(*c*) It is lost as heat
(*d*) It is used to reduce pyruvate

35. The general name for an enzyme that transfers phosphate groups from ATP to a Protein is
(*a*) Protein kinase (*b*) Phosphorylase
(*c*) Phosphatase (*d*) ATPase

36. How do the daughter cells at the end of mitosis and cytokinesis compare with their parent cell when it was in G1 of the cell cycle?
(*a*) The daughter cells have half the amount of cytoplasm and half the amount of DNA
(*b*) The daughter cells have the same number of chromosomes and the same amount of DNA
(*c*) The daughter cells have the same number of chromosomes and half the amount of DNA
(*d*) The daughter cells have half the number of chromosomes and half the amount of DNA

37. Which of the following is FALSE in comparing prophase I of meiosis and prophase of mitosis
    (*a*) The nuclear envelope disassembles in both
    (*b*) The chromosomes Condense in both
    (*c*) Each chromosome has two chromatids in both
    (*d*) Tetrads form in both

38. Once transcribed the eukaryotic primary transcript typically undergoes substantial alteration that includes.
    (*a*) Fusion into circular forms known as plasmids
    (*b*) Linkage to histone molecules
    (*c*) Union with ribosomes
    (*d*) Tetrads form in both

39. All of the following arc potential control mechanisms for regulation of gene expression in eukaryotic organisms EXCEPT
    (*a*) Gene amplification
    (*b*) The degradation of mRNA
    (*c*) The lactose operon
    (*d*) Transcription

40. It is theoretically possible for a gene from any organism to function in any other organism. Why is this possible?
    (*a*) All organisms have similar nuclei
    (*b*) All organisms have the same genetic code
    (*c*) All organisms are made up of cells
    (*d*) All organisms have transfer RNA

41. DNA fragments from a gel are transferred to a membrane via a procedure called Southern blotting. The purpose of Southern blotting is to
    (*a*) Analyze the RFLPs in the DNA
    (*b*) Separate out the PCRs'
    (*c*) Permanently attach the. DNA fragments to a substrate
    (*d*) Separate the two complementary DNA strands

42. Influenza viruses require the presence of the nucleus in their host cells because
    (*a*) They use reverse transcriptase to make a cDNA which is integrated into the host genome
    (*b*) They scavenge capped fragments from host mRNA in the nucleus to use as primers for viral mRNA
    (*c*) They use the host RNA polymerase II to transcribe viral mRNAs.
    (*d*) They scavenge poly [A] tails from host mRNAs in the nucleus

43. HIV is the causative agent of AIDS and is a member of the Lentivirus genus of the family Retroviridae. Which of the following features of HIV makes it different from other members of this family?
    (*a*) HIV uses reverse transcriptase to convert its RNA genome into cDNA

(*b*) HIV infects human cells that are CD4+
(*c*) HIV is enveloped
(*d*) The genomic RNA of HIV is 5′ capped and 3′ polyadenylated

44. Which of the following vectors can carry the longest piece of foreign DNA?
(*a*) Plasmids
(*b*) Bacteriophage
(*c*) Cosmids
(*d*) Yeast artificial chromosomes (YACs)

45. DNA and RNA synthesis polymerization [of deoxynucleotides] which takes place
(*a*) In a 3′ to 5′ direction
(*b*) In a 5′ to 3′ direction
(*c*) In either (or both) directions
(*d*) DNA in 5′ to 3′ and RNA in 3′ to 5′

46. TATA boxes and Pribnow boxes are components of
(*a*) Operators (*b*) Promoters
(*c*) Enhancers (*d*) Activators

47. The RNA in the cell with the greatest sequence diversity is
(*a*) Messenger RNA (*b*) Ribosomal RNA
(*c*) Transfer RNA (*d*) (*a*) and (*c*)

48. During the overall process of protein synthesis, amino acids become covalently attached to
(*a*) Messenger RNA (*b*) Ribosomal RNA
(*c*) Transfer RNA (*d*) More than one of the above

49. Proteins whose binding to DNA acts to prevent transcription are known as
(*a*) Activators (*b*) Operators
(*c*) Repressors (*d*) Transcription factors

50. Which of the following genes is not common to all retroviruses?
(*a*) Pal (*b*) Env
(*c*) Src (*d*) Gag

51. The presence of an extra chromosome in a eukaryotic cell is most likely due to
(*a*) Linkage (*b*) Fertilization
(*c*) Transposition (*d*) Non-disjunciton

52. In fruitflies, the autosomal gene R causes red eyes and an alternative allele r causes white eyes. A testcross is done with a fly that is Rr. What percent of the offspring can be expected to have white eyes?
(*a*) 0% (*b*) 25%
(*c*) 50% (*d*) 75%

53. Which of the following is a function of a singal peptide?
(*a*) To direct DNA polymerase to a site on DNA
(*b*) To direct RNA polymerase to a site on DNA
(*c*) To direct a ribosome to insert a growing portein into the E.R.
(*d*) To terminate translation on an mRNA

54. Which of the following is incorporated in the model of logistic population growth but NOT in the exponential population growth model?
(*a*) Change in population size over time
(*b*) Maximum sustainable population size
(*c*) Population birth rate
(*d*) Population death rate

55. Which of the following is the best example of competitive exlusion?
(*a*) Two fish species cannot live in the same habitat
(*b*) An introduced plant species will exclude a similar native species
(*c*) Two parasite species cannot occupy the same host
(*d*) Two bird species in the same forest cannot use the same set of resorces

56. Addition of detergents containing phosphates can disturb aquatic ecosystems because the phosphates
(*a*) Kill bacteria (*b*) Poison fish
(*c*) Stimulate algae growth (*d*) Fertilize crop plants

57. A genetic defect prevents guard cells from closing stomata in the leaves of a plant. This plant will most likely have excessive ______
(*a*) CO_2 in its leaves (*b*) O_2 in its leaves
(*c*) Nitrogen fixation (*d*) Loss of water

58. A hollow ball of cells best describes a
(*a*) Blastula (*b*) morula
(*c*) Gastrula (*d*) Gamete

59. In a nephron of the human kidney, urea can normally leave the _______ and enter the ______.
(*a*) Collecting duct / descending loop of Henle
(*b*) Collecting duct / ascending loop of Henle
(*c*) Ascending loop of Henle/ descending loop of Henle
(*d*) Ascending loop of Henle / collecting duct

60. In one complete turn of the Krebs cycle, what is the maximum number of ATP molecules that can be produced in the Krebs cycle itself?
(*a*) 0 (*b*) 1
(*c*) 2 (*d*) 3

61. Which of the following do chloroplasts and mitochondria NOT have in common?
(*a*) ATP synthase (*b*) Electons transport chain
(*c*) ATP (*d*) NADH

62. Microfilaments are part of the structure of
    (*a*) Cilia (*b*) Mitotic spindles
    (*c*) Cell cleavage furrows (*d*) Flagella

63. The pH of human blood is slightly basic. Which of the following is most likely to be the pH of human blood?
    (*a*) 10.6 (*b*) 7.4
    (*c*) 7.0 (*d*) 6.4

64. Euchromatin contains
    (*a*) Single-copy genetical1y-active DNA
    (*b*) Repetitive and genetically inactive sequences
    (*c*) Single-copy, genetically-inactive DNA
    (*d*) Repetitive and genetically active sequences

65. Centromeres are directly involved in
    (*a*) DNA replication (*b*) Transcription
    (*c*) DNA repair (*d*) Chromosome segregation

66. Telomere repeat sequences contain
    (*a*) $(T / A)_x G_y$ (*b*) $(A / T)_x C_y$
    (*c*) $(G / C)_x A_y$ (*d*) $(G / C)_x T_y$

67. The transcriptional initiation site usually starts with
    (*a*) AG (*b*) GC
    (*c*) AT (*d*) AC

68. A stretch of double-stranded DNA contains 1000 base pairs, and its base composition is 71 % G + C. How many thymine residues are in this region of DNA?
    (*a*) 270 (*b*) 280
    (*c*) 290 (*d*) 300

69. A 5-month-old male presents with seizures and delayed development. Upon newborn screen he was detected to have hyper phenyl alaninemia and is on a phenylalanine-restricted, synthetic diet. The most likely cause for his current symptoms is a
    (*a*) defect in tetrabydrofolate reductase
    (*b*) defect in dihydropteridine reductase
    (*c*) tyrosine deficiency
    (*d*) tryptophan deficiency

70. Coding regions of eukaryotic gene that encode polypeptides are called
    (*a*) hnRNAs (*b*) Exons
    (*c*) Enhancers (*d*) Leader peptide

Model Test Paper – 8

PART – A

1. For purifying drinking water alum is used
   (*a*) For coagulation of mud particles
   (*b*) To kill bacteria
   (*c*) To remove salts
   (*d*) To remove gases

2. A weather balloon is not fully inflated on the ground because
   (*a*) If the balloon is fully inflated, it may not remain stable in a storm
   (*b*) The air inside the balloon expands as it rises and may burst
   (*c*) It cannot withstand the outside pressure if fully inflated
   (*d*) None of these

3. Vitamin BI2 is most useful for combating
   (*a*) Anaemia (*b*) Goitre
   (*c*) Night blindness (*d*) Rickets

4. The volume of which of the following materials decreases when it is heated from 0° C to 5°C ?
   (*a*) Air (*b*) Copper
   (*c*) Water (*d*) Mercury

5. On a night when the sky is clear, the temperature may dip considerably; on a cloudy night the temperature will usually dip much less. The reason for this difference is that
   (*a*) the clear sky allows radiant energy to escape readily from the earth
   (*b*) on a cloudy night the clouds are warm and therefore retard the cooling
   (*c*) the clear sky allows the cold of outer space to reach the earth
   (*d*) currents of air carry the heat away from the earth on a clear night

6. Which of the following chemicals is useful in photography?
   (*a*) Aluminium hydroxide (*b*) Potassium nitrate
   (*c*) Silver bromide (*d*) Sodium chloride

7. The purest form of water can be obtained from
   (*a*) A deep tubewell (*b*) A running stream
   (*c*) A hot water spring (*d*) A heavy shower of rain

8. Which of the following vitamins is stored in the liver?
   (*a*) Vitamin A (*b*) Vitamin C
   (*c*) Vitamin E (*d*) Vitamin K

9. Which of the following is needed by a person suffering from diabetes?
   (*a*) Antibiotics (*b*) Insulin
   (*c*) Penicillin (*d*) Streptomycin

10. An element common to all acids is
    (*a*) Oxygen (*b*) Hydrogen
    (*c*) Sulphur (*d*) Chlorine

11. Which of the following statements relating to sound and light is true ?
    (*a*) Light is a form of kinetic energy, whereas sound is a form of potential energy
    (*b*) Light can be reflected but sound cannot be
    (*c*) Light travels faster in air than does sound
    (*d*) Sound travels in waves but light does not

12. Radioactive substances can be produced readily in
    (*a*) An electron gun (*b*) An atomic pile
    (*c*) A transistor (*d*) A Wilson cloud chamber

13. The method of estimating the age of the crust of the earth, which is now believed to be the most accurate, makes use of the rate of
    (*a*) Accumulation of sedimentary beds
    (*b*) Accumulation of salt in the ocean
    (*c*) Atomic disintegration (radioactivity)
    (*d*) Loss of heat by the earth

14. When a given amount of air is cooled
    (*a*) The amount of moisture it can hold decreases
    (*b*) Its absolute humidity decreases
    (*c*) Its relative humidity remains constant
    (*d*) Its absolute humidity increases

15. With the present-day advance in medical techniques, transplants are possible in all of the following except
    (*a*) Artery (*b*) Bone
    (*c*) Cornea (*d*) Kidney

16. A transistor is most likely to be found in a
    (*a*) Fuse (*b*) Fluorescent lamp
    (*c*) Hearing aid (*d*) Wrist watch

17. Steel is more elastic than rubber because
    (*a*) Its density is high
    (*b*) It is a metal
    (*c*) Ratio of stress to strain is more
    (*d*) Ratio of stress to strain is less

18. Free surface of a liquid behaves like a sheet and tends to contract to the smallest possible area due to the
    (*a*) Force of adhesion (*b*) Force of friction
    (*c*) Centrifugal force (*d*) Force of cohesion

19. If speed of rotation of the earth increases, weight of the body
    (*a*) Increases (*b*) Remains unchanged
    (*c*) Decreases (*d*) may decrease or increase

20. The buoyancy depends on
    (*a*) The shape of the body
    (*b*) The mass of the body
    (*c*) The mass of the liquid displaced
    (*d*) The depth to which the body is immersed

21. The working of a rocket is based on the principle of
    (*a*) Electricity (*b*) Kepler's Law
    (c) Newton's Law (*d*) Conservation of momentum

22. Friction can be reduced by changing over from
    (*a*) Sliding to rolling
    (*b*) Rolling to sliding
    (*c*) Potential energy to kinetic energy
    (*d*) Dynamic to static

23. It takes 30 days to fill a laboratory dish with bacteria. If the size of the bacteria doubles each day, how long will it take for the bacteria to fill one half of the dish
    (*a*) 10 days (*b*) 15 days
    (*c*) 29 days (*d*) 20 days

24. A tap can fill a cistern in 8 hours and another can empty it in 16 hours. If both the taps are opened simultaneously, the time (in hours) to fill the tank will be
    (*a*) 8 (*b*) 10
    (*c*) 16 (*d*) 24

25. A and B can together do a piece of work in 12 days. B and C together can do the same work in 16 days. After A has been working at it for 5 days, and B for 7 days, C finishes it in 13 days. In how many days will C alone be able to do the work ?
    (*a*) 16 (*b*) 24
    (*c*) 36 (*d*) 48

26. A certain distance is covered by a cyclist at a certain speed. If a jogger covers half the distance in double the time, the ratio of the speeds of the jogger to that of the cyclist is
    (*a*) 1:4 (*b*) 4:1
    (*c*) 1:2 (*d*) 2:1
27. If a man travels at 30 krn/hr, he reaches his destination late by 10 minutes, but if he travels at 42 krn/hr, then he reaches 10 minutes earlier. Therefore the distance travelled by him is
    (*a*) 36 km (*b*) 35 km
    (*c*) 40 km (*d*) 45 km
28. Receiving a file from another computer over network line is called-
    (*a*) Log in (*b*) Downloading
    (*c*) Copying in (*d*) Uploading
29. IP address is made up of –
    (*a*) 32 bits (*b*) 16 bits
    (*c*) 8 bits (*d*) 4 bits
30. Consider the following program-

```
        P=0
        Q=0
DOWHILE (i=5) i=i+1
        A=A+3
        B=B+2
        PRINT A,B
```

    (*a*) 10, 15 (*b*) 12, 18
    (*c*) 18, 12 (*d*) 15,10

PART – B

1. Which one of the following conditions differentiates eukaryotic DNA replication from prokaryotic DNA replication?
    (*a*) Bidirectional replication fork
    (*b*) No use of an RNA primer
    (*c*) Multiple origins of replication
    (*d*) Use of only one DNA polymerase
2. Restriction-modification system of bacteria exists to
    (*a*) Promote conjugation
    (*b*) Encourage recombination of new genetic material
    (*c*) Promote complementation
    (*d*) Protect bacteria from invading foreign DNA

3. With reference to the enzymes in mitochondria, match List-I (Location in Mitochondria) with List-II (Enzymes) and select the correct answer using the code given below the Lists

List-I (Location)	**List-II** (Enzymes)
A. Outer membrane	1. Adenylate cyclase
B. Inner membrane	2. Fatty acid CoA ligase
C. Inter-membranal space	3. Malate dehydrogenase
D. Matrix	4. Succinic acid dehydrogenase

Code:

(*a*)	A	B	C	B
	2	1	4	3
(*b*)	A	B	C	D
	2	4	1	3
(*c*)	A	B	C	D
	3	1	4	2
(*d*)	A	B	C	D
	3	4	1	2

4. Consider the following enzymes
   1. ATPase
   2. Acid phosphatase
   3. Glucose-6-phosphatase

   Which of the above enzymes is/are present in the Golgi complex of animal cells?
   (*a*) 1 only (*b*) 2 and 3 only
   (*c*) 1 and 3 only (*d*) 1, 2 and 3

5. Which one of the following statements is NOT correct?
   (*a*) In deoxyribose, the phosphate is attached to 3' carbon and the hydroxyl group is attached to 5' carbon
   (*b*) Any nucleic acid has a 3' end and a 5' end
   (*c*) A gene is always written from 5' end.
   (*d*) The length of the promoter sequence varies from gene to gene

6. A sequence of nucleotides on DNA 'CATCATCATCAT' is changed through mutation to 'CAATCATCATCAT'. What is this type of mutation called?
   (*a*) Frame shift (*b*) Transition
   (*c*) Transversion (*d*) Nonsense

7. Consider the following statements:
   1. Histones are found in all organisms that have nuclei.
   2. There are eleven types of histones.
   3. Histones are temporarily removed during transcription.
   4. Any change in the amino acid sequence of histone proteins is harmless for the organism.

Which of the statements given above is / are correct?

(*a*) 1 only (*b*) 2, 3 and 4 only

(*c*) 1 and 3 only (*d*) 1, 3 and 4 only

8. As an antibiotic inhibiting protein synthesis, what is the specific action of Rifamycin?
   (*a*) Inhibition of elongation at transcription in eukaryotes
   (*b*) Denaturing RNA polymerase thereby blocking initiation at transcription in prokaryotes
   (*c*) Inhibition of recognition on mRNA in both prokaryotes and eukaryotes
   (*d*) Blocking binding at A-site or causing misreading of codon in prokaryotes

9. Which among the following are the precursor amino acids for purines?
   (*a*) Arginine and Tyrosine
   (*b*) Aspartate and Glycine
   (*c*) Histidine and Tyrosine
   (*d*) Methionine and Tryptophan

10. Bacterial cells can be rendered more permeable to the uptake of plasinids by treatment with
    (*a*) Heat (*b*) Calcium phosphate
    (*c*) Alkali detergent (*d*) Ultrasound or magnetism

11. Which one of the following human genes has the longest stretch of DNA (~24 Mb)?
    (*a*) Globin gene (*b*) Histone gene
    (*c*) Dystrophin gene (*d*) Insulin gene

12. Consider the following statements :
    1. Chloramphenicol does not affect mitochondrial protein synthesis.
    2. Mitochondria employ *f*-methionine as the initiating amino acid.

    Which of the statements given above is/are correct?
    (*a*) 1 only (*b*) 2 only
    (*c*) Both 1 and 2 (*d*) Neither 1 nor 2

13. Which one of the following cells is diploid?
    (*a*) Primary polar body (*b*) Spermatid
    (*c*) Primary spermatocyte (*d*) Spermatozoon

14. Consider the following statements: A mammalian protein expressed in E. coli by means of recombinant DNA technology can lack
    1. glycosylation
    2. phosphorylation

    Which of the statements given above are correct?
    (*a*) 1 only (*b*) 2 only
    (*c*) Both 1 and 2 (*d*) Neither 1 nor 2

15. Hormones are thought to regulate gene activity primarily ay the level of
    (*a*) Transport of RNA from nucleus to cytoplasm
    (*b*) Post-translation processing of protein
    (*c*) Transcription
    (*d*) Translation

16. An antibiotic that resembles the 3' end of a charged tRNA molecule and brings premature termination of protein synthesis is
    (*a*) Streptomycin (*b*) Chloramphenicol
    (*c*) Tetracycline (*d*) Puromycin

17. Consider the following statements :
    1. In a bacterial ribosome, the 30 S subunit contains one molecule of rRNA and the large subunit contains two molecules each of three types of rRNA.
    2. All tRNAs have five loops caused by complementary base pairing and the anticodon is at the third loop from the 5' end.

    Which of the statements given above is / are correct?
    (*a*) 1 only (*b*) 2 only
    (*c*) Both 1 and 2 (*d*) Neither 1 nor 2

18. In DNA, the deoxygenation is at
    (*a*) First carbon atom (*b*) Second carbon atom
    (*c*) Third carbon atom (*d*) Fourth carbon atom

19. Consider the following statements regarding the structure of DNA :
    1. There are three hydrogen bonds between adenine and thymine whereas between cytosine and guanine the hydrogen bonds are two.
    2. Irrespective of the source of DNA, the ratio of adenine to thymine and the ratio of cytosine to guanine is always one.

    Which of the statements given above is / are correct?
    (*a*) 1 only (*b*) 2 only
    (c) Both 1 and 2 (*d*) Neither 1 nor 2

20. Which one of the following is correct?
    (*a*) DNA fingerprinting and DNA footprinting are one and the same
    (*b*) DNA fingerprinting is used to identify DNA from living organisms whereas DNA footprinting is used to identify DNA from fossils
    (*c*) DNA fingerprinting and DNA footprinting both are used for individual identification
    (*d*) DNA fingerprinting is used for individual identification whereas DNA footprinting is used for protein binding regions in DNA

21. Consider the following statements with reference to lactose (*lac*) operon in *E. coli* :
    1. Lac enzymes are encoded in a single polycistronic mRNA molecule (*lac* mRNA).
    2. Cyclic AMP induces the initiation of transcription of *lac* mRNA.

    Which of the statements given above is / are correct?
    (*a*) 1 only (*b*) 2 only
    (c) Both 1 and 2 (*d*) Neither 1 nor 2

22. Consider the following statements:
    1. The eyeball of rabbit is moved in the orbit by four sets of muscles and the eyeball of frog is moved by three sets of muscles.
    2. The pecten in the eye is more developed in diurnal birds than in nocturnal birds.

    Which of the statements given above is / are correct?

    (*a*) 1 only (*b*) 2 only
    (*c*) Both 1 and 2 (*d*) Neither 1 nor 2

23. Consider the following amino acids:
    1. Arginine 2. Alanine
    3. Histidine

    Which of the above amino acids are polar in nature?

    (*a*) 1 and 2 only (*b*) 2 and 3 only
    (*c*) 1 and 3 only (*d*) 1, 2 and 3

24. Consider the following statements :

    The most important role of folic acid in promoting growth is through
    1. conversion of decarboxylated pyruvic acid into acetyl CoA
    2. synthesis of purine and thymine synthesis
    3. calcium deposition in bones

    Which of the statements given above is / are correct?

    (*a*) 1 and 2 only (*b*) 2 only
    (*c*) 1 and 3 only (*d*) 3 only

25. Which one of the following sensations is not generated by impulses initiated in naked nerve endings?

    (*a*) Touch (*b*) Pain
    (*c*) Cold (*d*) Taste

26. In glycolysis, which enzyme acts on 2-phosphoglycerate to form phosphoenol pyruvate?

    (*a*) Aldolase (*b*) Enolase
    (*c*) Phosphoglycerokinase (*d*) Phosphoglyceromutase

27. In the vertebrates,. the hormones which control osmoregulation are

    (*a*) Vasopressin and thyrotropin
    (*b*) Aldosterone and corticotropin
    (*c*) Thyrotropin and corticotropin
    (*d*) Vasopressin and aldosterone

28. Which one of the following vitamins is the precursor of coenzyme A?

    (*a*) Pantothenic acid (*b*) Pyridoxamine
    (*c*) Riboflavin (*d*) Thiamine

29. Nicotinic acid can be synthesized biologically from

    (*a*) Gglutamic acid (*b*) Aspartic acid
    (*c*) Tyrosine (*d*) Tryptophan

30. With reference to mitochondrial 'Electron Transport Chain', which one of the following statements is correct?
    (*a*) Ubiquinone can carry two electrons and two protons simultaneously
    (*b*) The electrons that each molecule of NADH contributes to the mitochondrial electron transport chain provide enough power to create two ATPs
    (*c*) The contribution of FADH 2 provides enough power for the production of three ATPs
    (*d*) Cytochrome b and cytochrome c_1 are parts of an enzyme complex known as cytochrome oxidase

31. Consider the following statements :
    1. ATP cannot be stored in the cell.
    2. ATP can be moved from one cell to another.
    3. NAD+ picks up two electrons at once.

    Which of the statements given above is / are correct?
    (*a*) 1 only (*b*) 2 and 3 only
    (*c*) 1 and 3 only (*d*) 1, 2 and 3

32. Which one of the following hormones controls gluconeogenesis?
    (*a*) Thyroxine (*b*) Insulin
    (*c*) Cortisol (*d*) Glucagon

33. Dietary carotenes and carotenoids are absorbed & transported in the plasma of higher mammals as
    (*a*) Albumins (*b*) Globulins
    (*c*) Lipoproteins (*d*) Glycoproteins

34. Consider the following conditions
    1. Enlarged thyroid
    2. Protruding eyeballs
    3. Decreased blood sugar

    Which of the above is / are the symptom(s) of Graves' disease?
    (a) 1 and 2 only (b) 2 only
    (c) 1 and 3 only (d) 1, 2 and 3

35. Consider the following statements:
    In citric acid cycle
    1. the generation of A TP is done at two steps
    2. NAD+ is reduced to NADH at two steps
    3. FAD is reduced to FADH2 at one step

    Which of the statements given above is / are correct?
    (*a*) 1 and 2 only (*b*) 3 only
    (*c*) 1 and 3 only (*d*) 1, 2 and 3

36. Proteins also release the energy in our body but before that their deamination is carried out in

(*a*) Spleen (*b*) Muscles
(*c*) Lungs (*d*) Liver

37. Consider the following processes:

1. Generation of cytotoxic T -cells
2. Stimulation of interferon release
3. Formation of bursin
4. Release of opsin

Which of the above are the functions in mammalian tissues performed by interleukin (T-cell growth factor) which is secreted by certain activated T-Lymphocytes?

(*a*) 1 and 2 only (*b*) 1 and 3 only
(*c*) 2 and 3 only (*d*) 3 and 4 only

38. Which one of the following is a Tyrosine derivative?'

(*a*) Insulin
(*b*) Growth hormone
(*c*) Oxytocin
(*d*) Thyroxine

39. With reference to sucrose, consider the following statements:

1. Sucrose is a non-reducing sugar.
2. The linkage in it is an a2-b1 glycosidic bond
3. It is a disaccharide having a-glucose and b-fructose.

Which of the statements given above is(are) correct

(*a*) 1 only (*b*) 2 and 3 only
(*c*) 1and 3 only (*d*) 1, 2 and 3

40. The epididymis in viviparous mammals mainly helps in the

(*a*) Transport of sperms only
(*b*) Maturation of sperms only
(*c*) Storage and transport of sperms
(d) Maturation and storage of sperms

41. In frog, eye lens develops from

(*a*) Ectoderm (*b*) Mesoderm
(*c*) Endoderm (*d*) Mesenchyme

42. Which one of the following is the characteristic of an adult ascidian?

(*a*) Elongated tail
(*b*) Large notochord
(*c*) Enlarged pharynx
(*d*) Well-developed statocyst

43. With reference to the development of allantois in mammals, consider the following statements:
    1. It is composed of endoderm and splanchnic mesoderm.
    2. As it grows, mesodermal components of allantoic wall give rise to the blood vessel system of the allantois and fuse with mesoderm of chorion.
    3. Allantois of mammals supplies / oxygen and nutrients to the embryo.

    Which of the statements given above is/are correct?

    (*a*) 1 and 2 only (*b*) 2 and 3 only
    (*c*) 1 and 3 only (*d*) 1, 2 and 3

44. Consider the following statements:
    1. Haemophilia is determined by sex-linked recessive gene.
    2. Haemophilia is known only in males; and females homozygous for this gene are unknown.

    Which of the statements given above is / are correct?

    (*a*) 1 only (*b*) 2 only
    (*c*) Both 1 and 2 (*d*) Neither 1 nor 2

45. Who of the following proposed the theory that all organs of an individual produce minute particles carrying information about the organs?

    (*a*) Wallace (*b*) Darwin
    (c) Lamarck (*d*) Huxley

46. Neo-Lamarckism is getting a new life with the discovery of

    (*a*) RNA interference (*b*) Epistasis
    (*c*) Genetic imprinting (*d*) Paedomorphosis

47. consider the following :
    1. Alanine 2. Glycine
    3. Aspartic acid

    Which of the above amino acids were produced in Miller's experiment to produce organic molecules from the gaseous composition of early/primitive atmosphere of earth?

    (*a*) 1 and 2 only
    (*b*) 2 and 3 only
    (*c*) 1 and 3 only
    (*d*) 1, 2 and 3

48. Golden langur (*Presbytis geel*) is naturally found in which one of the Wildlife Sanctuaries/National Parks?

    (*a*) Periyar (*b*) Sariska
    (*c*) Manas (*d*) Sasan Gir

49. Which one among the following is a mammal with least number of diploid set of chromosomes?

    (*a*) Dog (*b*) Rhinoceros
    (*c*) Barking deer (*d*) Red deer

50. Who of the following has given the Y -shaped two-channel energy flow model consisting of grazing and detritus food chains?
    (*a*) Clements (*b*) Hardin
    (*c*) Odum (*d*) Tansley

51. Similar environment in different continents produce similar type of ecosystems. Species occupying similar ecological niche in such disjunct ecosystems are known as
    (*a*) Ecological guilds
    (*b*) Ecological equivalents
    (*c*) Ecotypes
    (*d*) Ecological indicators

52. The grazing pathway of energy flow is relatively more important than the detritus pathway
    (*a*) In grassland ecosystem
    (*b*) Tropical forest ecosystem
    (*c*) Pond ecosystem
    (*d*) Marine ecosystem

53. A taxon facing an extremely high risk of extinction in the wild in the immediate future is regarded as
    (*a*) Critically endangered (*b*) Endangered
    (c) Vulnerable (*d*) Near threatened

54. Consider the following characteristics
    1. Loss of hair on the skin
    2. Loss of sweat -glands
    3. Presence of thick blubber
    4. Presence of swim bladder

    In Cetacea, due to aquatic mode of life, which of the above are the adaptations that have taken place?
    (*a*) 1, 2 and 3 only
    (*b*) 2, 3 and 4 only
    (*c*) 1, 2 and 4 only
    (*d*) 1, 3 and 4 only

55. The area over which an individual animal roams during the course of its usual daily wandering and in which it spends most of its time is called
    (*a*) Nesting territory (*b*) Home range
    (*c*) Mating territory (*d*) Feeding range

56. The interspecific interaction between the termites and the protozoans (Trichonympha sp.), present in the guts of termites is called
    (*a*) Amensalism (*b*) Commensalism
    (*c*) Parasitism (*d*) Mutalism

57. Consider the following :
    1. Bandipur Wildlife Sanctuary
    2. Manas Wildlife Sanctuary
    3. Simlipal Wildlife Sanctuary

    Which of the above are tiger reserves under the Project Tiger?
    (*a*) 1 and 2 only (*b*) 2 and 3 only
    (*c*) 1 and 3 only (*d*) 1, 2 and 3

58. Thamin deer (*Cervus eldi*) is an inhabitant of
    (*a*) Kanha National Park
    (*b*) Keibul Lamjao National Park
    (*c*) Bandipur Wildlife Sanctuary
    (*d*) Periyar Wildlife Sanctuary

59. Similarity in the appearance of two or more unpalatable species resulting over evolutionary time is called
    (*a*) Mutual adaptation (*b*) Batesian mimicry
    (*c*) Mullerian mimicry (*d*) Convergent mimicry

60. The pyramids of biomass are always inverted in
    (*a*) Forest ecosystem
    (*b*) Grassland ecosystem
    (*c*) Pond ecosystem
    (*d*) Desert ecosystem

61. Consider the following statements:
    1. The king cobra is ophiophagus.
    2. The king cobra is the only snake in the world which builds a nest.

    Which of the statements given above is/are correct?
    (*a*) 1 only (*b*) 2 only
    (*c*) Both 1 and 2 (*d*) Neither 1 nor 2

62. Which one of the following refers to the largest tiger reserve?
    (*a*) Corbett (*b*) Sariska
    (*c*) Nagarjunasagar-Srisailam (*d*) Kanha

63. Consider the following statements:
    1. In India, the Sangai is confined to Nagaland only.
    2. Four-horned antelope (*Tetraeerus quadrieomis*) exclusively lives in Indian sub-continent.

    Which of the statements given above is/are correct?
    (*a*) 1 only (*b*) 2 only
    (*c*) Both 1 and 2 (*d*) Neither 1 nor 2

64. Who discovered Polymerase Chain Reaction (PCR) ?
    (*a*) James Watson (*b*) David Baltimore
    (*c*) Kary Mullis (*d*) F. Crick

65. Consider the following statements:

    1. Marfan syndrome is a sex linked disorder.
    2. Phenylketonuria is an autosomal disorder.

    Which of the statements given above is / are correct?

    (*a*) 1 only (*b*) 2 only
    (*c*) Both 1 and 2 (*d*) Neither 1 nor 2

66. The pollen basket in honeybee is located at the

    (*a*) Lower side of the abdomen
    (*b*) Tip of antenna
    (*c*) Tarsus of first leg
    (*d*) Tibia of third leg

67. Duchenne muscular dystrophy is a/an

    (*a*) Sex-linked disorder
    (*b*) Autosomal disorder
    (*c*) Pre-disposition to multiple cancer
    (*d*) Trinucleotide repeat expansion

68. Consider the following statements :

    1. The females, but not males, of all wasps have sting.
    2. The adult wasps have shorter tongue than bees, and so can suck the nectar only from shallow flowers.

    Which of the statements given above is / are correct?

    (*a*) 1 only (*b*) 2 only
    (*c*) Both 1 and 2 (*d*) Neither 1 nor 2

69. The synthesis of plasma albumin is done by

    (*a*) Liver (*b*) Muscle cells
    (*c*) Pancreas (*d*) Spleen

70. What is the role of secretin from the following?

    (*a*) It stimulates the testis to secrete testosterone
    (*b*) Stimulates stomach to release HCI
    (*c*) It stimulates pancreas to secrete the digestive enzymes
    (*d*) It stimulates spleen to release the stored RBC

Model Test Paper – 9

PART – A

1. An eye defect which usually results from an unequal curvature of the cornea is
   (*a*) Nearsightedness (*b*) Astigmatism
   (*c*) Colour blindness (*d*) Night blindness

2. The velocity of sound in air under normal conditions is
   (*a*) 30 m/sec
   (*b*) 320 m/sec
   (*c*) 332 m/sec
   (*d*) 3,320 m/sec

3. A photo-electric cell converts
   (*a*) Sound energy into electrical energy
   (*b*) Light energy into electrical energy
   (*c*) An electrical signal into sound waves
   (*d*) Electrical energy into light energy

4. Which of the following sounds cannot be heard by human ear?
   (*a*) 300 vibrations/sec
   (*b*) 1,000 vibrations/see
   (*c*) 10,000 vibrations/sec
   (*d*) 30,000 vibrations/sec

5. If force is expressed in newton and the distance in metre, then the work done is expressed in
   (*a*) Joule (*b*) Kg wt
   (*c*) Kg wt m (*d*) Watt

6. The Law of Natural Selection is associated with
   (*a*) Dalton (*b*) Darwin
   (*c*) Kepler (*d*) Mendel

7. When cream is separated from milk
   (*a*) The density of milk increases
   (*b*) The density of milk decreases
   (*c*) The density of milk remains unchanged
   (*d*) It becomes more viscous

8. The element of an electric stove is made of
   (*a*) Copper (*b*) Invar
   (*c*) Magnalium (*d*) Nicrome

9. Which of the following is based on the procesS'of fusion?
   (*a*) Atom bomb (*b*) Hydrogen bomb
   (*c*) Ordinary bomb (*d*) Napalm bomb

10. Hybridisation is
    (*a*) Downward movement of water through soil
    (*b*) A process of tilling the land
    (*c*) Decayed vegetable matter
    (*d*) Cross-fertilisation between two varieties

11. Of the following foods, which one is the best source of protein ?
    (*a*) Butter (*b*) Fish
    (*c*) Lettuce (*d*) Milk

12. The red blood cells are formed in the
    (*a*) Heart (*b*) Liver
    (*c*) Lymph nodes (*d*) Marrow of bones

13. A wet-bulb and a dry-bulb thermometer are used to determine
    (*a*) The minimum temperature at a place in any 24-hour period
    (*b*) Relative humidity
    (*c*) Air pressure
    (*d*) The maximum temperature at a place in any 24-hour period

14. One of the isotopes of iodine has a "half life" of 25 minutes. This information tells us that if we start with a given quantity of the isotopes, 50 minutes later there will remain
    (*a*) One-fourth of the original amount
    (*b*) None
    (*c*) One-half of the original amount
    (*d*) Approximately the same amount

15. Small amount of iodine are necessary in our diet to
    (*a*) Prevent pellagra
    (*b*) Compensate for underactivity of the thyroid gland
    (*c*) Stimulate clotting of blood
    (*d*) Stimulate pituitary gland

16. On sudden cardiac arrest, which of the following is advised as a first step to revive the functioning of human heart ?
    (*a*) Mouth to mouth resuscitation (*b*) Giving external cardiac massage
    (*c*) Sprinkling water on the face (*d*) Giving cool water to drink

17. A triode differs from a diode in the way that
    (*a*) It can amplify a signal
    (*b*) It has vacuum inside
    (*c*) It has a heated cathode
    (*d*) Its current is caused by the photo electric effect

18. If the angles of a triangle are in the ratio 5: 4 :3, how many degrees are there in the largest angle
    (*a*) 750 (*b*) 900
    (*c*) 400 (*d*) 450

19. Two numbers are in the ratio 5 : 4, and there difference is 10. What is the larger number?
    (*a*) 30 (*b*) 40
    (*c*) 50 (*d*) 60

20. The ratio of the prices of two houses A and B was 4 : 5 last year. This year, the price of A is increased by 25% and that of B by Rs. 50,000. If their prices are now in the ratio 9 : 10, the price of A last year was
    (*a*) Rs. 3,60,000 (*b*) Rs. 4,50,000
    (*c*) Rs. 4,80,000 (*d*) Rs. 5,00,000

21. Three-fourths of 68 is less than two thirds of 114 by
    (*a*) 12 (*b*) 25
    (*c*) 35 (*d*) 48

22. Two cards are drawn together from a pack of 52 cards (a set of traditional playing cards), at random. The probability that one is a spade and other is a heart is
    (*a*) 13/102 (*b*) 3/20
    (*c*) 47/100 (*d*) 29/34

23. A bag has 4 red and 5 black balls. A second bag has 3 red and 7 black balls. One ball is drawn from the first bag and two from the second. The probability, that there are two blacks balls and a red ball, is
    (*a*) 14/45 (*b*) 11/45
    (*c*) 7/15 (*d*) 9/54

24. The transverse, longitudinal and surface waves in an earthquake originate from
    (*a*) The epicentre within the body of the earth
    (*b*) The focus on the surface of the earth
    (*c*) The focus within the body of the earth
    (*d*) The epicentre on the surface of the earth

25. Seasonal contrasts are maximum in
    (*a*) Mid latitudes (*b*) Low latitudes
    (*c*) High latitudes (*d*) Subtropics

26. Although only the southern part of India lies in the tropical region, but the whole of India has tropical climate. This is because.
    (*a*) India comes under the influence of monsoons.
    (*b*) Northern part of India has large tracts of plain region
    (*c*) Tropic of Cancer passes through the middle of the country
    (*d*) High Himalayan mountain ranges separate it from the rest of Asia

27. What is the main cause of movement in the earth's atmosphere?
    (*a*) Difference in air pressure (*b*) Solar energy
    (*c*) Difference in temperature (*d*) Wind

28. Among the following which is a general purpose programming language-
    (*a*) C (*b*) COBOL
    (*c*) PASCAL (*d*) FORTRAN

29. Consider the following program:

```
    A=0
    B=0
    I=0
Do While I =/=0
    A=A^2+1
    B=B^2–3
Else
    PRINT A
```

The output of the programme will be
    (*a*) 0 (*b*) 16
    (*c*) 9 (*d*) 15

30. Among the following which is not an input device:
    (*a*) Mouse (*b*) Scanner
    (*c*) OMR (*d*) Plotter

PART – B

1. One of the parents of a cross has a mutation in its mitochondria. In that cross, that parent is taken as a male. During segregation of F_2 progenies that mutation is found in
    (*a*) One-third of the progenies
    (*b*) None of the progenies
    (*c*) All the progenies
    (*d*) Fifty percent of the progenies

2. When a fresh-water protozoan possessing a contractile vacuole, is placed in a glass containing marine water, the vacuole will
   (*a*) Increase in number (*b*) Disappear
   (*c*) Increase in size (*d*) Decrease in size

3. One of the following is a very unique feature of the mammalian body:
   (*a*) Homeothermy (*b*) Presence of Diaphragm
   (*c*) Four chambered heart (*d*) Rib cage

4. Chemically hormones are
   (*a*) Biogenic amines only
   (*b*) Proteins, steroids and biogenic amines
   (*c*) Proteins only
   (*d*) Steroids only

5. Which one of the following pairs is not correctly matched?
   (*a*) Vitamin B12 – Pernicious anaemia
   (*b*) Vitamin B6 – Loss of appetite
   (*c*) Vitamin B1 – Beri-beri
   (*d*) Vitamin B2 – Pellagra

6. Uricotelism is found in
   (*a*) Mammals and birds
   (*b*) Fishes and fresh-water protozoans
   (*c*) Birds, reptiles and insects
   (*d*) Frogs and toads

7. Duodenum has characteristic Brunner's glands which secrete two hormones called
   (*a*) Kinase, estrogen
   (*b*) Secretin, cholecystokinin
   (*c*) Prolactin, parathormone
   (*d*) Estradiol, progesterone

8. Mast cells of connective tissue contain
   (*a*) Vasopressin and relaxin
   (*b*) Heparin and histamine
   (*c*) Heparin and calcitonin
   (*d*) Serotonin and melanin

9. Cancer cells are more easily damaged by radiation than normal cells because they are
   (*a*) Lack of mutation
   (*b*) Undergoing rapid division
   (*c*) Different in structure
   (*d*) Non-dividing

10. Certain characteristic demographic features of developing countries are
    (*a*) High fertility, rapidly falling mortality rate, rapid population growth & young age distribution
    (*b*) High fertility, high density, rapidly rising mortality rate and a very young age distribution
    (*c*) High infant mortality, low fertility, uneven population growth and a very young age distribution
    (*d*) High mortality, high density, uneven population growth and a very old age distribution

11. ATPase enzyme needed for muscle contraction is located in
    (*a*) Actinin (*b*) Troponin
    (*c*) Myosin (*d*) Actin

12. Which one of the following is not correctly matched?
    (*a*) Glossina palpalis – Sleeping sickness
    (*b*) Culex pipiens – Filariasis
    (*c*) Aedes aegypti – Yellow fever
    (*d*) Anopheles culifacies – Leishmaniasis

13. Which one of the following pairs is not correctly matched?
    (*a*) Streptomyces – Antibiotic
    (*b*) Serratia – Drug addiction
    (*c*) Spirulina – Single cell protein
    (*d*) Rhizobium – Biofertilizer

14. A free living nitrogen-fixing cyanobacterium which can also form symbiotic association with the water fern Azolla is
    (*a*) Tolypothrix (*b*) Chlorella
    (*c*) Nostoc (*d*) Anabaena

15. In the ABO system of blood groups, if both antigens are present but no antibody, the blood group of the individual would be
    (*a*) B (*b*) O
    (*c*) AB (*d*) A

16. Which one of the following pairs correctly matches a hormone with a disease resulting from its deficiency?
    (*a*) Luteinizing hormone – Failure of ovulation
    (*b*) Insulin– Diabetes insipidus
    (*c*) Thyroxine – Tetany
    (*d*) Parathyroid hormone – Diabetes mellitus

17. Angiosperms have dominated the land flora primarily because of their
    (*a*) Power of adaptability in diverse habitat
    (*b*) Property of producing large number of seeds
    (*c*) Nature of self pollination
    (*d*) Domestication by man

18. Which of the following hormones is not a secretion product of human placenta?
    (*a*) Human chorionic gonadotropin
    (*b*) Prolactin
    (*c*) Estrogen
    (*d*) Progesterone

19. You are required to draw blood from a patient and to keep it in a test tube for analysis of blood corpuscles and plasma. You are also provided with the following four types of test tubes. Which of them will you not use for the purpose?
    (*a*) Test tube containing calcium bicarbonate
    (*b*) Chilled test tube
    (*c*) Test tube containing heparin
    (*d*) Test tube containing sodium oxalate

20. In your opinion, which is the most effective way to conserve the plant diversity of an area?
    (*a*) By tissue culture method
    (*b*) By creating biosphere reserve
    (*c*) By creating botanical garden
    (*d*) By developing seed bank

21. Which of the following is expected to have the highest value (gm/m^2/yr) in a grassland ecosystem?
    (*a*) Secondary Production
    (*b*) Tertiary Production
    (*c*) Gross Production (GP)
    (*d*) Net Production (NP)

22. If by radiation all nitrogenase enzymes are inactivated, then there will be no
    (*a*) Fixation of nitrogen in legumes
    (*b*) Fixation of atmospheric nitrogen
    (*c*) Conversion from nitrate to nitrite in legumes
    (*d*) Conversion from ammonium to nitrate in soil

23. What kind of evidence suggested that man is more closely related with chimpanzee than with other hominoid apes?
    (*a*) Evidence from DNA from sex chromosomes only
    (*b*) Comparison of chromosomes morphology only
    (*c*) Evidence from fossil remains, and the fossil mitochondrial DNA alone
    (*d*) Evidence from DNA extracted from sex chromosomes, autosomes and mitochondria

24. A gene which suppresses the action of another gene not situated on the same locus on the same chromosome is termed
    (*a*) Jumping gene (*b*) Epistatic gene
    (*c*) Supplementary gene (*d*) Hypostatic gene

25. Gene therapy is
    (*a*) Same as recombinant DNA technology
    (*b*) Aimed at growing plants in vitro
    (*c*) Aimed at growing animals in vitro
    (*d*) Employed to replace defective genes of animals or plants by correct genes

26. According to operon concept, an operator gene combines with
    (*a*) Inducer gene to 'switch on' transcription
    (*b*) Regulator gene to 'switch off, transcription
    (*c*) Regulator protein to 'switch off, transcription
    (*d*) Regulator protein to 'switch on' transcription

27. Which among the following is not an endocrine gland?
    (*a*) Pineal (*b*) Pituitary
    (*c*) Adrenals (*d*) Gonads

28. The excreta of lizards is rich in
    (*a*) Urea (*b*) Uric acid
    (*c*) Guanidine (*d*) Alantoin

29. Which among the following is not a stem modification?
    (*a*) Rhizome of ginger
    (*b*) Sweet potato tuber
    (*c*) Corn of Colocasia
    (*d*) Potato tuber

30. Down's syndrome is due to
    (*a*) Trisomy of chromosome 21
    (*b*) Trisomy of Y chromosome
    (*c*) Trisomy of X chromosome
    (*d*) Deletion of X chromosome

31. To get a constant specific growth rate in a fed batch reactor the feeding pattern should be
    (*a*) Constant rate
    (*b*) Linearly increasing rate
    (*c*) Pulse feeding
    (*d*) Exponential feeding

32. A plasmid was treated with topoisomerase followed by an intercalator which is known to unwind DNA by 18 degrees. Subsequently the ligand-DNA mixture was extracted with phenol chloroform and run on an agarose gel where it was found to have 2 positive supercoils. The number of ligand molecules bound to one plasmid is
    (*a*) Zero (*b*) 20
    (*c*) 40 (*d*) 80

33. When a protein is denatured by heating, the absorbance as measured in a UV spectrometer will
    (*a*) Always increase
    (*b*) Always decrease
    (*c*) Increase or decrease depending on wavelength
    (*d*) Remain unaffected

34. Chymotrypsinogen in the native state and reduced unfolded states is loaded in well A and B respectively. They are electrophoreses and stain, one of the following results is likely to be observed.
    (*a*) Protein in well A would have moved longer distance than that in well B
    (*b*) Protein in well A would have moved shorter distance than that in well B
    (*c*) Protein in well A and B would have moved the same distance
    (*d*) Protein in well A and B would not move at all

35. Urea is known to denature proteins at high concentration due to
    (*a*) Its ability to disrupt water structure
    (*b*) Its ability to hydrogen bond with the peptide group in proteins
    (*c*) Both (*a*) and (*b*)
    (*d*) Its ability to disrupt electrostatic interactions

36. Super antigens activate
    (*a*) T cells only in an antigen non-specific manner by cross linking T cell receptors with the MHC-II molecules
    (*b*) B cells only in an antigen non-specific manner by Cross linking a large number of surface immunoglobulin molecules
    (*c*) Both T and B cells without interacting through TCR or BCR
    (*d*) T cells only through an unknown mechanism

37. Macrophages. which are also called monocytes, have the ability to
    (*a*) Process and present antigens to T cells
    (*b*) Produce antibodies
    (*c*) Express IgM molecules on their surface
    (*d*) Differentiate into dendritic cells when necessary

38. Indicate which statement is not correct. T helper cells
    (*a*) Stimulate migration of macrophages
    (*b*) Help B cells to produce antibodies
    (*c*) Are cytotoxic to virus infected cells
    (*d*) Help in generation of cytotoxic T Cells

39. Which of the following substances will not produce antibodies when injected into an animal?
    (*a*) Bacterial polysaccharides (*b*) DNA
    (*c*) Dinitrophenol (*d*) Actin

40. Monoclonal antibodies are secreted by Hybridomas which are generated by
    (*a*) Fusion of immune spleen cells with any type of cells capable of growing in tissue culture
    (*b*) Fusion of immune spleen cells with plasmacytoma cells
    (*c*) Growing immune spleen cells in the presence of HAT
    (*d*) Growing immune spleen cells in the presence of B cell growth factors

41. The dendritic cells can only present antigen to naive T cells-
    (*a*) Because they constitutively express MHC-II and costimulatory molecules on their surface
    (*b*) Because they can phagocytose antigens very rapidly and process them
    (*c*) Because they are the only antigen presenting cells present at the site of antigen entry
    (*d*) Because they are the only type of cells which have receptors for naive T cells

42. In a mouse during the embryonic stage of development of the immune system (gestation period)
    (*a*) Both $\gamma\delta$ and $\alpha\beta$ thymocytes are generated in equal numbers
    (*b*) The $\gamma\delta$ thymocytes predominate over the $\alpha\beta$ thymocytes till about 17 days of gestation
    (*c*) The $\alpha\beta$ thymocytes predominate over the $\alpha\beta$ thymocytes till about 17 days of gestation
    (*d*) There are no $\gamma\delta$ or $\alpha\beta$ thymocytes produced during the gestation period

43. Which class of proteins is not generally specified by an oncogene?
    (*a*) Ion channels
    (*b*) Growth factors
    (*c*) Transcription factors
    (*d*) Signal transduction protein

44. A characteristic of homologous chromosomes is that
    (*a*) They carry alleles for the same genes in the same relative positions
    (*b*) They regularly exchange parts by crossing over at meiosis
    (*c*) They physically pair at meiosis
    (*d*) All of the above

45. Which one of the following characteristics best applies to an allosteric effector?
    (*a*) Competes with substrate for the catalytic site
    (*b*) Binds to a site on the enzyme molecule distinct from the catalytic site
    (*c*) Changes the nature of the product formed
    (*d*) Changes the substrate specificity of the enzyme

46. Which one of the following toxins inhibits eukaryotic protein synthesis through the depurination of a single adenine residue in 28S ribosomal RNA (rRNA)?
    (*a*) Diptheria toxin (*b*) Ricin
    (*c*) α-Sarcin (*d*) Colicin E-3

47. Which one of the following enzyme-catalyzed reactions generates a high-energy phosphate bond?
   (*a*) The phosphorylation of glucose
   (*b*) 2_phosphoglycerate to phosphoenolpyruvate
   (*c*) 3_phosphoglycerate to 2_phosphoglycerate
   (*d*) Dihydroxyacetone phosphate to glyceraldehyde-3-phosphate

48. Which one of the following enzymes is tightly associated with the inner mitochondrial membrane?
   (*a*) Citrate synthase
   (*b*) Alpha-ketoglutarate dehydrogenase
   (*c*) Succinate dehydrogenase
   (*d*) Fumarase

49. Which one of the following supports glycogen synthesis?
   (*a*) High cyclic adenosine monophosphate (cAMP) levels
   (*b*) Inactive adenyl cyclase
   (*c*) Active phosphorylase-a
   (*d*) Epinephrine

50. A patient is suffering from a deficiency in the activity of acetyl coenzyme A (CoA) carboxylase. Which one of the following metabolites is most likely to accumulate in the patient's serum?
   (*a*) Short-chain fatty acids
   (*b*) Long-chain.fatty acids
   (*c*) Ketone bodies
   (*d*) Malonyl CoA

51. Which one of the following statements describes the ubiquitin-mediated degradation of proteins in the cytosol?
   (*a*) One molecule of ubiquitin binds. to the protein to be degraded
   (*b*) The process is catalyzed by a single enzyme
   (*c*) The process depends on adenosine triphosphate (ATP)
   (*d*) The N-terminal residue of ubiquitin becomes covalently attached to the protein to be degraded

52. A patient is suffering from untreated insulin-dependent diabetes. Which one of the following metabolic actions is occurring in this patient?
   (*a*) Glucose is used by skeletal muscle for fuel
   (*b*) Ketone bodies are released by the liver into the blood
   (*c*) Glucose is used by the liver for fuel
   (*d*) Fatty acids are transported from the liver to the adipose tissue

53. The initiator codon in eukaryote is-
   (*a*) AUG (*b*) GUG
   (*c*) CUG (*d*) UUU

54. If the same aminoacid is coded by 2 or more codons, it is called-
   (*a*) Universal (*b*) Overlapping type
   (*c*) Degenerate (*d*) Non-sense

55. Uncoiled DNA in differentiating cells is generally busy in synthesis of-
   (*a*) DNA (*b*) mRNA
   (*c*) Proteins (*d*) Glucose

56. What do mutation and recombination have in common-
   (*a*) They increase variation (*b*) They cause genetic drift
   (*c*) They cause natural selection (*d*) All of the above

57. Actinomycin D is an inhibitor of
   (*a*) Respiration (*b*) Photosynthesis
   (*c*) Protein synthesis (*d*) Transcription

58. The B-form of the DNA molecule takes a complete turn after
   (*a*) Every base pair (*b*) Every five base pairs
   (*c*) Every ten base pairs (*d*) Every two base pairs

59. Stem cells are
   (*a*) Callus cells from plant stems
   (*b*) Embryonic cells of higher animals in culture
   (*c*) Tumor cells from kidneys
   (*d*) Tumor cells from bone marrow

60. All of the following are sources of energy for active transport except
   (*a*) ATP (*b*) Proton gradients
   (*c*) Light (*d*) All of the above

61. While studying a cell with the electron microscope, a scientist notes the following numerous ribosomes, a well-developed endoplasmic reticulum, chloroplasts, and a cell wall. Which of the following could be the source of this cell?
   (*a*) A fungus (*b*) An animal
   (*c*) A bacterium (*d*) A plant

62. Which of the following statements is true about the Krebs (citric acid) cycle and the Calvin (light-independent) cycle?
   (*a*) They both result in a net production of ATP and NADH
   (*b*) They both result in a release of oxygen
   (*c*) They both are carried out by enzymes located within an organelle matrix
   (*d*) They both take place within the cytoplasmic matrix

63. Which therapeutic antibiotic blocks the peptidyl transferase reaction of protein synthesis?
   (*a*) Chloramphenicol (*b*) Erythromycin
   (*c*) Tetracycline (*d*) Puromycin

64. The mitochondrial electron transport chain carriers are located
   (*a*) In the inner mitochondrial membrane
   (*b*) In the mitochondrial matrix
   (*c*) in the inter-membrane space
   (*d*) On the inner surface of the outer mitochondrial membrane

65. The release of arachidonate from membrane glycerophospholipids is inhibited by which one of the following compounds?
   (*a*) Aspirin
   (*b*) Linoleic acid
   (*c*) A specific protein induced by glucocorticoids
   (*d*) 2-Acyl lysophosphatidylcholine

66. Cell lysis can be brought about by
   (*a*) Ligase
   (*b*) Gyrase
   (*c*) Lysozyme
   (*d*) Cellulase

67. The two principals and products of photosynthesis are
   (*a*) Starch and sucrose
   (*b*) Glycerol and glycogen
   (*c*) Cellulose and glycogen
   (*d*) Glycerol and cellulose

68. Find out which is not the correct statement

   The collagen triple helix domain
   (*a*) Is rich in glycine
   (*b*) is rich in proline
   (*c*) Is rich in alanine
   (*d*) Is rich in hydroxyproline

69. Extranuclear inheritance is a consequence of presence of genes in
   (*a*) Mitochondria and chloroplasts
   (*b*) Endoplasmic reticulum and mitochondria
   (*c*) Ribosomes and chloroplast
   (*d*) Lysosomes and ribosomes

70. An ecosystem which can be easily damaged but can recover after some time if damaging effect stops will be having
   (*a*) Low stability and high resilience
   (*b*) High stability and low resilience
   (*c*) Low stability and low resilience
   (*d*) High stability and high resilience

Model Paper – 10

PART – A

1. Effect of ozone layer on life on earth is:
   (*a*) Harmful because it cuts cosmic rays
   (*b*) Beneficial because it cuts down UV radiation
   (*c*) Prevention of mutation
   (*d*) Negligible

2. Age of the oldest rock on the earth is about
   (*a*) 4 billion years
   (*b*) 3 billion years
   (*c*) 2 billion years
   (*d*) 1 billion years

3. The land-sea breezes arise because
   (*a*) Land has a higher heat capacity than land
   (*b*) Ocean has higher heat capacity than land
   (*c*) Of a periodic variation in trade winds
   (*d*) Of rotation of the earth

4. According to current understanding, the Himalayas have resulted from:
   (*a*) Cometary impact on earth
   (*b*) Asymmetrical pull of the moon on earth
   (*c*) Uneven cooling of solidified magma
   (*d*) Collision of continents due to continental drift

5. An ideal material for making cooking vessels must have
   (*a*) Small conductivity and large heat capacity
   (*b*) Large heat capacity and large conductivity
   (*c*) Small heat capacity and large conductivity
   (*d*) Small heat capacity and small conductivity

6. X-rays are electromagnetic radiations. They can therefore be deflected by
   (*a*) Electric and magnetic fields together
   (*b*) Electric fields only
   (*c*) Magnetic fields only
   (*d*) Neither electric nor magnetic fields

7. Which one of these is caused by extrinsic factors
   (*a*) Malfunctioning of organs
   (*b*) Genetic disorders
   (*c*) Normal disturbance
   (*d*) Deficiency diseases

8. For a rection to be exothermic, the value of ΔG and ΔS should be
   (*a*) +, – (*b*) –, +
   (*c*) +, + (*d*) –, –

9. Predict which relation cannot occur?
   (*a*) $Cu + 2HCl \rightarrow CuCl_2 + H_2$
   (*b*) $H_2 + CuO \rightarrow H_2O + Cu$
   (*c*) $Mg + 2HCl \rightarrow MgCl_2 + H_2$
   (*d*) $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

10. pH of 10^{-8} M HCl is
   (*a*) 8 (*b*) 4
   (*c*) 7 (*d*) 6.8

11. Which of the following is not correct?
   (*a*) Sucrose is a carbohydrate
   (*b*) Ribonuclease is an enzyme
   (*c*) $C_{12}H_{25} - C_{15}H_{31}$ fraction of petroleum is kerosene oil
   (*d*) Cellulose is a lipid

12. A flight started from Adelade on 5.00 A.M. Monday to california. It crosses International date line at 10.00 AM, the time and day after crossing it would be
   (*a*) 10.00 A.M. Sunday
   (*b*) 5.00 A.M. Tuesday
   (*c*) 10.00 A.M. Tuesday
   (*d*) 5.00 A.M. Sunday

13. During the earthquake most damage is seen on earth crust because earth crust is
   (*a*) rigid (*b*) brittle
   (*c*) inelastic (*d*) molten

14. Both mother and father are of AB blood type. The possible blood types of their children will be
   (*a*) AB only (*b*) AA only
   (*c*) AA and BB only (*d*) AA, BB and AB

15. Which among the following animals has the tongue fixed in front and free at the back?
    (*a*) Monkey (*b*) Rabbit
    (*c*) Cat (*d*) Frog

16. Rauwolfia serpentine is a
    (*a*) Helminth parasite
    (*b*) Causative organism of AIDS
    (*c*) Medicinal plant
    (*d*) Poisonous snake

17. Which of the following sets of substances are parts of the essential requirements for the growth of green plants?
    (*a*) Carbon dioxide, oxygen, sulfate
    (*b*) Nitrate, carbon dioxide, phosphate
    (*c*) Nitrate, vitamin B1, sulfate
    (*d*) ADP, carbon dioxide, nitrate

18. The roots of the equation $x^2 + 7x + 12 = 0$ are a and b. The real value of $a^2 + b^2$ is
    (*a*) 5 (b) 2
    (*c*) 0 (*d*) 3

19. The number of real solutions of $\cos^2 - \frac{1}{4} = 0$ is
    (*a*) 1/2 (*b*) 1
    (*c*) 2 (*d*) infinity

20. The value of $\int_{-\pi/2}^{\pi/2} \frac{1}{\sqrt{1-x^2}} dx$ is
    (*a*) 2 (*b*) 0
    (*c*) π (*d*) $\pi/2$

21. The average age of 40 students of a class is 15 years. When 10 new students are admitted, the average is increased by 0.2 years. The average age of new students is
    (*a*) 16 years (*b*) 15.2 years
    (*c*) 16.2 years (*d*) 16.4 years

22. Which one of the following is not an electronic computer?
    (*a*) IBM-PC (*b*) ENIAC
    (*c*) PC-DOS (*d*) IBM-1620

23. A statement of the type
    10 LET AS = 'STRING' is allowed in
    (*a*) FORTRAN (*b*) COBOL
    (*c*) C language (*d*) BASIC language

24. Integrated Circuits were first used in
    (*a*) First generation system
    (*b*) Second generation system
    (*c*) Third generation system
    (*d*) Fourth generation system

25. Microcomputer application software is usually written in
    (*a*) Multiprogramming environment
    (*b*) Timesharing environment
    (*c*) User friendly environment
    (*d*) Network Environment

26. The UNIX operating system has been written in
    (*a*) Machine language (*b*) C language
    (*c*) Assembly language (*d*) PASCAL language

27. Indicate which one of the software requires a COMPILER for execution
    (*a*) SPSS (*b*) LOTUS
    (*c*) COBOL (*d*) ORACLE

28. An Hexadigit can be represented by
    (*a*) Three binary consecutive bits
    (*b*) Four binary consecutive bits
    (*c*) Eight binary consecutive bits
    (*d*) Sixteen binary consecutive bits

29. Which one of the following is the correct matching of a vitamin, its nature and its deficiency disease?
    (*a*) Vitamin A – Fat-soluble – Night blindness
    (*b*) Vitamin K – Fat-soluble – Beri-beri
    (*c*) Vitamin A – Fat-soluble – Beri-beri
    (*d*) Vitamin K – Water -soluble – Pellagra

30. Lack of independent assortment of two genes A and B in fruit fly **Drosophila** is due to
    (*a*) Repulsion (*b*) Recombination
    (*c*) Linkage (*d*) Crossing over

PART – B

1. Which of the following amino acid is entirely incorporated in the nucleotide bases
    (*a*) Glutomic acid
    (*b*) Alanine
    (*c*) Glycine
    (*d*) Serine

2. 9 + 2 fibrillar arrangement is present in
   (*a*) Bacterial flagella (*b*) Bacterial Fimbriae
   (*c*) Eukaryotic flagella (*d*) T_4 bacteriaophage

3. Coated vesicles in the cell gives rise to
   (*a*) Endosome (*b*) Microsome
   (*c*) Ribosome (*d*) Episome

4. Mitochondria and chloroplasts are suggested to have evolved from symbiotic prokaryotes present in primitive eukaryotic cells. One evidence for this is that
   (*a*) These organelles contain cristae or thylakoids
   (*b*) These organelles contain electron transport chain
   (*c*) The ribosome in these organelles share properties with those of prokaryotes
   (*d*) The genetic code in these organelles is same as in all organisms

5. A genetic region found in all humans whose products are primarily responsible for the rejection of grafts between individuals, is called
   (*a*) Junctional
   (*b*) Diversity
   (*c*) Major histocompatibility complex
   (*d*) Fc

6. Chiasmata are formed during meiosis
   (*a*) Before metaphase I (*b*) After metaphase
   (*c*) During prophase II (*d*) During metaphase II

7. In animals differentiation of cells is mostly due to
   (*a*) Cell type specific mutations
   (*b*) Deletion of specific DNA sequence in specific cell types
   (*c*) Specific gene repression and expression
   (*d*) Regulated expression of mitochondria DNA

8. Button like points of intercellular contact that serve as anchoring sites of intermediate filaments and help to hold adjacent cells together are called
   (*a*) Gap junctions (*b*) Connexons
   (*c*) Cadherins (*d*) Desmosomes

9. DNA duplication occurs in
   (*a*) Mitosis only (*b*) Meiosis only
   (*c*) meiosis-I and mitosis (*d*) meiosis II and mitosis

10. The (OH^-) concentration of a 0.01 N HCl solution is
    (*a*) 1×10^{-8} g mol per litre
    (*b*) 1×10^{-10} g mol per litre
    (*c*) 1×10^{-12} g mol per litre
    (*d*) 1×10^{-14} g mol per litre

11. Activity of which of the followig enzymes is not increased by insuline
    (*a*) acetyl CoA carboxylase (*b*) pyruvate carboxylase
    (*c*) glycogen synthase (*d*) glucokinase

12. Infant suffering from galactosemia are unable to utilize normal milk because they
    (*a*) Lack the enzyme glucokinase in the liver
    (*b*) Are unable to hydrolyse lactose
    (*c*) Lack the enzyme glactose-1-phosphate uridylyl transferase
    (*d*) Accumulate the sugar alcohol

13. The number of high energy phosphate bonds in ATP is
    (*a*) 1 (*b*) 2
    (*c*) 3 (*d*) 0

14. Which bond has the minimum length?
    (*a*) C = C (*b*) C = C
    (*c*) C – C (*d*) C = O

15. The Tm of DNA can be calculated using the formula: Tm = 69.1 + 0.41 (*G*C), where GC is the per cent of guanine + cytosine. A double stranded DNA has 27% adenine. Its Tm is
    (*a*) 79° C (*b*) 80.37° C
    (*c*) 95.40° C (*d*) 88° C

16. Intron is a region of the chromosomal DNA
    (*a*) Which is a part of a gene that is transcribed but is removed during maturation of the transcript
    (*b*) Which is a part of a gene that is transcribed and persists in the mature mRNA
    (*c*) That is located between two adjacent genes
    (*d*) That is located at the centromere

17. The characteristics of a weak acid is
    (*a*) High Ka (*b*) Low pKa
    (*c*) High pKa (*d*) None of these

18. Colchicine treated cells are arrested in
    (*a*) S phase (*b*) Prophase
    (*c*) G1 phase (*d*) Metaphase

19. One of the following enzymes is involved in translation step in protein biosynthesis
    (*a*) Aminoacyl-tRNA synthetase
    (*b*) RNA polymerase
    (*c*) Ribozyme
    (*d*) Reverse transcriptase

20. The sites of O_2 evolution and photophosphorylation in chloroplast are
    (*a*) Grana stacks (*b*) Matrix
    (*c*) Inner wall of chloroplast (*d*) Surface of chloroplast

21. Photophosphorylation in chloroplasts requires movement of
    (*a*) Electrons across the membrane
    (*b*) Ions across the membrane
    (*c*) Protons across the membrane
    (*d*) Electrons and protons across the membrane

22. Bacterial sporulation is induced in response to
    (*a*) Starvation of nutrients (*b*) Change in temperature
    (*c*) Change in pH (*d*) Change in light intensity

23. Fixation of one molecules of $14CO_2$ by photosynthesis will yield
    (*a*) One molecule of 14C-phosphoglyceric acid
    (*b*) Two molecule of 14C-phosphoglyceric acid
    (*c*) Three molecule of 14C-acetate
    (*d*) One molecule of 14C-glucose

24. Pick out from the following the mammalian stress hormone
    (*a*) Glucocorticosteriods (*b*) Estrogen
    (*c*) Growth hormone (*d*) Relaxin

25. Solar tracking is exhibited by
    (*a*) *Helianthus annuus* (*b*) *Arabidopsis thaliana*
    (*c*) *Mimosa pudica* (*d*) *Xanthium strumarium*

26. Which of the following compounds have been reported to accumulate in a plant in large amounts as a result of water stress?
    (*a*) Aspartic acid (*b*) Proline
    (*c*) Citric acid (*d*) Indoleacetic acid

27. Inhibition of photosynthesis by oxygen is called as
    (*a*) Emerson effect (*b*) Warburg effect
    (*c*) Pasteur effect (*d*) Red drop phenomenon

28. Tetrodoxin is used as a
    (*a*) K channel blocker (*b*) Na channel broker
    (*c*) Ca channel broker

29. Erythrocytes resist shearing forces while travelling through narrow blood vessels because they contain mesh work of
    (*a*) Glycophoria A (*b*) Spectrin
    (*c*) Hemoglobin (*d*) Ankyrin

30. Cytoplasmic male sterility in maize is due to
    (*a*) Absence of mitochondrial genome
    (*b*) Absence of plastid genome
    (*c*) Deletions in plastid genome
    (*d*) Alteration(*s*) in the mitochondrial genome

31. In a typical Mendelian population, individuals carrying gene 'a' in homozygous condition suffer from phenylketonurea. Those with A in homozygous condition are normal. Others, who are heterozygotic with Aa, are carriers. If the frequency of 'a' in a population is 0.005 what is the percentage of carriers in the population?
    (*a*) 10.0 (*b*) 1.0
    (*c*) 0.1 (*d*) 90.0

32. The rate of occurrence, per generation, of spontaneous mutations in all living organisms is
    (*a*) 10^{-2} to 10^{-4} (*b*) 10^{-5} to 10^{-7}
    (*c*) 10^{-10} to 10^{-15} (*d*) 10^{-20} to 10^{-30}

33. Chromatid-type breaks occur during the cell cycle in the
    (*a*) S-phase (*b*) G1-phase
    (*c*) G2-phase (*d*) Mitosis

34. After digestion of chromatin for a short time with micrococcal nuclease, DNA fragments of this size are obtained
    (*a*) 100 base pairs (*b*) Variable length
    (*c*) 200 base pairs (*d*) 146 base pairs

35. Which one of the following is not true for a disease inherited as a sex-linked dominant in humans?
    (*a*) All daughters of an affected male will inherit the disease
    (*b*) Sons will inherit the disease, only if their mother has the diseases
    (*c*) Daughters will inherit the disease, only if their father has the diseases
    (*d*) Both affected males and affected heterozygous females will pass the trait to half their children

36. Frame shift mutations occur following
    (*a*) Tautomeric shifts
    (*b*) base substitutions
    (*c*) Dimer formation
    (*d*) Insertion/deletion of single base

37. Genetic element in bacteria that can replicate in the cytoplasm or can integrate into the bacterial chromosome and replicate with the host chromosome
    (*a*) Retrovirus (*b*) Plasmid
    (*c*) Episome (*d*) Plastome

38. Hypophosphatemia is caused by an X-linked dominant gene in humans, if a hypophosphatemic man marries a normal woman, which of their children will have Hypophosphatemia?
    (*a*) All daughters
    (*b*) half of their daughters
    (*c*) All of the sons
    (*d*) half of their sons

39. The most common cause of the pleiotropic effect of gene is due to
    (*a*) The same product of the given gene being involved in different metabolic pathways
    (*b*) The gene making very different products in different cell types
    (*c*) The DNA sequence of the gene getting changed in cell specific manner
    (*d*) The gene not functioning in some cells

40. Life is believed to have originated on earth
    (*a*) 3.6 billion years ago
    (*b*) 3.6 million years ago
    (*c*) 4.5 billion years ago
    (*d*) 4.5 million years ago

41. The evolutionary divergence of higher taxonomic groups is due to
    (*a*) Adaptive radiations (*b*) Anagenesis
    (*c*) Cladogenesis (*d*) Stasigenesis

42. Molecular drive, which is associated with the origin of biological discontinuities, is the consequence of
    (*a*) Unequal crossing over, gene conversion and DNA transposition
    (*b*) Environmental control of gene expression
    (*c*) Selection
    (*d*) DNA methylation

43. The process that led to the evolution of the common bread wheat from its progenitors is
    (*a*) Triploidy
    (*b*) Aneuploidy
    (*c*) Introgression
    (*d*) Hybridization followed by doubling of the chromosomes

44. The hypothesis of Oparin and Haldane regarding origin of life is called as
    (*a*) Autotroph hypothesis (*b*) Heterotroph hypothesis
    (*c*) Chemotroph hypothesis (*d*) biogenesis hypothesis

45. Ribosomal RNAs are better molecules for phylogenetic studies because
    (*a*) Antiquity of protein synthesizing process, and moderately well conserved
    (*b*) They can be easily sequenced
    (*c*) They are present in 70 S and 80 S ribosomes
    (*d*) None of the above

46. The chemical evolution preceding biological evolution during origin of life was initiated through formation of
    (*a*) Condensing agents, e.g. cyanogens
    (*b*) ATP and other triphosphates
    (*c*) Both A and B
    (*d*) Pre-biotic catalyst-like compounds

47. The evolutionary process involving long periods of stasis interrupted by short periods of rapid speciation is called
   (*a*) Quantum evolution (*b*) Punctual equilibria
   (*c*) Macroevolution (*d*) Irregular modes

48. The nature of the pre-biotic environment on the earth was
   (*a*) Reducing (*b*) Oxidizing
   (*c*) Nitrifying (*d*) Rich in ozone

49. lThe condition which leads to a reduction in population to only a few individuals is called
   (*a*) Population oscillation (*b*) Migration
   (*c*) Population crash (*d*) Bottleneck phenomenon

50. Acid rain is caused by
   (*a*) CO and CO_2 (*b*) CO_2 and O_2
   (*c*) O_2 and CO (*d*) SO_2 and NO_2

51. CO_2 present in the atmosphere
   (*a*) Helps in stopping the sun radiation reaching the earth surface
   (*b*) Works only as insulator protecting the earth from cooling
   (*c*) Merely gives life to plants
   (*d*) Absorbs and reradiates some of the longer-wave length infra-red radiation that otherwise would be transmitted back into the space from the surface of the earth

52. The most productive ecosystem in the biosphere is
   (*a*) Desert (*b*) Open ocean
   (*c*) Estuary (*d*) Tundra

53. Biodegradable plastics are made using the following bacterial compounds
   (*a*) Proteins (*b*) Lipids
   (*c*) Poly β-hydroxy alconates (*d*) Alkaloids

54. Population of plants within a species adapted genetically to a particular habitat but able to cross freely with other plants of the same species is called
   (*a*) Ecophene (*b*) Ecad
   (*c*) Ecotype (*d*) Ecotone

55. Biotic potential of a species is
   (*a*) Intrinsic rate of natural increase
   (*b*) Theoretical maximum production of new individuals
   (*c*) Difference between the intrinsic rate and the rate that occurs in an actual field condition
   (*d*) Instantaneous coefficient of population growth

56. Maximum stratospheric ozone concentration occurs above
   (*a*) Equator (*b*) temperate latitudes
   (*c*) Poles (*d*) Subtropical latitudes

57. Biological Oxygen Demand (BOD) is measure of
   (*a*) Amount of dissolved oxygen present in a water body
   (*b*) The rate anaerobic decomposition of organic matter
   (*c*) The amount of dissolved oxygen required to oxidize the organic matter present in the water by aerobic decomposers
   (*d*) The rate of consumption of dissolved oxygen by aerobic decomposers for decomposing the organic matter present in the water body

58. The intrinsic rate of population increase is high
   (*a*) For a population consisting of more juveniles
   (*b*) For a population consisting of more reproductive females
   (*c*) For a population consisting of more reproductive males
   (*d*) For a population consisting of more senescent individuals

59. Chronologic ordering of species is based on
   (*a*) Electrophoretic mobility of protein
   (*b*) Molecular weights of proteins
   (*c*) Number of amino acids substituted in a protein molecule
   (*d*) 2-D analysis of proteins

60. The correct sequence of taxonomic hierarchy in eukaryotes is
   (*a*) Phylum – class – order – family – genus – species
   (*b*) Class – order – phylum – family – genus – species
   (*c*) Phylum – order – class – family – genus – species
   (*d*) Phylum – family – class – order – genus – species

61. A classic example of utilization of biodiversity in green revolution is
   (*a*) Cryopreservation of germplasm
   (*b*) in vitro regeneration of somatic hybrids
   (*c*) Photoperiod insensitivity
   (*d*) Use of frozen gametes

62. The species replacement that occurs over very large geographic region is described as
   (*a*) Alpha diversity (*b*) Beta diversity
   (*c*) Gamma diversity (*d*) Point diversity

63. Consider an island population where a majority of the individuals display hexadactylyty of their hands. Evolutionary biologist would readily explain this phenomenon based on
   (*a*) Dominance of hexadactyl condition
   (*b*) Small size of founder population
   (*c*) Novel mutation
   (*d*) Improved fitness and adaptation of the hexadactyl individuals

64. Populations that are morphologically similar but do not interbreed for physiological or behavioural reasons are grouped as
    (*a*) Races (*b*) Varieties
    (*c*) Sub-species (*d*) Sibling species

65. Which is the hot-spot for biodiversity in India?
    (*a*) Western ghats (*b*) Eastern ghats
    (*c*) Central ghats (*d*) Upper Gangetic ghats

66. When all the original material collected by the author who described a new species, is lost, the specimen designated to serve as nomenclatural type is
    (*a*) Neotype (*b*) Lecotype
    (*c*) Isotype (*d*) Holotype

67. In a stable ecosystem the food chain mostly contains
    (*a*) Three to five links (*b*) Two links
    (*c*) Six links (*d*) Seven links

68. A predation series linking animals to ultimate plant food is called
    (*a*) Food web (*b*) Tropic level
    (*c*) Food cycle (*d*) Food chain

69. What is a keystone species?
    (*a*) A species which makes up only a small proportion of the total biomass of a community, yet has a huge impact on the community's organisation and survival
    (*b*) A common species that has plenty of biomass, yet has a fairly low impact on the community's organization
    (*c*) A rare species that has minimal impact on the biomass and on other species in the community
    (*d*) A dominant species that constitutes a large proportion of the biomass and which affects many other species

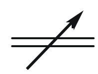
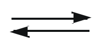
70. DNA fingerprinting refers to
    (*a*) Molecular analysis of profiles of DNA samples
    (*b*) Analysis of DNA samples using imprinting devices
    (*c*) Techniques used for molecular analysis of different specimens of DNA
    (*d*) Techniques used for identification of fingerprints of individuals

CSIR-NET Life Sciences DEC., 2003

PART-A

1. If a pendulum with a time period 'T' is placed on moon then its time period will-
   (*a*) Increase (*b*) Decrease
   (*c*) Unchanged (*d*) Infinity

2. When the canon is fired, it will move-
   (*a*) Front (*b*) Back
   (*c*) Randomly (*d*) not moves

3. Which is not correct representation of line of forces-
   (*a*) (*b*) 
   (*c*)  (*d*) 

4. Soldiers are not allowed to pass in synchronized march over a bridge because-
   (*a*) It produces more noise
   (*b*) Bridge may break due to resonance
   (*c*) Uniform force distribution will break the bridge
   (*d*) Center of mass of bridge will increase

5. On putting a thin water film over a glass plate it becomes more transparent to light because-
   (*a*) Lesser would be reflection
   (*b*) Lesser will be refraction
   (*c*) Trapped air increase transparency
   (*d*) It does not happens

6. For equilibrium reaction the value for Δ G will be -
   (*a*) Zero (*b*) Negative
   (*c*) Positive (*d*) Infinity

7. The tetrahedral geometry of carbon is best explained by-
   (*a*) Monochoro methane (*b*) Dichloro methane
   (*c*) Choloroform (*d*) Carbon tetrachloride

8. About Haber's process for ammonia production, the false statement is-
   (*a*) It is second order reaction
   (*b*) Slow at room temperature
   (*c*) High pressure is required
   (*d*) Al_2 O_3 is used as catalyst

9. On increasing the NaCl into water it boiling point decreases because-
   (*a*) Due to more energetic molecules
   (*b*) Weak H-bonding
   (*c*) More collision between molecules
   (*d*) Activation energy is decreased

10. The necessary condition for reaction to be spontaneous is-
   (*a*) H - ve & S + ve (*b*) H – ve & S – ve
   (*c*) H + ve & S + ve (*d*) H – ve & S + ve

11. Moon does not have atmospheric gases-
   (*a*) Gravity is not sufficient to hold gases
   (*b*) Speed of rotation is very high
   (*c*) Water and plants are absent
   (*d*) Absence of sheathing ozone layer

12. Earth is slightly inclined on its axes, if axis of rotation is made perpendicular then major effect will be on-
   (*a*) Day & night (*b*) Seasons
   (*c*) Tides of ocean (*d*) Rotation of earth

13. The magnetic field around earth is a result of -
   (*a*) Structure of earth crust (*b*) Plate faults
   (*c*) Motion of liquid mantle (*d*) Motion in liquefied core

14. Which of them is a result of process of sedimentation-
   (*a*) Coal (*b*) $CaCO_3$
   (*c*) Igneous rocks (*d*) Granite

15. Among the following which radioisotope is routinely used for determination of age of fossils-
   (*a*) P 32 (*b*) S 35
   (*c*) C 14 (*d*) O 18

16. Convert the binary number 1101.101 into decimal number-
   (*a*) 13.625 (*b*) 13.5
   (*c*) 13.62 (*d*) 13.26

17. Which of them is not programming language-
   (*a*) BASIC (*b*) COBOL
   (*c*) PASCAL (*d*) LOTOUS

18. The clock speed in computer is usually measured in-
   (*a*) Bytes (*b*) Seconds
   (*c*) Hertz (*d*) RAM

19. Bug, in computer terminology means-
    (*a*) Logical error (*b*) Syntax error
    (*c*) Organism effecting computer (*d*) High level Programming

20. Consider the following programme and write the result that will print at end of program-

```
Do While A ≠ 0
If A ≥ B
A=A–B
Else
B=B–A
EndIf
PRINT A, B
```

    (*a*) 0, 0 (*b*) 0, 1
    (*c*) 1, 1 (*d*) 1, 0

21. If there is double bond between A& T and triple bond between GC, then which sequence will be most stable at higher temperature-
    (*a*) ATTGTACCAAA (*b*) AATTATATATA
    (*c*) AGCAGAGAGTT (*d*) AGGCCGGCCCTA

22. If a tall pea plant is crossed with pure dwarf pea plant, all F_1 progenies were tall, in subsequent generation after selfing of F_1 generation progeny, the ratio of tall to dwarf plant will be-
    (*a*) 1:1 (*b*) 1:2:1
    (*c*) 3:1 (*d*) All tall

23. White blood cells (*W*BC) have major function as-
    (*a*) Defensive role (*b*) respiration
    (*c*) Tumor suppressor (*d*) Phagocytosis of cell debris

24. Rules stating that as we move toward the polar region from tropics the size of organism increases-
    (*a*) Allen's rule (*b*) Bergman's rule
    (*c*) Fischer rule (*d*) Copes rule

25. During photosynthesis evolution of oxygen is from-
    (*a*) Water (*b*) CO_2
    (*c*) Glucose (*d*) Chlorophyll

26. Maximum numbers of lines producing symmetrical planes from a regular hexagon-
    (*a*) 3 (*b*) 4
    (*c*) 6 (*d*) 8

27. If P = (1, 2), Q = (–2, –10) & R = (1, m) and PQ + QR = Minimum, then the value of 'm' will be-
    (*a*) + 6 (*b*) – 6
    (*c*) + 8 (*d*) – 8

28. Twenty-Five student participate in competition, marks obtained by first two students are 6 & 10. Each subsequent student gains an average of preceding students, then the marks obtained by the 100 student will be-
    (*a*) 6 (*b*) 8
    (*c*) 10 (*d*) 16

29. How many boxes of size 2 × 2 × 4 can be fitted in a box of size 11 × 8 × 20-
    (*a*) 100 (*b*) 110
    (*c*) 120 (*d*) 220

30. Carbon dioxide is
    (*a*) a basic oxide (*b*) an acidic oxide
    (*c*) a neutral oxide (*d*) none of these

PART – B LIFE SCIENCES

1. In Human number of linkage groups present in male is:
    (*a*) 21 (*b*) 22
    (*c*) 23 (*d*) 24

2. Holiday junction is observed during:
    (*a*) Mitosis (*b*) Interphase
    (*c*) Recombination (*d*) DNA Repair

3. Layer of Atmosphere possessing ozone is-
    (*a*) Stratosphere (*b*) Mesosphere
    (*c*) Ionosphere (*d*) Troposphere

4. The Ozone layer saves from lethal UV. It mainly absorbs-
    (*a*) UV-A (*b*) UV-B
    (*c*) UV-A & B (*d*) UV-B & C

5. Major hot spot of biodiversity in India are-
    (*a*) Andaman & western ghats
    (*b*) Eastern Ghats & Western Himalayas
    (*c*) Western ghats & N.E Himalayas
    (*d*) North East and Western Himalayas

6. In humans, XX males and XY Females are rare, such rare sexes are due to-
    (*a*) Deletion of X chromosome
    (*b*) Deletion of Y chromosome
    (*c*) XY translocation
    (*d*) Duplication of X chromosomes

7. The major difference in PS-I and PS-II found in Chloroplast are-
    (*a*) Position on lamellae (*b*) Chlorophyll a
    (*c*) Position of electron carriers (*d*) Energy harvesting

8. Testosterone hormone necessary for spermatogenesis is secreted by-
   (*a*) Leydig cells (*b*) Sertoli cells
   (*c*) Spermatozoa (*d*) Cowpers gland

9. The major site of attack by HIV-virus on immune system is-
   (*a*) MHC (*b*) B- Lymphocytes
   (*c*) T-Lymphocytes (*d*) Macrophages

10. Rarely there is occurrence of gill clefts in higher animals, this shows-
   (*a*) They may be useful for that organism
   (*b*) Ancestral returns of that character
   (*c*) Favorable mutation in organism
   (*d*) Retrogressive Evolution

11. A single base pair mutation occurs in strand CATTACCG, its complementary strand had a sequence GTTATGGC. It means mutation has changed base pair-
   (*a*) $A \rightarrow T$ (*b*) $T \rightarrow T$
   (*c*) $T \rightarrow A$ (*d*) $A \rightarrow A$

12. Crossing over occurs during-
   (*a*) Mitotic metaphase (*b*) Meiotic Metaphase
   (*c*) Mitotic Prophase (*d*) Meiotic Prophase

13. Maize has 10 pairs of chromosome, what will be number of chromosome and chromatids at Metaphase II-
   (*a*) 10 & 10 (*b*) 10 & 20
   (*c*) 20 & 40 (*d*) 5 & 10

14. In a cell if acidity of Lysosome is lost, then loss of -
   (*a*) Phagocytosis of invading bacteria
   (*b*) Elevated phosphatase level
   (*c*) Glycogen degradation
   (*d*) No major effect

15. Criss-cross inheritance is shown by-
   (*a*) Sex linked traits (*b*) Sex influenced traits
   (*c*) Sex limited traits (*d*) Autosomes

16. In plants IAA causes cell elongation due to-
   (*a*) Increase in pH of Apoplast
   (*b*) Increase in pH of cytoplasm
   (*c*) Decrease in pH of Apoplast
   (*d*) Increase in pH of cytoplasm

17. In bacteria site of respiration is-
   (*a*) Glogi bodies (*b*) cytoplasm
   (*c*) Endoplasmic reticulum (*d*) Microsomes

18. In human females there is inactivation of one X chromosomes for dosage compensation due to-
    (*a*) Methylation (*b*) Acetylation
    (*c*) Phosphorylation (*d*) Formylation

19. Type of proofreading activity by DNA polymerase I in E. Coli is-
    (*a*) 5′-3′ exonuclease (*b*) 5′-3′ endonuclease
    (*c*) 3′-5′ exonuclease (*d*) 3′-5′ endonuclease

20. Fungus used for commercial production of citric acid is-
    (*a*) Neurospora (*b*) Penicillum
    (*c*) Aspergillus (*d*) Sacchromyces

21. Wild Ass are found at-
    (*a*) Kaziranga (*b*) Nandan Kanan
    (*c*) Runn of Kutch (*d*) Nilgiri hills

22. Besides nomenclature of plants in wild, ICBN also gives binomial names for-
    (*a*) Bacteria & Fungus (*b*) Fungus
    (*c*) Fungus & cultivated plants (*d*) Cultivated plants

23. In geological time scale, the Era of reptiles is -
    (*a*) Paleozoic (*b*) Mesozioc
    (*c*) Holozoic (*d*) Proterozoic

24. Age of Fossils is usually determined by-
    (*a*) Sediment deposition (*b*) Mineral deposition
    (*c*) Radioactive decay of isotopes (*d*) Age of surrounding rock

25. Cells absorbs Iron by the process of-
    (*a*) Phagocytosis (*b*) Pinocytosis
    (*c*) endocytosis (*d*) Active transport

26. The optimum pH of soil for easy absorption of Minerals by plants is-
    (*a*) 4 – 5 (*b*) 5 – 6
    (*c*) 7 – 8 (*d*) 7 – 10

27. For muscles the major source of energy is-
    (*a*) ATP (*b*) Phosphocreatin
    (*c*) GTP (*d*) Lactic Acid

28. Pelvic girdle and hind limbs in python are example of-
    (*a*) Analogous organ (*b*) Homologous organ
    (*c*) Vestigial organ (*d*) Orthologous organ

29. Reverse transcriptase of retero virus is-
    (*a*) DNA dependent DNA polymerase
    (*b*) DNA dependent RNA polymerase

(*c*) RNA dependent DNA polymerase
(*d*) RNA dependent RNA polymerase

30. Which chemical is used for cryo-preservation-
(*a*) DMSO (*b*) DCMU
(*c*) PITC (*d*) Thiourea

31. The major pollution in lake by effluents coming from cloth industry containing high detergents is by-
(*a*) Nitrates (*b*) Sulphates
(*c*) Phosphates (*d*) Silcates

32. In a stable well adapted populations there are frequent increase and decrease in population size around a mean value, such population fluctuations are due to-
(*a*) Genetic drift (*b*) Disease & Mortality
(*c*) Carrying capacity (*d*) Migration

33. Hardy-weinberg law helps in detecting-
(*a*) Allele frequency (*b*) Genotype frequency
(*c*) Heterozygote frequency (*d*) Inbreeeding

34. A normal ovulating female may be sterile due to-
(*a*) Blockage in fallopian tube (*b*) Hyposecretion of LH
(*c*) Hyposecretion of FSH (*d*) Hyposecretion estrogen

35. Bacterial genomes is prevented by its own endonucleases by-
(*a*) Methylation at restriction sites
(*b*) Immune mechanism
(*c*) Nuclease resistant genome
(*d*) Are not much effective on bacterial genome

36. In some cases there are male characteristics in females due to-
(*a*) Hormonal imbalance (*b*) XXY chromosomes
(*c*) XYY (*d*) XXX

37. In Eukaryotic 5' -Capping in m-RNA is required for-
(*a*) Initiation of transcription (*b*) Initiation of translation
(*c*) Intron removal (*d*) Termination of transcription

38. Plasmids in bacteria helps in-
(*a*) Transformation (*b*) Transduction
(*c*) Conjugation (*d*) Replication

39. Production of sound due to grinding of hind limbs can been seen in-
(*a*) Cricket (*b*) Dragon fly
(*c*) Mouse (*d*) Cockroach

40. In Present condition origin of life from inorganic molecules is not possible because of-
(*a*) Absence of raw material (*b*) Presence of Oxygen
(*c*) Low enthalpy (*d*) Presence of ozone layer

41. A female with 47 chromosomes have normal phenotype. Her chromosome complements will be-
(*a*) 44 + XXY (*b*) 44 + XXX
(*c*) 45 + XX (*d*) 44 + XYY

42. A Rh + ve male marries a Rh-ve female, their progenies will be-
(*a*) Rh +ve only (*b*) Rh -ve only
(*c*) Both Rh +ve & – ve (*d*) Cannot be predicted

43. Self cross between Aa results in AA, Aa & aa F_1 progenies, the force of evolution preserving either AA or aa is-
(*a*) Stabilizing selection (*b*) Cyclic
(*c*) Disruptive (*d*) Directional

44. A non harmful species copies a harmful and tasteless form, the type of mimicry shown is-
(*a*) Bateson (*b*) Mullerian
(*c*) Darwinian (*d*) Morganarian

45. In mitochondria the enzymes of electron transport chain are located at-
(*a*) Outer membrane (*b*) Inter membrane space
(*c*) Inner membrane (*d*) Matrix

46. Glucose-1-P level is increased in body by the action of glycogen phosphorylase, this is released from-
(*a*) Increased glycogen breakdown (*b*) Reduced glycogenesis
(*c*) Both (*d*) None

47. False statement of competitive inhibition is-
(*a*) Structure same as substrate
(*b*) Inhibits substrate binding
(*c*) Binds to active site
(*d*) Reaction cannot be favorably biased by increasing substrate concentration

48. Change in elasticity of cell membrane is due to-
(*a*) Change in cis-trans phase of fatty acids
(*b*) Change in Protein confirmation
(*c*) Cholesterol
(*d*) phospholipids

49. Amino acid sequence for a protein is known, we can estimate the sequence of m-RNA coding that protein -
(*a*) Precisely (*b*) Can't be predicted
(*c*) Precisely to certain extent if codon frequency is known
(*d*) Data not sufficient

50. Modern molecular taxonomy involves comparison of-
    (*a*) chromosome morphology (*b*) r-RNA
    (*c*) C-DNA (*d*) t-RNA

51. Exotic weed which proved very harmful for forest and grassland is-
    (*a*) Eupatromia (*b*) verbenia
    (*c*) Eichornia (*d*) Salvia

52. Latest news of conflicts between human and wild animals has happened due to-
    (*a*) Habitat destruction (*b*) Increased poaching
    (*c*) Increased conservation (*d*) Increased Human population

53. Percentage (%) energy transferred from plants to herbivores is-
    (*a*) 1 (*b*) 10
    (*c*) 50 (*d*) 80

54. Milk sugar Lactose, a disaccharide has linkage-
    (*a*) Glucose + galactose $1 \to 4$
    (*b*) Glucose + Glucose $1 \to 4$
    (*c*) Glucose + Fructose $1 \to 6$
    (*d*) Glucose + Galactose $1 \to 6$

55. Sex determination in Drossophila is based on ratio of number of X chromosomes to-
    (*a*) Number of autosomes (*b*) Sets of autosomes
    (*c*) Number of Y chromosome (*d*) Sets of total chromosomes

56. Human biodiversity is characterized by-
    (*a*) Y chromosome (*b*) Mitochondrial genes
    (*c*) Both A&B (*d*) VNTR

57. Which technique is used for biodiversity characterization-
    (*a*) RAPD (*b*) RFLP
    (*c*) SSR (*d*) SNP

58. Which branch of taxonomy gives equal weightage to all characters under study-
    (*a*) Chemo taxonomy (*b*) Numerical taxonomy
    (*c*) Paleotaxonomy (*d*) @ taxonomy

59. Human genome contains 3×10^9 bp having all four bp in equal proportion . A restriction endonuclease can cut a segment of 4 bp long. then how many fragments will be obtained after digestion-
    (*a*) 1.2×10^7 (*b*) 1.2×10^6
    (*c*) 1.2×10^5 (*d*) 1.2×10^4

60. Biological magnification is maximum in human it proves that human is-
    (*a*) Top consumer in food chain (*b*) More susceptible
    (*c*) Major Pollutant (*d*) Most efficient in storage of reserve food

61. Early embryonic stages of pig and mouse are almost identical, it reveals-
(*a*) Common ancestry (*b*) Progressive evolution
(*c*) Directional Evolution (*d*) Homology

62. Endemism is shown by-
(*a*) Grassland (*b*) Island
(*c*) plateaus (*d*) Mountains ranges

63. Ventral nerve cord and tubular heart is present in
(*a*) Annelida & arthopoda (*b*) Annelida & mollusca
(*c*) Arthopoda & mollusca (*d*) Coelentera and mollusca

64. Zygote formation by sperm and egg is result of phenomenon called-
(*a*) Fusion (*b*) Endocytosis
(*c*) Phagocytosis (*d*) En-nucleation

65. A Plant with variegated plants were allowed for photosynthesis by placing it in light and then brought into dark, then final reserve material of photosynthesis, the starch will accumulate in which part of leaf-
(*a*) Green portion (*b*) Colored portion
(*c*) In whole leaf (*d*) No where

66. All genes of mendelian population makes-
(*a*) Genome (*b*) Gene pool
(*c*) Genotype (*d*) Alleles

67. Abrupt change in gene frequency of small population is termed as-
(*a*) Genetic loss (*b*) Genetic erosion
(*c*) Founders effect (*d*) Genetic load

68. Kingdom protista includes-
(*a*) Slime moulds (*b*) Archaebacteria
(*c*) Cyanobacteria (*d*) Diatoms

69. Benthic organism of lakes or sea are usually-
(*a*) Producer (*b*) Herbivores
(*c*) Carnivores (*d*) Decomposers

70. A apple plant yielding 1 pound apple was crossed with a 1.5 pound apple yielding plant, all F_1 progenies yielded apples of 2 pound, the F_2 generation will be in ratio of -
(*a*) 9:4:3 (*b*) 1:2:1
(*c*) 3:1 (*d*) 9:3:4

CSIR-NET Life Sciences, June, 2004

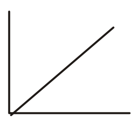
PART – A

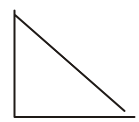
1. If the cylinder of mass ‘m’ and radius ‘r’ is transformed into disc with radius ‘2r’, then its moment of inertia will be-

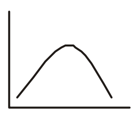
   (*a*) 2 (*b*) 4

   (*c*) 1/2 (*d*) 1/4

2. Among the following which is correct representation of rate constant ‘k’ and temperature ‘t’, for an enzymatic reaction-

   (*a*) 

   (*b*) 

   (*c*) 

   (*d*) 

3. If 10 g of substance at temperature 200 °C with specific heat 2 is mixed with other substance of 20 g at 20 °C with specific heat of 1. Then the final temperature of mixture would be-

   (*a*) 90 (*b*) 110

   (*c*) 1000 (*d*) 1110

4. Force felt by driver and passengers in car while it is moving in the arch of a tunnel will be-

   (*a*) Perpendicular to arch of tunnel

   (*b*) Away from the center of arch of tunnel

   (*c*) In forward direction

   (*d*) Toward the center of arch of tunnel

5. In coal CO_2 is formed in

   (*a*) through the fire

   (*b*) in top layers

   (*c*) in lower layers

   (*d*) in middle layers

6. The isotpops of hydrogen have

   (*a*) different number of electrons

   (*b*) different number of protons

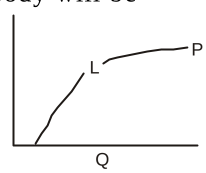
   (*c*) different number of neutron

   (*d*) different numbers of orbits

7. Among the following which is not a ketone body-
   (*a*) Hydroxy butyrate (*b*) Acetoacetate
   (*c*) Acetone (*d*) Acetyl CoA

8. Water is made purified by adding-
   (*a*) NaCl (*b*) NaOCl
   (*c*) $CaCl_2$ (*d*) $BeCl_2$

9. Certain deformity is observed in body on applying stress as shown in the diagram. If stress is removed at point 'P'. Then path of body will be-
   (*a*) Break along PLO
   (*b*) Break along PQ
   (*c*) Break along PLQ
   (*d*) Break Along LQ



10. Rational number is designated in form 'm/n'. What would be maximum possible rational number between 3/11 and 8/11-
    (*a*) Infinite (*b*) 6
    (*c*) 9 (*d*) 7

11. The perimeter of the rectangle whose length and bredth are 30m and 20m is-
    (*a*) 250m (*b*) 100m
    (*c*) 60m (*d*) 40m

12. If the sum of square of two numbers is 12402 and the product of two numbers is 999. Then what would be the sum of two numbers-
    (*a*) $\sqrt{12402}$ (*b*) $\sqrt{909}$
    (*c*) 120 (*d*) 306

13. Differentitation of below mentioned equation would be-

$$\frac{d}{dx}e^x \sin^2\theta + \frac{d}{dx}e^x \sin^2(\theta - \pi/2)$$

    (*a*) $2e^x(\sin\theta - \cos\theta)$ (*b*) e^x
    (*c*) $2e^x(\cos\theta)$ (*d*) $e^x(\sin\theta - \cos\theta)$

14. There are 15 boys and 13 girls in a class. 4 members are to be selected for a quiz program such that two are girls and two are boys. In how may ways selection can be made-
    (*a*) $\dfrac{15\times14\times13\times12}{4}$ (*b*) $\dfrac{15\times14\times13\times12}{4\times3}$
    (*c*) $\dfrac{15\times14\times13\times12}{4\times3\times2\times1}$ (*d*) $\dfrac{28\times27\times26\times25}{4}$

15. Which is not an programming language-
    (*a*) BASIC (*b*) C
    (*c*) MS-WORD (*d*) LOGO

16. Number of values that can be stored in 8 bits are-
    (*a*) 8 (*b*) 16
    (*c*) 64 (*d*) 256

17. If 11X11=100. Then which statement is correct-
    (*a*) Left hand side is binary and right is octal
    (*b*) Left hand side is binary and right is ternary
    (*c*) Left hand side is hexadecimal and right is octal
    (*d*) Left hand side is binary and right is also binary

18. Consider the following truth table.

P	Q	P < Q	$P \neq Q$
3	3	0	0
4	5	A	B

The value of A and B will be-
    (*a*) 0, 0 (*b*) 0, 1
    (*c*) 1, 0 (*d*) 1, 1

19. Bug, in computer terminology means-
    (*a*) Logical error (*b*) syntax error
    (*c*) organism effecting computer (*d*) high level programming

20. During the earthquake most damage is seen on earth crust because earth crust is-
    (*a*) Rigid (*b*) Brittle
    (*c*) Enelastic (*d*) Molten

21. A certain planet is revolving in a fixed orbit. If the radius of its orbit in increased four times then its mean surface temperature will decrease-
    (*a*) 1 (*b*) 2
    (*c*) 4 (*d*) 16

22. Charge density is more at poles because-
    (*a*) Magnetic field is parallel to poles
    (*b*) Magnetic field is parallel to equator
    (*c*) Magnetic field is perpendicular to poles
    (*d*) Magnetic field is perpendicular to equator

23. If an object absorbs green part of white light, then its color will be-
    (*a*) Blue (*b*) Yellow
    (*c*) Green (*d*) Purple

24. Biston betualaria population have different colored individuals because-
    (*a*) To escape from predators
    (*b*) To keep genetic equilibrium
    (*c*) To occupy different niche
    (*d*) To keep distinct identity

25. In honey bee males are developed parthenogenetically while female gives females and sterile workers on fertilization. It means-
    (*a*) Males cannot have male child
    (*b*) Males cannot have female child
    (*c*) Females cannot have male child
    (*d*) Females cannot have female child

26. The main reason for various genetic disorders are-
    (*a*) Mutation in gene at one more location'
    (*b*) Faulty repair mechanism
    (*c*) Faulty Transcription process
    (*d*) Incorrect protein synthesis

27. Farmers generally grow legumes after cereals. Since leguminous plant have symbiotic nitrogen fixing bacteria which provide nitrogen to plants. The nitrogen available to plant is in form of-
    (*a*) Nitrates (*b*) Nitrites
    (*c*) Ammonia (*d*) Ammonium nitrate

28. The main force involved in protein folding are-
    (*a*) H-bonding (*b*) Hydrophobicity
    (*c*) Covalent bonds (*d*) Vanderwall force

29. Fossils are generally found in-
    (*a*) Sedimentary rocks (*b*) Igneous rocks
    (*c*) Metamorphic rocks (*d*) Ice reserves

30. Pepsin which digest protein donot digest the cells of intestine because-
    (*a*) Intestine cells do not have proteins
    (*b*) Half life of pepsin is very low
    (*c*) Pepsin acts only in acidic pH
    (*d*) Pepsin do not digest intestine proteins

PART – B

1. Which one is the main function of Golgi complex-
    (*a*) Protein synthesis (*b*) Protein sorting
    (*c*) Detoxification (*d*) Phagocytosis

2. Cytological manifestation of crossing over during meiosis is visible as-
   (*a*) Synaptinemal complex (*b*) Chaisma
   (*c*) Diakinesis (*d*) Sister chromatid exchange

3. Recombination of genes takes place during-
   (*a*) Pachytene (*b*) Diplotene
   (*c*) Zygotene (*d*) Diakinesis

4. In mammals effective dosage of genes of two sexes is made equal by-
   (*a*) Elimination of X chromosome
   (*b*) Hyper activation of X
   (*c*) Hypoactivation of X
   (*d*) Inactivation of X

5. A well known genetic disorder is carried by a woman. She marries a normal man and her all female child are alive but she lost all male child. Such a disorder must be-
   (*a*) X-linked dominant (*b*) X-linked recessive
   (*c*) Y-linked dominant (*d*) Autosomal recessive

6. Among the following enzyme which is not involved in DNA replication process-
   (*a*) Primase (*b*) RNA polymerase
   (*c*) DNA polymerase (*d*) Helicase

7. Ratio of observed double crossover frequency to the expected frequency of double crossover gamete is termed as-
   (*a*) Coefficient of interference (*b*) Coefficient of Coincidence
   (*c*) Coefficient of variance (*d*) Coefficient of suppression

8. The somatic cell hybridization of human and mouse cell can be effectively carried out using-
   (*a*) PEG (*b*) Dextron
   (*c*) Inactivated Sendai virus (*d*) Enzymatic treatment

9. Which enzyme is involved in repair mechanism-
   (*a*) DNA polymerase (*b*) RNA polymerase
   (*c*) Restriction endonuclease (*d*) Photolase

10. Which statement is not true for DNA transcription-
    (*a*) Template strand & m-RNA have complementary sequences
    (*b*) Template strand is used as coding strand
    (*c*) Transcription is in 5’ $\rightarrow$ 3’ direction
    (*d*) Template strand & m-RNA have identical sequences

11. The most critical step for correct proteins synthesis is-
    (*a*) Binding of ribosome to m-RNA
    (*b*) Formation of Initiation complex
    (*c*) Aminoacylation of t-RNA
    (*d*) Translocation of ribosome

12. Point mutation in which there is deletion or addition of one base pair is termed as-
    (*a*) Deletion (*b*) Transition
    (*c*) Transversion (*d*) Frame shift mutation

13. Chromosome aberration in which suppression of crossing over, psuedo-dominance, lethal gene and non-reversal of mutation occurs in-
    (*a*) Inversion (*b*) Deletion
    (*c*) Translocation (*d*) Duplication

14. In human males, autosomal and sex trisomy mainly occurs due to-
    (*a*) Non-dysjuncion of chromosome
    (*b*) Error in meiosis
    (*c*) Dominant Y chromosome
    (*d*) Faulty Repair mechanism

15. Among the following which do not have any role in blood clotting mechanism-
    (*a*) Ca^{++} (*b*) Na^{+}
    (*c*) Prothrombin (*d*) Platelets

16. Among the following which chemical inhibits the mitochondrial electron transport chain-
    (*a*) Streptomycin (*b*) Nystanin
    (*c*) Azides (*d*) Penicillin

17. The main force involved in protein folding are-
    (*a*) H-bonding (*b*) Hydrophobicity
    (*c*) Covalent bonds (*d*) Vanderwall force

18. RBC obtain their energy from-
    (*a*) Mitochondria (*b*) Fatty acid synthesis
    (*c*) Anaerobic glycolysis (*d*) Glyoxylate cycle

19. Shape of RBC is-
    (*a*) Circular Biconcave (*b*) Oval Biconcave
    (*c*) Circular Biconvex (*d*) Oval Biconvex

20. The Shape of RBC is maintained by-
    (*a*) Proteins of Cytoskeleton (*b*) Hemoglobin
    (*c*) Fibronectin (*d*) Cell wall

21. Degradation of protein takes place in-
    (*a*) Lysosome (*b*) Lysome & Cytoplasm
    (*c*) Mitochondria & Lysosome (*d*) Mitochondria

22. pH of endosome is about-
    (*a*) 3-4.5 (*b*) 5-6
    (*c*) 7 (*d*) 8-9

23. Phytohormone responsible for conversion of stored proteins into glucose in germinating cereals is-
    (*a*) Cytokinin (*b*) Auxin
    (*c*) Gibberellin (*d*) Abscissic Acid

24. Direct oxidation of peroxides in plants is carried our by-
    (*a*) Superoxide Dismutase (*b*) Glutathione Synthase
    (*c*) Catalase (*d*) Peroxidase

25. A strong peptide bond is present in arginine and aspartic aci(*d*) This Bond will be weak if arginine is being replaced by-
    (*a*) Glutamic Acid (*b*) Lysine
    (*c*) Histidine (*d*) Proline

26. Mainly absorption of glucose by intestine is by-
    (*a*) Na-K Pumps (*b*) Diffusion
    (*c*) Na-glucose Symporters (*d*) Uniporters

27. Pepsin which digest protein donot digest the cells of intestine because-
    (*a*) Intestine cells do not have proteins
    (*b*) Half life of pepsin is very low
    (*c*) Pepsin acts only in acidic pH
    (*d*) Pepsin do not digest intestine proteins

28. During nerve impulse when acetyl choline binds receptors, there is-
    (*a*) In flow of Na & K ions
    (*b*) In flow of Na and outflow of K ions
    (*c*) In flow of K ions and outflow of Na ions
    (*d*) In flow of K and H ions

29. Cellulose digester digest cellulose of fermentation. Fore gut fermentors such as rabit and elephant ferment before intestine while hind gut digestor like deer ferment in large intestine. It suggest that-
    (*a*) Hind gut fermentor are effective digestor of Cellulose
    (*b*) Fore gut fermentor are effective digestor of Cellulose
    (*c*) Both hind gut & fore gut fermentor are effective digestor of Cellulose
    (*d*) Cellulose digestion do not depend on gut position

30. Addison disease and Cushing syndrome are due to malfunctioning of –
    (*a*) Adrenal medulla (*b*) Adrenal cortex
    (*c*) Thyroid (*d*) Pituitary

31. Which hormone is present in high amount during pregnancy in urine and used for pregnancy test-
    (*a*) hCG (*b*) Progestrone
    (*c*) Estrogen (*d*) Relaxin

32. Osmotic potential in plant cell is maintained by-
    (*a*) Proline & beta Glycine (*b*) Histidine
    (*c*) Lysine (*d*) Glycine

33. Which of the following are involved in antibody production-
    (*a*) T cells, Macrophages
    (*b*) B cells
    (*c*) B cells, T cells, Macrophages
    (*d*) Macrophages

34. Drug such as methotrexate which inhibit DNA synthesis are generally used for treatment of cancer because-
    (*a*) Cancer cells are converted into normal cells
    (*b*) Drugs act only on rapidly dividing cells
    (*c*) Cancerous cells are selectively eliminated
    (*d*) Enzyme telomerase is inhibited

35. When two fungi namely one sterile and other Microconidial are grown together in culture, it was seen that sterile fungi get degenerated while size of conidia of microconidial fungi increased. The probable reason might be-
    (*a*) Sterile fungi suicide to provide nutrition to micro conidial fungi
    (*b*) Microconidial fungi secreted toxins in medium
    (*c*) Both cultures can not be grown together
    (*d*) Nutritional requirement of both fungi is different

36. During inhibition of enzyme action Vmax remains unchanged while Km is altered. Inhibition is-
    (*a*) Competitive (*b*) Non-competitive
    (*c*) Un-competitive (*d*) Allosteric

37. During an enzyme assay if the initial velocity Vo=Vmax , then substrate concentration will be-
    (*a*) a Km (*b*) Km
    (*c*) ½ Km (*d*) 0.2 Km

38. The maximum possible available energy of substance is termed as-
    (*a*) Free energy (*b*) Entropy
    (*c*) Enthalpy (*d*) Chemical potential

39. The primary cause of variation among individual is-
    (*a*) Recombination (*b*) Mutation
    (*c*) Isolation (*d*) Hybridization

40. Biological species are defined on basis of-
    (*a*) Morphology (*b*) Alkaloids
    (*c*) Anatomy (*d*) Reproductive isolation

41. In phylogenetic relationship can be best established by-
(*a*) Allozymes
(*b*) Alakaloids
(*c*) Alcohol dehydrogenase
(*d*) Morphology

42. Among the following which trend shows the decreasing population-
(*a*) More individual in post reproductive stage
(*b*) More individual in pre-repd stage and repd. stage
(*c*) Less individual in pre-repd stage & more in post repd stage
(*d*) Less individual in repd stage & more in repd stage

43. r-selection is characterized by-
(*a*) Rapidly developing individuals
(*b*) Slowly developing individuals
(*c*) Small number of offsprings
(*d*) Large sized offsprings

44. Water potential decreases when-
(*a*) Solute concentration increases
(*b*) O.P decreases
(*c*) Solute concentration decreases
(*d*) DPD decreased

45. Pyramid of energy may be inverted in-
(*a*) Desert
(*b*) Oceans
(*c*) Tundra
(*d*) Grasslands

46. Net productivity of closed ecosystem is-
(*a*) 0
(*b*) <0
(*c*) >0
(*d*) $+1/-1$

47. Number of individual surviving to reproductive stage is termed as-
(*a*) Fecundity
(*b*) Net reproduction rate
(*c*) Survivorship curve
(*d*) Reproductive Mortality

48. Major source of green house gases are-
(*a*) Burning of plants
(*b*) Burning of fossil fuels
(*c*) Respiration
(*d*) Use of LPG

49. Global warming is due to-
(*a*) Absorption of UV by Ozone
(*b*) Absorption of IR by CO_2
(*c*) Absorption of IR by ozone
(*d*) Absorption of UV by CO_2

50. Soil in naturally growing vegetation is-
(*a*) Acidic due to Bicarbonate in soil
(*b*) Basic due to Bicarbonate in soil
(*c*) Neutral
(*d*) Acidic due to Sulphuric acid

51. Deepest enriched soil with nutrients is present at-
(*a*) Tropical rain forests (*b*) Dry deciduous forests
(*c*) Grasslands (*d*) Conifers

52. Maximum biodiversity occurs at-
(*a*) Tropics (*b*) Equator
(*c*) Temperate (*d*) Shooth

53. The place is designated as hot spot of biodiversity, if it have percentage of endemic species more then-
(*a*) 0.5 % (*b*) 2 %
(*c*) 15 % (*d*) 30 %

54. On earth there are 15 hot spot of biodiversity. They covers total-
(*a*) 24 % of total plant species and 1.8 % of total land area
(*b*) 44 % of total plant species and 1.8 % of total land area
(*c*) 24 % of total plant species and 15 % of total land area
(*d*) 44 % of total plant species and 15 % of total land area

55. When different species formed are touching a boundary, such a speciation is termed as-
(*a*) Sympatric (*b*) Allopatric
(*c*) Allo-sympatric (*d*) Parapatric

56. Diversity within community or habitat is termed as-
(*a*) α-biodiversity (*b*) β-biodiversity
(*c*) γ-biodiversity (*d*) λ-biodiversity

57. Hanuman languor when occupy Haram starts infanticide because-
(*a*) They does not want child of earlier dominant male to survive
(*b*) For reproductive advantage
(*c*) To remove alleles of dominant gene
(*d*) To maintain the constant population

58. Zea mays originated in-
(*a*) South America (*b*) Asia
(*c*) Europe (*d*) Africa

59. Coenozoic era is characterized by-
(*a*) Disappearance of reptiles and adaptive radiation in aves
(*b*) Disappearance of Dinosours and adaptive radiation in aves
(*c*) Disappearance of Dinosours and adaptive radiation in mammals
(*d*) Appearance of Mammals and Aves

60. Phylogenetic relationship cannot be established on basis of-
(*a*) 5 S r-RNA (*b*) 16 S r-RNA
(*c*) Mitochondrial genes (*d*) Ribosomal DNA

61. The first oxygen evolving forms among the following were-
    (*a*) Anaerobic autotrophs (*b*) Cyanobacteria
    (*c*) Protists (*d*) Algae

62. Fossils are generally found in-
    (*a*) Sedimentary rocks (*b*) Igneous rocks
    (*c*) Metamorphic rocks (*d*) Ice

63. Rapid nutritional recycling takes place in-
    (*a*) Coral (*b*) Deserts
    (*c*) Grasslands (*d*) Oceans

64. Shannon index is measure of –
    (*a*) Biodiversity evenness (*b*) Population
    (*c*) Pollution (*d*) Speciation

65. During Beagle voyage of Charles Darwin he observed that the flora of tropical America is most similar to-
    (*a*) Asia (*b*) Temperate America
    (*c*) Europe (*d*) Australia

66. When a marine fish is placed in fresh water, it dies becuase-
    (*a*) Entry of water and it floats
    (*b*) Exit of water and shrinks
    (*c*) Deficiency of salts
    (*d*) Deficiency of nutrients

67. The Cuvier's theory, which states that there had been several creations, each preceded by another due to some geographical disturbances. Such theory is termed as-
    (*a*) Theory of catastrophism (*b*) Special creation
    (*c*) Pangenesis (*d*) Eternity of life

68. In winter pollution rate enhances due to-
    (*a*) SPM (*b*) SO_2 and NO_2
    (*c*) Burning of fuels (*d*) Low temperature

69. Distance between two genes is measured in which units-
    (*a*) cM (*b*) Å
    (*c*) bp (*d*) nm

70. Among the following which ions are not used in active transport-
    (*a*) Na^+ (*b*) K^+
    (*c*) Ca^{++} (*d*) Cl^-

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PART – A

1. Among the following, which is maximum soluble in water-
   (*a*) Phenol (*b*) Benzaldehyde
   (*c*) Chlorobenzene (*d*) Aniline

2. KCl is highly soluble in water but MgO_2 is insoluble in it because-
   (*a*) KCl is ionic while MgO_2 is covalent molecule
   (*b*) Hydration energy of MgO_2 cannot overcome its lattice energy.
   (*c*) Size of K and Cl ion is small
   (*d*) Both are equally soluble

3. Number of geometrical isomers for an octahedral molecule MA_3B_3 would be-
   (*a*) 2 (*b*) 3
   (*c*) 5 (*d*) 8

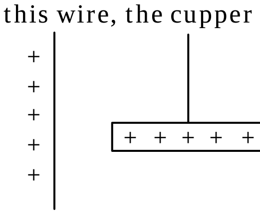
4. Rate constant for any reaction may be represented as $K \propto [A]^n$. When the substrate concentration of substrate is increased twice its rate of reaction increases four times, then the value for n will be-
   (*a*) 1 (*b*) 2
   (*c*) 4 (*d*) 1/4

5. Among the following which compound prevents the teeth decay-
   (*a*) SnF_2 (*b*) BF_4
   (*c*) BeF_2 (*d*) CF_4

6. A sound source is moving with the velocity V_s toward the moving object which is moving with velocity V_o toward the sound source, then the ratio of frequency of sound heard after time period 't' will be-
   (*a*) $V_s + Vo/Vs + V_o$ (*b*) $V_s - V/Vs + V_o$
   (*c*) $V_s + V_o/V_s - V_o$ (*d*) $V_s - Vo/Vs - V_o$

7. There is dispersal of light into several colors after falling on oil drop suspended in water due to-
   (*a*) Diffraction of light by oil
   (*b*) Different refractive index of oil and water
   (*c*) Interference of light from lower & upper layers of oil
   (*d*) Refraction of light from oil medium

8. An uniformly positive charged cupper wire is suspended by a rope as shown in diagram. on bringing another unit positive charge toward one end of this wire, the cupper wire would-



   (*a*) Repel away from positive charge
   (*b*) Will be attracted toward positive charge
   (*c*) Displace away from mean position
   (*d*) There would be no deflection

9. Which statement is correct regarding the Archimedes principle-
   (*a*) A body immersed in a fluid displaces fluid equal to its weight.
   (*b*) The displaced fluid molecule tries to regain their original position
   (*c*) All compounds equally sinks in water
   (*d*) There is up thrust inversely proportional to mass of body

10. Consider the following program for factorial of real number 'n'. It will not give the valid result when the value of 'n' is –

```
START
READ N
FOR N=√N²+1
DO N=N+1
ELSE
END
```

   (*a*) – 1 (*b*) 0
   (*c*) + 1 (*d*) –1 and 0

11. In an computer program it is written that A=10, it means-
   (*a*) There are 10 bits allocated to location A
   (*b*) Location A can store 10 characters
   (*c*) The previous value of A has changed to 10
   (*d*) The program performs 10 calculations

12. Consider the following, truth table-

P	Q	P < Q	P< = Q
3	7	1	A
5	5	B	1

   The values for A and B will be-
   (*a*) 0, 0 (*b*) 0, 1
   (*c*) 1, 0 (*d*) 0, 0

13. Which of the following is not an operating system-
   (*a*) DOS (*b*) Unix
   (*c*) Linux (*d*) Oracle

14. Consider the following binary numbers
   1 + 10 + 100 + 1000 ………… + 100000000
   The sum of following binary number would be-
   (*a*) $2^9 - 1$ (*b*) $2^{10} - 1$
   (*c*) $2^9 + 1$ (*d*) $2^{10} + 1$

15. The height of Himalaya is gradually increasing due to-
   (*a*) Shifting of Asian plates toward NE Asia
   (*b*) Sinking of East Asia into pacific

(*c*) Volcanic disturbances
(*d*) Separation of plates between Asia and China

16. The rate of evaporation is more in Bay of Bengal as compare to Arabian sea because-
(*a*) More drainage of rivers in Bay of Bengal
(*b*) Strong winds over Bay of Bengal
(*c*) Bay of Bengal is swallow
(*d*) Monsoon winds

17. During the ice age the mean sea level decreased by 15 m and ice masses floated to poles, during that time the period of rotation which is 24 hours would have been-
(*a*) Increased by one hour
(*b*) Decreased by an hour
(*c*) Decreased by more then one hour
(*d*) Remained unchanged.

18. On evaporation, there is cooling in surrounding because-
(*a*) Winds blows away energy from the water vapors
(*b*) More radiation absorbs heat
(*c*) Temperature of surrounding is always low
(*d*) Molecules evaporating gains energy

19. When a ship floats on water
(*a*) it displaces no water
(*b*) the mass of water displaced is equal to the mass of ship
(*c*) the mass of water displaced is lesser than the mass of the ship
(*d*) the mass of water displaced is greater than the mass of the ship

20. The probability of getting two girls and one boy for a family in sib ship of three would be-
(*a*) 1/8 (*b*) 3/8
(*c*) 5/8 (*d*) 2/3

21. The outcome of following addition would be-

$$\frac{1+2+3+4+5\ldots+100}{1+2+3+4+5\ldots+99}$$

(*a*) 1 + 100/99 (*b*) 1 + 99/100
(*c*) 101/99 (*d*) 99/100

22. The out come following equation would be-
$n \rightarrow \infty\ (1 + 2/n)^2$
(*a*) e^2 (*b*) e
(*c*) e^2+1 (*d*) e^2-1

23. $f(x) = ax^2 + bx + C$
$g(x) = px^2 + q + r$
$f(x).g(x) = 0$
If a, b, c & p, q, r = real, then
(*a*) $\sqrt{b^2 - 4ac} = 0$ & $\sqrt{P^2 - 4pr} = 0$
(*b*) $\sqrt{b^2 - 2ac} = 0$
(*c*) $b^2 - 4ac = 0$ & $P^2 - 4pr = 0$
(*d*) $\sqrt{P^2 - 4pr} = 0$

24. Among the following which organ is not used for respiration in organisms-
(*a*) Nose
(*b*) Lung
(*c*) Skin
(*d*) Gills

25. How genes are involved in carbohydrate synthesis-
(*a*) Gene code m-RNA, which code for carbohydrates
(*b*) Genes directly synthesize carbohydrate
(*c*) Gene code m-RNA, which is used by ribosome for protein synthesis
(*d*) Gene code for enzymes, which are involved in carbohydrate metabolism

26. According to Darwin theory of natural selection, the cause of variations in population is-
(*a*) Inheritance of acquired character
(*b*) They are pre-existing
(*c*) Due to environmental changes
(*d*) Due to mutation

27. Why we are wording about increasing concentration of CO_2, since in past the CO_2 was higher then today's amount-
(*a*) Burning of fossil fuels
(*b*) It has been never been so high
(*c*) It is added at highest rate on earth's history.
(*d*) It is causing global warming

28. The order of following organisms as phylogenetic closeness to human-
(*a*) Chimpanzee > languor > lemur > tree shrews
(*b*) Languor > chimpanzee > tree shrews > lemur
(*c*) Chimpanzee > languor > tree shrews > lemur
(*d*) Languor > lemur > chimpanzee > tree shrews

29. When there is lunar eclipse on earth, a man is standing in shadow of earth he will observe-
(*a*) Lunar eclipse
(*b*) Total sun eclipse
(*c*) Annular sun eclipse
(*d*) He will not see anything

30. There is a certain bond between A and B which is stronger then bond between A-A and B-B because-
(*a*) The bond length between A-B is more then A-A and B-B
(*b*) More energy is required to break bond between A-B
(*c*) The energy of A/2 is and B/2 is more then AB/2
(*d*) The entropy of AB is less then A and B

31. The basic unit of the genetic material, which can be visualized, is -
    (*a*) Metaphase chromosome
    (*b*) Anaphase chromosome
    (*c*) Interphase chromonema
    (*d*) Nucleosome

PART – B

1. Which statement supports the second law of thermodynamics-
    (*a*) Photosynthetic efficiency of plants is low
    (*b*) There is limited numbers of tropic level
    (*c*) Energy transfer from one tropic level to another always below 15 %
    (*d*) High numbers of producers

2. Among the following which equation denotes the population growth when resources are not limitating-
    (*a*) $N_t = N_o e^{-rt}$ (*b*) dN/dt = rt
    (*c*) $N_t/N_t = N_t–N_o$ (*d*) dN/dt = Krt

3. The cause of blood borne hepatitis is-
    (*a*) HAV (*b*) HBV
    (*c*) HCV (*d*) HGV

4. The enzyme responsible for conversion of $O^{-2} \rightarrow H_2O_2$ is-
    (*a*) Catalase (*b*) Ascorbate
    (*c*) Superoxide dismutase (*d*) Peroxidase

5. Dosage compensation in drosophila can be visualized using-
    (*a*) Gel electrophoresis
    (*b*) Autoradiography
    (*c*) Chromosome banding
    (*d*) Tritium hydrogen labeled DNA

6. N-linked glycosylation of protein begins in-
    (*a*) ER (*b*) Golgi
    (*c*) Lysosome (*d*) Cytoplasm

7. The portion of golgi which contain irregular cisternae and tubules is known as-
    (*a*) Cis golgi (*b*) Trans golgi
    (*c*) Medial golgi (*d*) Intercisternal golgi

8. Mannose-6 phosphate tagged protein are targeted to-
    (*a*) Lysosome (*b*) Peroxisome
    (*c*) Mitochondria (*d*) Vacuole

9. The frame shift mutation is induced by-
   (*a*) Nitrous oxide (*b*) Acradines
   (*c*) EMS (*d*) UV rays

10. Then typical Mendel test cross ratio in two point cross is-
    (*a*) 9:3:3:1 (*b*) 1:2:1
    (*c*) 1:1 (*d*) 1:1:1:1

11. Germplasm theory was proposed by-
    (*a*) Dobszzhanky (*b*) Weismann
    (*c*) Meyer (*d*) Mendel

12. Mendel's laws of inheritance is applicable to-
    (*a*) Nucleus (*b*) Plasmid
    (*c*) Mitochondria (*d*) Plastid

13. Number of base pairs in 68 μm long DNA would be-
    (*a*) 2×10^4 (*b*) 2×10^5
    (*c*) 6.8×10^5 (*d*) 3.4×10^5

14. Three DNA strands have 40%, 50 % and 60 % GC sequence. The probability of matching 8 bp sequences will be more in-
    (*a*) A (*b*) B
    (*c*) C (*d*) A& C

15. During RNA processing splicing is mediated by-
    (*a*) Sn RNA (*b*) m-RNA
    (*c*) r-RNA (*d*) t-RNA

16. Hormone which is responsible for absorption of water by kidney and prevents water loss is-
    (*a*) ACTH (*b*) Insulin
    (*c*) Vasopressin (*d*) Oxytocin

17. The main function of oxytocin is-
    (*a*) Relaxation of uterine muscles during pregnancy
    (*b*) Contraction of uterine muscles at birth
    (*c*) Ovulation of egg from ovary
    (*d*) Maintenance of embryo attached to placenta

18. Possible types of gametes formation from genotype AABBCcDdEe would be-
    (*a*) 16 (*b*) 64
    (*c*) 8 (*d*) 128

19. Generally the number of cells present in the embryo sac of angiosperm are-
    (*a*) 7 (*b*) 8
    (*c*) 3 (*d*) 5

20. Among the following which is not responsible for maintaining ionic balance in animal cell-
    (*a*) Ca^{++} (*b*) Mg^{++}
    (*c*) Na^{+} (*d*) K^{+}

21. There is always unidirectional flow of nerve impulse because-
    (*a*) It is transmitted from pre-synaptic membrane to post synaptic membrane through acetyl choline
    (*b*) Due to presence of myelin sheath
    (*c*) Axon and Dendrites
    (*d*) Polarization and depolarization

22. Lesch-Nyann syndrom is due to defect in
    (*a*) Recessive X-chromosome (b) Dominant X-chromosome
    (c) Autosomes (d) Y-chromosomes

23. Profitability of prey for predator lies in its energy content and
    (*a*) Prey density (*b*) Palatability
    (*c*) Foraging time (*d*) Prey availability

24. Besides sexual reproduction in *Planaria* it also shows -
    (*a*) Conjugation
    (*b*) Budding
    (*c*) Fragmentation and regeneration
    (*d*) Binary fission

25. Among the following which is source of maximum antibiotics-
    (*a*) Streptomyces (*b*) Penicillin
    (*c*) Actinomyces (*d*) Bacillus

26. The gradual mode of speciation in single lineage in which species diverge in spurts of relatively rapid change which result in increase in species is termed as-
    (*a*) Punctuated equilibrium
    (*b*) Adaptive radiation
    (*c*) Anagenesis
    (*d*) Cladogenesis

27. Among the following which statement is false about r-selected species-
    (*a*) Long generation time
    (*b*) Large number of offspring
    (*c*) Short life cycle
    (*d*) Tendency to disperse

28. Cataloging and classification of plant species in India are maintained by-
    (*a*) BSI (*b*) NBPGR
    (*c*) Forest survey of India (*d*) National botanical garden

29. The branch of science which deals with classification, naming, identification of plants on morphological basis without establishing the phylogenetic relationship is termed as-
    (*a*) Taxonomy (*b*) Systematics
    (*c*) Phenetics (*d*) Cladastics

30. In India, among the following the maximum number of species are of-
    (*a*) Antelops (*b*) Apes
    (*c*) *Panthera* sps (*d*) Marsupials

31. Type of speciation observed in slow moving organisms is termed as-
    (*a*) Sympatric (*b*) Parapatric
    (*c*) Allopatric (*d*) Peripetric

32. Taxol, an anti-cancerous drug is obtained from plant *Taxus bacata* which belongs to-
    (*a*) Bryophytes (*b*) Pteridophytes
    (*c*) Gymnosperms (*d*) Angiosperms

33. Among the following commonly used method for classification in numerical taxonomy is-
    (*a*) Simple Matching Coefficient (*S*)
    (*b*) Centroid Matching Coefficient
    (*c*) Clustered Arithmetic average
    (*d*) Unweighted Pair Group Method

34. If there is mutation in cdk/cyclin, the key molecule in regulating the cell cycle, then-
    (*a*) There would be uncontrolled growth
    (*b*) Cell will not pass to S phase
    (*c*) The level of cdk/cyclins will enhance
    (*d*) Cells will arrest to G_o phase

35. Allergy or hypersensitivity reaction are due to secretions of –
    (*a*) T-cells (*b*) Mast cells
    (*c*) B-cells (*d*) Basophils

36. In humoral immunity humor means-
    (*a*) lymph and plasma (*b*) Bone marrow
    (*c*) Interstitial cells (*d*) B-cells

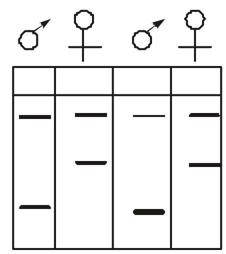
37. The structural change which leads into crossover suppression is-
    (*a*) Deletion (*b*) Duplication
    (*c*) Inversion (*d*) Translocation

38. NADPH enters the electron transport chain through-
    (*a*) Co Q (*b*) FAD
    (*b*) Succinate dehydrogenase (*d*) Cytochrome oxidase

39. Formation of glucose from acetyl CoA is called-
    (*a*) Glycogenesis (*b*) Gluconeogenesis
    (*c*) TCA cycle (*d*) Glycolysis

40. Cells absorbs insulin by-
    (*a*) Endocytosis (*b*) Pinocytosis
    (*c*) Phagocytosis (*d*) Active transport

41. The deficiency of cyanocobaltamine leads to-
    (*a*) Microcytic anemia
    (*b*) Macrocytic Anemia
    (*c*) Thalsemmia
    (*d*) Hypochoramtosis



42. An enzyme profile due to certain disease is shown in following figure. It means that this disease is-
    (*a*) Sex linked
    (*b*) X linked
    (*c*) Autosomal
    (*d*) Both B & C

43. When an radioactive phosphorus is incorporated into DNA strand, the phospho diester bond generally break after a short while because-
    (*a*) The bond number of phosphorus decreases
    (*b*) Phosphorus on radioactive decay converts into sulphur, which has valency of two
    (*c*) It attacks glycosidic bond
    (*d*) It breaks hydrogen bond

44. Among the following which is generally not utilized for establishing phylogenetic relationship between two species-
    (*a*) % similarity (*b*) Geographical distance
    (*c*) Marcoli distance (*d*) ______similarity

45. Mangroves are highly productive ecosystem but they are rich in bird diversity because-
    (*a*) Lack of structural diversity
    (*b*) Rich in food diversity
    (*c*) More number of predators that feed on birds
    (*d*) Lack of breeding place

46. Among the following which would lead into new species formation-
    (*a*) Increased resources
    (*b*) Niche overlapping tolerance
    (*c*) Niche specialization
    (*d*) Lack of competition

47. Origin of life is not possible under present environmental conditions because-
    (*a*) Hydrogen is absent (*b*) Due to presence of oxygen
    (*c*) Lack of source of energy (*d*) Lack of raw material for origin of life

48. Disaster such as earthquake or fire may reduce the size of population drastically and the genetic make up of the small surviving population is unlikely to be representative of make up of original population the situation is termed as-
    (*a*) Bottle neck effect (*b*) Adaptive radiation
    (*c*) Founder effect (*d*) Gene migration

49. A certain organism developed an adaptation as to adapt existing environment but if this adaptation prove useful for some other function as well, it is termed as-
    (*a*) Co-adaptation (*b*) Adaptive radiation
    (*c*) Exadaptation (*d*) Co-evolution

50. In a population frequency of a homozygous recessive disease is 16% then the frequency of dominant allele would be-
    (*a*) 0.84 (*b*) 0.6
    (*c*) 0.16 (*d*) 0.4

51. Ferritin tagged antibody can be visualized through-
    (*a*) Fluorescence microscopy
    (*b*) Electron microscopy
    (*c*) Autoradiography
    (*d*) Phase contrast microscopy

52. The bonding which are responsible for holding two beta sheets together is-
    (*a*) Disulphide bond (*b*) Covalent bond
    (*c*) Hydrogen bond (*d*) Hydrophobic interaction

53. The best example of regulation of enzyme by reversible covalent modification is-
    (*a*) Phosophorylation (*b*) Acetylation
    (*c*) Glycosylation (*d*) Proteolytic cleavage

54. Use of inactivated Sendai virus and PEG for fusion of two cells has proved very beneficial in studies for-
    (*a*) Transgenic
    (*b*) Tissue culture
    (*c*) Genetic manipulation
    (*d*) Recombinant DNA technology

55. In a population individuals having heterozygous phenotype are more favored then homozygous dominant which are more favored then homozygous recessive genotypes, under such condition-
    (*a*) Recessive alleles would be lost from population
    (*b*) Dominant alleles would be lost
    (*c*) Both alleles would remain in population
    (*d*) Alleles would be lost randomly

56. The graph between new species encountered with progressive area covered would be-
    (*a*) Straight line (*b*) Hyperbola
    (*c*) Sigmoid (*d*) Parabola

57. Minimata disease is an example of-
    (*a*) Bioaccumulation (*b*) Bioconcentration
    (*c*) Biomagnification (*d*) Air Pollution

58. First child of an parent is diseased They want to take help from genetic counselor for their second child. The genetic counselor must know to predict the fate of second child
    (*a*) Both parents are diseased
    (*b*) Disease is hereditary
    (*c*) Marker for disease is monomorphic
    (*d*) Marker for disease is polymorphic

59. C-AMP is directly involved in regulation of
    (*a*) Adenylate cyclase (*b*) Protein kinase A
    (*c*) Phospho frucotokinase (*d*) ATP

60. There is net gain of energy in form of ATP, if glucose which has converted into acetyl coA enters-
    (*a*) TCA cycle (*b*) Glycolysis
    (*c*) Beta oxidation (*d*) Pentose phosphate pathway

61. When organisms are restricted to certain area and they are found nowhere else they are called-
    (*a*) Cosmopolitan (*b*) Endemic
    (*c*) Sibling species (*d*) Ecotypes

62. If + represents the beneficial interaction and – represents the harmful interaction, then the commensalism may be designated as interaction-
    (*a*) ++ (*b*) + –
    (*c*) + 0 (*d*) – 0

63. In small intestine, cholera toxin acts by
    (*a*) active absorption of NaCl
    (*b*) activation of GTPase
    (*c*) inhibition of adenyl cyclase
    (*d*) ADP-ribosylation of the G-protein

64. Transfer of impulse across the nerve fibres is not directly proportional to-
    (*a*) Insulation of myelin sheath (*b*) Diameter
    (*c*) Cold temperature (*d*) Length of neuron

65. Drosophila shares more its genes with sister (75%) as compare to its daughter (50%) due to-
    (*a*) Eusocialbilty (*b*) Kin selection
    (*c*) Haploidy diploidy (*d*) Parthenogensis

66. Electrons excited from PS II are accepted by-
    (*a*) PQ (*b*) Pheophylin
    (*c*) PC (*d*) Cyt b_6

67. Total energy available for work at equilibrium is termed as-
    (*a*) Free energy (*b*) Entropy
    (*c*) Activation energy (*d*) Enthalpy

68. A group of species which are phylogenitically closer but they are lacking common ancestor. Such an group is regarded as-
    (*a*) Monophyletic (*b*) Polyphyletic
    (*c*) Paraphyletic (*d*) Sympatric

69. Among the following which is not an characteristic of r-Selected species-
    (*a*) Short maturation time
    (*b*) Short life span
    (*c*) Small size of offspring's
    (*d*) More then one time offspring production

70. In India most of plant flowers during spring or summer because-
    (*a*) It is breeding season for butterflies
    (*b*) More solar radiation are available
    (*c*) Fruit and seed setting must be complete before onset of monsoon
    (*d*) Environmental fluctuations are low

CSIR-NET Life Sciences, June, 2005

PART – A

1. Moon have many craters which are easily visible from earth, but earth looks almost without craters when seen from the space because-
   (*a*) Earth have atmosphere
   (*b*) Moon is located near asteroid belt
   (*c*) Earth is bigger then moon
   (*d*) Moon have formed earlier then earth

2. Consider the following reaction.
   $A + B \rightarrow C$
   If the concentration of A is doubled the rate of reaction doubles and if the concentration of both A and B is doubled the rate becomes 16 times. So the rate constant can be represented as-
   (*a*) $K \alpha [A][B]^2$ (*b*) $K \alpha [A]^2[B]^2$
   (*c*) $K \alpha [A]^2[B]^3$ (*d*) $K \alpha [A][B]^3$

3. The binary representation of decimal number 63 will be-
   (*a*) 11111 (*b*) 111111
   (*c*) 100101 (*d*) 10101010

4. For a computer among the following which is NOT a peripheral device-
   (*a*) Keyboard (*b*) Mouse
   (*c*) CPU (*d*) Monitor

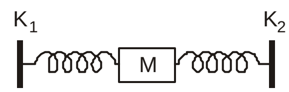
5. For element among the following properties, which donot show trends in periodic properties-
   (*a*) Electro negativity (*b*) Bond behaviour
   (*c*) Neutron/proton ratio (*d*) Electron affinity

6. $^{235}_{92}U$ was bombarded with a slow moving neutron which resulted in its fission forming $^{149}_{50}X + ^{84}_{42}Y$ and some neutrons. The number of neutron released were-
   (*a*) 2 (*b*) 3
   (*c*) 4 (*d*) 5

7. Among the following which will have maximum pH at their 1M concentration-
   (*a*) Sodium hydroxide
   (*b*) Sodium carbonate
   (*c*) Acetic Acid
   (*d*) Potassium hydroxide

8. An laser beam with the wavelength 6300nm formed an interference pattern of 8.1 nm while another laser beam of unknown wavelength produced an interference pattern of 7.2 nm. Then the wavelength of second laser beam will be-
   (*a*) 5600 (*b*) 4600
   (*c*) 4800 (*d*) 3200

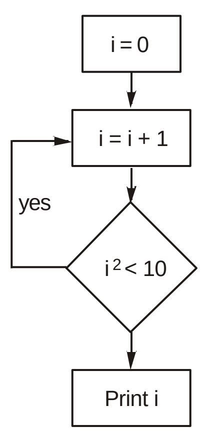
9. A wooden box of mass M is suspended between two springs having spring constant K1 and K2. Both springs are fixed to walls. If the wooden block is displaced along (+) X–axis then the time period for oscillation will be-
   (*a*) T = 2π√m/k1+k2
   (*b*) T = 2π√m(k1/k2) g
   (*c*) T = 2π√m(k1-k2)^2/g
   (*d*) T = 2π√(k1-k2)/m



10. During winters in Tundra when the lake freezes into ice, the temperature of water just beneath the ice would be-
   (*a*) 0 °C (*b*) –4 °C
   (*c*) –10 °C (*d*) 4 °C

11. Consider the statement “Value of P lies in Q”. It means-
   (*a*) P is true or Q is true
   (*b*) P is true and Q is true
   (*c*) P is false or Q is true
   (*d*) P is false and Q is true

12. What would be the output of following program
   (*a*) 2
   (*b*) 3
   (*c*) 4
   (*d*) 5



13. If an integer occupies five character in its binary form. The number of characters required for its decimal form will be-
   (*a*) 1 (*b*) 2
   (*c*) 3 (*d*) 4

14. n [redacted] $\to \infty \left[2 + \frac{1}{n}\right]$ equals to

(*a*) Ve (*b*) e

(*c*) e^2 (*d*) e^3

15. Integers 1 to 7 are randomly arranged in a line. What is the probability that first two numbers in line are odd-

(*a*) 2/7 (*b*) 4/9

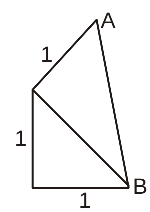
(*c*) 12/9 (*d*) 7/9

16. If the value of integer a = 8 and c = 10. The values of log a, log b and log c are in certain arithmetic progression. The value for integer b will be-

(*a*) $\sqrt{81}$ (*b*) $\sqrt{80}$

(*c*) $\sqrt{18}$ (*d*) $\sqrt{1.8}$

17. The distance between point A and B will be-



(*a*) $\sqrt{2}$

(*b*) 3

(*c*) $3\sqrt{3}$

(*d*) $\sqrt{3}$

18. If all the oxygen present in atmosphere is replaced by nitrogen. What would be effect on atmospheric pressure-

(*a*) Increase by 9% (*b*) Decrease by 9%

(*c*) Increase by 3% (*d*) Remain unchanged

19. The main function of ozone layer is-

(*a*) Protect us from UV rays

(*b*) Maintain global temperature

(*c*) Global warming

(*d*) Absorption of cosmic rays

20. Generally the deeper layers of oceans have low temperature, probable reason is-

(*a*) Sunlight cannot penetrate below 100 m

(*b*) Salt decreases the freezing point

(*c*) Endothermic reaction of ocean due to tidal forces

(*d*) Exchange of heat from deeper layer of ocean to earth crust

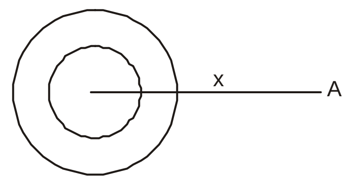
21. A satellite is revolving around an planet with orbital radius R. If mean density of planet is ρ and universal gravitational constant is G. Then the orbital velocity will depend on-

(*a*) G & ρ (*b*) ρ & R

(*c*) G, R & ρ (*d*) only on R

22. In an photoelectric effect if the light incident is above the threshold frequency with constant intensity then-
   (*a*) Kinetic energy of emitted electron will increase and no effect on frequency of electrons
   (*b*) Number of electrons emitted is more
   (*c*) Frequency of emission of electron will be more
   (*d*) No net effect

23. If the sphere is uniformly charged with charge density ρ. Then the electric field at point A which is at distance x from centre will be-



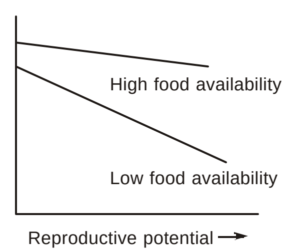
   (*a*) $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{x^2}$ (*b*) $E = 4\pi\varepsilon_0 \frac{q}{x^2}$
   (*c*) $E = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{x^2}$ (*d*) $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{x}$

24. DNA differs from RNA in-
   (*a*) Bases (*b*) Sugar and Bases
   (*c*) Sugar, bases and phosphate (*d*) Sugar and phosphate

25. The Rh-factor present on RBC gets it names from rhesus monkey which occurs in
   (*a*) Africa (*b*) N. America
   (*c*) S. America (*d*) Europe

26. If protein synthesis can start without start codon, then the number of different amino acids coded by fragment 5' TAGGCATAGGCACTATAGG-3'
   (*a*) 4 (*b*) 3
   (*c*) 5 (*d*) 7

27. The given graph suggest that



   (*a*) Survibility decreases with increase in reproductive potential
   (*b*) Survibility is independent of food availability
   (*c*) Reproductive potential is independent of food
   (*d*) Adverse effect of food on survibilty is more on organisms with low food availability as compare to high food availability

28. A plant was taken from Leningrad to Brazil and Russi*a*. The plant in Brazil flowered during February while that in Russia flowered in July. The reason for these differences would be-
   (*a*) Cold temperature decreases flowering
   (*b*) Inclination of axis of earth
   (*c*) Differences in day length
   (*d*) Rotation of earth on its axis

29. Given $y = a^x = \frac{dy}{dx}$

(*a*) xa^{x-1} (*b*) $1/a^x$

(*c*) $a^x \ln a$ (*d*) None of the above

30. Carbon dioxide is being depleted from the atmosphere because of –

(*a*) Photosynthesis (*b*) Forest fire

(*c*) Coral reef formation (*d*) Volcanic erruption

PART – B

1. Maximum recombination frequency between two genes is-

(*a*) 25 % (*b*) 50 %

(*c*) 75 % (*d*) 100 %

2. The distance between two base pairs in Watson-Crick B-DNA is

(*a*) 34 nm (*b*) 3.4 nm

(*c*) 0.34 nm (*d*) 0.034 nm

3. The stage of meiosis I in which crossing over takes place

(*a*) Zygotene (*b*) Diplotene

(*c*) Diakinesis (*d*) Pachytene

4. Among the following which mutagen induces formation of thymidine dimmers in DNA

(*a*) UV (*b*) Ethyl methyl sulphate

(*c*) Nitrous oxide (*d*) Ethydium bromide

5. $Na^+ – K^+$ pump is-

(*a*) Symport system (*b*) Antiport system

(*c*) ABC transporter (*d*) Diffusion pump

6. Consider the following statements. Which is correct?

(*a*) Intracellular concentration of Na^+ is always high

(*b*) Intracellular concentration of K^+ ion is low

(*c*) Extra cellular concentration of K^+ and Na^+ ion is isotonic to intracellular concentration

(*d*) Extra cellular concentration of Na^+ and intracellular concentration of K^+ is always high in normal cell

7. Exrachromosomal inheritance can be detected by-

(*a*) Back cross (*b*) Test cross

(*c*) Reciprocal cross (*d*) Dihybrid cross

8. Dosage compensation occurs in-

(*a*) Insects and mammals (*b*) Reptiles and mammals

(*c*) Reptiles and aves (*d*) Insects and reptiles

9. Drosophilla with chromosome complement XXXXY/AA will be-
   (*a*) fertile female (*b*) meta male
   (*c*) normal male (*d*) Intersex

10. During fusion of Rat and Human cell it was found that chromosomes of one species was selectively eliminated, this had opened new doors to study-
   (*a*) Transgenic study
   (*b*) Chromosomal incompatibility
   (*c*) Gene and linkage mapping
   (*d*) Dominance of genes

11. B and T-cells of immune system are activated by-
   (*a*) T-cytotoxic cells (*b*) T-helper cells
   (*c*) Macrophages (*d*) B-cells

12. Immunoglobulin playing role in allergic reaction
   (*a*) IgG (*b*) IgM
   (*c*) IgD (*d*) IgE

13. A bacteria growing exponentially with doubling rate of 10 minutes. The intrinsic rate of growth would be maximum when bacterial numbers are-
   (*a*) at carrying capacity
   (*b*) half of carrying capacity
   (*c*) start of log phase
   (*d*) remains constant at all phases

14. The nutritional medium was supplied to growing bacteria. If whole nutrient get depleted in 20 cycles, then stage at which the amount of nutrient was half used-
   (*a*) At end of 10 cycle (*b*) At beginning of 19 cycle
   (*c*) At end of 19 cycle (*d*) At end of 11 cycle

15. Regarding gene expression in prokaryotes and Eukaryotes, which statement is correct-
   (*a*) m-RNA and DNA are colinear
   (*b*) m-RNA and protein synthesis can occur simultaneously
   (*c*) processing of hn-RNA yields m-RNA
   (*d*) RNA polymerase can bind to promoters situated upstream to gene

16. DNA fragment between size 2000 KD and 500 Kd can be separated using-
   (*a*) PAGE (*b*) chromatography
   (*c*) centrifugation (*d*) Pulsed field gel electrophoresis

17. The strongest evidence which suggest that RNA was ancient then DNA
   (*a*) RNA can act as template for DNA synthesis
   (*b*) RNA can work as catalyst
   (*c*) RNA is single stranded
   (*d*) RNA is genetic material in certain viruses

18. In an polypeptide if alanine is replaced by praline then-
    (*a*) Its tendency to form á-helix increases
    (*b*) Its tendency to form â-sheets increase
    (*c*) The hydrophobicity of chain decreases
    (*d*) There would no effect

19. Phosopho fructokinase is allosterically regulated by-
    (*a*) ATP (*b*) ADP
    (*c*) AMP (*d*) Fructose-6-P

20. cdK-2 exerts its effect during which stage of cell cycle
    (*a*) G1 phase (*b*) S phase
    (*c*) G2 phase (*d*) M phase

21. Diploid maize have 10 pairs of chromosome. Number of chromosome at Metaphase-I will be-
    (*a*) 10 (*b*) 20
    (*c*) 30 (*d*) 40

22. For an endothermic reaction to occur spontaneously the
    (*a*) $\Delta G = 0$ (*b*) $\Delta G > 0$
    (*c*) $\Delta G < 0$ (*d*) independent of ΔG

23. Arrage them according to decreasing order of strength
    (*a*) $sp^3 > sp^2 > sp^1$ (*b*) $sp^1 > sp^2 > sp^3$
    (*c*) $sp^3 > sp^1 > sp^2$ (*d*) $sp^1 > sp^3 > sp^2$

24. The birds in tropics are generally smaller in size because of-
    (*a*) To increase surface area to volume ratio
    (*b*) To decrease surface area to volume ratio
    (*c*) For easy flight
    (*d*) Aestivation

25. In an pond ecosystem, net productivity by zooplankton is ‘p’ and biomass consumed by small fishes is ‘c’, then the ratio of c/p is termed as-
    (*a*) Assimilation efficiency
    (*b*) Net secondary productivity
    (*c*) Consumption efficiency
    (*d*) Conversion efficiency

26. For climax which statement is INCORRECT?
    (*a*) Number of perennial species increases
    (*b*) Dependency on detritious food chain increases
    (*c*) Vertical stratification of community increases
    (*d*) Exploitation competition is more then normal competition

27. At present, the relationship between human and monkey can be stated as
    (*a*) They both have common ancestors
    (*b*) Human have evolved from monkey
    (*c*) Both have very distinct phylogeny
    (*d*) Relationship can not be established

28. Most of new species are formed by the process of –
    (*a*) Anagenesis (*b*) Cladogenesis
    (*c*) Sympatric speciation (*d*) Phylogenetic evolution

29. The alternative pathway of respiration can be inhibited by
    (*a*) Cyanide (*b*) SHAM
    (*c*) Arachodoic acid (*d*) Amphicillin

30. Dendrogram is-
    (*a*) Arrangement of chromosomes
    (*b*) graphical representation of phylogenetic tree
    (*c*) taxonomic key to establish relationship
    (*d*) evolutionary time scale representation

31. Development of sporophyte directly from gametes without fertilization is termed as-
    (*a*) Apogamy (*b*) Apospory
    (*c*) Adventive embryony (*d*) Apomixis

32. Goblet cells are located in-
    (*a*) Liver (*b*) Oesophagus
    (*c*) Intestinal villi (*d*) Duodenum

33. The phytohormone which provides desiccation resistance to embryo in germinating seed is-
    (*a*) Gibberlic Acid (*b*) Ethylene
    (*c*) Abssicic acid (*d*) Cytokinin

34. Plants growing in cold environments generally have
    (*a*) high cholesterol (*b*) high saturated fatty acid
    (*c*) high unsaturated fatty acid (*d*) short chain fatty acids

35. Which is not true about TCA cycle-
    (*a*) takes place in mitochondrial matrix
    (*b*) Single largest source of direct ATP
    (*c*) is linked to glycolysis via pyruvate
    (*d*) there is formation of NADPH and FADH

36. Which is correct relationship between habitat disturbance and biodiversity-
    (*a*) Areas with no habitat disturbance tends to have high biodiversity
    (*b*) Areas with high habitat disturbance tends to have high biodiversity
    (*c*) Areas with moderate habitat disturbance tends to have high biodiversity
    (*d*) Areas with no habitat disturbance tends to have low biodiversity

37. The probability of capturing an individual of certain species is P_i, then total biodiversity can be represented as
    (*a*) $\Sigma(P_i)^2$ (*b*) $1 - \Sigma (P_i)^2$
    (*c*) $1- \Sigma(1\text{-}P_i)^2$ (*d*) $1/\Sigma(P_i)^2$

38. Hardy Weinberg law operates on-
    (*a*) Non-evolving population (*b*) Slow evolving population
    (*c*) Random evolving population (*d*) Fast evolving population

39. If a gene have a three alleles namely p, q, r. Then Hardy- Weinberg law can be represented as-
    (*a*) $(p + q + r)^2$ (*b*) $(p + q + r)^3$
    (*c*) $(p + q + r)$ (*d*) $(p + q)^2$

40. In a graph population density is plotted on X-axis then what should be plotted on Y-axis to get a bell shape curve
    (*a*) dN/dt (*b*) 1 – dN/dt
    (*c*) T (*d*) $N_t - 1$

41. In an organism G + C content is 50 %. What is probability of matching 6 nucleotide sequence in genome
    (*a*) $(0.25)^4$ (*b*) $(0.25)^5$
    (*c*) $(0.25)^6$ (*d*) $(0.25)^7$

42. The bacteria which are classified on basis of morphology are-
    (*a*) Spore forming bacteria
    (*b*) non-sporulating bacteria
    (*c*) aerobic bacteria
    (*d*) anaerobic bacteria

43. Among the following which groups do not obey Linneus Nomenclature?
    (*a*) Virus (*b*) Bacteria
    (*c*) Archae (*d*) fungi

44. ICBN stands for
    (*a*) International Code for Botanical Nomenclature
    (*b*) International Code for Biological Nomenclature
    (*c*) International Code for Botanical Naming
    (*d*) International Code for Binomial Nomenclature

45. The differences in chromosome morphology between different species can be compared by
    (*a*) chromosome banding
    (*b*) Tritium Hydrogen labeling
    (*c*) Fluorescence screening
    (*d*) in-situ hybridization

46. Typical mendelian dihybrid ratio for F_2 generation is-
    (*a*) 9:3:3:1 (*b*) 9:7
    (*c*) 1:2:1 (*d*) 9:7

47. Smallest unit which can evolve is-
    (*a*) Individual (*b*) Species
    (*c*) population (*d*) cell

48. Nerves are connected to each other by
    (*a*) hormone (*b*) neurotransmitter
    (*c*) bones (*d*) muscles

49. Endocrine signaling is analogous to-
    (*a*) Making a telephone call (*b*) Radio transmission
    (*c*) Talking to self (*d*) Talking to partner over walky-talky

50. Examples of connective tissue are
    (*a*) Bone and muscle (*b*) Bone and Blood
    (*c*) Bone and cartilage (*d*) Blood and skin

51. Which enzyme is involved in detoxification reaction-
    (*a*) glutathione oxidase (*b*) topoisomerase
    (*c*) catalse (*d*) restriction enzymes

52. First organism evolved on earth were-
    (*a*) aerobic heterotrophs (*b*) anaerobic heterotrophs
    (*c*) aerobic autotrophs (*d*) anaerobic autrotrophs

53. Among the following most primitive eukaryotes are-
    (*a*) Fungi (*b*) Diatoms
    (*c*) Diplomonads (*d*) Tricomonads

54. Main cause of respiratory problem arising from pollution from automobile combustion is due to-
    (*a*) NO_x (*b*) SO_2
    (*c*) SPM < 10μm (*d*) SPM > 50μm

55. Among the following which is global cycle-
    (*a*) Carbon (*b*) Sulphur
    (*c*) Boron (*d*) Nitrogen

56. Virus which replicates via DS DNA as intermediates-
    (*a*) HPV (*b*) HIV
    (*c*) HBV (*d*) HCV

57. Chlorosis in plants is due to deficiency of
    (*a*) Boron (*b*) Nitrogen
    (*c*) Phosphorus (*d*) Sulphur

58. Botanical name of 'Great Indian Banayan tree" is
(*a*) Ficus reliogosa
(*b*) Ficus bengalensis
(*c*) Ficus elipitca
(*d*) Ficus indica

59. Which protein is coded by chloroplast genome
(*a*) Small sub-unit of RUBISCO
(*b*) Large sub-unit of RUBISCO
(*c*) Entire RUBISCO
(*d*) none

50. During evolution the limbs of snakes were lost. The explanation for this is
(*a*) Limbs degenerated due to disuse
(*b*) This was more adapted
(*c*) Limbs were not desirable
(*d*) none of the above

51. A normal man was found to have 45 chromosomes the probable reason is-
(*a*) Deletion (*b*) Translocation
(*c*) Ecentric Fission (*d*) Mutation

52. Changes in gene frequency in a small population is termed as-
(*a*) Gene migration (*b*) Genetic drift
(*c*) gene flow (*d*) Gene fluctuation

53. Size of insect doesnot increased during the course of evolution as compare to vertebrates because of-
(*a*) larval feeding (*b*) tracheal respiration
(*c*) heavy exoskeleton (*d*) None of the above

54. Which is essential for evolution
(*a*) Mutation (*b*) Reproduction
(*c*) Meiosis (*d*) Natural selection

55. Salt exclusion is mechanism necessary for
(*a*) Halophiles (*b*) Xerophytes
(*c*) Plants in cold habitat (*d*) Hydrophytes

56. Areas with annual cool temperature and almost contant rate of precipitation throughout year is
(*a*) Tundra
(*b*) Temperate deciduous
(*c*) Tropics
(*d*) Poles

57. What should be the criteria for choosing prey-predator relationship for long term of biological control
   (*a*) High host specificity and high virulence
   (*b*) low host specificity and high virulence
   (*c*) High host specificity and moderatevirulence
   (*d*) moderate host specificity and moderate virulence

58. In receptor mediated endocytosis the pits are coated by
   (*a*) laminin (*b*) clathrin
   (*c*) intergrin (*d*) tubulin

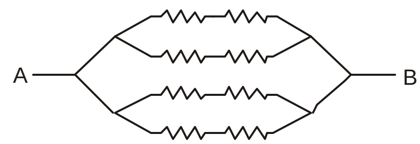
59. Inositol at first placei in anticodon can base pair with any base in third place of codon. This suggest that
   (*a*) There is flexibility over last base of codon and first base of anticodon
   (*b*) There is flexibility over first base of codon and first base of anticodon
   (*c*) There is flexibility over last base of codon and last base of anticodon
   (*d*) There is flexibility over only at last base of codon

70. The excretory waste in birds is uric acid, it suggests that
   (*a*) Birds are more advanced
   (*b*) Birds are omnivores
   (*c*) Birds are adapted for conservation of water
   (*d*) Uric acid is toxic metabolite

CSIR-NET Life Sciences, DEC., 2005

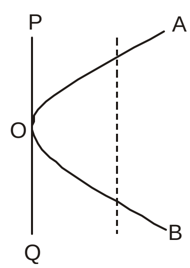
PART – A

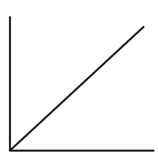
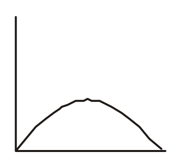
1. If each resistance in the given circuit is 1 ohm, then effective resistance between point A and B will be-
   (*a*) 0.5 ohm
   (*b*) 1 ohm
   (*c*) 8 ohm
   (*d*) 12 ohm

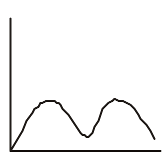
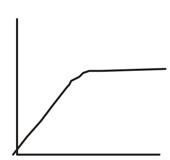


2. According to debroglies equation wavelength associated with the charged particle is-
   (*a*) $\lambda = nh/2\pi$ (*b*) $\lambda = nh/4\pi$
   (*c*) $\lambda = 2ME$ (*d*) $\lambda = h/\sqrt{2ME}$

3. A wire AOB is placed perpendicular to magnetic field shown by dotted lines. If another wire PQ slides from top to bottom parallel to magnetic field, then the graph for the change in e.m.f as function of 't' will be is as follows-



(*a*)  (*b*) 

(*c*)  (*d*) 

4. When beam of light falls on oil droplet following phenomenon is observed-
   (*a*) Refraction (*b*) Reflection
   (*c*) Interference (*d*) Diffraction

5. Resolution of electron microscope is better then compound microscope because-
   (*a*) Wavelength used is very small
   (*b*) Power of lens is very high
   (*c*) Specimen is very thin
   (*d*) Frequency of light is very small

6. The electronic configuration of Atom 'A' is $1S^2 2S^2 2P^6 3S^2$ and atom 'B' is $1S^2 2S^2 2P^1$. Their molecular formula will be-
   (*a*) A_3B_2 (*b*) A_2B_2
   (*c*) A_2B_3 (*d*) AB

7. Among the following which oxides are not found-
   (*a*) Fe_2O_3, BaO, CaO (*b*) FeO, BaO_2, Mn_3O_2
   (*b*) Co_2, CO, O_3 (*d*) CO_3, MnO_4

8. Among the following which atom do not form any molecules
   (*a*) Argon (*b*) Krypton
   (*c*) Uranium (*d*) Helium

9. What would be the mass of air in a room of size of 6 × 11 × 4 at normal temperature and pressure
   (*a*) 3.4 kg (*b*) 34 kg
   (*c*) 17 kg (*d*) 340 kg

10. The series of lines present in the visible region of the hydrogen spectrum is
    (*a*) Lyman (*b*) Balmer
    (*c*) Paschan (*d*) Brackets

11. If the amount of ice at poles is doubled, then according to energy conservatives the length of day will-
    (*a*) Increase (*b*) Decrease
    (*c*) No effect (*d*) Unpredictable

12. If earth would not have been not inclines 23 ½ on its axis, then there would be-
    (*a*) Lesser rainfalls
    (*b*) Hotter summers and cooler winters
    (*c*) Length of day increase in northern hemisphere
    (*d*) No seasonal rainfalls

13. If the mean temperature of earth would have been increased from 20 to 25 °C, then the rate of radiation from earth will be-
    (*a*) $\left(\frac{298}{293}\right)^1$ (*b*) $\left(\frac{298}{293}\right)^2$
    (*c*) $\left(\frac{298}{293}\right)^3$ (*d*) $\left(\frac{298}{293}\right)^4$

14. Main cause of scarcity of water in India-
    (*a*) Lack of sufficient rainfall
    (*b*) Most of water runs to oceans
    (*c*) Soil don't percolates the water
    (*d*) Due to green house effect

15. The fossils are generally seen in-
    (*a*) Metamorphic rocks
    (*b*) Igneous rocks
    (*c*) Sedimentary rocks
    (*d*) Ocean beds

16. If an Mendelian cross between pure tall and pure dwarf yield all tall plants in F_1 generation while in F_2 generation the ratio of tall to dwarf plant is 75:5. The number of genes involved for plant height are-
    (*a*) one (*b*) two
    (*c*) Three (*d*) Many

17. There are 64 codons for 20 amino acids it means-
    (*a*) Most of codon do not code for any amino acid
    (*b*) Most of codon are involved in other types of amino acids
    (*c*) One amino acid can be coded by more then one codon
    (*d*) One codon can code for more then one amino acid

18. During replication process in bacteria-
    (*a*) One bacteria possess parental DNA while another possess new copy
    (*b*) Both bacteria possess new copy
    (*c*) Half of the DNA in both bacteria is parental while another half is newly synthesized
    (*d*) Both bacteria possess only parental DNA

19. Which of the following macromolecule denaturates at 65 °C
    (*a*) Lipids (*b*) Carbohydrates
    (*c*) Proteins (*d*) DNA

20. Which one of the following is lewis base
    (*a*) NH_3 (*b*) HCl
    (*c*) HNO_3 (*d*) HF

21. If I AI = 10

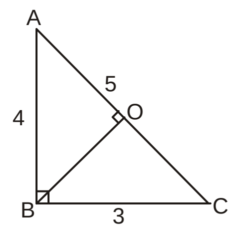
    I B I = 7

    It means that always
    (*a*) $A \cup B \geq 10$ (*b*) $A \cup B = 17$
    (*c*) $A \cap B \geq 10$ (*d*) $A \cap B \geq 7$

22. The equation $x^2 + 4xy + 3y^2 = 7$ will give a/an-
(*a*) Straight line (*b*) Ellipse
(*c*) Parabola (*d*) Hyperbola

23. If P is rational
Q is irrational
Then sum of P+Q will always-
(*a*) rational (*b*) Irrational
(*c*) Real number (*d*) Prime number

24. In the given figure the length BO will be
(*a*) 12/5
(*b*) 3/4
(*c*) 5/3
(*d*) 4/5



25. $4x + 6y = 12$
$6x + 9y = C$
(*a*) It has unique solution
(*b*) Have many solutions
(*c*) Have many solutions if C = 15
(*d*) Have many solution if C ≠ 15

26. If an pendulum clock strikes 6 times at 6 O' clock and takes 30 seconds. Then the time taken to strike 12 times at 12 O' clock will be-
(*a*) 60 (*b*) 54
(*c*) 66 (*d*) 61

27. Given A =12, which is followed by condition A≥11 it means-
(*a*) A cannot be 12
(*b*) A is lesser then 11
(*c*) A must be 12
(*d*) A must be smaller or equal to 11

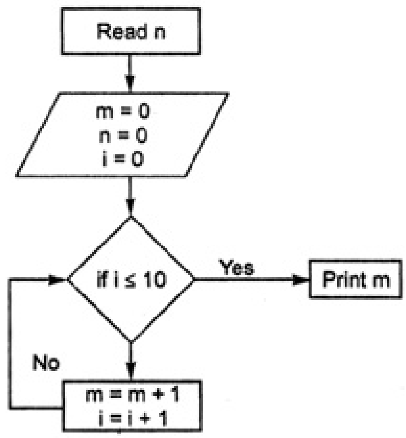
28. Among the following which is not an programming language-
(*a*) BASIC (*b*) UNIX
(*c*) FORTRAN (*d*) COBOL

29. Consider the truth table where 'F' stands for 'false' and 'T' for 'true'; 'V' stands for 'and' and 'A' stands for 'Or'

P	Q	PVQ	PAQ
T	T	A	T
F	F	T	B

(*a*) A = True B = False (*b*) A = True B = True
(*c*) A = False B = False (*d*) A = False B = True

30. The output of the following program will be-



(a) 9 (b) 45
(c) 55 (d) 66

PART – B

1. The conversion of glucose from fats in plants takes place in-
   (a) Lysosome (b) Plastids
   (c) Glyoxisomes (d) Peroxisomes

2. Mannose-6-phosphate tagged protein are targeted to-
   (a) Lysosome (b) Plastids
   (c) Golgi complex (d) Nucleus

3. Cancer cells secretes chemicals for angiogenesis whose target are-
   (a) B-cells (b) Platelets
   (c) RBC (d) Endothelial cells

4. Multidrug resistance in cancerous cell is due to-
   (a) Efflux of drugs across membrane
   (b) Influx of drugs across membrane
   (c) Phosphorylation of CDKs
   (d) Due to presence of P glycoprotein

5. Among the following which correctly represents "gain of function"-
   (a) Binding of RNA polymerase to promoter
   (b) Over-expression of any gene
   (c) Presence of basal transcription sequences
   (d) Expression at unpredictable time and unpredictable space

6. T-helper cells can be marked on basis of-
   (*a*) CD4 (*b*) CD8
   (*c*) Phagocytotic activity (*d*) Membrane lipids

7. Among the following which exerts its effect during 'S' phase in yeast-
   (*a*) cdc1 (*b*) cdc2
   (*c*) cdc3 (*d*) cdc28

8. Dosage compensation in drosophila is achieved by-
   (*a*) Selective elimination of maternal X chromosome
   (*b*) Heterochromatization of paternal X chromosome
   (*c*) Hyperactivation of maternal X chromosome
   (*d*) Hyperactivation of paternal X chromosome

9. Chromosomes of yeast and protozoa are best studied by-
   (*a*) Visible Microscopy
   (*b*) Electron microscopy
   (*c*) PAGE
   (*d*) Pulse field gel electrophoresis

10. Systemic Lupus Erytheromatosus(SLE) is an-
   (*a*) Metabolic disorder
   (*b*) genetic disorder
   (*c*) Autoimmune disorder
   (*d*) Vitamin disorder

11. In India maximum biodiversity is seen at-
   (*a*) Eastern and western Himalayas
   (*b*) Eastern Himalayas and western Ghats
   (*c*) Eastern and Western Ghats
   (*d*) Eastern Himalayas and Andaman and Nicobar Islands

12. Among the following which amino acid can act as buffer against addition of acid-
   (*a*) Glycine (*b*) Histidine
   (*c*) Arginine (*d*) Phenylalanine

13. Which bond is can not be observed between enzyme and substrate-
   (*a*) ionic covalent bond (*b*) Hydrogen bond
   (*c*) Peptide bond (*d*) ionic bond

14. Lipids which ranges from 120-160 kD in size. Then also they are kept amongst the macromolecules because-
   (*a*) They are main component of membrane
   (*b*) They are main component of cell
   (*c*) In water they form large complex structures
   (*d*) They are present in large amount

15. Consider the following redox reaction of glycolysis

Pyruvate + $2e^- \rightarrow$ lactate

$NADH_2 \rightarrow NAD^+ + 2H^+ + 2e^-$

The correct statement is-

(*a*) The electron are readily picked up by NAD from pyruvate
(*b*) $NADH_2$ provide electrons to pyruvate for oxidation
(*c*) Both reaction are independent
(*d*) $NADH_2$ is not formed during glycolysis

16. Which statement is FALSE about glycolysis-

(*a*) $NADH_2$ is formed
(*b*) $FADH_2$ is formed
(*c*) Electron are transferred from glucose to Pyruvate
(*d*) Pyruvic acid is formed at last step

17. The role of carrier proteins in light reaction is-

(*a*) To transfer energetic electrons from PSII to PSI.
(*b*) Pumping of Protons
(*c*) Formation of ATP
(*d*) Transferring of high energy electrons from PSI to PSII

18. Among the following which mineral plays an important role in photolysis of water-

(*a*) Mg^{++} (*b*) Ca^{++}
(*c*) Na^+ (*d*) Mn^{++}

19. Chlrosis in young leaves is generally due to deficiency of-

(*a*) Mg^{++} (*b*) Ca^{++}
(*c*) Na^+ (*d*) Mn^{++}

20. Which statement is correct if we compare a protein and its DNA for phylogenetic studies-

(*a*) DNA and protein have similar differences
(*b*) Proteins are more similar then DNA
(*c*) DNA is more similar then the protein sequences
(*d*) Differences in DNA and protein do not have any similarity

21. Which is one of the major step during programmed cell death in plants-

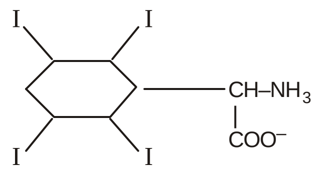
(*a*) Systemic acquired resistance
(*b*) Hypersensitivity
(*c*) Cell lysis
(*d*) Cell necrosis

22. Which plant growth regulator is involved in activating α-amylase activity in germinating seeds-

(*a*) Auxin (*b*) Cytokinin
(*c*) Gibberlic acid (*d*) Brassicosteroids

23. The hormone secreted by developing placenta is-
    (*a*) Choronic gonadotropin (*b*) Estrogen
    (*c*) Relaxin (*d*) ADH

24. The given structure is of –
    (*a*) Thyroxine
    (*b*) Calcitonin
    (*c*) Parathormone
    (*d*) Aldosteroids



25. Arrange the following according to increasing order of concentrated urine-
    (*a*) Beever < Human < Sand Rat
    (*b*) Human < Beever < Sand Rat
    (*c*) Sand Rat < Beever < Human
    (*d*) Beever < Sand Rat < Human

26. If we compare the respiration in amphibian and mammals we will find that-
    (*a*) Positive pressure in both amphibian and mammals
    (*b*) Negative pressure in both amphibian and mammals
    (*c*) Positive pressure in amphibian and Negative in mammals
    (*d*) Negative pressure in amphibian and Positive in mammals

27. Athletes are usually trained at high altitudes because-
    (*a*) To increase the number of RBC
    (*b*) To form modified haemoglobin
    (*c*) To increase number of WBC
    (*d*) To increase the amount of proteins

28. Which statement is FALSE about animal hormones-
    (*a*) They are secreted by many specialized cells
    (*b*) They can influence through humoral root
    (*c*) They can bind to variety of receptors
    (*d*) They are required in large amount to elicit their response

29. Among the following which muscle protein as affinity to bind with Ca^{++} ions-
    (*a*) Troposmyosin (*b*) Troponin
    (*c*) Actin (*d*) Myosin

30. If 10 ml of 540 dpm of Cr was injected in a person and 1 ml of blood was withdrawn after 10 minutes, it was found that it contains 40 dpm of Cr, it means the total volume of blood in that person will be-
    (*a*) 5.4 lt (*b*) 6.0 lt
    (*c*) 6.2 lt (*d*) 6.4 lt

31. Among the following which is probable cause of unequal results during the reciprocal crosses-
    (*a*) X-linked inheritance (*b*) Polygenic inheritance
    (*c*) Mendelian Inheritance (*d*) Epitasis

32. The maps based on recombination frequency are termed as-
    (a) Genetic Map (b) Linkage map
    (c) Physical Map (d) Cytogenetic Map

33. The minimum number of genes in an autonomous replicating organism is
    (a) 50 – 100 (b) 300 – 400
    (c) 1000 – 1500 (d) 4000 – 5000

34. If bacteria possess two copies of certain genes then they are referred as-
    (a) Amphidiploid (b) Merodiploid
    (c) Euploid (d) Polyploid

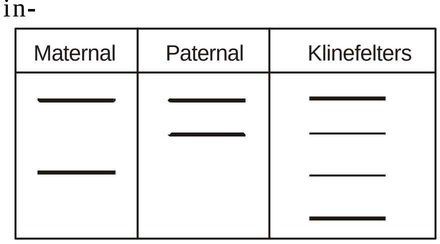
35. HIV are kept under category of retero-viruses because-
    (a) RNA is genetic Material
    (b) RNA directly form m-RNA
    (c) RNA is used as template for DNA synthesis
    (d) DNA is not present at any stage of life cycle

36. If substitution is the only possible type of mutation, then which technique would be no more useful
    (a) Allignment (b) PCR amplification
    (c) Database searching (d) Restriction fragment analysis

37. Number of linkage group in human male is-
    (a) 22 (b) 23
    (c) 24 (d) 46

38. If observed number of recombinant are more (or less) the what is expected from Mendelian crosses, the probable cause is-
    (a) Linkage equilibrium (b) Linkage disequilibrium
    (c) Epitasis (d) Polygenic Inheritance

39. The PAGE profile of certain protein associated with klinefelter syndrome is as follows, it means the non-disjuction of chromosome was in-
    (a) Maternal
    (b) Paternal
    (c) Maternal and Paternal
    (d) Cannot be predicted



40. Among the following the living fossil is-
    (a) *Ginkgo biloba*
    (b) *Taxus bacata*
    (c) *Psilotum*
    (d) *Nepenthes*

41. Inter-specific somatic hybridization are often followed by-
    (a) Fusion of paternal chromosome
    (b) Fragmentation of Paternal chromosomes

(*c*) Selective elimination of one of parental chromosome
(*d*) Fusion of nuclei

42. If *E. coli* are grown on lactose free medium for 20 generations under presence of constant mutagen which produces the lac$^-$ mutants as well as lac$^-$ revertant in equal amount. At the end it will be observed that
(*a*) Equal number of Lac$^-$ and Lac revertant
(*b*) More number of Lac revertant at the end
(*c*) More number of Lac$^-$ at the end of experiment
(*d*) Cannot be predicted

43. Selection which operates against any direction and donot allow to disrupt the present mean is termed as-
(*a*) Directional (*b*) Stabilizing
(*c*) Disruptive (*d*) Balancing

44. In a population obeying Hardy-Weinberg equilibrium, the frequency of recessive allele is 0.88, while of dominant allele us 0.12. The frequency of heterozygotes in population will be-
(*a*) 11.1 % (*b*) 21.1%
(*c*) 79.9 % (*d*) 14.4%

45. After implication of Green Air Act in England which species become virtually absent-
(*a*) Biston betularia carbonifera
(*b*) Biston betularia typica
(*c*) Drosophila
(*d*) Apes Americana

46. If an allele is linked to the second allele at other locus which is favorably selected are inherited together. Such an movement of an allele without any evolutionary benefit to next generation is termed as-
(*a*) Selective drive (*b*) Evolutionary drive
(*c*) Hitch hiking (*d*) Linkage

47. Random change of gene frequency in a population is termed as-
(*a*) Genetic drift (*b*) Gene flow
(*c*) Mutation (*d*) Evolution

48. The morphological modification is transferred to next generation without any present application which may prove beneficial in changed environment is termed as –
(*a*) Exadaptation (*b*) Pre-adaptation
(*c*) Analogous (*d*) Paralogous

49. The changes in prey brings changes in predator and vice-vers(*a*) Such an evolution due to competition for existence is termed as-
(*a*) Converging evolution (*b*) Diverging Evolution
(*c*) Co-evolution (*d*) Parallel Evolution

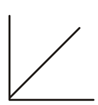
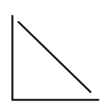
50. The anti-cancerous drug vincristine is obtained from-
   (*a*) Catharanthus (*b*) Taxus
   (*c*) Raulofia (*d*) Cinchona

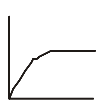
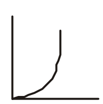
51. In comparison to aquatic ecosystem, in terrestrial ecosystem autotrophs expends their most of energy in production of material which are indigestible by heterotrophs because-
   (*a*) Autotroph diversity is high in terrestrial ecosystems
   (*b*) Autotroph diversity is high in aquatic ecosystems
   (*c*) Heterotroph diversity is high in terrestrial ecosystems
   (*d*) Energy takes a longer period to pass from autotroph to top consumer in terrestrial ecosystem

52. On application of certain pesticide it was observed that the population of pests increased. The probable cause would have been-
   (*a*) Development of resistance
   (*b*) Pesticide is ineffective
   (*c*) Pesticide is not used properly
   (*d*) Pesticide has removed natural biological control

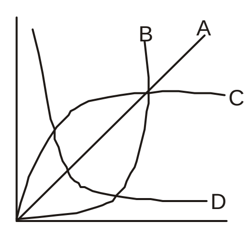
53. The mean temperature and rainfall in Taiga is-
   (*a*) –5 to 10 and 50 to 100 mm
   (*b*) –5 to 10 and 150 to 200 mm
   (*c*) 5 to 15 and 50 to 100 mm
   (*d*) 5 to 15 and 150 to 200 mm

54. Which graph best explains the relation between the body size of an organism and intrinsic rate of growth ‘r’-

   (*a*)  (*b*) 

   (*c*)  (*d*) 

55. Among the following which is logistic equation-
   (*a*) A
   (*b*) B
   (*c*) C
   (*d*) D



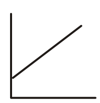
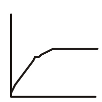
56. If rate of mortality and natality become constant in each age group. Then the result would be-
   (*a*) Number of childrens increase
   (*b*) Number of older one will increase
   (*c*) Number of individuals in repd stage will increase
   (*d*) The increase or decrease within any cohort will become independent

57. What would happen if we release the high BOD water into fresh lake-
    (*a*) Opacity will decrease
    (*b*) Number of organism will decrease
    (*c*) Amount of dissolved oxygen will decrease
    (*d*) No effect

58. Which sporulating bacteria also possess the phenomenon of social behaviour and communication-
    (*a*) Actinomycetes (*b*) Bacillus
    (*c*) Cyanobacteria (*d*) Archaebacteria

59. During succession the bare rock is first colonized by-
    (*a*) Algae (*b*) Bacteria
    (*c*) Fungi (*d*) Lichens

60. Which graph correctly represents density dependent growth

    (*a*) 
    (*b*) 
    (*c*) 
    (*d*) 

61. The bird biodiversity in India is-
    (*a*) 50 (*b*) 1200
    (*c*) 3200 (*d*) 5200

62. The dendrogram in numerical taxonomy represents-
    (*a*) Phylogenetic relationship
    (*b*) Evolutionary relationship
    (*c*) All observable characters
    (*d*) Few characters

63. Among the following which has permanent status and is governed by central legislation-
    (*a*) National park (*b*) Wild sanctuary
    (*c*) Forests (*d*) Sport gardens

64. The phenomenon of bioluminescence is observed in-
    (*a*) Dinoflagelletes (*b*) Copypods
    (*c*) Cyanobacteria (*d*) Archie bacteria

65. Silicon is essential requirement for-
    (*a*) Diatoms (*b*) Fungi
    (*c*) Algae (*d*) Cyanobacteria

66. Ernst Meyer is known for
   (*a*) Taxonomic classification
   (*b*) Biological species concept
   (*c*) Five kingdom classification
   (*d*) Evolutionary history

67. Maximum productivity is observed at-
   (*a*) Corals (*b*) Mangroves
   (*c*) Oceans (*d*) Lakes

68. If α-diversity is diversity of pathogen per host and β-diversity is diversity of pathogen between the two host and g-diversity is overall diversity. If γ-diversity is constant and α-diversity increases then-
   (*a*) β-diversity will also increase
   (*b*) β-diversity will decrease
   (*c*) Both β and γ-diversity will increase
   (*d*) Both β and γ-diversity will decrease

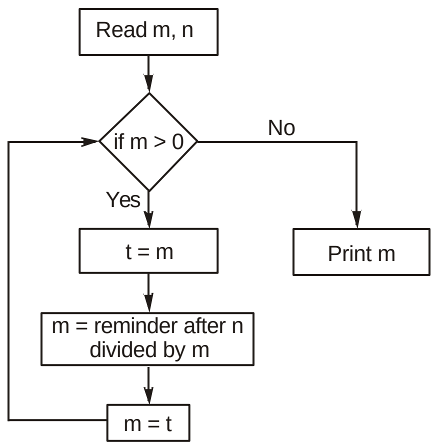
69. Which is Incorrect statement both for Deer and Antelope-
   (*a*) Both are gregarious
   (*b*) Male and female both have antlers
   (*c*) There is female heirchy
   (*d*) Live in social unions

70. Which is best technique to separate the two loci on chromosome-
   (*a*) C-banding (*b*) G-banding
   (*c*) Gel electrophoresis (*d*) Chromatography

CSIR-NET Life Sciences, June, 2006

PART – A

1. Consider the following program



What would be print if initial value for m and n is 462 and 242

(*a*) 22 (*b*) 11
(*c*) 13 (*d*) 14

2. Let there is any numbers f and g and f>any number 'n' and $n \geq n_0$. $f(n) > g(n)$. Then $f_3 n = e\sqrt{\log_e{}^{n}}$ will be

(*a*) $\sqrt{n}$ (*b*) n^2
(*c*) n (*d*) 1/n

3. Among the following what would be increasing order of gases dissolved in oceans

(*a*) $CO_2 < O_2 < NH_4$ (*b*) Ar < N < Oxygen
(*c*) CO_2 < Oxygen < Argon (*d*) $CH_4 < NH_3 < CO_2$

4. Under what conditions reaction will be exothermic at all temperatures

(*a*) $\Delta H<0$ and $\Delta S>0$ (*b*) $\Delta H>0$ and $\Delta S>0$
(*c*) $\Delta H<0$ and $\Delta S<0$ (*d*) $\Delta H<0$ and $\Delta S=0$

5. If there is any salt TiCl similar to $CeCl_2$ in geometry, then coordinate numbers for Ti will be

(*a*) 6, **8** (*b*) 6, 6
(*c*) 4, 4 (*d*) 6, 4

6. If $\vee$ stands for 'and', $\wedge$ stands for 'or', $\neg$ stands for 'not' and $\Rightarrow$stand for 'implies' then under what condition $p \Rightarrow q = \neg p V q$ stands true

(*a*) $p \vee (p \wedge q)$ (*b*) $\neg p V q$
(*c*) $p \wedge (p \vee q)$ (*d*) $\neg\ p \wedge (p \vee q)$

7. For an ideal gas at 1 atmospheric pressure if volume occupied is 830 cm^3 at temperature 123 °C, calculate the number of moles in given gas (if R = 6. moles, 1 atmosphere = 10^5)
   (*a*) 1.5×10^{-1} (*b*) 1.5×10^{-6}
   (*c*) 1.5×10^{-9} (*d*) 1.5×10^{-4}

8. Among the following which cannot act as electrolyte when dissolved in water
   (*a*) $C_6H_{12}O_6$ (*b*) CH_3COOH
   (*c*) $NaHCO_3$ (*d*) NaCl

9. What would be the bond angle in cyclopropane, cylcobutane and cylopentane respectively
   (*a*) 60, 90, 108 (*b*) 60, 90, 109
   (*c*) 90, 120, 108 (*c*) 60, 90, 120

10. A stone of mass 'm' is moved in a circle of radius 'r' with constant speed 'v^2'. The work done by the force over half the circumtence of the circe is
   (*a*) Zero (*b*) $\frac{mv^2}{r} \times \pi r$
   (*c*) $\frac{mv^2}{r} \times 2\pi r$ (*d*) $mg \times 2\pi r$

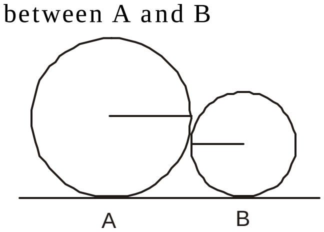
11. If Q is antiparticle of P which will hold true
   (*a*) mass will same (*b*) Will have opposite spin
   (*c*) Obey pauli exclusion principle (*d*) Same number of neutrons

12. If all ice locked in icebergs melts what will happen to sea water level
   (*a*) Increase by large extent (*b*) No effect
   (*c*) Increase slightly (*d*) It will decrease

13. If a bacteria doubles itself in 5 minutes. What would be number of bacteria at end of 20 minutes if you start with 4 bacteria
   (*a*) 64 (*b*) 32
   (*c*) 48 (*d*) 16

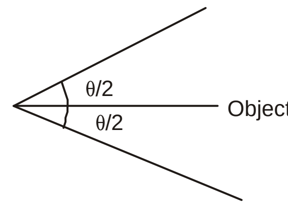
14. Given $fx = \frac{x+2}{x+3}$ then $f\left(f\frac{1}{3}\right)$
   (*a*) 4/7 (*b*) 11/18
   (*c*) 16/49 (*d*) 121/324

15. If radius of Circle A is 18 and of Circle B is 8 and both circle are touching each other and tangent to line AB. Then what would be distance between A and B
   (*a*) 24
   (*b*) 28
   (*c*) 25
   (*d*) 32



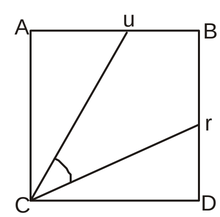
16. If number n is greater then or equal to 1000 and lesser then 10000 ($1000 \leq n > 10000$) and its factorial f_x are separate and members of {0, 1, 2, 3, 4, 5}, then f_x will be
    (*a*) 6 × 6 × 6 × 6 × 6 (*b*) 5 × 6 × 6 × 6 × 6
    (*c*) 5 × 4 × 3 × 2 × 1 (*d*) 6 × 5 × 3 × 2

17. Given x – y = 1, x and y are real number then the value of $x^3 - y^3$ cannot be
    (*a*) 0
    (*b*) 1/4
    (*c*) –1
    (*d*) –1/4

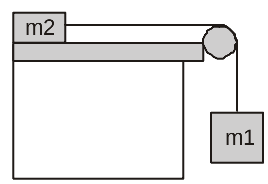


18. If a person see five images in mirror of an object, then the θ between two mirror will be
    (*a*) 60 (*b*) 45
    (*c*) 90 (*d*) 120

19. If u is at midpoint of AB and r is at midpoint of BD, then sine of angle UCR will be
    (*a*) $\sqrt{3}/2$
    (*b*) $1/\sqrt{3}$
    (*c*) 1/3
    (*d*) $\sqrt{3}$



20. Mass m_1 is suspended to pulley and connected to mass m_2. If mass m_1 can move only in vertical direction then acceleration for m_1 and m_2 will be
    (*a*) $m_1/m_2 + m_1g$ $m_1/m_2 + m_1g$
    (*b*) $m_2/m_1 + m_2g$ $m_1/m_1 + m_2g$
    (*c*) $m_1/m_1 + m_2g$ $m_1/m_1 + m_2g$
    (*d*) $m_2/m_1 + m_2g$ $m_1/m_1 + m_2g$



21. Among the following which is a gaseous hormone
    (*a*) Ethylene (*b*) Abscisic acid
    (*c*) Gibberllic acid (*d*) Auxins

22. Among the following which cannot be a part of a gene
    (*a*) UUUUUUUUU (*b*) AAAAAAAAA
    (*c*) CATCATCAT (*d*) GCGCGCGCG

23. Conservation of ground water can be done efficiently by
    (*a*) Construction of dams
    (*b*) Banning tube wells
    (*c*) Controlled consumption of ground water
    (*d*) Water restoration by checking flow of running water

24. Type of genotype in individual having blood group will be
    (*a*) $I^B I^o$ (*a*) $I^A I^o$
    (*c*) $I^A I^B$ (*d*) $I^o I^o$

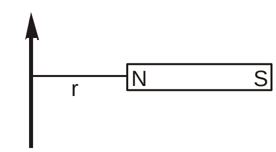
25. Among the following which are programming language
    (*a*) C, JAVA, VC (*b*) EXCEL. MS OFFICE
    (*c*) ORACLE, WINDOWS (*d*) POWERPOINT, WORD, EXCEL

26. 10^9 Flop's are equal to
    (*a*) 1 giga flop (*b*) 1000 flop
    (*c*) 1 terra flop (*d*) 1 Mega flop

27. Ratio of daughter radioisotope to parent isotope in certain sample was found to be 3:1. If half life of radioisotope is 5 m.y, then the age of sample is
    (*a*) 20 my (*b*) 15 my
    (*c*) 10 my (*d*) 25 my

28. If a sedimentary rock A is 20 m.y old. An another rock B is lying over it which is dissected by 10 m.y. intrusive rock. Then the age of rock B will be
    (*a*) In between 10 m.y and 20 m.y
    (*b*) 20 m.y
    (*c*) 10 m.y
    (*d*) Lesser then 10 m.y

29. A magnet is suspended near an current carrying conductor as shown in diagram



    If r is very small the torque acting will be in direction
    (*a*) k (*b*) j
    (*c*) i (*d*) cannot be estimated

30. The oxidative phosphorylation occurs at
    (*a*) Inner membrane of mitochondria
    (*b*) Vacoule
    (*c*) Cytoplasm
    (*d*) Chloroplast

PART – B

1. Major regulatory step in cholesterol biosynthesis is
    (*a*) HMG coenzyme reductase (*b*) HMG coenzyme synthase
    (*c*) Epimerase (*c*) Acetyl CoA carboxylase

2. Group of members which are morphologically identical bur genetically different are termed as
    (*a*) Sibling species (*b*) Taxonomic species
    (*c*) Morphospecies (*d*) Biological species

3. Occurrence of similar morphological forms in clade at different interval is termed as
   (*a*) Iterative (*b*) Convergent
   (*c*) Coevolution (*d*) Parallel evolution

4. Group of members which cannot interbreed freely are termed as
   (*a*) Biological species (*b*) Taxonomic species
   (*c*) Morphospecies (*d*) Sibling species

5. Which is true for gap junction
   (*a*) It is made of connexin protein
   (*b*) Allows free movement of large molecules across cells
   (*c*) Made up of two subunit of connexons
   (*d*) Movement of gases takes place by gases

6. The mode of action of antiobiotic penicillin is
   (*a*) It inhibits glycolase moiety of cell wall enzyme
   (*b*) Antibode is exclude by membrane
   (*c*) Antibiotic is not allowed to enter the cell
   (*d*) It deactivates membrane transport

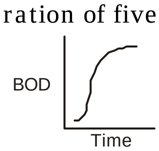
7. β-diversity is defined as diversity
   (*a*) Between two different ecosystems
   (*b*) Overall large area
   (*c*) Within a sampling area
   (*d*) total species richness

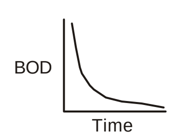
8. Speciation occurring due to geographical barrier is termed as
   (*a*) Allopatric (*b*) Sympatric
   (*c*) Parapatric (*d*) Peripatric

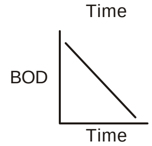
9. Diffusion of gas in plant cells is by
   (*a*) Symplast (*b*) Plasmodesmata
   (*c*) Apoplast (*d*) Passive transport

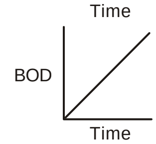
10. Among the following which hormone can induce flowering in short day plants grown under long duration of light
   (*a*) Gibberllic acid (*b*) Auxins
   (*c*) Cytokinin (*d*) Abscisic acid

11. If water is oxygenated and inoculated by bacteria, then the graph of BOD with time for duration of five days will be

   (*a*) 

   (*b*) 

   (*c*) 

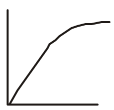
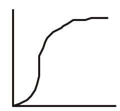
   (*d*) 

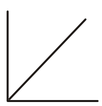
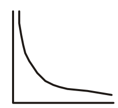
12. Probability of occurring similar amino acid sequence in two oligopeptides of length n will be

(*a*) $1/20^n$ (*b*) n^{20}

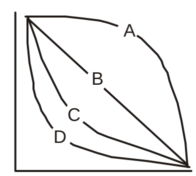
(*c*) 20^n (*d*) $1/n^{20}$

13. The graph between area studied and number of species encountered will be

(*a*)  (*b*) 

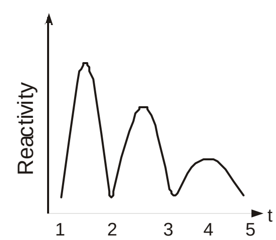
(*c*)  (*d*) 

14. The type of survivorship curve present in Paleozoic fishes was



(*a*) D
(*b*) B
(*c*) C
(*d*) A

15. If a nerve extracted is activated in reverse direction by giving impulses and following reactivity is obtained with time, then the speed of transmission of impulse across the nerve is



(*a*) 500m/s 100m/s 10 m/s
(*b*) 500m/s 100m/s 50 m/s
(*c*) 100m/s 50m/s 10 m/s
(*d*) 200m/s 100m/s 50 m/s

16. Among the following which relationship shows positive logarithmic interaction

(*a*) Generation time and animal size
(*b*) Generation time and longevity of animal
(*c*) Animal size and number of offspring
(*d*) Longevity and number of offspring

17. Among the following which is not an characteristic feature of r-selected species

(*a*) Maturity at later stage (*b*) Large clutch size

(*c*) Small size of offspring (*d*) Maturity at early stage of life

18. If a sequence 5'AAA(*A*AA)$_n$ AAAAAC 3' was transcribed in cell free system and peptide obtained was partially hydrolyzed with carboxypeptidase, the result was an Aspargine residue and oligopeptide. It suggest the direction of translation was

(*a*) 5′ – 3′ (*b*) 3′ – 5'

(*a*) 3′ – 5′ at pH 7.2 (*d*) 5′ – 3′at pH 5.4

19. The given graph shows
    (*a*) Cooperativity
    (*b*) Lograthimic growth
    (*c*) Linear rise
    (*d*) Saturation kinetics

20. Albinos have visual problem in bright light because they lacks
    (*a*) Melanin (*b*) Rods
    (*c*) Cones (*d*) Creatin

21. The percentage of protein coding sequence in *E. coli* genome is
    (*a*) 70 % (*b*) 24%
    (*c*) 3 % (*d*) 0.2 %

22. If the frequency of recessive allele causing disease in homozygous recessive condition in a population of 10,000 is 0.04, then the number people affected by disease will be
    (*a*) 16 (*b*) 400
    (*c*) 3600 (*d*) 496

23. Hard-Weinberg law in a population represents
    (*a*) Genotype frequency
    (*b*) Allele frequency
    (*c*) Heterozygote frequency
    (*d*) Homozygote frequency

24. The F^+ segment of bacteria may be transferred to F^- bacteria by the process of
    (*a*) Conjugation (*b*) Transduction
    (*c*) Transformation (*d*) Fragmentation

25. In a genetic test 9 : 7 ratio in F_2 generation represents
    (*a*) Epitasis (*b*) Co-dominance
    (*c*) Incomplete dominance (*d*) Complete dominance

26. Periodic toxic algal booms in oceans are due to
    (*a*) Dinoflagellates (*b*) Cyanobacteria
    (*c*) Diatoms (*d*) Green Algae

27. Among the following which is best indicator of water pollution due mixing of human faeces
    (*a*) *E. coli* (*b*) *Trypanosoma*
    (*c*) *Paramecium* (*d*) *Bacillus*

28. The main alkaloid obtained for *Dioscorea deltoids* is
    (*a*) Diosgenin (*b*) Digitoxin
    (*c*) Qunene (*d*) Serpentine

29. If the two or more morphological forms are favored against heterozygotes, such an selection is termed as
    (*a*) Disruptive (*b*) Directional
    (*c*) Stabilizing (*d*) Cyclic

30. It has been observed the bacteria secretes toxin at high population density to check the population size. This phenomenon is termed as
    (*a*) Quremsensing (*b*) Population control
    (*c*) Allelopathy (*d*) Inter specific Competition

31. Dosage compensation in mammal females is achieved by
    (*a*) Methylation of one X chromosome
    (*b*) Hyper activation of one X chromosome
    (*c*) Elimination of one X chromosome
    (*d*) Hypoactivation of Both X chromosome

32. It has been observed the transfer of certain X segment in XO *Caenorhhabditis elegans*, restores female character. It suggest that mode of sex determination is
    (*a*) X/A ratio (*b*) XY type
    (*c*) A/X (*d*) Ploidy difference

33. Number of cycles required to completely hydrolyze arachodoic acid into acetyl CoA is
    (*a*) 9 (*b*) 8
    (*c*) 10 (*d*) 11

34. Endocytic vesicles are usually coated by
    (*a*) Clathrin (*b*) Laminin
    (*c*) Desmins (*d*) Actin

35. Which of the following gene is involved in apoptosis
    (*a*) caspace (*b*) cyl_2
    (*c*) bxl (*d*) apc

36. Mast cells have receptor for
    (*a*) Ig E (*b*) Ig A
    (*c*) Ig G (*d*) Ig M

37. Secondary immune response is generated due to
    (*a*) Memory cells (*b*) Naive B-cells
    (*c*) Naive T-cells (*d*) Natural killer cells

38. Which is true about Mitosis Promoting Factor (MPF)
    (*a*) concentration cyclically varies during entire M phase
    (*b*) Its concentration can be sensed during S
    (*c*) Its concentration can be sensed during G_1
    (*d*) Control the replication of DNA

39. Among vertebrates the maximum biodiversity occurs in
    (*a*) Pisces (*b*) Aves

(*c*) Mammals (*d*) Reptiles

40. Which is observed after crossing over between chromosomes having pericentric inversion and normal
(*a*) Segmental Deletion and Duplication
(*b*) Bridge formation
(*c*) Ring formation
(*d*) Acentric and dicentric chromosomes

41. If a gene product in Sps A is 90 % similar to gene product in Sps.B. Such genes are termed as
(*a*) Orthologou**s** (*b*) Perilogous
(*c*) Paralogous (*d*) Allologous

42. Formation of various species from one common ancestor is termed as
(*a*) Adaptive radiation (*b*) Phylogeny
(*c*) Cladisitics (*d*) Natural selection

43. If mutation in regulatory gene increases 1000 fold efficiency of repressor protein to operator under such condition, which is true about operon
(*a*) No protein production
(*b*) Basal protein production
(*c*) Normal protein synthesis
(*d*) Increased protein synthesis

44. What would be decreases order of viability bacteria if it is stored at
a. 4–9 °C b. 0 °C c. –196 °C
(*a*) c b a (*b*) a b c
(*c*) b c a (*d*) c a b

45. The type of vegetation in climate having annual temperature range 5–20 °C and rainfall 150–300 mm will be
(*a*) Temperate deciduous (*b*) Temperate evergreen
(*c*) Taiga (*d*) Grasslands

46. Heavy metal (Pb) resistance in *Thalspie curulesiensis* is due to
(*a*) Presence of cation efflux pumps
(*b*) Presence of Na-K pumps
(*c*) Metal adsorbtion
(*d*) Metal metabolism

47. Which ion gradient is formed across the thylakoid membrane If a light is incident on isolated thylakoid
(*a*) H^+ (*b*) Na^+
(*c*) Both Na^+ and H^+ (*d*) Cl^-

48. In haemoglobin efficiency for oxygen increases when there is
(*a*) Low pO_2
(*b*) High pCO_2
(*c*) Low pCO_2
(*d*) High pO_2

49. Molecular phylogenetics is based on
(*a*) Neutral evolution
(*b*) Natural selection
(*c*) Parallel evolution
(*d*) Co evolution

50. Advantage of numerical taxonomy is
(*a*) Objective in nature
(*b*) Subjective in nature
(*c*) Easily manageable
(*d*) Few characters are considered

51. Among the following which is characteristic feature of Meiosis-I
(*a*) Separation of homologous chromosome
(*b*) Separation of chromatids
(*c*) Doubling of DNA content
(*d*) Movement of chromosome towards poles

52. RNA dependent DNA polymerase is present in
(*a*) Human Papiloma Virus
(*b*) Hepatitis B
(*c*) Hepatitis C
(*d*) Epstein-Barr Virus

53. Aldosterone is involved in
(*a*) Electrolyte balance
(*b*) Carbohydrate metabolism
(*c*) Fat metabolism
(*d*) Growth and Developmemt

54. Insulin resistance females generally have problem in ovulation because
(*a*) The elevated androgens cause an increase in free estrogen which results in a decrease in follicle stimulating hormone (FSH).
(*b*) The androgens are decreased thus follicle stimulating hormone (FSH) is increased.
(*c*) Amount of free estrogen decreases
(*d*) Ovary become non-functional

55. If the organism carrying the gene, the bearer survives to reproduce and also helps the borne who carry many of the same genes survive to reproduce. This phenomenon is termed as
(*a*) Inclusive fitness
(*b*) Darwinian fitness
(*c*) Reproductive fitness
(*d*) Survival fitness

56. In glycolysis if concentration of Gyceraldehyde-3-P is 2×10^{-6} and of Di hydroxyl acetone Phosphate is 4×10^{-4} at pH 7.2 and DG_0 value 9.2 K cal/mole. Then the reaction will proceed
(*a*) More toward Glyceraldehyde-3-P
(*b*) More toward Dihydroxy Acetone phosphate
(*c*) Remain at equilibrium
(*d*) Cannot be predicted by given information

57. The penta-cyclic ring common is Vitamin A, Vitamin K and Chlorophyll is
    (*a*) Isoprene (*b*) Phenol
    (*c*) Pentose (*d*) Aldehyde

58. The repeating structure common in Haemoglobin, Chlorophyll and cytochrome is
    (*a*) Porphyrin (*b*) Pentose
    (*c*) Benzene (*d*) Phenol

59. The accumulation of DDT has decreased the population of Pelican ducks because DDT
    (*a*) Decreased availability of Ca for egg shells which leads into thin shelled fragile eggs
    (*b*) Killed all ducken
    (*c*) Interfered Ca Metabolism
    (*d*) Stopped synthesis of eggs

60. DNA is destabilized by
    (*a*) Formamide (*b*) Polyglycine
    (*c*) Sucrose (*d*) PEG

61. The present concept for origin of life is
    (*a*) At hydrothermal vents (*b*) In mid oceans
    (*c*) Pangenesis (*d*) On land

62. Section 1 of Indian wild life act deals with
    (*a*) Preservation of endangered animals
    (*b*) Formation of zoo and botanical gardens
    (*c*) Banning poaching and hunting
    (*d*) Allowing limited wildlife sports

63. Hot spots are primarily designated on basis
    (*a*) endemism (*b*) Species diversity
    (*c*) Area covered (*d*) Flowering plant species

64. Phytoplankton spends very little energy on developing protective structures against predator, this suggest that why
    (*a*) Assimilation efficiency is high in aquatic ecosystem
    (*b*) Productivity of aquatic ecosystem is low
    (*c*) There is less competition
    (*d*) Food chain is small

65. If bacteria genome and plasmid are allowed to replicate in same manner then
    (*a*) Plasmid genome will replicate fast
    (*b*) Bacterial genome will replicate fast
    (*c*) Both will replicate at same time
    (*d*) Depends on GC content

66. Interspecific hybrids have proved very useful for
    (*a*) Gene mapping (*b*) Genetic manipulation
    (*c*) Gene structure (*d*) Gene function

67. Semi-conservative mode of DNA replication can be experimentally demonstrated by using
    (*a*) BrU labeling (*b*) S^{32}
    (*c*) In situ hybridisitation (*d*) G-banding

68. Stenohaline organisms can
    (*a*) tolerate Narrow range of salt concentration
    (*b*) tolerate wide range of salt
    (*c*) Can excrete extra salt to keep salt amount constant
    (*d*) Escapes salty conditions

69. Temporary fluctuation in population size is due to
    (*a*) Migration (*b*) Carrying capacity
    (*c*) Bottle neck (*d*) Interspecific competition

70. Maximum number of species are of
    (*a*) Amphibians (4780) (*b*) Fish (27000)
    (*c*) Aves (9700) (*d*) Mammals (4650)

CSIR-NET Life Sciences, Dec, 2006

PART – A

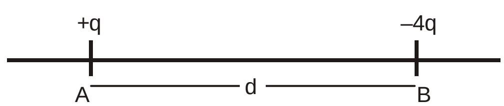
1. A ball is dropped from a height of 1 meter, collision with floor is inelastic and ball looses half the energy after collision. What would be the total vertical distance covered by the ball before it comes to rest-

   (*a*) 2 m (*b*) 2.5 m
   (*c*) 3 m (*d*) 4 m

2. Objects can not be seen from the corner of building but sound produced at back of building can be heard because of -

   (*a*) Diffraction
   (*b*) Interference
   (*c*) Reverbation of sound from building
   (*d*) Refraction of sound

3. If two charges '+q' and '–4q' are placed on X-axis as shown in diagram. Where a another charge '+q' must be placed on X-axis that it do not experience any force



   (*a*) d/2 (*b*) d
   (*c*) –d (*d*) –4d

4. Length of two vectors A and B is equal. Sum of A and B is thrice of A–B. Then the angle between the vectors A and B will be

   (*a*) $\cos^{-}(3/4)$ (*b*) $\cos^{-}(1/4)$
   (*c*) $\cos^{-}(1/\sqrt{2})$ (*d*) $\cos^{-}(\sqrt{3}/2)$

5. Wavelength of one light waves is λ while other have $\lambda/2$ but then also they have the same intensity I. Then the ratio of number of photons associated with each light waves is

   (*a*) $\frac{n_1}{n_2} = \sqrt{\frac{1}{2}}$ (*b*) $\frac{n_1}{n_2} = \frac{1}{2}$
   (*c*) $\frac{n_1}{n_2} = \frac{3}{2}$ (*d*) $\frac{n_1}{n_2} = 1$

6. If atom A is at corners of cube while atom B is located on all planar faces, then probable formula for the compound will be

   (*a*) AB (*b*) AB_2
   (*c*) A_2B (*d*) A_3B

7. Among the following which equation best represents the formation of proton from neutron

(*a*) ${}^{1}_{1}N \rightarrow {}^{1}_{1}P + {}_{-1}^{0}e$ (*b*) ${}^{1}_{1}N \rightarrow {}^{0}_{1}P + {}_{-1}^{0}e + v$

(*c*) ${}^{1}_{1}N \rightarrow {}^{1}_{1}P + {}_{-1}^{0}e + v$ (*d*) ${}^{1}_{1}N \rightarrow {}^{1}_{1}P + {}^{-1}_{1}e + v$

8. Consider the following compounds

(i) BF_3 (ii) Ethene (iii) Cyclopropene

Out of these which compounds have planar triagonol geometry

(*a*) i only (*b*) i and iii

(*c*) i and ii (*d*) i, ii and iii

9. Volume of most of liquids shrinks when they freezes but volume of water increases when it converts into ice. On basis of this we can conclude that

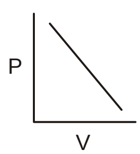
(*a*) Freezing point decreases with pressure

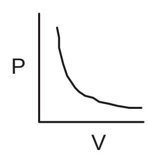
(*b*) There is non-characteristic curve obtained during solid-liquid transition

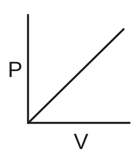
(*c*) Triple point of water is not affected by pressure

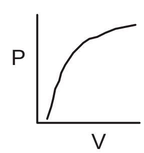
(*d*) Boiling point of water decreases on removal of pressure

10. Among the following which graph correctly represents relationship between P and V for ideal gas

(*a*) 

(*b*) 

(*c*) 

(*d*) 

11. If $f(x) = e^x(x^2-2x^2+3x-5)$, then $f'(x)$ will be

(*a*) $e^x(x^2-x^2+5x)$ (*b*) $e^x(3x^2+3x-3)$

(*c*) $e^x(3x^2+5x-2)$ (*d*) $e^x(x^3+x^2-x-2)$

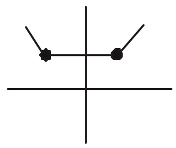
12. The value for term described below will be

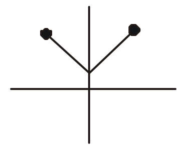
$$\frac{2\sqrt{2}+4\sqrt{3}}{4\sqrt{2}+2\sqrt{3}}$$

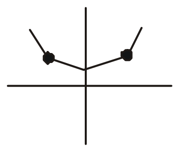
(*a*) $\frac{2\sqrt{2}+2\sqrt{2}}{5}$ (*b*) $\frac{4\sqrt{2}+2\sqrt{3}}{5}$

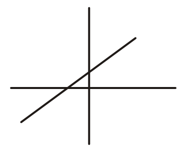
(*c*) $\frac{2-2\sqrt{2}}{5}$ (*d*) $\frac{3-2\sqrt{2}}{5}$

13. Consider the following equation $Y = |x+1| + |x-1|$. The graphical representation for above equation will be

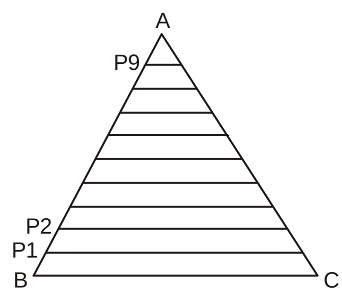
(*a*) 

(*b*) 

(*c*) 

(*d*) 

14. Consider the ΔABC.



If length BC is 10 cm and triangle is divided horizontally into nine zones by line P1, P2, P3…P9 which are parallel to BC. The total length of all lines from P1 to P9 will be

(*a*) 40 (*b*) 80
(*c*) 45 (*d*) 90

15. If a weight of one elephant is 10,000 kg and of a rat is 10 g. Then amount of calories needed to maintain constant body temperature for one elephant and for 10,0000 rats will be
(*a*) More for elephant
(*b*) More for rat
(*c*) Both will require equal calories
(*d*) Calories are not needed to maintain body temperature

16. The DNA sequence for two DNA was found to be different then also they code similar protein. It may be due to
(*a*) Start of transcription at different sites
(*b*) Using similar enzymes for transcription
(*c*) More the one codon can code single amino acid
(*d*) Due to mutation in DNA

17. If inheritance of disease to next generation is only possible through females. The probable inheritance is
    (*a*) Sex-linked
    (*b*) Mendelian
    (*c*) Organeller
    (*d*) Autosomal

18. Till date we have not succeeded in generating vaccine against HIV because
    (*a*) It has reverse transcriptase
    (*b*) It mutates rapidly
    (*c*) It don't have any protein over its surface
    (*d*) It is intracellular pathogen

19. The key difference between Lamarckism and Darwinism is
    (*a*) Genes are made up of DNA not RNA
    (*b*) DNA codes for proteins
    (*c*) Variations are at random
    (*d*) Evolution is abrupt

20. Among the following which process does not remove CO_2 from environment?
    (*a*) Photosynthesis
    (*b*) Eruption of Volcano
    (*c*) Dissolution in Oceans
    (*d*) Weathering of rocks

21. During ice age there was large ice deposit at poles and thus there was large temperature gradient between poles-Equator. The wind velocity at that time would have been
    (*a*) Stronger in summers
    (*b*) Stronger in Winters
    (*c*) Stronger in all seasons
    (*d*) No effect was seen

22. Same face of moon is visible on earth during its orbital revolution of 28 days. Considering earth as stationary then with reference to earth correct statement for the rotation of moon over its axis is
    (*a*) Moon completes 28 rotation in 28 days in same direction to earth.
    (*b*) Moon completes 28 rotation in 28 days opposite in direction to earth.
    (*c*) Moon completes 1 rotation in 28 days in same direction to earth.
    (*d*) Moon completes 1 rotation in 28 days opposite in direction to earth.

23. We can find terrestrial rocks as old as 3 billion year but rocks more then 200 million is not seen in oceans because
    (*a*) During this period rock dissolves in ocean
    (*b*) In 200 MY rocks subduct into floor of ocean

(*c*) Sensitive techniques to study age are not present
(*d*) Weathering of rocks takes place in 200 MY

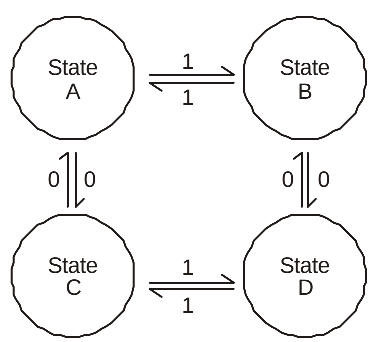
24. Budha statue of limestone at Ladakh would be preserved for longer time then one at Sri Lanka because
(*a*) Humidity at Sri Lanka is more
(*b*) Sri Lanka is close to equator
(*c*) Peoples care less in Sri Lanka
(*d*) Both will be preserved for same time

25. Tsunami are more common in Japan than any other part of world because
(*a*) There are many islands
(*b*) Wave velocity is very vigorous
(*c*) There are many seaquakes
(*d*) It is in pacific sea

26. There are various electronic gates like OR, AND, NOR, XOR etc. Which GATE is described as universal?
(*a*) OR (*b*) AND
(*c*) XOR (*d*) NOR

27. Among the following which is not an hardware bus/port
(*a*) USB (*b*) CMOS
(*c*) Printer Port (*d*) Mouse Port

28. Consider the following flow diagram. If 1001 means from STATE A move to STATE B then to STATE C return to STATE B and then to STATE A. The STATE achieved after following code 001100010010



(*a*) STATE A
(*b*) STATE B
(*c*) STATE C
(*d*) STATE D

29. Consider the programme

    n=0

    If n >2

    Factorial ‘f’

    Else

    i=f(n–1)+f(n–2)

    return

    If initial value n=5, then output of the program will be

    (*a*) 0 (*b*) 4

    (*c*) 5 (*d*) No result will be produced

30. What would be the output of the following program if

    Smallest integer≥x

    Float i

    Input i

    i=[i /2]

    Return

    Initial value of i= 7

    (*a*) 0 (*b*) 1

    (*c*) 7 (*d*) 3

PART – B

1. Cell fusion is an essential phenomenon in development of

   (*a*) Nerve (*b*) Muscle

   (*c*) Spleen (*d*) Liver

2. Gibberllic acid activates α-amylase activity in

   (*a*) Endosperm

   (*b*) Aleuronic layer

   (*c*) Cotyledons

   (*d*) Embryo

3. Protein RNAase A have 8 cysteine residue which involves in 4 disulphide bond formation in a random manner. If the probability for formation of first correct disulphide bond is 1/7, then what would be the probability that all four correct disulphide bonds are formed

   (*a*) 1/28 (*b*) 1/32

   (*c*) 1/105 (*d*) 1/210

4. Light signals for flowering is received by

   (*a*) Flower bud (*b*) Apical bud

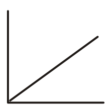
   (*c*) Leaves (*d*) Flower bract

5. Which hormone induces formation of Late Embryogenesis Abundant (LEA) protein during seed maturation?
   (*a*) Gibberllic acid
   (*b*) Ethylene
   (*c*) Abscisic acid
   (*d*) Cytokinin

6. Effective population size for completely monogamous species having 40 males and 10 females would be
   (*a*) 40
   (*b*) 30
   (*c*) 20
   (*d*) 10

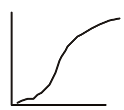
7. Musk deer is abundant in
   (*a*) Gharwal Himalaya
   (*b*) Eastern Himalaya
   (*c*) Kumau Himalaya
   (*d*) All

8. Among the following which follows the population growth pattern according to equation dN/dt=rN when no limitating force is acting

   (*a*) 

   (*b*) 

   (*c*) 

   (*d*) 

9. Among the following ecological factor which is density independent factor
   (*a*) Food
   (*b*) Predation
   (*c*) Disease
   (*d*) Extreme temperatures

10. The curve for renaturation of denaturated DNA
   (*a*) Linear
   (*b*) Inverse
   (*c*) Direct
   (*d*) Hyperbolic

11. Among the following which has highest Productivity/Biomass ratio
   (*a*) Opean sea
   (*b*) Large lakes
   (*c*) Rain forests
   (*d*) Grassland

12. Patch of evergreen forest surrounded by grassland is termed as
   (*a*) Prarie
   (*b*) Pampas
   (*c*) Chapprals
   (*d*) Shola

13. The correlation between species richness and productivity is
   (*a*) Species richness directly increases as increase in productivity
   (*b*) Species richness has inverse relation to productivity
   (*c*) Species richness and productivity is independent
   (*d*) Species richness is maximum at intermediate levels of productivity

14. In a massive earthquake on island only few related species of lizards survived and occupied the island. The phenomenon is also referred as
    (*a*) Founder effect
    (*b*) Bottle Neck effect
    (*c*) Vodka-Bertoni effect
    (*d*) Darwin's effect

15. Numerical taxonomy involves
    (*a*) Overall similarity
    (*b*) Phylogenetic relationship
    (*c*) Evolutionary relationship
    (*d*) Molecular taxonomy

16. Genetic Drift occurs by
    (*a*) Chance
    (*b*) Immigration
    (*c*) Emigration
    (*d*) Mutation

17. Organism inhabiting water scarce environment are likely
    (*a*) Uricotelic
    (*b*) Ureotellic
    (*c*) Ammonotellic
    (*d*) to have small kidney size

18. Circadian rhythms are controlled by
    (*a*) Medulla
    (*b*) Cortex
    (*c*) Pituatory gland
    (*d*) Suprachaismatic nucleus

19. What is prophage
    (*a*) λ phage DNA
    (*b*) Stage of cell cycle
    (*c*) DNA of temperate phage inserted into host chromosome
    (*d*) A transposons

20. Among the following which plant family can be separated on basis of inflorescence
    (*a*) Asteraceae
    (*b*) Euphorbiaceae
    (*c*) Leguminosae
    (*d*) Solanacae

21. DNA sequence responsible for chromatid separation is
    (*a*) Kinetochore
    (*b*) Centromere
    (*c*) Satellite
    (*d*) Telomere

22. Glycoconjugates on proteins in intra cellular membranes are oriented toward
    (*a*) Cytoplasmic face
    (*b*) Lumen side
    (*c*) Embedded in membrane
    (*d*) On both sides

23. Which of the histone protein is not involved in nucleosome assembly?
    (*a*) H1
    (*b*) H2A
    (*c*) H2B
    (*d*) H4

24. Synthesis of Betalain is characteristics of family
    (*a*) Chenopodiacae
    (*b*) Carophyllaceae
    (*c*) Asteraceae
    (*d*) Solanaceae

25. The book by Rachel Carson -'Silent Spring' is related with
   (*a*) Environmental pollution
   (*b*) Use of pesticides in agriculture
   (*c*) Flowering in spring season
   (*d*) Effect of pesticides on non-target organism

26. The mechanism of action of steroid hormone is
   (*a*) Binding to membrane receptor and activating secondary messenger
   (*b*) Binding to cytosolic receptor and hormone-receptor complex activates target gene expression
   (*c*) Hormone moves to nucleus and starts transcription
   (*d*) Hormone effect mainly protein synthesis

27. On buyout density centrifugation of certain DNA band was observed as high peak corresponding to low density as compare to other DNA. It means
   (*a*) DNA is AT rich
   (*b*) DNA is GC rich
   (*c*) Equal AT to GC ratio
   (*d*) Single Stranded DNA

28. Which of the following can induce SOS response in bacteria
   (*a*) Thymidine dimers (*b*) Hydorxylamine
   (*c*) 5-Fluro Uracil (*d*) 2-Aminopurine

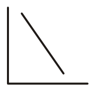
29. Cyanobacteria out competes the green algae in eutrophic lakes due to organic pollutions because they can
   (*a*) tolerate low oxygen level
   (*b*) tolerate high phosphorus level
   (*c*) fix nitrogen, so it is not limitating for them
   (*d*) low light is required for photosynthesis

30. The organism with high parental care will also show
   (*a*) Semelparity
   (*b*) Iteroperety
   (*c*) Maturation at early stage
   (*d*) Small size of offsprings

31. If any one of the parent invest more time for parental care on offsprings it would lead to differences in
   (*a*) Life span (*b*) Mental level
   (*c*) Metabolism (*d*) Differential sex mate

32. The development of social behavior is related to
   (*a*) Complex Brain size
   (*b*) Genetic relatedness
   (*c*) Size of population
   (*d*) Size of organism

33. The correct graphical representation of a bacteria growing exponentially under depleting nutrient condition is

(*a*) 
(*b*) 
(*c*) 
(*d*) 

34. The acidic nature of orange juice is mainly due to citric acid. What would be pH of 0.1 M citric acid, if K_1 for citric acid is 8.4×10^{-4}.
(*a*) 2 (*b*) 3
(*c*) 4 (*d*) 5

35. Vavilov's origin of centre for sorghum is
(*a*) South East Asia (*b*) Central Africa
(*c*) India (*d*) East Asia

36. Oogenesis in human females results in
(*a*) 1 egg and 3 polar bodies
(*b*) 2 egg and 2 polar bodies
(*c*) 3 egg and 1 polar bodies
(*d*) 1 egg and 1 polar bodies

37. Direct correlation between recombination frequency and distance between genes can be disturbed by presence
(*a*) Heterochromatin region between genes
(*b*) Exons
(*c*) Introns
(*d*) Euchromatin

38. Among the following interactions which will not force co-evolution
(*a*) Commensalisms (*b*) Parasitism
(*c*) Mutualism (*d*) Interspecific competition

39. Antibiotic resistance among bacteria represents
(*a*) Balancing selection
(*b*) Stabilizing selection
(*c*) Directional selection
(*d*) Disruptive selection

40. In a population a single gene locus has two alleles A and a with allele frequency of 'a' = 0.3. If genotype Aa is lethal and only individual with genotype AA and aa are favored then over several generation
(*a*) Allele frequency will be 1:1
(*b*) Allele frequency will remain same to that of present
(*c*) Allele 'a' would be lost from population
(*d*) Genetic drift will be seen

41. The most variable stage of cell cycle is
(*a*) G1 (*b*) G2
(*c*) Go (*d*) S

42. Among the following which order of arthropods has maximum species richness
(*a*) Hymenoptera (*b*) Lepidoptera
(*c*) Coleoptera (*d*) Diptera

43. The probability of a son to be color blind for parent with color blind father and normal homozygous mother would be
(*a*) 0 % (*b*) 25 %
(*c*) 50 % (*d*) 100 %

44. Which statement is correct for following biological reaction:
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
(*a*) Entropy of system will increase
(*b*) Enthalpy for system will increase
(*c*) Free Energy for system will increase
(*d*) No change would be seen in free energy

45. Second most affecting green house gas after CO2 is
(*a*) Methane (*b*) NOx
(*c*) CFC (*d*) Ozone

46. Among the following which gas was totally absent during period of primitive origin of life
(*a*) Oxygen (*b*) Hydrogen
(*c*) Methane (*d*) Ammonia

47. If a certain parasitic bacteria on insect prevents cross breeding among them. It will lead into
(*a*) rapid speciation
(*b*) Divergence of insects
(*c*) Extinction of insects
(*d*) No effect

48. Among the following which compound links glycolysis and Kreb's cycle
(*a*) Acetyl Co A
(*b*) Pyruvic Acid
(*c*) Glucose
(*d*) Oxaloacetic acid

49. Secretion of histamine by degranulation from which cell leads in immediate hypersensitivity
(*a*) Basophils (*b*) Mast cells
(*c*) T-helper cells (*d*) B-cells

50. Which cell is involved in eliminating antigen by engulfing them without recognition
(*a*) phagocytotic cells
(*b*) T-helper cells
(*c*) Killer T-cells
(*d*) B-cells

51. Recently reptile fossils of age 200-250 MY have been found in Brazil and Ghana-portion of West Africa. The landmass during that period was a portion of
(*a*) Pangea
(*b*) Laurasia
(*c*) Gondwana
(*d*) Tethys Sea

52. Among the following which gene is not concerned with induction of cancer
(*a*) Src
(*b*) Ras
(*c*) P_{53}
(*d*) Actin

53. The morphological distinct sexual dimorphism is absent in
(*a*) Peacock, Myena, bulbul
(*b*) Crow, peacock, bulbul
(*c*) Hyena, bulbul, Sparrow
(*d*) Myena, bulbul, Hyena

54. Among the following Mendelian inheritance is obeyed by
(*a*) Quantitative traits
(*b*) Transposons
(*c*) Organelles
(*d*) Gene for vertical transfer of disease

55. Which species concept stress mainly on failure of interbreeding to keep them in distinct species
(*a*) Biological species concept
(*b*) Ecological species concept
(*c*) Morphological species concept
(*d*) Phylogenetic species concept

56. The cells of warm blooded animals can be best stored at temperatures
(*a*) 37 °C
(*b*) 0 °C
(*c*) –100 °C
(*d*) –196 °C

57. The polysome can be describes as
(*a*) A special ribosome occurring in prokaryotes
(*b*) A DNA strand which is being transcribed by may RNA polymerase
(*c*) String of RNA occupied by many ribosomes
(*d*) Involved in control of transcription in prokaryotes

58. If there is no correct initiation of transcription. Which subunit of RNA polymerase holoenzyme would have defect
(*a*) a subunit
(*b*) β
(*c*) β'
(*d*) s-subunit

59. The pattern of genomic imprinting is maintained from one generation to another by
    (*a*) Phosphorylation of DNA
    (*b*) Methylation
    (*c*) Acetylation
    (*d*) Glycosylation

60. If an enzyme obeying Hills reaction shows negative cooperativity. It means
    (*a*) Binding of substrate to any one site of multisubunit enzyme decreases affinity for other substrate to other sub-units
    (*b*) Binding of substrate to any one site of single unit enzyme decreases affinity for other substrate
    (*c*) Binding of substrate to any one site of multisubunit enzyme increases affinity for other substrate to other sub-units
    (*d*) Binding of substrate to any one site of multisubunit enzyme makes enzyme non-funtional

61. In mitochondria succinyl CoA synthetase produces
    (*a*) ATP (*b*) ADP
    (*c*) GTP (*d*) AMP

62. λ-phage insert their DNA into bacterial host. The site for recombination on host is termed as-
    (*a*) attP (*b*) attB
    (*c*) Xis (*d*) Int

63. A person heterozygous for sickle cell anemia has advantage for both malaria and sickle cell anemia. It illustrates
    (*a*) Directional selection
    (*b*) Heterozygote advantage
    (*c*) Disruptive selection
    (*d*) Directed mutation selection

64. Vibrio cholrae causes diahorrea by
    (*a*) Opening ion channels
    (*b*) Constitutive expression of adenylate cyclase
    (*c*) Closing absorption of water from gut epithelium
    (*d*) Destroys cells of intestinal lining

65. The fungus which is pathogenic to human is
    (*a*) Candida albicans
    (*b*) Saccromyces cervesae
    (*c*) Penicillium
    (*d*) Rhyzopus

66. The eukaryotic mitochondria is more similar to
    (*a*) Bacteria (*b*) Virus
    (*c*) protist (*d*) moulds

67. During photorespiration which organelle is involved in conversion of glycolate into glyoxylate
   (*a*) Mitochondria
   (*b*) Peroxisomes
   (*c*) Chloroplast
   (*d*) Nucleus

68. Which pump is activated by light during closure of stomata
   (*a*) H+-ATPase
   (*b*) K+-ATPase
   (*c*) Na+-H+-ATPase
   (*d*) Na+-K+-ATPase

79. The steady state hypothesis for enzyme suggest that
   (*a*) Rate of formation of ES complex by substrates is equal to rate of breakdown of ES complex into products
   (*b*) Rate of formation of ES complex is equal to rate of formation of products
   (*c*) Rate of formation of ES complex and its dissociation into E and S are equal
   (*d*) Enzyme are steadily consumed in the reaction

80. Which is correct for a-helix of a protein
   (*a*) It has H-bonding in two or more parallel running chains
   (*b*) There is interchain H-bonding in single helix
   (*c*) No H- bonding is seen
   (*d*) is tertiary structure

Answer Key

ANSWER KEY: Chapter 1 – Cell biology

Test Paper-I

1. (*c*)	2. (*a*)	3. (*c*)	4. (*c*)	5. (*c*)	6. (*d*)
7. (*c*)	8. (*d*)	9. (*a*)	10. (*d*)	11. (*b*)	12. (*b*)
13. (*a*)	14. (*b*)	15. (*a*)	16. (*d*)	17. (*b*)	18. (*a*)
19. (*b*)	20. (*c*)	21. (*c*)	22. (*b*)	23. (*a*)	24. (*d*)
25. (*c*)	26. (*d*)	27. (*a*)	28. (*a*)	29. (*c*)	30. (*d*)
31. (*b*)	32. (*a*)	33. (*a*)	34. (*b*)	35. (*a*)	36. (*d*)
37. (*b*)	38. (*c*)	39. (*c*)	40. (*b*)	41. (*b*)	42. (*d*)
43. (*a*)	44. (*c*)	45. (*c*)	46. (*c*)	47. (*c*)	48. (*b*)
49. (*a*)	50. (*b*)	51. (*b*)	52. (*d*)	53. (*b*)	54. (*d*)
55. (*b*)	56. (*d*)	57. (*d*)	58. (*c*)	59. (*a*)	60. (*d*)
61. (*d*)	62. (*b*)	63. (*d*)	64. (*d*)	65. (*a*)	66. (*d*)
67. (*c*)	68. (*b*)	69. (*c*)	70. (*c*)	71. (*b*)	72. (*c*)
73. (*a*)	74. (*d*)	75. (*c*)	76. (*d*)	77. (*d*)	78. (*a*)
79. (*a*)	80. (*b*)	81. (*d*)	82. (*c*)	83. (*b*)	84. (*c*)
85. (*d*)	86. (*a*)	87. (*c*)	88. (*b*)	89. (*d*)	90. (*a*)
91. (*d*)	92. (*a*)	93. (*b*)	94. (*d*)	95. (*a*)	96. (*b*)
97. (*d*)	98. (*a*)	99. (*d*)	100. (*c*)		

Test paper-II

1. (*b*)	2. (*b*)	3. (*a*)	4. (*a*)	5. (*b*)	6. (*d*)
7. (*d*)	8. (*a*)	9. (*b*)	10. (*a*)	11. (*d*)	12. (*d*)
13. (*a*)	14. (*b*)	15. (*b*)	16. (*c*)	17. (*b*)	18. (*d*)
19. (*c*)	20. (*a*)	21. (*d*)	22. (*c*)	23. (*b*)	24. (*d*)
25. (*c*)	26. (*c*)	27. (*d*)	28. (*c*)	29. (*d*)	30. (*d*)
31. (*a*)	32. (*b*)	33. (*c*)	34. (*b*)	35. (*b*)	36. (*d*)
37. (*d*)	38. (*a*)	39. (*d*)	40. (*d*)	41. (*c*)	42. (*d*)
43. (*c*)	44. (*d*)	45. (*d*)	46. (*c*)	47. (*c*)	48. (*d*)
49. (*d*)	50. (*b*)	51. (*b*)	52. (*a*)	53. (*d*)	54. (*b*)
55. (*d*)	56. (*d*)	57. (*b*)	58. (*d*)	59. (*c*)	60. (*d*)
61. (*d*)	62. (*d*)	63. (*d*)	64. (*d*)	65. (*d*)	66. (*d*)
67. (*c*)	68. (*c*)	69. (*b*)	70. (*d*)	71. (*c*)	72. (*c*)
73. (*d*)	74. (*a*)	75. (*d*)	76. (*c*)	77. (*b*)	78. (*b*)
79. (*d*)	80. (*d*)	81. (*d*)	82. (*c*)	83. (*d*)	84. (*d*)
85. (*c*)	86. (*d*)	87. (*c*)	88. (*a*)	89. (*d*)	90. (*d*)
91. (*a*)	92. (*d*)	93. (*d*)	94. (*a*)	95. (*d*)	96. (*b*)
97. (*a*)	98. (*d*)	99. (*b*)	100. (*c*)		

ANSWER KEY: Chapter 2 – Biochemistry

Test Paper-I

1. (*a*)	2. (*b*)	3. (*c*)	4. (*a*)	5. (*a*)	6. (*a*)
7. (*d*)	8. (*a*)	9. (*d*)	10. (*d*)	11. (*d*)	12. (*a*)
13. (*d*)	14. (*b*)	15. (*d*)	16. (*d*)	17. (*a*)	18. (*c*)
19. (*c*)	20. (*b*)	21. (*b*)	22. (*b*)	23. (*a*)	24. (*a*)
25. (*b*)	26. (*c*)	27. (*c*)	28. (*d*)	29. (*d*)	30. (*a*)
31. (*d*)	32. (*b*)	33. (*b*)	34. (*d*)	35. (*d*)	36. (*d*)
37. (*c*)	38. (*d*)	39. (*d*)	40. (*b*)	41. (*c*)	42. (*a*)
43. (*c*)	44. (*a*)	45. (*b*)	46. (*d*)	47. (*b*)	48. (*a*)
49. (*b*)	50. (*c*)	51. (*c*)	52. (*c*)	53. (*d*)	54. (*d*)
55. (*a*)	56. (*b*)	57. (*a*)	58. (*a*)	59. (*d*)	60. (*a*)
61. (*a*)	62. (*c*)	63. (*d*)	64. (*c*)	65. (*b*)	66. (*b*)
67. (*a*)	68. (*a*)	69. (*d*)	70. (*c*)	71. (*a*)	72. (*c*)
73. (*d*)	74. (*d*)	75. (*a*)	76. (*c*)	77. (*d*)	78. (*c*)
79. (*d*)	80. (*d*)	81. (*a*)	82. (*d*)	83. (*a*)	84. (*a*)
85. (*b*)	86. (*d*)	87. (*a*)	88. (*b*)	89. (*a*)	90. (*b*)
91. (*c*)	92. (*b*)	93. (*c*)	94. (*b*)	95. (*a*)	96. (*b*)
97. (*d*)	98. (*a*)	99. (*b*)	100. (*d*)		

Test Paper-II

1. (*c*)	2. (*d*)	3. (*b*)	4. (*b*)	5. (*d*)	6. (*c*)
7. (*d*)	8. (*b*)	9. (*b*)	10. (*b*)	11. (*c*)	12. (*d*)
13. (*d*)	14. (*c*)	15. (*a*)	16. (*b*)	17. (*d*)	18. (*d*)
19. (*b*)	20. (*d*)	21. (*c*)	22. (*b*)	23. (*d*)	24. (*a*)
25. (*a*)	26. (*b*)	27. (*b*)	28. (*a*)	29. (*b*)	30. (*d*)
31. (*a*)	32. (*d*)	33. (*a*)	34. (*a*)	35. (*d*)	36. (*a*)
37. (*c*)	38. (*b*)	39. (*a*)	40. (*c*)	41. (*c*)	42. (*b*)
43. (*b*)	44. (*d*)	45. (*a*)	46. (*b*)	47. (*d*)	48. (*a*)
49. (*a*)	50. (*b*)	51. (*b*)	52. (*c*)	53. (*a*)	54. (*a*)
55. (*c*)	56. (*b*)	57. (*a*)	58. (*d*)	59. (*d*)	60. (*d*)
61. (*b*)	62. (*b*)	63. (*a*)	64. (*c*)	65. (*c*)	66. (*c*)
67. (*b*)	68. (*c*)	69. (*d*)	70. (*b*)	71. (*a*)	72. (*c*)
73. (*d*)	74. (*b*)	75. (*a*)	76. (*c*)	77. (*a*)	78. (*c*)
79. (*b*)	80. (*c*)	81. (*b*)	82. (*a*)	83. (*b*)	84. (*d*)
85. (*c*)	86. (*d*)	87. (*c*)	88. (*a*)	89. (*d*)	90. (*a*)
91. (*b*)	92. (*c*)	93. (*b*)	94. (*d*)	95. (*c*)	96. (*d*)
97. (*d*)	98. (*c*)	99. (*a*)	100. (*a*)		

ANSWER KEY: Chapter 3 – Physiology

Test Paper-I

1. (*b*)	2. (*d*)	3. (*a*)	4. (*c*)	5. (*c*)	6. (*c*)
7. (*d*)	8. (*d*)	9. (*c*)	10. (*c*)	11. (*b*)	12. (*b*)
13. (*a*)	14. (*d*)	15. (*c*)	16. (*c*)	17. (*d*)	18. (*b*)
19. (*d*)	20. (*a*)	21. (*a*)	22. (*d*)	23. (*c*)	24. (*b*)
25. (*c*)	26. (*b*)	27. (*b*)	28. (*d*)	29. (*b*)	30. (*c*)
31. (*a*)	32. (*d*)	33. (*a*)	34. (*d*)	35. (*b*)	36. (*c*)
37. (*d*)	38. (*c*)	39. (*c*)	40. (*d*)	41. (*c*)	42. (*c*)
43. (*c*)	44. (*d*)	45. (*b*)	46. (*a*)	47. (*b*)	48. (*b*)
49. (*d*)	50. (*d*)	51. (*a*)	52. (*b*)	53. (*a*)	54. (*b*)
55. (*d*)	56. (*a*)	57. (*b*)	58. (*a*)	59. (*d*)	60. (*c*)
61. (*b*)	62. (*a*)	63. (*a*)	64. (*d*)	65. (*a*)	66. (*c*)
67. (*d*)	68. (*b*)	69. (*c*)	70. (*c*)	71. (*a*)	72. (*d*)
73. (*b*)	74. (*b*)	75. (*c*)	76. (*d*)	77. (*d*)	78. (*c*)
79. (*d*)	80. (*d*)	81. (*c*)	82. (*a*)	83. (*c*)	84. (*a*)
85. (*c*)	86. (*b*)	87. (*b*)	88. (*d*)	89. (*c*)	90. (*d*)
91. (*c*)	92. (*c*)	93. (*c*)	94. (*b*)	95. (*b*)	96. (*d*)
97. (*d*)	98. (*d*)	99. (*d*)	100. (*c*)		

Test Paper-II

1. (*d*)	2. (*c*)	3. (*a*)	4. (*b*)	5. (*d*)	6. (*c*)
7. (*d*)	8. (*c*)	9. (*d*)	10. (*d*)	11. (*c*)	12. (*b*)
13. (*c*)	14. (*b*)	15. (*b*)	16. (*a*)	17. (*b*)	18. (*b*)
19. (*d*)	20. (*a*)	21. (*c*)	22. (*d*)	23. (*d*)	24. (*a*)
25. (*c*)	26. (*d*)	27. (*c*)	28. (*b*)	29. (*d*)	30. (*b*)
31. (*b*)	32. (*a*)	33. (*a*)	34. (*b*)	35. (*c*)	36. (*d*)
37. (*b*)	38. (*a*)	39. (*a*)	40. (*c*)	41. (*c*)	42. (*c*)
43. (*a*)	44. (*a*)	45. (*b*)	46. (*a*)	47. (*c*)	48. (*c*)
49. (*d*)	50. (*b*)	51. (*b*)	52. (*d*)	53. (*b*)	54. (*d*)
55. (*d*)	56. (*b*)	57. (*d*)	58. (*d*)	59. (*c*)	60. (*d*)
61. (*c*)	62. (*b*)	63. (*a*)	64. (*b*)	65. (*b*)	66. (*a*)
67. (*d*)	68. (*c*)	69. (*d*)	70. (*b*)	71. (*d*)	72. (*d*)
73. (*c*)	74. (*a*)	75. (*b*)	76. (*b*)	77. (*a*)	78. (*d*)
79. (*d*)	80. (*a*)	81. (*a*)	82. (*b*)	83. (*b*)	84. (*d*)
85. (*b*)	86. (*b*)	87. (*d*)	88. (*a*)	89. (*c*)	90. (*c*)
91. (*d*)	92. (*c*)	93. (*c*)	94. (*b*)	95. (*c*)	96. (*b*)
97. (*a*)	98. (*a*)	99. (*c*)	100. (*a*)		

ANSWER KEY: Chapter 4 – Genetics

Test Paper-I

1. (*d*)	2. (*b*)	3. (*b*)	4. (*d*)	5. (*c*)	6. (*b*)
7. (*a*)	8. (*b*)	9. (*c*)	10. (*c*)	11. (*d*)	12. (*c*)
13. (*c*)	14. (*d*)	15. (*c*)	16. (*b*)	17. (*c*)	18. (*c*)
19. (*a*)	20. (*c*)	21. (*b*)	22. (*d*)	23. (*c*)	24. (*d*)
25. (*d*)	26. (*a*)	27. (*c*)	28. (*a*)	29. (*d*)	30. (*a*)
31. (*b*)	32. (*b*)	33. (*b*)	34. (*d*)	35. (*b*)	36. (*a*)
37. (*b*)	38. (*b*)	39. (*d*)	40. (*c*)	41. (*a*)	42. (*d*)
43. (*a*)	44. (*a*)	45. (*d*)	46. (*b*)	47. (*b*)	48. (*d*)
49. (*d*)	50. (*a*)	51. (*c*)	52. (*c*)	53. (*c*)	54. (*b*)
55. (*c*)	56. (*c*)	57. (*c*)	58. (*c*)	59. (*a*)	60. (*c*)
61. (*d*)	62. (*a*)	63. (*b*)	64. (*c*)	65. (*c*)	66. (*d*)
67. (*b*)	68. (*d*)	69. (*c*)	70. (*c*)	71. (*b*)	72. (*d*)
73. (*d*)	74. (*c*)	75. (*b*)	76. (*a*)	77. (*b*)	78. (*c*)
79. (*c*)	80. (*d*)	81. (*c*)	82. (*c*)	83. (*c*)	84. (*c*)
85. (*d*)	86. (*b*)	87. (*a*)	88. (*d*)	89. (*a*)	90. (*a*)
91. (*b*)	92. (*a*)	93. (*b*)	94. (*b*)	95. (*d*)	96. (*a*)
97. (*b*)	98. (*b*)	99. (*a*)	100. (*c*)		

Test Paper-II

1. (*c*)	2. (*d*)	3. (*b*)	4. (*d*)	5. (*c*)	6. (*b*)
7. (*d*)	8. (*b*)	9. (*a*)	10. (*c*)	11. (*b*)	12. (*a*)
13. (*d*)	14. (*d*)	15. (*c*)	16. (*d*)	17. (*a*)	18. (*d*)
19. (*c*)	20. (*b*)	21. (*b*)	22. (*a*)	23. (*b*)	24. (*c*)
25. (*b*)	26. (*a*)	27. (*b*)	28. (*b*)	29. (*a*)	30. (*d*)
31. (*d*)	32. (*c*)	33. (*c*)	34. (*c*)	35. (*d*)	36. (*b*)
37. (*c*)	38. (*b*)	39. (*d*)	40. (*a*)	41. (*b*)	42. (*b*)
43. (*a*)	44. (*d*)	45. (*b*)	46. (*b*)	47. (*a*)	48. (*c*)
49. (*c*)	50. (*c*)	51. (*d*)	52. (*a*)	53. (*a*)	54. (*c*)
55. (*a*)	56. (*d*)	57. (*c*)	58. (*c*)	59. (*b*)	60. (*d*)
61. (*b*)	62. (*a*)	63. (*c*)	64. (*a*)	65. (*b*)	66. (*c*)
67. (*a*)	68. (*c*)	69. (*b*)	70. (*b*)	71. (*a*)	72. (*c*)
73. (*b*)	74. (*b*)	75. (*b*)	76. (*d*)	77. (*d*)	78. (*b*)
79. (*d*)	80. (*b*)	81. (*d*)	82. (*c*)	83. (*c*)	84. (*a*)
85. (*b*)	86. (*b*)	87. (*d*)	88. (*d*)	89. (*b*)	90. (*b*)
91. (*a*)	92. (*c*)	93. (*a*)	94. (*b*)	95. (*d*)	96. (*c*)
97. (*c*)	98. (*c*)	99. (*a*)	100. (*d*)		

ANSWER KEY: Chapter 5 – Evolution

Test Paper-I

1. (*d*)	2. (*b*)	3. (*b*)	4. (*d*)	5. (*a*)	6. (*c*)
7. (*a*)	8. (*a*)	9. (*c*)	10. (*b*)	11. (*b*)	12. (*b*)
13. (*a*)	14. (*a*)	15. (*d*)	16. (*c*)	17. (*d*)	18. (*b*)
19. (*c*)	20. (*a*)	21. (*d*)	22. (*c*)	23. (*b*)	24. (*a*)
25. (*d*)	26. (*b*)	27. (*d*)	28. (*c*)	29. (*d*)	30. (*d*)
31. (*d*)	32. (*b*)	33. (*b*)	34. (*d*)	35. (*a*)	36. (*c*)
37. (*d*)	38. (*a*)	39. (*b*)	40. (*b*)	41. (*d*)	42. (*c*)
43. (*a*)	44. (*d*)	45. (*a*)	46. (*b*)	47. (*b*)	48. (*b*)
49. (*b*)	50. (*b*)	51. (*d*)	52. (*d*)	53. (*b*)	54. (*b*)
55. (*d*)	56. (*c*)	57. (*d*)	58. (*b*)	59. (*a*)	60. (*d*)
61. (*a*)	62. (*b*)	63. (*d*)	64. (*a*)	65. (*a*)	66. (*b*)
67. (*b*)	68. (*a*)	69. (*b*)	70. (*d*)	71. (*a*)	72. (*a*)
73. (*c*)	74. (*c*)	75. (*c*)	76. (*c*)	77. (*a*)	78. (*b*)
79. (*c*)	80. (*b*)	81. (*a*)	82. (*d*)	83. (*a*)	84. (*b*)
85. (*a*)	86. (*a*)	87. (*a*)	88. (*b*)	89. (*b*)	90. (*b*)
91. (*c*)	92. (*b*)	93. (*a*)	94. (*a*)	95. (*b*)	96. (*c*)
97. (*b*)	98. (*a*)	99. (*c*)	100. (*b*)		

Test Paper-II

1. (*c*)	2. (*d*)	3. (*b*)	4. (*b*)	5. (*a*)	6. (*a*)
7. (*c*)	8. (*d*)	9. (*b*)	10. (*c*)	11. (*a*)	12. (*c*)
13. (*a*)	14. (*b*)	15. (*c*)	16. (*a*)	17. (*a*)	18. (*b*)
19. (*a*)	20. (*b*)	21. (*d*)	22. (*d*)	23. (*c*)	24. (*d*)
25. (*b*)	26. (*b*)	27. (*b*)	28. (*a*)	29. (*c*)	30. (*a*)
31. (*d*)	32. (*b*)	33. (*a*)	34. (*a*)	35. (*b*)	36. (*b*)
37. (*a*)	38. (*c*)	39. (*b*)	40. (*b*)	41. (*a*)	42. (*c*)
43. (*a*)	44. (*c*)	45. (*b*)	46. (*b*)	47. (*c*)	48. (*b*)
49. (*d*)	50. (*a*)	51. (*c*)	52. (*b*)	53. (*d*)	54. (*a*)
55. (*b*)	56. (*a*)	57. (*c*)	58. (*b*)	59. (*c*)	60. (*d*)
61. (*d*)	62. (*d*)	63. (*c*)	64. (*a*)	65. (*a*)	66. (*c*)
67. (*b*)	68. (*b*)	69. (*b*)	70. (*c*)	71. (*b*)	72. (*b*)
73. (*c*)	74. (*d*)	75. (*b*)	76. (*b*)	77. (*d*)	78. (*c*)
79. (*c*)	80. (*c*)	81. (*d*)	82. (*b*)	83. (*d*)	84. (*c*)
85. (*c*)	86. (*a*)	87. (*c*)	88. (*b*)	89. (*c*)	90. (*c*)
91. (*a*)	92. (*d*)	93. (*b*)	94. (*a*)	95. (*b*)	96. (*b*)
97. (*b*)	98. (*d*)	99. (*d*)	100. (*a*)		

ANSWER KEY: Chapte 6 – Environment Biology

Test Paper-I

1. (*d*)	2. (*d*)	3. (*a*)	4. (*b*)	5. (*b*)	6. (*b*)
7. (*a*)	8. (*b*)	9. (*a*)	10. (*a*)	11. (*c*)	12. (*d*)
13. (*b*)	14. (*a*)	15. (*c*)	16. (*b*)	17. (*c*)	18. (*d*)
19. (*a*)	20. (*b*)	21. (*c*)	22. (*c*)	23. (*c*)	24. (*b*)
25. (*c*)	26. (*b*)	27. (*d*)	28. (*a*)	29. (*a*)	30. (*c*)
31. (*d*)	32. (*d*)	33. (*d*)	34. (*a*)	35. (*c*)	36. (*a*)
37. (*a*)	38. (*d*)	39. (*a*)	40. (*a*)	41. (*c*)	42. (*a*)
43. (*b*)	44. (*c*)	45. (*d*)	46. (*b*)	47. (*a*)	48. (*b*)
49. (*c*)	50. (*b*)	51. (*b*)	52. (*c*)	53. (*d*)	54. (*b*)
55. (*c*)	56. (*d*)	57. (*a*)	58. (*c*)	59. (*d*)	60. (*c*)
61. (*c*)	62. (*b*)	63. (*a*)	64. (*d*)	65. (*d*)	66. (*d*)
67. (*d*)	68. (*d*)	69. (*d*)	70. (*c*)	71. (*b*)	72. (*b*)
73. (*d*)	74. (*d*)	75. (*d*)	76. (*d*)	77. (*c*)	78. (*b*)
79. (*b*)	80. (*d*)	81. (*c*)	82. (*c*)	83. (*c*)	84. (*b*)
85. (*a*)	86. (*d*)	87. (*a*)	88. (*d*)	89. (*c*)	90. (*d*)
91. (*d*)	92. (*b*)	93. (*d*)	94. (*b*)	95. (*d*)	96. (*d*)
97. (*a*)	98. (*a*)	99. (*c*)	100. (*b*)		

Test Paper-II

1. (*c*)	2. (*c*)	3. (*b*)	4. (*b*)	5. (*a*)	6. (*b*)
7. (*a*)	8. (*a*)	9. (*d*)	10. (*d*)	11. (*c*)	12. (*a*)
13. (*c*)	14. (*a*)	15. (*c*)	16. (*a*)	17. (*a*)	18. (*b*)
19. (*b*)	20. (*b*)	21. (*c*)	22. (*a*)	23. (*a*)	24. (*c*)
25. (*a*)	26. (*b*)	27. (*d*)	28. (*c*)	29. (*d*)	30. (*a*)
31. (*d*)	32. (*d*)	33. (*d*)	34. (*c*)	35. (*c*)	36. (*b*)
37. (*b*)	38. (*c*)	39. (*c*)	40. (*a*)	41. (*b*)	42. (*a*)
43. (*c*)	44. (*c*)	45. (*c*)	46. (*d*)	47. (*a*)	48. (*a*)
49. (*c*)	50. (*a*)	51. (*c*)	52. (*a*)	53. (*c*)	54. (*c*)
55. (*a*)	56. (*d*)	57. (*a*)	58. (*d*)	59. (*a*)	60. (*b*)
61. (*a*)	62. (*a*)	63. (*d*)	64. (*d*)	65. (*a*)	66. (*c*)
67. (*a*)	68. (*b*)	69. (*b*)	70. (*a*)	71. (*a*)	72. (*a*)
73. (*c*)	74. (*d*)	75. (*a*)	76. (*c*)	77. (*b*)	78. (*b*)
79. (*c*)	80. (*b*)	81. (*c*)	82. (*b*)	83. (*a*)	84. (*d*)
85. (*a*)	86. (*c*)	87. (*d*)	88. (*c*)	89. (*b*)	90. (*c*)
91. (*c*)	92. (*d*)	93. (*d*)	94. (*c*)	95. (*b*)	96. (*d*)
97. (*c*)	98. (*d*)	99. (*c*)	100. (*a*)		

ANSWER KEY: Chapter 7 – Biodiversity

Test Paper- I

1. (*b*)	2. (*b*)	3. (*d*)	4. (*d*)	5. (*c*)	6. (*d*)
7. (*d*)	8. (*d*)	9. (*b*)	10. (*d*)	11. (*a*)	12. (*a*)
13. (*d*)	14. (*d*)	15. (*d*)	16. (*a*)	17. (*a*)	18. (*b*)
19. (*c*)	20. (*d*)	21. (*a*)	22. (*d*)	23. (*a*)	24. (*d*)
25. (*a*)	26. (*a*)	27. (*a*)	28. (*d*)	29. (*a*)	30. (*c*)
31. (*d*)	32. (*a*)	33. (*a*)	34. (*c*)	35. (*a*)	36. (*b*)
37. (*d*)	38. (*b*)	39. (*b*)	40. (*c*)	41. (*c*)	42. (*b*)
43. (*b*)	44. (*d*)	45. (*b*)	46. (*d*)	47. (*d*)	48. (*b*)
49. (*b*)	50. (*d*)	51. (*c*)	52. (*a*)	53. (*d*)	54. (*a*)
55. (*c*)	56. (*d*)	57. (*a*)	58. (*a*)	59. (*a*)	60. (*a*)
61. (*b*)	62. (*c*)	63. (*a*)	64. (*a*)	65. (*a*)	66. (*b*)
67. (*a*)	68. (*d*)	69. (*a*)	70. (*b*)	71. (*d*)	72. (*b*)
73. (*d*)	74. (*d*)	75. (*c*)	76. (*d*)	77. (*d*)	78. (*c*)
79. (*d*)	80. (*a*)	81. (*a*)	82. (*d*)	83. (*a*)	84. (*b*)
85. (*a*)	86. (*d*)	87. (*b*)	88. (*b*)	89. (*b*)	90. (*c*)
91. (*d*)	92. (*b*)	93. (*d*)	94. (*d*)	95. (*d*)	96. (*a*)
97. (*c*)	98. (*d*)	99. (*c*)	100. (*a*)		

Test Paper-II

1. (*b*)	2. (*b*)	3. (*b*)	4. (*b*)	5. (*a*)	6. (*c*)
7. (*b*)	8. (*b*)	9. (*d*)	10. (*b*)	11. (*b*)	12. (*d*)
13. (*d*)	14. (*d*)	15. (*b*)	16. (*c*)	17. (*b*)	18. (*d*)
19. (*d*)	20. (*b*)	21. (*a*)	22. (*d*)	23. (*a*)	24. (*c*)
25. (*c*)	26. (*d*)	27. (*b*)	28. (*a*)	29. (*b*)	30. (*b*)
31. (*a*)	32. (*d*)	33. (*b*)	34. (*b*)	35. (*c*)	36. (*b*)
37. (*b*)	38. (*b*)	39. (*b*)	40. (*b*)	41. (*d*)	42. (*a*)
43. (*b*)	44. (*b*)	45. (*a*)	46. (*d*)	47. (*c*)	48. (*a*)
49. (*c*)	50. (*a*)	51. (*c*)	52. (*d*)	53. (*c*)	54. (*d*)
55. (*b*)	56. (*c*)	57. (*a*)	58. (*b*)	59. (*a*)	60. (*c*)
61. (*a*)	62. (*b*)	63. (*c*)	64. (*b*)	65. (*d*)	66. (*a*)
67. (*b*)	68. (*d*)	69. (*b*)	70. (*a*)	71. (*d*)	72. (*a*)
73. (*d*)	74. (*a*)	75. (*d*)	76. (*d*)	77. (*a*)	78. (*b*)
79. (*d*)	80. (*a*)	81. (*d*)	82. (*a*)	83. (*c*)	84. (*a*)
85. (*a*)	86. (*b*)	87. (*d*)	88. (*a*)	89. (*c*)	90. (*a*)
91. (*d*)	92. (*d*)	93. (*d*)	94. (*d*)	95. (*b*)	96. (*a*)
97. (*a*)	98. (*c*)	99. (*d*)	100. (*a*)		

ANSWER KEY: Model Test Paper – 1

Part – A

1. (*b*)	2. (*b*)	3. (*b*)	4. (*c*)
5. (*a*)	6. (*a*)	7. (*d*)	8. (*a*)
9. (*b*)	10. (*d*)	11. (*a*)	12. (*d*)
13. (*d*)	14. (*a*)	15. (*c*)	16. (*a*)
17. (*d*)	18. (*c*)	19. (*a*)	20. (*d*)
21. (*d*)	22. (*c*)	23. (*a*)	24. (*b*)
25. (*a*)	26. (*c*)	27. (*c*)	28. (*b*)
29. (*b*)	30. (*b*)		

Part – B

1. (*d*)	2. (*c*)	3. (*a*)	4. (*b*)
5. (*c*)	6. (*c*)	7. (*d*)	8. (*a*)
9. (*c*)	10. (*b*)	11. (*a*)	12. (*d*)
13. (*b*)	14. (*c*)	15. (*b*)	16. (*a*)
17. (*c*)	18. (*c*)	19. (*c*)	20. (*b*)
21. (*c*)	22. (*b*)	23. (*b*)	24. (*a*)
25. (*a*)	26. (*b*)	27. (*a*)	28. (*d*)
29. (*d*)	30. (*d*)	31. (*b*)	32. (*c*)
33. (*d*)	34. (*b*)	35. (*d*)	36. (*a*)
37. (*a*)	38. (*a*)	39. (*a*)	40. (*a*)
41. (*a*)	42. (*a*)	43. (*c*)	44. (*c*)
45. (*c*)	46. (*d*)	47. (*d*)	48. (*c*)
49. (*a*)	50. (*b*)	51. (*a*)	52. (*c*)
53. (*b*)	54. (*b*)	55. (*c*)	56. (*b*)
57. (*d*)	58. (*c*)	59. (*a*)	60. (*d*)
61. (*a*)	62. (*c*)	63. (*b*)	64. (*c*)
65. (*b*)	66. (*c*)	67. (*a*)	68. (*c*)
69. (*b*)	70. (*b*)		

ANSWER KEY: Model Test Paper – 2

PART – A

1. (*d*)	2. (*b*)	3. (*d*)	4. (*b*)
5. (*d*)	6. (*c*)	7. (*c*)	8. (*c*)
9. (*b*)	10. (*c*)	11. (*d*)	12. (*b*)
13. (*c*)	14. (*a*)	15. (*d*)	16. (*b*)
17. (*d*)	18. (*a*)	19. (*a*)	20. (*a*)
21. (*a*)	22. (*c*)	23. (*b*)	24. (*d*)
25. (*a*)	26. (*d*)	27. (*c*)	28. (*c*)
29. (*c*)	30. (*a*)		

Part – B

1. (*a*)	2. (*d*)	3. (*b*)	4. (*a*)
5. (*d*)	6. (*d*)	7. (*c*)	8. (*c*)
9. (*b*)	10. (*a*)	11. (*a*)	12. (*b*)
13. (*c*)	14. (*c*)	15. (*a*)	16. (*a*)
17. (*c*)	18. (*c*)	19. (*b*)	20. (*d*)
21. (*c*)	22. (*c*)	23. (*b*)	24. (*b*)
25. (*c*)	26. (*b*)	27. (*d*)	28. (*b*)
29. (*a*)	30. (*a*)	31. (*a*)	32. (*a*)
33. (*c*)	34. (*b*)	35. (*a*)	36. (*a*)
37. (*c*)	38. (*b*)	39. (*c*)	40. (*b*)
41. (*b*)	42. (*d*)	43. (*c*)	44. (*a*)
45. (*a*)	46. (*b*)	47. (*b*)	48. (*b*)
49. (*d*)	50. (*c*)	51. (*b*)	52. (*a*)
53. (*d*)	54. (*b*)	55. (*b*)	56. (*b*)
57. (*c*)	58. (*a*)	59. (*b*)	60. (*d*)
61. (*c*)	62. (*c*)	63. (*a*)	64. (*c*)
65. (*c*)	66. (*c*)	67. (*b*)	68. (*c*)
69. (*c*)	70. (*a*)		

ANSWER KEY: Model Test Paper – 3

Part – A

1. (*c*)	2. (*a*)	3. (*b*)	4. (*b*)
5. (*b*)	6. (*d*)	7. (*b*)	8. (*b*)
9. (*b*)	10. (*c*)	11. (*a*)	12. (*c*)
13. (*a*)	14. (*c*)	15. (*c*)	16. (*d*)
17. (*c*)	18. (*d*)	19. (*c*)	20. (*b*)
21. (*a*)	22. (*a*)	23. (*d*)	24. (*a*)
25. (*a*)	26. (*b*)	27. (*d*)	28. (*c*)
29. (*d*)	30. (*c*)		

Part – B

1. (*d*)	2. (*b*)	3. (*d*)	4. (*c*)
5. (*b*)	6. (*d*)	7. (*a*)	8. (*d*)
9. (*a*)	10. (*a*)	11. (*d*)	12. (*c*)
13. (*c*)	14. (*b*)	15. (*d*)	16. (*b*)
17. (*b*)	18. (*c*)	19. (*c*)	20. (*d*)
21. (*d*)	22. (*d*)	23. (*c*)	24. (*b*)
25. (*c*)	26. (*b*)	27. (*a*)	28. (*b*)
29. (*a*)	30. (*d*)	31. (*c*)	32. (*b*)
33. (*a*)	34. (*a*)	35. (*c*)	36. (*a*)
37. (*d*)	38. (*c*)	39. (*c*)	40. (*b*)
41. (*a*)	42. (*b*)	43. (*b*)	44. (*d*)
45. (*c*)	46. (*c*)	47. (*c*)	48. (*c*)
49. (*c*)	50. (*a*)	51. (*c*)	52. (*a*)
53. (*d*)	54. (*c*)	55. (*d*)	56. (*d*)
57. (*d*)	58. (*a*)	59. (*b*)	60. (*a*)
61. (*d*)	62. (*b*)	63. (*d*)	64. (*d*)
65. (*a*)	66. (*c*)	67. (*c*)	68. (*d*)
69. (*d*)	70. (*c*)		

ANSWER KEY: Model Test Paper – 4

PART – A

1. (*c*)	2. (*b*)	3. (*d*)	4. (*c*)
5. (*a*)	6. (*b*)	7. (*b*)	8. (*c*)
9. (*c*)	10. (*b*)	11. (*b*)	12. (*b*)
13. (*b*)	14. (*a*)	15. (*c*)	16. (*b*)
17. (*c*)	18. (*d*)	19. (*d*)	20. (*b*)
21. (*b*)	22. (*c*)	23. (*a*)	24. (*b*)
25. (*b*)	26. (*d*)	27. (*a*)	28. (*d*)
29. (*c*)	30. (*c*)		

Part – B

1. (*b*)	2. (*d*)	3. (*b*)	4. (*b*)
5. (*d*)	6. (*b*)	7. (*b*)	8. (*b*)
9. (*c*)	10. (*b*)	11. (*d*)	12. (*c*)
13. (*a*)	14. (*c*)	15. (*b*)	16. (*a*)
17. (*a*)	18. (*a*)	19. (*c*)	20. (*d*)
21. (*c*)	22. (*b*)	23. (*c*)	24. (*b*)
25. (*c*)	26. (*d*)	27. (*a*)	28. (*c*)
29. (*a*)	30. (*c*)	31. (*c*)	32. (*c*)
33. (*b*)	34. (*a*)	35. (*d*)	36. (*c*)
37. (*a*)	38. (*c*)	39. (*b*)	40. (*a*)
41. (*b*)	42. (*c*)	43. (*d*)	44. (*a*)
45. (*c*)	46. (*b*)	47. (*c*)	48. (*a*)
49. (*a*)	50. (*a*)	51. (*b*)	52. (*a*)
53. (*d*)	54. (*c*)	55. (*b*)	56. (*b*)
57. (*a*)	58. (*d*)	59. (*a*)	60. (*c*)
61. (*d*)	62. (*b*)	63. (*b*)	64. (*a*)
65. (*b*)	66. (*c*)	67. (*d*)	68. (*a*)
69. (*b*)	70. (*b*)		

ANSWER KEY: Model Test Paper – 5

Part – A

1. (*d*)	2. (*c*)	3. (*b*)	4. (*b*)
5. (*a*)	6. (*b*)	7. (*a*)	8. (*d*)
9. (*a*)	10. (*b*)	11. (*d*)	12. (*b*)
13. (*a*)	14. (*a*)	15. (*d*)	16. (*b*)
17. (*a*)	18. (*b*)	19. (*a*)	20. (*c*)
21. (*c*)	22. (*d*)	23. (*a*)	24. (*c*)
25. (*a*)	26. (*b*)	27. (*a*)	28. (*a*)
29. (*c*)	30. (*b*)		

Part – B

1. (*d*)	2. (*a*)	3. (*d*)	4. (*b*)
5. (*a*)	6. (*a*)	7. (*c*)	8. (*a*)
9. (*a*)	10. (*d*)	11. (*d*)	12. (*a*)
13. (*a*)	14. (*b*)	15. (*c*)	16. (*d*)
17. (*d*)	18. (*b*)	19. (*a*)	20. (*d*)
21. (*a*)	22. (*c*)	23. (*d*)	24. (*a*)
25. (*d*)	26. (*c*)	27. (*a*)	28. (*d*)
29. (*b*)	30. (*a*)	31. (*a*)	32. (*c*)
33. (*b*)	34. (*b*)	35. (*d*)	36. (*a*)
37. (*c*)	38. (*c*)	39. (*a*)	40. (*a*)
41. (*a*)	42. (*a*)	43. (*c*)	44. (*a*)
45. (*d*)	46. (*b*)	47. (*a*)	48. (*c*)
49. (*d*)	50. (*d*)	51. (*a*)	52. (*a*)
53. (*a*)	54. (*b*)	55. (*a*)	56. (*b*)
57. (*d*)	58. (*c*)	59. (*a*)	60. (*c*)
61. (*a*)	62. (*b*)	63. (*b*)	64. (*d*)
65. (*b*)	66. (*d*)	67. (*d*)	68. (*c*)
69. (*b*)	70. (*a*)		

ANSWER KEY: Model Test Paper – 6

Part – A

1. (*b*)	2. (*c*)	3. (*c*)	4. (*d*)
5. (*b*)	6. (*b*)	7. (*d*)	8. (*a*)
9. (*d*)	10. (*b*)	11. (*c*)	12. (*d*)
13. (*a*)	14. (*c*)	15. (*b*)	16. (*a*)
17. (*b*)	18. (*a*)	19. (*c*)	20. (*a*)
21. (*c*)	22. (*c*)	23. (*c*)	24. (*c*)
25. (*a*)	26. (*b*)	27. (*b*)	28. (*a*)
29. (*d*)	30. (*d*)		

Part – B

1. (*a*)	2. (*d*)	3. (*c*)	4. (*c*)
5. (*b*)	6. (*d*)	7. (*b*)	8. (*c*)
9. (*a*)	10. (*a*)	11. (*c*)	12. (*c*)
13. (*c*)	14. (*c*)	15. (*d*)	16. (*d*)
17. (*b*)	18. (*b*)	19. (*b*)	20. (*b*)
21. (*a*)	22. (*c*)	23. (*c*)	24. (*a*)
25. (*d*)	26. (*a*)	27. (*b*)	28. (*a*)
29. (*c*)	30. (*d*)	31. (*a*)	32. (*c*)
33. (*b*)	34. (*a*)	35. (*a*)	36. (*c*)
37. (*b*)	38. (*a*)	39. (*a*)	40. (*a*)
41. (*b*)	42. (*a*)	43. (*a*)	44. (*a*)
45. (*a*)	46. (*d*)	47. (*b*)	48. (*c*)
49. (*d*)	50. (*c*)	51. (*a*)	52. (*a*)
53. (*b*)	54. (*b*)	55. (*d*)	56. (*c*)
57. (*c*)	58. (*a*)	59. (*c*)	60. (*b*)
61. (*c*)	62. (*c*)	63. (*d*)	64. (*a*)
65. (*c*)	66. (*b*)	67. (*c*)	68. (*b*)
69. (*a*)	70. (*a*)		

ANSWER KEY: Model Test Paper – 7

Part – A

1. (*b*)	2. (*a*)	3. (*a*)	4. (*b*)
5. (*c*)	6. (*d*)	7. (*b*)	8. (*b*)
9. (*b*)	10. (*c*)	11. (*a*)	12. (*c*)
13. (*a*)	14. (*b*)	15. (*a*)	16. (*c*)
17. (*a*)	18. (*a*)	19. (*a*)	20. (*a*)
21. (*d*)	22. (*a*)	23. (*a*)	24. (*c*)
25. (*c*)	26. (*d*)	27. (*b*)	28. (*d*)
29. (*d*)	30. (*c*)		

Part – B

1. (*b*)	2. (*d*)	3. (*d*)	4. (*d*)
5. (*b*)	6. (*a*)	7. (*c*)	8. (*b*)
9. (*d*)	10. (*b*)	11. (*a*)	12. (*a*)
13. (*b*)	14. (*b*)	15. (*c*)	16. (*d*)
17. (*c*)	18. (*b*)	19. (*c*)	20. (*d*)
21. (*a*)	22. (*c*)	23. (*b*)	24. (*a*)
25. (*a*)	26. (*c*)	27. (*b*)	28. (*b*)
29. (*d*)	30. (*c*)	31. (*c*)	32. (*d*)
33. (*b*)	34. (*b*)	35. (*a*)	36. (*b*)
37. (*c*)	38. (*c*)	39. (*c*)	40. (*b*)
41. (*a*)	42. (*c*)	43. (*b*)	44. (*d*)
45. (*b*)	46. (*b*)	47. (*a*)	48. (*c*)
49. (*c*)	50. (*c*)	51. (*d*)	52. (*c*)
53. (*c*)	54. (*b*)	55. (*b*)	56. (*c*)
57. (*d*)	58. (*a*)	59. (*d*)	60. (*b*)
61. (*d*)	62. (*c*)	63. (*b*)	64. (*a*)
65. (*d*)	66. (*a*)	67. (*c*)	68. (*c*)
69. (*a*)	70. (*b*)		

ANSWER KEY: Model Test Paper – 8

Part – A

1. (*a*)	2. (*b*)	3. (*a*)	4. (*c*)
5. (*c*)	6. (*c*)	7. (*a*)	8. (*a*)
9. (*b*)	10. (*b*)	11. (*c*)	12. (*b*)
13. (*c*)	14. (*d*)	15. (*a*)	16. (*c*)
17. (*c*)	18. (*d*)	19. (*c*)	20. (*c*)
21. (*c*)	22. (*a*)	23. (*c*)	24. (*c*)
25. (*b*)	26. (*a*)	27. (*a*)	28. (*b*)
29. (*b*)	30. (*d*)		

Part – B

1. (*c*)	2. (*d*)	3. (*a*)	4. (*c*)
5. (*a*)	6. (*a*)	7. (*c*)	8. (*b*)
9. (*b*)	10. (*b*)	11. (*c*)	12. (*b*)
13. (*c*)	14. (*c*)	15. (*c*)	16. (*d*)
17. (*d*)	18. (*b*)	19. (*d*)	20. (*d*)
21. (*c*)	22. (*b*)	23. (*c*)	24. (*a*)
25. (*c*)	26. (*d*)	27. (*d*)	28. (*a*)
29. (*d*)	30. (*a*)	31. (*c*)	32. (*d*)
33. (*c*)	34. (*a*)	35. (*b*)	36. (*d*)
37. (*a*)	38. (*d*)	39. (*d*)	40. (*d*)
41. (*a*)	42. (*c*)	43. (*d*)	44. (*a*)
45. (*b*)	46. (*c*)	47. (*d*)	48. (*c*)
49. (*c*)	50. (*c*)	51. (*b*)	52. (*a*)
53. (*a*)	54. (*a*)	55. (*a*)	56. (*d*)
57. (*d*)	58. (*b*)	59. (*c*)	60. (*c*)
61. (*a*)	62. (*a*)	63. (*b*)	64. (*c*)
65. (*b*)	66. (*a*)	67. (*a*)	68. (*c*)
69. (*a*)	70. (*c*)		

ANSWER KEY: Model Test Paper – 9

Part – A

1. (*b*)	2. (*c*)	3. (*b*)	4. (*d*)
5. (*a*)	6. (*b*)	7. (*a*)	8. (*d*)
9. (*b*)	10. (*d*)	11. (*b*)	12. (*d*)
13. (*b*)	14. (*a*)	15. (*b*)	16. (*b*)
17. (*b*)	18. (*a*)	19. (*c*)	20. (*a*)
21. (*b*)	22. (*a*)	23. (*a*)	24. (*c*)
25. (*d*)	26. (*a*)	27. (*c*)	28. (*a*)
29. (*a*)	30. (*d*)		

Part – B

1. (*b*)	2. (*d*)	3. (*b*)	4. (*b*)
5. (*d*)	6. (*c*)	7. (*b*)	8. (*b*)
9. (*b*)	10. (*a*)	11. (*c*)	12. (*d*)
13. (*b*)	14. (*d*)	15. (*c*)	16. (*a*)
17. (*a*)	18. (*b*)	19. (*b*)	20. (*b*)
21. (*c*)	22. (*b*)	23. (*d*)	24. (*b*)
25. (*d*)	26. (*c*)	27. (*d*)	28. (*b*)
29. (*b*)	30. (*a*)	31. (*c*)	32. (*c*)
33. (*a*)	34. (*a*)	35. (*d*)	36. (*a*)
37. (*a*)	38. (*c*)	39. (*b*)	40. (*b*)
41. (*c*)	42. (*c*)	43. (*a*)	44. (*d*)
45. (*b*)	46. (*c*)	47. (*b*)	48. (*c*)
49. (*b*)	50. (*c*)	51. (*c*)	52. (*b*)
53. (*a*)	54. (*c*)	55. (*b*)	56. (*d*)
57. (*d*)	58. (*c*)	59. (*b*)	60. (*c*)
61. (*d*)	62. (*c*)	63. (*a*)	64. (*a*)
65. (*a*)	66. (*c*)	67. (*a*)	68. (*c*)
69. (*a*)	70. (*a*)		

ANSWER KEY: Model Test Paper – 10

PART – A

1. (*b*)	2. (*a*)	3. (*b*)	4. (*d*)
5. (*c*)	6. (*a*)	7. (*d*)	8. (*b*)
9. (*b*)	10. (*d*)	11. (*d*)	12. (*a*)
13. (*b*)	14. (*d*)	15. (*d*)	16. (*c*)
17. (*b*)	18. (*a*)	19. (*a*)	20. (*a*)
21. (*a*)	22. (*b*)	23. (*a*)	24. (*c*)
25. (*c*)	26. (*a*)	27. (*c*)	28. (*d*)
29. (*d*)	30. (*c*)		

Part – B

1. (*c*)	2. (*c*)	3. (*a*)	4. (*c*)
5. (*c*)	6. (*a*)	7. (*c*)	8. (*d*)
9. (*c*)	10. (*c*)	11. (*b*)	12. (*b*)
13. (*b*)	14. (*a*)	15. (*d*)	16. (*a*)
17. (*c*)	18. (*d*)	19. (*c*)	20. (*a*)
21. (*c*)	22. (*d*)	23. (*a*)	24. (*a*)
25. (*a*)	26. (*b*)	27. (*b*)	28. (*b*)
29. (*b*)	30. (*d*)	31. (*c*)	32. (*c*)
33. (*d*)	34. (*c*)	35. (*c*)	36. (*d*)
37. (*c*)	38. (*a*)	39. (*a*)	40. (*a*)
41. (*c*)	42. (*a*)	43. (*d*)	44. (*c*)
45. (*a*)	46. (*c*)	47. (*b*)	48. (*a*)
49. (*d*)	50. (*d*)	51. (*d*)	52. (*c*)
53. (*c*)	54. (*c*)	55. (*b*)	56. (*b*)
57. (*c*)	58. (*b*)	59. (*c*)	60. (*a*)
61. (*d*)	62. (*c*)	63. (*b*)	64. (*d*)
65. (*a*)	66. (*a*)	67. (*a*)	68. (*d*)
69. (*a*)	70. (*a*)		

ANSWER KEY: CSIR UGC NET, Dec., 2003

PART – A

1. (*a*)	2. (*b*)	3. (*b*)	4. (*b*)
5. (*a*)	6. (*a*)	7. (*d*)	8. (*a*)
9. (*b*)	10. (*a*)	11. (*a*)	12. (*b*)
13. (*d*)	14. (*a*)	15. (*c*)	16. (*a*)
17. (*d*)	18. (*c*)	19. (*a*)	20. (*b*)
21. (*d*)	22. (*c*)	23. (*a*)	24. (*b*)
25. (*a*)	26. (*c*)	27. (*d*)	28. (*b*)
29. (*b*)	30. (*c*)		

Part – B

1. (*d*)	2. (*c*)	3. (*a*)	4. (*d*)
5. (*c*)	6. (*c*)	7. (*d*)	8. (*a*)
9. (*c*)	10. (*b*)	11. (*a*)	12. (*d*)
13. (*b*)	14. (*c*)	15. (*a*)	16. (*c*)
17. (*b*)	18. (*a*)	19. (*c*)	20. (*c*)
21. (*c*)	22. (*b*)	23. (*b*)	24. (*c*)
25. (*c*)	26. (*c*)	27. (*b*)	28. (*c*)
29. (*c*)	30. (*a*)	31. (*c*)	32. (*c*)
33. (*b*)	34. (*a*)	35. (*a*)	36. (*a*)
37. (*b*)	38. (*c*)	39. (*a*)	40. (*b*)
41. (*b*)	42. (*a*)	43. (*d*)	44. (*a*)
45. (*c*)	46. (*c*)	47. (*d*)	48. (*c*)
49. (*c*)	50. (*b*)	51. (*b*)	52. (*a*)
53. (*b*)	54. (*a*)	55. (*b*)	56. (*c*)
57. (*a*)	58. (*b*)	59. (*a*)	60. (*a*)
61. (*a*)	62. (*b*)	63. (*c*)	64. (*a*)
65. (*a*)	66. (*b*)	67. (*c*)	68. (*a*)
69. (*d*)	70. (*d*)		

ANSWER KEY: CSIR UGC NET, June, 2004

PART – A

1. (*c*)	2. (*c*)	3. (*b*)	4. (*d*)
5. (*c*)	6. (*c*)	7. (*b*)	8. (*b*)
9. (*c*)	10. (*a*)	11. (*b*)	12. (*c*)
13. (*b*)	14. (*b*)	15. (*c*)	16. (*d*)
17. (*b*)	18. (*d*)	19. (*a*)	20. (*b*)
21. (*d*)	22. (*c*)	23. (*d*)	24. (*b*)
25. (*a*)	26. (*a*)	27. (*a*)	28. (*b*)
29. (*a*)	30. (*c*)		

Part – B

1. (*b*)	2. (*b*)	3. (*a*)	4. (*d*)
5. (*a*)	6. (*b*)	7. (*b*)	8. (*c*)
9. (*a*)	10. (*d*)	11. (*d*)	12. (*d*)
13. (*a*)	14. (*a*)	15. (*b*)	16. (*c*)
17. (*b*)	18. (*c*)	19. (*b*)	20. (*a*)
21. (*b*)	22. (*b*)	23. (*c*)	24. (*a*)
25. (*a*)	26. (*c*)	27. (*c*)	28. (*b*)
29. (*b*)	30. (*b*)	31. (*a*)	32. (*a*)
33. (*b*)	34. (*b*)	35. (*a*)	36. (*a*)
37. (*c*)	38. (*a*)	39. (*b*)	40. (*d*)
41. (*a*)	42. (*a*)	43. (*a*)	44. (*a*)
45. (*c*)	46. (*a*)	47. (*a*)	48. (*b*)
49. (*b*)	50. (*b*)	51. (*d*)	52. (*a*)
53. (*a*)	54. (*b*)	55. (*d*)	56. (*a*)
57. (*b*)	58. (*a*)	59. (*c*)	60. (*c*)
61. (*b*)	62. (*a*)	63. (*a*)	64. (*a*)
65. (*d*)	66. (*a*)	67. (*a*)	68. (*a*)
69. (*a*)	70. (*d*)		

ANSWER KEY: CSIR UGC NET, Dec., 2004

PART – A

1. (*b*)	2. (*b*)	3. (*c*)	4. (*b*)
5. (*a*)	6. (*a*)	7. (*b*)	8. (*c*)
9. (*a*)	10. (*a*)	11. (*c*)	12. (*c*)
13. (*a*)	14. (*d*)	15. (*a*)	16. (*a*)
17. (*c*)	18. (*a*)	19. (*b*)	20. (*b*)
21. (*c*)	22. (*c*)	23. (*a*)	24. (*d*)
25. (*c*)	26. (*c*)	27. (*a*)	28. (*d*)
29. (*b*)	30. (*d*)		

Part – B

1. (*c*)	2. (*b*)	3. (*b*)	4. (*c*)
5. (*b*)	6. (*a*)	7. (*c*)	8. (*a*)
9. (*b*)	10. (*d*)	11. (*b*)	12. (*a*)
13. (*b*)	14. (*b*)	15. (*a*)	16. (*c*)
17. (*b*)	18. (*a*)	19. (*a*)	20. (*b*)
21. (*a*)	22. (*a*)	23. (*c*)	24. (*c*)
25. (*a*)	26. (*a*)	27. (*a*)	28. (*a*)
29. (*b*)	30. (*a*)	31. (*a*)	32. (*c*)
33. (*d*)	34. (*a*)	35. (*b*)	36. (*a*)
37. (*c*)	38. (*b*)	39. (*b*)	40. (*a*)
41. (*b*)	42. (*c*)	43. (*b*)	44. (*b*)
45. (*b*)	46. (*c*)	47. (*b*)	48. (*a*)
49. (*a*)	50. (*b*)	51. (*a*)	52. (*c*)
53. (*a*)	54. (*c*)	55. (*c*)	56. (*b*)
57. (*c*)	58. (*b*)	59. (*b*)	60. (*a*)
61. (*b*)	62. (*c*)	63. (*c*)	64. (*a*)
65. (*b*)	66. (*b*)	67. (*a*)	68. (*b*)
69. (*d*)	70. (*c*)		

ANSWER KEY: CSIR UGC NET, June, 2005

PART – A

1. (*a*)	2. (*d*)	3. (*b*)	4. (*c*)
5. (*b*)	6. (*b*)	7. (*a*)	8. (*a*)
9. (*a*)	10. (*d*)	11. (*d*)	12. (*c*)
13. (*b*)	14. (*c*)	15. (*a*)	16. (*a*)
17. (*d*)	18. (*d*)	19. (*a*)	20. (*c*)
21. (*c*)	22. (*a*)	23. (*a*)	24. (*b*)
25. (*a*)	26. (*a*)	27. (*d*)	28. (*c*)
29. (*b*)	30. (*a*)		

Part – B

1. (*b*)	2. (*c*)	3. (*d*)	4. (*a*)
5. (*c*)	6. (*d*)	7. (*c*)	8. (*a*)
9. (*a*)	10. (*c*)	11. (*b*)	12. (*d*)
13. (*b*)	14. (*c*)	15. (*d*)	16. (*a*)
17. (*b*)	18. (*b*)	19. (*a*)	20. (*a*)
21. (*b*)	22. (*c*)	23. (*b*)	24. (*d*)
25. (*c*)	26. (*b*)	27. (*a*)	28. (*b*)
29. (*b*)	30. (*c*)	31. (*b*)	32. (*b*)
33. (*a*)	34. (*c*)	35. (*c*)	36. (*c*)
37. (*b*)	38. (*a*)	39. (*a*)	40. (*b*)
41. (*c*)	42. (*a*)	43. (*c*)	44. (*a*)
45. (*a*)	46. (*a*)	47. (*c*)	48. (*b*)
49. (*b*)	50. (*b*)	51. (*a*)	52. (*b*)
53. (*c*)	54. (*c*)	55. (*a*)	56. (*b*)
57. (*b*)	58. (*b*)	59. (*b*)	60. (*b*)
61. (*b*)	62. (*b*)	63. (*a*)	64. (*a*)
65. (*a*)	66. (*b*)	67. (*d*)	68. (*b*)
69. (*a*)	70. (*c*)		

ANSWER KEY: CSIR UGC NET, Dec., 2005

PART – A

1. (*b*)	2. (*b*)	3. (*b*)	4. (*c*)
5. (*a*)	6. (*d*)	7. (*b*)	8. (*a*)
9. (*a*)	10. (*b*)	11. (*b*)	12. (*d*)
13. (*d*)	14. (*b*)	15. (*c*)	16. (*b*)
17. (*c*)	18. (*c*)	19. (*c*)	20. (*d*)
21. (*a*)	22. (*c*)	23. (*a*)	24. (*a*)
25. (*a*)	26. (*c*)	27. (*c*)	28. (*b*)
29. (*b*)	30. (*b*)		

Part – B

1. (*c*)	2. (*a*)	3. (*d*)	4. (*a*)
5. (*b*)	6. (*a*)	7. (*b*)	8. (*d*)
9. (*d*)	10. (*c*)	11. (*b*)	12. (*b*)
13. (*b*)	14. (*c*)	15. (*b*)	16. (*b*)
17. (*a*)	18. (*d*)	19. (*a*)	20. (*b*)
21. (*b*)	22. (*c*)	23. (*a*)	24. (*a*)
25. (*a*)	26. (*c*)	27. (*a*)	28. (*d*)
29. (*b*)	30. (*c*)	31. (*d*)	32. (*b*)
33. (*b*)	34. (*a*)	35. (*c*)	36. (*d*)
37. (*c*)	38. (*b*)	39. (*a*)	40. (*a*)
41. (*c*)	42. (*c*)	43. (*b*)	44. (*b*)
45. (*a*)	46. (*c*)	47. (*a*)	48. (*a*)
49. (*c*)	50. (*a*)	51. (*d*)	52. (*a*)
53. (*b*)	54. (*b*)	55. (*c*)	56. (*d*)
57. (*c*)	58. (*a*)	59. (*d*)	60. (*b*)
61. (*b*)	62. (*a*)	63. (*a*)	64. (*a*)
65. (*a*)	66. (*b*)	67. (*a*)	68. (*b*)
69. (*b*)	70. (*b*)		

ANSWER KEY: CSIR UGC NET, June, 2006

PART – A

1. (*a*)	2. (*a*)	3. (*a*)	4. (*a*)
5. (*a*)	6. (*a*)	7. (*a*)	8. (*a*)
9. (*a*)	10. (*a*)	11. (*a*)	12. (*c*)
13. (*a*)	14. (*a*)	15. (*a*)	16. (*a*)
17. (*a*)	18. (*a*)	19. (*c*)	20. (*c*)
21. (*a*)	22. (*a*)	23. (*d*)	24. (*a*)
25. (*a*)	26. (*a*)	27. (*a*)	28. (*a*)
29. (*a*)	30. (*a*)		

Part – B

1. (*a*)	2. (*a*)	3. (*a*)	4. (*a*)
5. (*a*)	6. (*a*)	7. (*a*)	8. (*a*)
9. (*a*)	10. (*a*)	11. (*a*)	12. (*a*)
13. (*a*)	14. (*a*)	15. (*a*)	16. (*a*)
17. (*a*)	18. (*a*)	19. (*a*)	20. (*a*)
21. (*a*)	22. (*a*)	23. (*a*)	24. (*a*)
25. (*a*)	26. (*a*)	27. (*a*)	28. (*a*)
29. (*a*)	30. (*a*)	31. (*a*)	32. (*a*)
33. (*a*)	34. (*a*)	35. (*a*)	36. (*a*)
37. (*a*)	38. (*a*)	39. (*a*)	40. (*a*)
41. (*a*)	42. (*a*)	43. (*a*)	44. (*a*)
45. (*a*)	46. (*a*)	47. (*a*)	48. (*a*)
49. (*a*)	50. (*a*)	51. (*a*)	52. (*a*)
53. (*a*)	54. (*a*)	55. (*a*)	56. (*a*)
57. (*a*)	58. (*a*)	59. (*a*)	60. (*a*)
61. (*a*)	62. (*a*)	63. (*a*)	64. (*a*)
65. (*a*)	66. (*a*)	67. (*a*)	68. (*a*)
69. (*a*)	70. (*b*)		

ANSWER KEY: CSIR UGC NET, Dec., 2006

Part – A

1. (*c*)	2. (*a*)	3. (*a*)	4. (*c*)
5. (*b*)	6. (*d*)	7. (*b*)	8. (*c*)
9. (*a*)	10. (*a*)	11. (*d*)	12. (*c*)
13. (*a*)	14. (*c*)	15. (*c*)	16. (*c*)
17. (*c*)	18. (*b*)	19. (*c*)	20. (*b*)
21. (*c*)	22. (*d*)	23. (*b*)	24. (*a*)
25. (*c*)	26. (*d*)	27. (*b*)	28. (*a*)
29. (*d*)	30. (*b*)		

Part – B

1. (*b*)	2. (*b*)	3. (*c*)	4. (*c*)
5. (*c*)	6. (*c*)	7. (*a*)	8. (*d*)
9. (*d*)	10. (*d*)	11. (*c*)	12. (*d*)
13. (*a*)	14. (*b*)	15. (*b*)	16. (*a*)
17. (*a*)	18. (*d*)	19. (*c*)	20. (*b*)
21. (*b*)	22. (*b*)	23. (*a*)	24. (*b*)
25. (*d*)	26. (*b*)	27. (*a*)	28. (*a*)
29. (*c*)	30. (*b*)	31. (*d*)	32. (*a*)
33. (*c*)	34. (*d*)	35. (*b*)	36. (*a*)
37. (*a*)	38. (*a*)	39. (*c*)	40. (*b*)
41. (*a*)	42. (*d*)	43. (*a*)	44. (*a*)
45. (*a*)	46. (*a*)	47. (*a*)	48. (*a*)
49. (*b*)	50. (*c*)	51. (*a*)	52. (*d*)
53. (*d*)	54. (*a*)	55. (*a*)	56. (*d*)
57. (*c*)	58. (*d*)	59. (*b*)	60. (*a*)
61. (*c*)	62. (*b*)	63. (*b*)	64. (*b*)
65. (*a*)	66. (*a*)	67. (*b*)	68. (*a*)
69. (*a*)	70. (*b*)		