NCERT Class 12 Biology Exercise Solutions

Chapter 9 – Biotechnology Principles and Processes

1. Can you list 10 recombinant proteins which are used in medical practice? Find out where they are used as therapeutics (use the internet).

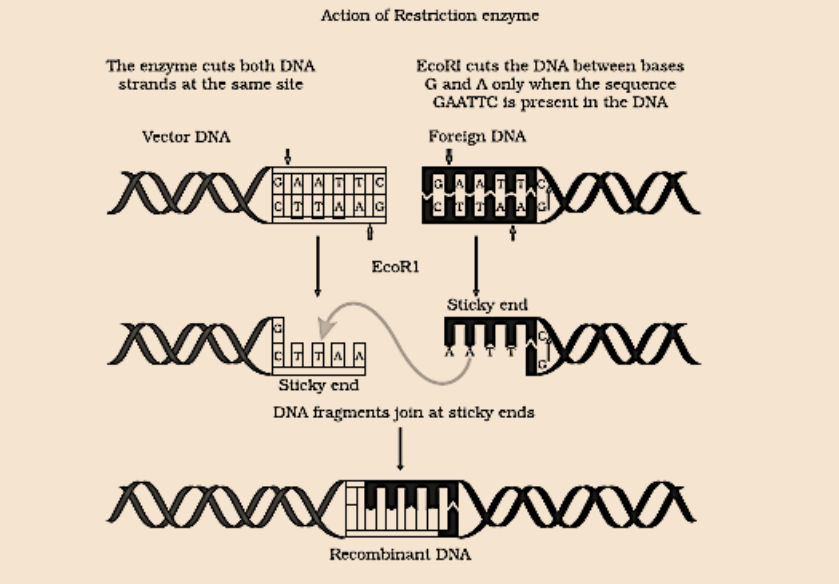
Ans: Recombinant proteins utilized in the field of medicine are derived from recombinant DNA technology. This process involves the transfer of specific genes from one organism to another using vectors and restriction enzymes as molecular instruments.

10 recombinant proteins are as follows:

Recombinant protein	**Therapeutic application**
Insulin	In the treatment of type I diabetes mellitus
Interferon-α	In the treatment of chronic hepatitis C
Interferon-β	Use to treat herpes and viral enteritis
Interferon B	In the treatment of Multiple Sclerosis
Anti-thrombin III	Blood-clot prevention
Human recombinant growth hormone	To promote growth in an individual
Coagulation factor VIII	In the treatment of haemophilia A
Coagulation factor IX	In the treatment of haemophilia B
DNAase I	In the treatment of cystic fibrosis
Tissue plasminogen activator	In the treatment of acute myocardial infection

2. Make a chart (with diagrammatic representation) showing a restriction enzyme, the substrate DNA on which it acts, the site at which it cuts DNA and the product it produces.

Ans: Steps in the formation of recombinant DNA by the action of restriction endonuclease enzyme – EcoRI. It can be diagrammatically represented as follows:



3. From what you have learnt, can you tell whether enzymes are bigger or DNA is bigger in molecular size? How did you know?

Ans: Enzymes are smaller in size compared to DNA molecules. DNA serves as the genetic material necessary for the proper growth and operation of organisms. DNA molecules contain the necessary instructions for the creation of DNA molecules and proteins. On the other hand, enzymes are proteins produced from genes, which are small segments of DNA. Enzymes play a vital role in the formation of the polypeptide chain.

4. What would be the molar concentration of human DNA in a human cell? Consult your teacher.

Ans: The molar concentration of human DNA in a human cell can be given as

6.023×10^{23} x Total number of chromosomes

$6.023 \times 10^{23} \times 46$

2.77×10^{23} moles

Therefore, 2.77×10^{23} moles is the molar concentration of DNA in each of the diploid cells in humans.

5. Do eukaryotic cells have restriction endonucleases? Justify your answer.

Ans: Eukaryotic cells lack restriction endonucleases due to the extensive methylation of DNA by methylase, an enzyme responsible for modification. This methylation serves as a protective measure against the activity of restriction enzymes. Conversely, prokaryotic cells possess these enzymes, which play a crucial role in defending against DNA invasion by viruses.

6. Besides better aeration and mixing properties, what other advantages do stirred tank bioreactors have over shake flasks?

Ans: Stirred tank bioreactors are designed for the mass production of biotechnology products, while the shake flask technique is utilized for the small-scale production of biotechnological products conducted in a laboratory setting. The stirred tank bioreactor offers several benefits compared to shake flasks:

(i) It allows for easy extraction of small culture samples for testing and sampling.

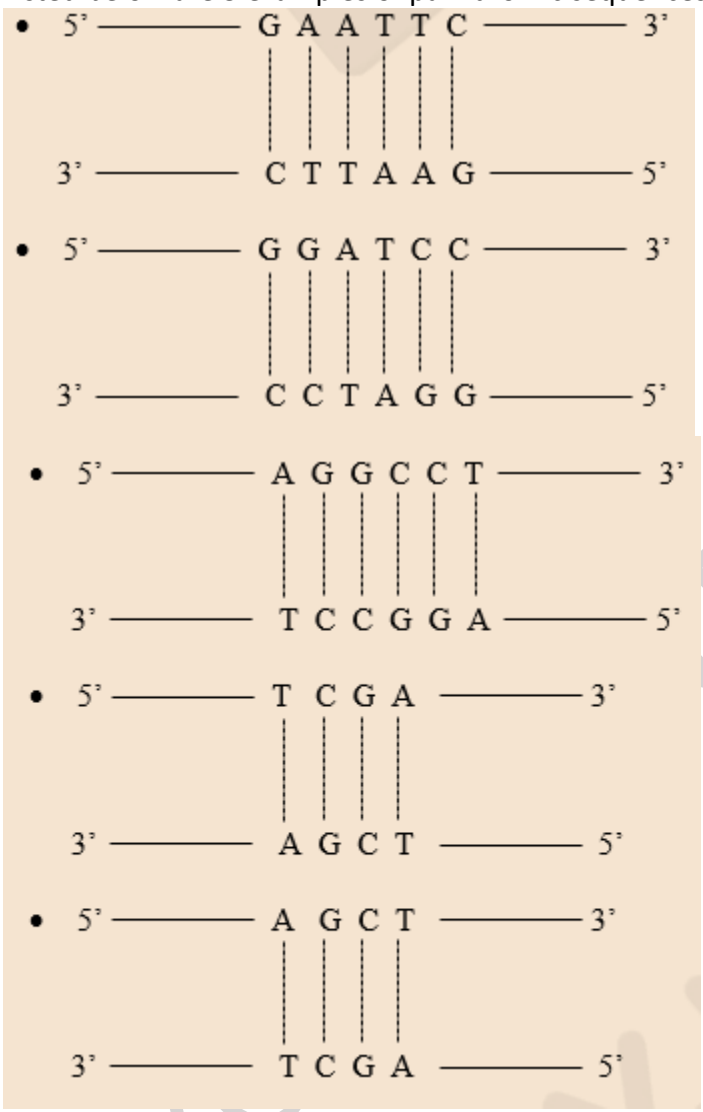
(ii) (ii) It is equipped with a control system to maintain optimal pH and temperature levels.

(iii) (iii) The stirred tank bioreactors come with a foam breaker to control foam formation.

7. Collect 5 examples of palindromic DNA sequences by consulting your teacher. Better try to create a palindromic sequence by following base-pair rules.

Ans: A palindromic sequence is a DNA sequence that can be read the same way whether read from the 5' to 3' direction or from the 3' to 5' direction. These sequences serve as the sites where restriction enzymes act. The majority of restriction enzymes are composed of palindromic sequences.

Listed below are 5 examples of palindromic sequences, and they are



8. Can you recall meiosis and indicate at what stage a recombinant DNA is made?

Ans: Meiosis, a form of cell division, refers to the process of reducing the amount of genetic material. It consists of two phases, meiosis I and meiosis II. During the pachytene stage of prophase I, chromosomes undergo crossing over, where segments are exchanged between non-sister chromatids of homologous chromosomes. This results in the creation of recombinant DNA during meiosis.

9. Can you think and answer how a reporter enzyme can be used to monitor the transformation of host cells by foreign DNA in addition to a selectable marker?

Ans: In order to monitor the alteration of host cells through the introduction of foreign DNA, scientists can utilize a reporter gene. This gene acts as a selectable marker, allowing researchers to determine whether

the host cell has incorporated the foreign DNA and if the foreign gene is being expressed within the cell. Both the reporter gene and the foreign gene are inserted into the same DNA construct by scientists. This combined DNA construct is then introduced into the cell, with the reporter gene serving as a selectable marker to identify the successful uptake of foreign genes or genes of interest. An instance of a reporter gene is the lac Z gene found in jellyfish, which codes for a green fluorescent protein.

10. Describe briefly the following.

(a) Origin of replication

(b) Bioreactors

(c) Downstream processing

Ans: (a) Origin of replication

It is possible to describe it as a DNA sequence within a genome that serves as the starting point for replication. Replication initiation can occur in either one direction or both directions. When any DNA fragment is connected to this specific sequence, it has the ability to replicate inside the host cells. This sequence also plays a role in regulating the number of copies of the connected DNA. Therefore, in order to obtain numerous copies of the target DNA, it must be inserted into a vector with an origin that allows for a high copy number.

(b) Bioreactor

These vessels are of considerable size and are utilized for the extensive manufacturing of biotechnological goods from natural resources. To achieve the desired outcome, these bioreactors provide ideal circumstances by ensuring the optimal levels of pH, temperature, vitamins, oxygen, and more. They are equipped with an oxygen delivery system, a foam control system, and a temperature and pH control system. Additionally, they include a sampling port for extracting a small portion of the culture for sampling purposes.

(c) Downstream processing

Following the completion of the biosynthetic stage, foreign gene products are separated and purified using a specific method called downstream processing. Subsequently, the product undergoes various procedures to ensure its purity. After the entire process is finished, the product is formulated and subjected to multiple clinical trials to assess its quality and other relevant factors.

11. Explain briefly.

(a) PCR

(b) Restriction enzymes and DNA

(c) Chitinase

Ans: (a) PCR

In the field of molecular biology, PCR, also known as polymerase chain reaction, is a method utilized to amplify a gene or a segment of DNA in order to produce numerous copies. This technique is commonly employed in genetic engineering procedures. The process entails the in vitro creation of sequences using a

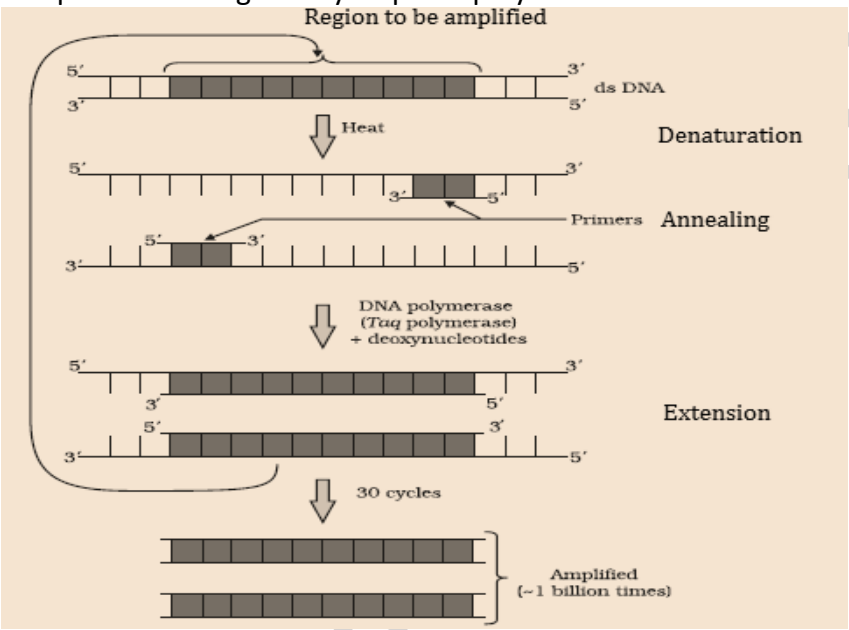
template strand, a primer, and a thermostable DNA polymerase enzyme derived from a bacterium called Thermus aquaticus. The enzyme utilizes deoxynucleotides (dNTPs) as building blocks to elongate the primer.

The PCR process consists of three main steps:

(i) Initially, the double-stranded DNA molecules are heated to a high temperature to separate into single-stranded DNA molecules. This step is known as denaturation.

(ii) The single-stranded DNA molecule then serves as a template for the synthesis of a new strand by the DNA polymerase enzyme. This stage, referred to as annealing, results in the replication of the original DNA molecule, and the process is repeated through multiple cycles to generate multiple copies of the DNA fragment.

(iii) The primer is elongated by Taq DNA polymerase obtained from Thermus aquaticus.



(b) Restriction enzymes and DNA

In the field of molecular biology, restriction enzymes are utilized as molecular scissors to precisely cut DNA sequences from a specific location. They play a crucial role in the process of gene manipulation. These enzymes are capable of recognizing a specific six-base pair sequence, known as the recognition sequence, and cleaving the sequence at specific sites.

There are two types of restriction enzymes: (i) Endonuclease - This type of restriction enzyme cuts within the DNA at specific sites. It is an important tool in genetic engineering, often used to create DNA fragments with sticky ends. These ends can later be joined together using the enzyme DNA ligase. (ii) Exonuclease - This type of restriction enzyme removes nucleotides from either the 3' or 5' ends of the DNA molecule.

(c) Chitinase

Chitinase enzymes belong to a class of enzymes utilized for breaking down chitin, the primary constituent of fungal cell walls. Consequently, the Chitinase enzyme is employed to disrupt the cell and liberate the enclosed DNA within the fungal cell membrane, facilitating the isolation of its genetic material.

12. Discuss with your teacher and find out how to distinguish between

(a) Plasmid DNA and Chromosomal DNA

(b) RNA and DNA

(c) Exonuclease and Endonuclease

Ans:

The differences are as follows:

(a) Plasmid DNA and Chromosomal DNA

Plasmid DNA	**Chromosomal DNA**
It is an extra chromosomal DNA molecule found in bacteria, capable of replicating and is independent of chromosomal DNA	It forms the complete DNA of an entity found inside the chromosomes

(b) RNA and DNA

RNA	**DNA**
Single-stranded molecule	Double-stranded molecule
Cannot replicate by themselves	Have the potential to replicate
Consists of the ribose sugar	Consists of deoxyribose sugar
Pyrimidines are uracil and adenine	Pyrimidines are thymine and adenine
It is a component of ribosomes	It is a component of chromosomes

(c) Exonuclease and Endonuclease

Exonuclease	**Endonuclease**
It is a kind of restriction enzyme which removes the nucleotides from 5’ or 3’ terminals of the DNA molecule	It is a kind of restriction enzyme that snips within the DNA at particular sites to produce sticky ends