CSIR NET Life Science Unit 4

Cell Communication

Autocrine signaling

Autocrine signaling is a kind of cell signaling in which a cell secretes a hormone or chemical messenger that binds to autocrine receptors on the same cell, causing it to alter. Pain perception and inflammatory reactions are also regulated by autocrine signaling. Furthermore, if a cell is infected with a virus, the virus can be killed by signaling the cell to undergo programmed cell death.

1. One important example of such autocrine signaling is the response of cells of the vertebrate immune system to foreign antigens. When antigens stimulate T lymphocytes, they produce a growth factor and IL-2 that stimulates their own proliferation, boosting the number of responding T lymphocytes and enhancing the immune response.
2. 2A A well-characterized form of autocrine signaling is the secretion of IL-1 by macrophages. The binding of IL-1 by receptors on macrophages further activates these cells and triggers the secretion of additional cytokines (including additional IL-1).

Paracrine signaling

A substance secreted by one cell acts on neighbouring target cells in paracrine signaling. One example is the action of neurotransmitters in transporting signals between nerve cells at a synapse. Diffusion transports paracrine signals across the extracellular matrix. These signals generally evoke rapid responses that are only present for a brief period of time. Paracrine ligand molecules are typically immediately destroyed by enzymes or eliminated by adjacent cells to keep the reaction confined. Examples are as follows:

1. **Nitric oxide (NO)** is a significant paracrine signaling molecule. NO can diffuse directly across the plasma membrane of its target cells, just like steroid hormones. However, the molecular mechanism of NO action differs from that of steroid action; rather than attaching to a receptor that affects transcription, NO modifies the activity of intracellular target enzymes.
2. **Carbon monoxide (CO)** gas also serves as a signaling molecule in the nervous system.
3. The **eicosanoids** (prostaglandins, prostacyclin, thromboxanes, leukotrienes, etc.) are a class of lipids that function in paracrine and autocrine signaling. They stimulate a variety of responses in their target

cells, including blood platelet aggregation, inflammation, and smooth-muscle contraction.

Juxtracrine signaling

Juxtracrine signaling, unlike other types of cell signaling, needs physical contact between the cells involved. e.g.,

1. A communicating junction links the intracellular compartments of two adjacent cells, allowing the transit of relatively small molecules. Gap junctions in animals and plasmodesmata in plants. Example-Electrical synapses are electrically conductive gap junctions between neurons.
2. An extracellular matrix (ECM) glycoprotein and a membrane protein interact. Cells use mainly the receptor integrin to interact with ECM proteins. This signaling can influence the cell cycle and cellular differentiation.

Endocrine signaling

Endocrine signals are signals that come from distant cells and are produced by endocrine cells. Endocrine glands, such as the thyroid gland, hypothalamus, and pituitary gland, contain a large number of endocrine cells. These signals tend to elicit a slower response but have a longer-lasting effect. Hormones are ligands released in endocrine signaling, signaling molecules generated in one area of the body but affecting other parts of the body at a distance. The steroid hormone estrogen, which is generated by the ovary and supports the development and maintenance of the female reproductive system as well as secondary sex characteristics, is a typical example of endocrine signalling.

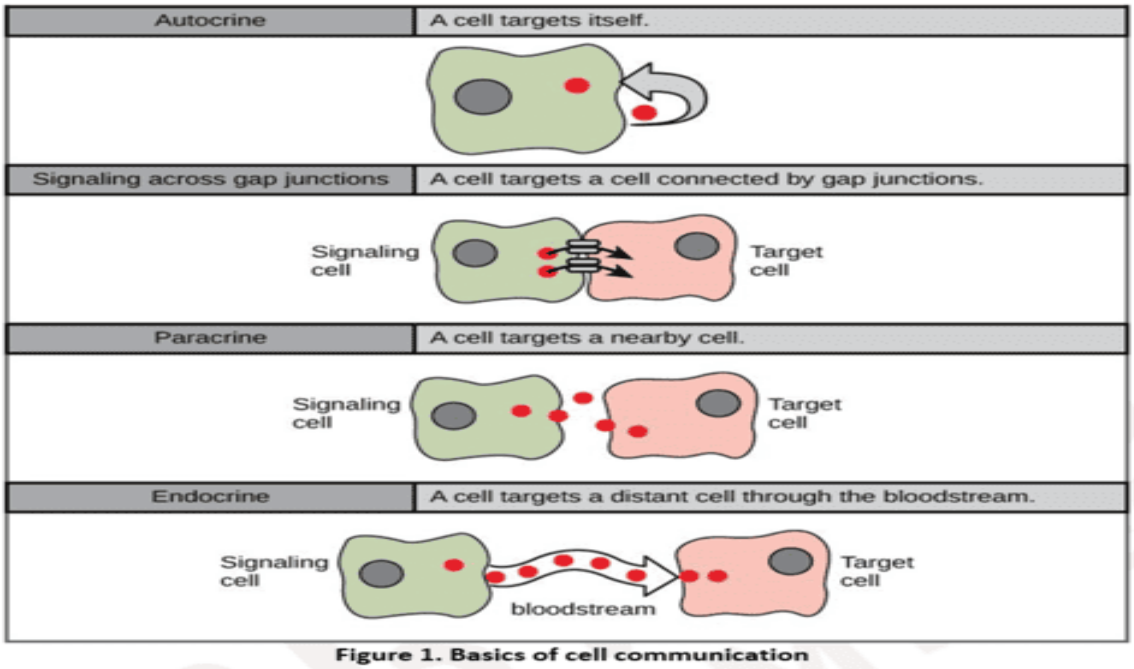

Figure 1. Basics of cell communication

Quorum sensing

Quorum sensing or quorum signalling (QS) is the ability to detect and respond to cell population density by gene regulation. For example, QS enables bacteria to restrict the expression of specific genes to the high cell densities at which the resulting phenotypes will be most beneficial. Many species of bacteria use quorum sensing to coordinate gene expression according to the density of their local population. In a similar fashion, some social insects use quorum sensing to determine where to nest. Quorum sensing may also be useful for cancer cell communications.

For the bacteria to use quorum sensing constitutively, they must possess three abilities: secretion of a signaling molecule, secretion of an autoinducer (to detect the change in concentration of signaling molecules), and regulation of gene transcription as a response. This process is highly dependent on the diffusion mechanism of the signaling molecules. QS Signaling molecules are usually secreted at a low level by individual bacteria. At low cell density, the molecules may just diffuse away. At high cell density, the local concentration of signaling molecules may exceed its threshold level, triggering gene expression changes.

Quorum sensing in gram-positive bacteria

Gram-positive bacteria use **auto-inducing peptides (AIP)** as their autoinducers. When gram-positive bacteria detect a high concentration of AIPs in their environment, that happens by way of AIPs binding to a receptor to activate a kinase. The kinase phosphorylates a transcription factor, which regulates gene transcription. This is called a **two-component system**. Another possible mechanism is that AIP is transported into the cytosol and binds directly to a transcription factor to initiate or inhibit transcription.

Quorum sensing in gram-negative bacteria

Gram-negative Bacteria produce **N-acyl homoserine lactones (AHL)** as their signalling molecule. Usually, AHLs do not need additional processing and bind directly to transcription factors to regulate gene expression. Still, some gram-negative bacteria may use the two-component system as well.

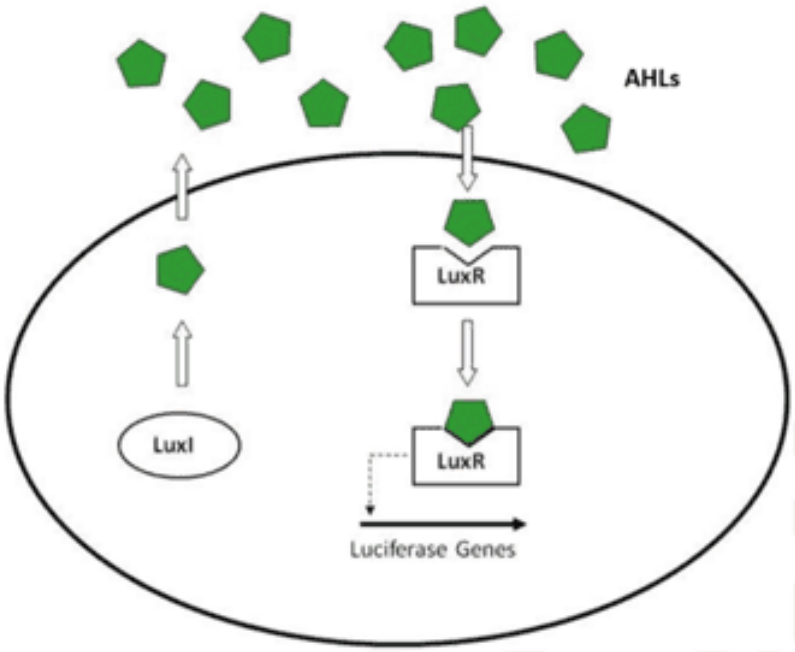

Figure 2. Quorum sensing and gene expression in *A. fischeri*

For example, the bioluminescent bacterium ***Aliivibrio Fischer*** is the first organism in which QS was observed. It lives as a mutualistic symbiont in the Hawaiian bobtail squid's photophore (or light-producing organ). When *A. Fischer* cells are free-living (or planktonic), the autoinducer is at a low concentration, and, thus, cells do not show luminescence. However, when the population reaches the threshold in the photophore (about 1011 cells/ml), transcription of luciferase is induced, leading to bioluminescence. In *A. fischeri* bioluminescence is regulated by AHLs, a product of the *LuxI* gene whose transcription is regulated by the *LuxR* activator. LuxR works only when AHLs bind to the *LuxR*.