

# Cell to cell communication



**Direct contact:** When cells are very close to one another, some of the molecules on the plasma membrane of one cell can be recognized by receptors on the plasma membrane of an adjacent cell. Many of the important interactions between cells in early development occur by means of direct contact between cell surfaces. Cells also signal through gap junctions.

**Paracrine signaling:** Signal molecules released by cells can diffuse through the extra-cellular fluid to other cells. If those molecules are taken up by neighboring cells, destroyed by extracellular enzymes, or quickly removed from the extracellular fluid in some other way, their influence is restricted to cells in the immediate vicinity of the releasing cell. Signals with such short-lived, local effects are called paracrine signals. Paracrine signaling plays an important role in early development, coordinating the activities of clusters of neighboring cells.

**Endocrine signaling:** A released signal molecule that remains in the extracellular fluid may enter the organism's circulatory system and travel widely throughout the body. These longer-lived signal molecules, which may affect cells very distant from the releasing cell, are called hormones, and this type of intercellular communication is known as endocrine signaling.

**Synaptic signaling:** In animals, the cells of the nervous system provide rapid communication with distant cells. Their signal molecules, neurotransmitters, do not travel to the distant cells through the circulatory system as hormones do. Rather, the long, fiber like extensions of nerve cells release neurotransmitters from their tips very close to the target cells. The association of a neuron and its target cell is called a chemical synapse, and

this type of intercellular communication is called synaptic signaling. Neurotransmitters cross the synaptic gap and persist only briefly.

Describe the mechanisms of cell signaling that uses intracellular receptors.

-Many cell signals are lipid-soluble or very small molecules that can readily pass through the plasma membrane of the target cell and into the cell, where they interact with an intracellular receptor. Some of these ligands bind to protein receptors located in the cytoplasm; others pass across the nuclear membrane as well and bind to receptors within the nucleus. Hydrophobic signaling molecules can cross the membrane and bind to intracellular receptors. The steroid hormone receptors act by directly influencing gene expression. On binding hormone, the hormone-receptor moves into the nucleus to turn on or sometimes turn off gene expression. This also requires another protein called a coactivator that functions with the hormone-receptor. Thus, the cell's response to a hormone depends on the presence of a receptor and coactivators as well.

Describe the mechanisms of cell signaling that employ cell surface receptors. Include a brief description of the three receptor super families.

-When a receptor is a transmembrane protein, the ligand binds to the receptor outside of the cell and never actually crosses the plasma membrane. In this case, the receptor itself, and not the signaling molecule is responsible for information crossing the membrane. Such receptor transmits information from the extracellular environment to the inside of the cell by changing shape or aggregating when a specific ligand binds to it. Membrane receptors can be categorized based on their structure and function. The

three receptor super families are: Chemically gated ion channels, enzymatic receptors and G protein-coupled receptors. IN the center of the protein is a pore that connects the extracellular fluid with the cytoplasm. The pore is big enough for ions to pass through, so the protein functions as an ion channel. Chemically gated ion channels are made up of multipass transmembrane protein forming a central pore and the way they function is that the molecular “ gates” are triggered chemically to open or close. The Enzymatic receptors are made of Single-pass transmembrane protein and the way they function is by binding signal extracellularly, and catalyzing response intracellularly. The G protein-coupled receptors are made up of Seven-pass transmembrane protein with cytoplasmic binding site for G protein and the way they function in the following way: Binding of signal to receptor causes GTP to bind a G protein; G protein, with attached GTP, detaches to deliver the signal inside the cell.

Describe how signal can be amplified by protein kinase cascades.

One important class of cytoplasmic kinases are mitogen activated protein (MAP) kinases. A mitogen is a chemical that stimulates cell division by activating the normal pathways that control division. The MAP kinases are activated by a signaling module called a phosphorylation cascade or a kinases cascade. This module is a series of protein kinases that phosphorylate each other in succession. The final step in the cascade is the activation by phosphorylation of MAP kinase itself. One function of a kinase cascade is to amplify the original signal. Because each step in the cascade is an enzyme, it can act on a number of substrate molecules. With each enzyme in the cascade acting on many substrates this produces a large

amount of the final product. This allows a small number of initial signaling molecules to produce a large response. The cellular response to this cascade in any particular cell depends on the targets of the MAP kinase, but usually involves phosphorylating transcription factors that then activate gene expression. An example of this kind of signaling through growth factor receptors is provided in chapter 10 and illustrates how signal transduction initiated by a growth factor can control the process of cell division through a kinase cascade. The proteins in a kinase cascade need to act sequentially to be effective. One way the efficiency of this process can be increased is to organize them in the cytoplasm. Proteins called scaffold proteins are thought to organize the components of a kinase cascade into a single protein complex, the ultimate in a signaling module. The scaffold protein binds to each individual kinase such that they are spatially organized for optimal function. There is a receptor in the plasma membrane. Each kinase is named starting with the last, the MAP kinase (MK), which is phosphorylated by a MAP kinase (MKK), which is in turn phosphorylated by a MAP kinase kinase (MKKK). The cascade is linked to the receptor protein by an activator protein. At each step the enzymatic action of the kinase on multiple substrates leads to amplification of the signal.

A. Define the term cell junction

-A cell junction is a long-lasting or permanent connection between one cell and another.

b. Briefly describe the three categories of cell junction

- Tight junctions- Tight junctions connect the plasma membranes of adjacent cells in a sheet. This sheet of cells acts as a wall within the organ, keeping molecules on one side or the other. The junctions between neighboring cells are so securely attached that there is no space between them for leakage. Hence, nutrients absorbed from the food in the digestive tract must pass directly through the cells in the sheet to enter the bloodstream because they cannot pass through spaces between cells. The tight junctions between the cells lining the digestive tract also partition the plasma membranes of these cells into separate compartments. Transport proteins in the membrane facing the inside of the tract carry nutrients from that side to the cytoplasm of the cells. Other proteins located in the membrane on the opposite side of the cells, transport those nutrients from the cytoplasm to the extracellular fluid, where they can enter the bloodstream. For the sheet to absorb nutrients properly, these proteins must remain in the correct locations within the fluid membrane. Tight junctions effectively segregate the proteins on opposite sides of the sheet, preventing them from drifting within the membrane from one side of the sheet to the other. When tight junctions are experimentally disrupted, just this sort of migration occurs.

Anchoring junctions: Anchoring junctions mechanically attach the cytoskeleton of a cell to the cytoskeletons of other cells or to the extracellular matrix. Anchoring junctions called adherens junctions connect the actin filaments of one cell with those of neighboring cells or with the extracellular matrix. The linking proteins in these junctions are members of a large superfamily of cell-surface receptors called integrins that bind to a

protein component of the extracellular matrix. At least 20 different integrins exist each with a differently shaped binding domain.

**Communicating Junctions:** Many cells communicate with adjacent cells through direct connections called communicating junctions. In these junctions, a chemical or electrical signal passes directly from one cell to an adjacent one. Communicating junctions permit small molecules or ions to pass from one cell to the other in animals, these direct communication channels between cells are called gap junctions, and in plants, plasmodesmata. A gap junction forms when the connexons of two cells align perfectly, creating an open channel that spans the plasma membranes of both cells. Gap junctions provide passageways large enough to permit small substances, such as simple sugars and amino acids, to pass from one cell to the next. Yet the passages are small enough to prevent the passage of larger molecules, such as proteins. Gap junction channels are dynamic structures that can open or close in response to a variety of factors, including Calcium and Hydrogen ions. This gating serves at least one important function. When a cell is damaged, its plasma membrane often becomes leaky. Ions in high concentrations outside the cell, such as Calcium ion, flow into the damaged cell and close its gap junction channels. This isolates the cell and so prevents the damage from spreading to other cells. In plants, cell walls separate every cell from all others. Cell-cell junctions occur only at holes or gaps in the walls, where the plasma membranes of adjacent cells can come into contact with one another. Cytoplasmic connections that form across the touching plasma membranes are called plasmodesmata. The majority of living cells within a higher plant are connected to their neighbors by these junctions.