# I. Chapter 11

## A. 11.3 How Do Distant Cells Communicate?

### 1. Cell-Cell Signaling in Multicellular Organisms

- **Hormones**: information-carrying molecules that can act on distant target cells because they are secreted by plant and animal cells in bodily fluids.
- Most lipid soluble signaling molecules are able to diffuse across the plasma membrane and enter the cytoplasm of their target cell.
- Large or hydrophilic signaling molecules are lipid insoluble and do not cross the plasma membrane. To affect a target cell, they have to be recognized at the cell's surface.

### 2. Signal Reception

- The presence of an appropriate receptor dictates which cells will respond to a particular hormone.
- Identical receptors in diverse cells and tissues allow long distance signals to coordinate the activities of cells throughout a multicellular organism.
- Receptors are dynamic: the sensitivity of a cell to a particular hormone may change over time in response to level of stimulation.
- Receptors can be blocked.
- Most signal receptors reside in the plasma membrane, however, some exist inside the cell.
- **A signal receptor**: a protein that changes shape and activity after binding to a signal molecule.

### 3. Signal Processing

- When lipid soluble signals enter the cell, the information they carry is processed directly-without any intermediate steps.
- When a signal binds to the cell's surface, it triggers **transduction**: the conversion of a signal from one form to another. A long and often complex series of events ensues, collectively called a **signal transduction pathway**.
- Signal transduction converts extracellular signals to intracellular signals.
- **G-protein-coupled receptors** initiate the production of intracellular or "second" messengers that then amplify the signal.
- **Enzyme-linked receptors** amplify the signal by triggering the activation of a series of proteins inside the cell, through the addition of a phosphate group.
- When G proteins are activated by a signal receptor, they trigger a key step in signal transduction: the production of a messenger inside the cell. They link the receipt of an extracellular signal to the production of an intracellular signal.
- **G protein sequence**:
    - **1.** G protein is off (bound to GDP). Signal arrives and binds to the receptor.
    - **2.** Signal-receptor complex changes conformation. The G protein binds to GTP and splits into two parts.
    - **3.** Activated G protein binds to an enzyme and induces the production of a second messenger, which triggers a response.
- Signal transduction amplifies the signal.

- **Protein kinases**: proteins that activate or inactivate other proteins by adding a phosphate group to them.
- Second messengers aren't restricted to a single role or a single cell type. The same second messenger can initiate dramatically different events in different cell types.
- It is common for more than one second messenger to be involved in triggering a cell's response to the same extracellular signaling molecule.
- How enzyme linked receptors work:
    - **1.** Signaling molecule arrives and binds to receptor monomers, causing them to dimerize.
    - **2.** Activated receptor complex turns on the receptor's kinase activity, which phosphorylates itself at tyrosine residues.
    - **3.** Binding proteins bind to the phosphorylated receptor and one of them activates Ras by causing it to exchange GDP for GTP.
    - **4.** Activated Ras triggers phosphorylation and activation of protein kinase.
    - **5.** Phosphorylation cascade results, where each kinase phosphorylates a different kinase until a response is triggered in the cell.
- **Phosphorylation cascade**: a series of enzyme catalyzed phosphorylation reactions commonly used in signal transduction pathways to amplify and convey a signal inward from the plasma membrane.
- **Mitogen-activated protein kinases**: Enzymes involved in signal transduction pathways that often lead to induction of cell replications. Different types are organized in a series, where one kinase activates another via phosphorylation
- The signal transduction event has two results:
    - **1.** It converts an easily transmitted extracellular message into an intracellular message.
    - **2.** In some case it amplifies the original message many times over.

## 4. Signal Response

## 5. Signal Deactivation

- **Phosphatases**: enzymes that remove phosphate groups from a cascade protein.
- Signal transduction systems trigger a rapid response and can be shut down quickly. As a result, they are exquisitely sensitive to small changes in the concentration of hormones or in the number and activity of signal receptors.

## 6. Crosstalk: Synthesis Input from Many Signals

- Signal transduction pathways form a network. This complexity allows cells to respond to many different signals in an integrated way.
- **Crosstalk**: when the signals from different pathways interact to modify the cell response
    - **1.** Elements or products from one pathway may inhibit steps in a different pathway- reducing the cell's response, even though the appropriate signal is present.
    - **2.** A response from one pathway may stimulate a greater response by a protein in a different pathway, increasing the cell's response to the other signal.
    - **3.** The presence of multiple steps in each signaling pathway provides a series of points where crosstalk can regulate the flow of information. These interactions allow the cell to respond appropriately to many signals at the same time.

## B. 11.4 Signaling between Unicellular Organisms

### 1. Responding to Sex Pheromones.

- **Pheromones**: any chemical substance released by an animal that serves to influence the physiology or behavior of other members of the same species.

### 2. Responding to Population Density

- **Quorum sensing**: signaling pathways that respond to population density in microbes.
- Quorum sensing allows unicellular organisms to communicate and coordinate activity.