**Cell Communication Notes Guide:**

**Concept: External signals are converted to responses within the cell**

Reception-The target cell’s detection of a signal molecule coming from the outside.

Transduction-The conversion of the signal to a form that can bring about a specific cellular response.

Response-The specific cellular response to the signal molecule.

**Concept: A signal molecule binds to a receptor protein, causing it to change shape**

Ligand (key): The signaling molecule

Receptor (lock): Protein that detects specific ligands

The type of signaling a cell uses is based on the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ between the cell it is trying to signal

**Autocrine Signaling:**  This occurs when a cell signals itself. The production and secretion of an extracellular mediator by a cell followed by the binding of that mediator to receptors on the same cell to initiate signal transduction.

-Examples include: cancer cells making their own growth hormone rather than relying on its release from the pituitary gland, macrophages which attack infected cells. Used in the development of embryos so cells can take on and reinforce their correct identities.

4 Main types of cell signaling:

**Juxtacrine/Direct Communication (contact):** Cells are touching. One cell can recognize the molecules on the adjacent cell. Similar to two people having a personal conversation

Tight Junctions: Belts around the epithelial cells that line organs and serve as a barrier to prevent leakage into or out of those organs. (Animal Cells)

Desmosomes: “spot welds” found in many tissues that are subjected to severe mechanical stress such as skin epithelium or the neck of the uterus, which must expand greatly during childbirth (Animal Cells)

\_\_\_\_\_\_\_\_\_ junctions permit the passage of materials directly from the cytoplasm from one cell to the cytoplasm of an adjacent cell. In the muscle tissue of the heart, the flow of ions through the gap junctions coordinate the contractions of the cardiac cells. (Animal Cells)

Plasmodesmata: connect one plant cell to the next. They are analogous to gap junctions in animal cells. (Plant cells)

Example from Plants: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Example from Animals: \_\_\_\_\_\_\_\_\_\_\_\_

Orchestrates early embryo development

**Paracrine Signaling:** Ligands produced by cells can travel through extracellular fluid (diffusion) and be read by other ***\_\_\_\_\_\_\_\_\_\_\_\_*** cells. Similar to a teacher teaching a class.

-Short-lived molecules: eg neurotransmitters

-Two Outcomes:

* + - * Read by another cell
      * Degraded by enzymes

**Endocrine Signaling:** Ligand released by a cell and makes it way to the (blood) circulatory system. Similar to someone making an announcement over the PA system.

* Can be spread to the ***\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*** body
* Long-lived molecules known as ***hormones***
* Used extensively in plants and animals

**Synaptic Signaling:** Rapid communication with distant cells using nerve cells’ long fiber-like extensions. Similar to emailing where info bounces from one server to the next until they reach a destination.

* Ligands are called ***\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_***
* Chemical Synapse: association of the neuron and its target cell
* Used by the nervous system - ex: touch, reflexes

**Concept: External signals are converted to responses within the cell**

**Reception**-The target cell’s detection of a signal molecule coming from the outside.

Reception occurs when a \_\_\_\_\_\_\_\_\_\_\_\_\_\_ molecule (ligand) \_\_\_\_\_\_\_\_\_ to a receptor protein.

Found in two places:

plasma membrane receptor proteins

-Binds to water-soluble ligands

intracellular receptor proteins

-Found inside the plasma membrane in the cytoplasm or nucleus. The signal molecule (ligand) must cross the plasma membrane and therefore must be hydrophobic, like the steroid hormone testosterone.

**-Example: G Protein-coupled receptor** is a membrane receptor that works with the help of a G protein.

Step 1: The ligand or signaling molecule has bound to the G protein-coupled receptor. This causes a conformational change in the receptor so that it may now bind to an inactive G protein, causing a GTP (Guanine Triphosphate) to displace the GDP (Guanine Diphosphate). This activates the G Protein.

Step 2: The G protein binds to a specific enzyme and activates it. When the enzyme is activated, it can trigger the next step in a pathway leading to a cellular response. All the molecular shape changes are temporary. To continue the cellular response, new signal molecules are required.

**-Example: Receptor Tyrosine Kinase**

Step 1: The binding of signal molecules to the receptors and the subsequent formation of a dimer. In the dimer configuration each tyrosine kinase adds a phosphate from ATP molecule.

Step 2: The fully activated receptor protein as it initiates a unique cellular response for each phosphorylated tyrosine.

-The key ability of a single ligand to activate multiple cellular responses is a key difference between G protein-coupled receptors and receptor tyrosine kinases.

-Protein kinase receptors belong to a class of plasma membrane receptors that function as enzymes. One example is RTK, receptor tyrosine kinase. Steroid messengers diffuse directly through the cell membrane and once inside the cell, bind to a second messenger, like cAMP.

**-Example:** **Plasma Membrane Receptor Proteins**:

Step 1: a ligand arrives at the receptor protein (ligand-gated ion channel receptor) in the plasma membrane

Step 2: the gate opens allowing ions to flow into the cell.

Step 3: The gate closes as the signal molecule leaves or is broken down.

* **Intracellular Receptors:**  Intracellular Receptors bind hydrophobic ligands
  + Hydrophobic ligands can easily cross the plasma membrane
* Main class of Intracellular Receptors are ***\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Receptors***

**Concept: Transduction: Cascades of molecular interactions relay signal from receptors to target molecules in the cell**

**Transduction**-The conversion of the signal to a form that can bring about a specific cellular response.

At each step, the signal is transduced into a different form

-Commonly a shape change in a protein

-Shape change is brought about by phosphorylation (addition of a phosphate group)

-Signal transduction often involve a phosphorylation cascade.

When receptors are membrane proteins, the transduction stage is usually a multistep pathway

-Multistep pathways can \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ a signal

-Enzymes called protein kinases phosphorylate and thereby activate many proteins at the next level. This cascade of phosphorylation greatly enhances the signal, allowing for a large cellular response.

* Kinase Proteins
  + Enzyme that *adds* a phosphate to an amino acid

-Dephosphorylation occurs when a phosphate group is ***\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_***

-Phosphatases: -Enzyme that *removes* phosphate groups.

-Thus, the signal can be turned on by kinases and off by phosphatases.

-Not all components of signal transduction pathways are proteins.

* -Many signaling pathways involve small, nonprotein water-soluble molecules or ions called second messengers. Calcium ions and cyclic AMP are two common second messengers. The second messengers, once activated, can initiate a phosphorylation cascade resulting in a cellular response.

-Earl Sutherland received the Nobel Prize for his discovery of cAMP as a second messenger. Sutherland noticed that glycogen was broken down only when a hormone epinephrine was administered to intact cells. Epinephrine is the ligand (signal molecule) that activates the G protein-coupled receptor which is responsible for glycogen breakdown. Epinephrine does not enter the cell, suggesting a second messenger. Only in intact cells could the first messenger (epinephrine) be translated to a cellular response-glycogen breakdown.

**Concept: Response: cell signaling leads to regulation of transcription or cytoplasmic activities**

**Response**-The specific cellular response to the signal molecule.

Signal Transduction results in a cellular response

* Leads to regulation of **cytoplasmic activities** or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Many signaling pathways ultimately regulate protein synthesis, usually by turning on or off in the nucleus. Often, the final activated molecule in a signaling pathway functions as a transcription factor.
* In the cytoplasm, signaling pathways often regulate the activity of proteins rather than their synthesis. For example, the final step in the signaling pathway may affect the activity of enzymes or cause cytoskeleton rearrangement.
* One of the main responses is a change in protein composition
  + Some proteins are activated
  + Other proteins are deactivated

How does the cell do this? **Phosphorylation!**

**Concept: Apoptosis integrates multiple-cell signaling pathways**

An example of cell signaling is a program of controlled cell suicide called apoptosis.

During apoptosis the cell is systematically dismantled and digested.

This protects neighboring cells from damage that would occur if a dying cell merely leaked out its digestive and other enzymes

Apoptosis is triggered by signals that activate a cascade of “suicide” proteins in the cell.

In vertebrates (organisms with backbones), apoptosis is a normal part of development and is essential for a normal nervous system, for the operation of the immune system, and for normal morphogenesis of hands and feet in humans.

**Concept: Feedback regulation and antagonistic hormone pairs are common in endocrine systems**

-Hormones are assembled into regulatory pathways

Simple Hormone Pathways

-Hormones are released from an endocrine cell, travel through the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and interact with specific receptors within a target cell to cause a physiological response

-For example, the release of acidic contents of the stomach into the duodenum stimulates endocrine cells there to secrete secretin

-This causes target cells in the pancreas, a gland behind the stomach, to raise the pH in the duodenum

-In a simple neuroendocrine pathway, the stimulus is received by a sensory neuron, which stimulates a neurosecretory cell

-The neurosecretory cell secretes a neurohormone, which enters the bloodstream and travels to target cells

Feedback Regulation

-A \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ feedback loop inhibits a response by reducing the initial stimulus, thus preventing excessive pathway activity

-Positive feedback reinforces a stimulus to produce an even greater response

-For example, in mammals oxytocin causes the release of milk, causing greater suckling by offspring, which stimulates the release of more oxytocin

Insulin and Glucagon: Control of Blood Glucose

-Insulin (decreases blood glucose) and glucagon (increases blood glucose) are antagonistic hormones that help maintain glucose homeostasis

-The pancreas has clusters of endocrine cells called pancreatic islets with alpha cells that produce glucagon and beta cells that produce insulin

Target Tissues for Insulin and Glucagon

Insulin reduces blood glucose levels by

-Promoting the cellular uptake of glucose

-Slowing glycogen breakdown in the liver

-Promoting fat storage, not breakdown

Glucagon increases blood glucose levels by

-Stimulating conversion of glycogen to glucose in the liver

-Stimulating breakdown of fat and protein into glucose