Endocrine & Cell Communication Part III: Hormonal Communication

You may want to print slide 39 for students so they can complete the chart as an activity. You will also want to have your set of “Testosterone Manipulatives” handy.

Enduring Understanding 3.D Cells communicate by generating, transmitting and receiving chemical signals.

1. Endocrine signals are produced by endocrine cells that release signaling molecules, which are specific and can travel long distances through the blood to reach all parts of the body.

The Process of Communication: Signal-Transduction Pathway

Three stages of the Signal-Transduction Pathway

1. reception
2. transduction
3. response

Most cell communication involves three basic steps, reception, transduction and response. Today, we will see this signal transduction pathway being initiated by hormones. We will look at specific examples of how communication is completed using this pathway.

The diagram shows a typical signal transduction pathway. In our example today, we will consider a ligand or signal molecule to be a hormone produced by one of the endocrine glands we discussed earlier.

The word transduce means to convert. A signal transduction pathway “converts” the original signal molecule into a cellular response. This conversion requires several intermediate messenger molecules (sometimes called “second messengers”), so the signal is actually “converted” or transduced several times, as shown in the blue box above labeled Transduction. The concept of signal transduction pathways will be seen over and over again in AP Biology and is certain to be on the exam.
The hormones we consider today fall into three main categories. Polypeptides, amines and steroid hormones. The chemical make up of each is different so it is not surprising that these ligands impact cells very differently.

The transduction pathway at the target cell begins when the ligand binds to the receptor forming a temporary ligand/receptor complex. This stimulates transduction which leads to a response from the cell. Have students cite some examples of ligands.

Emphasize that “Reception” begins when the ligand establishes an IMF (intermolecular force) or electrostatic attraction to a specific site on the “Receptor”. Point out these IMFs are NOT covalent chemical bonds but rather a strong attraction that can be overcome with far less energy than it would take to “break” an actual covalent chemical bond.

Receptor proteins may be found ON the cell or IN the cell.

G protein linked receptors are located in the membrane of the cell. When activated, the G-protein linked receptor sets off a chain of events inside the cell.
Ion channel receptors, integral proteins found within the cell membrane undergo a conformational (which is fancy for “shape”) change when the ligand binds to the receptor. Ions bear a charge and cannot enter the cell by diffusion across the membrane. Instead, ions are allowed to enter the cell when the ligand is present and bound to the receptor. This allows the influx of ions to be a regulated process. Emphasize that any time charged particles (ions) are transported a difference in electric potential (as in potential energy) is established. This electric potential is now available to do “work”!

We saw an example of ion channel communication when we studied the transmission of impulses from one neuron to the next via neurotransmitters. The neurotransmitters serve as ligand molecules allowing the influx of sodium ions when the channel is open.

Some receptors are located inside the cell and are described as intracellular receptors. The receptor for testosterone, for example is found inside the cell.

Testosterone is a steroid hormone. Challenge students to explain why steroid hormones have intracellular receptors, while protein hormones have extracellular receptors. (Steroids are lipids and therefore easily diffuse through the membrane and into the cell. Proteins will not diffuse through the membrane due to both charge and size, so they must bind with receptors on the cell’s surface.)

You should be able to give examples of membrane bound receptors (G-protein linked and ion channel receptors) as well as intracellular receptors.)
Ask students to explain what this image represents – what is “transduction?”

Answers:
Signal transduction, any process by which a biological cell converts one kind of signal or stimulus into another OR A process by which a transducer converts one type of energy to another (chemical to electrical for example)

Note that the GDP is replaced by higher energy GTP in order for the process to continue.

Transduction

• Binding changes the receptor protein.
• Can set off a cascade reaction

Response

Set any of a variety of cell activities in motion.
—Activation of an enzyme
—Rearrangement of cytoskeleton features
—Activation of a specific gene
Overview of cell signaling.
Which is the receptor? G-Protein? Ligand?

A—Ligand or signal molecule such as epinephrine
B—receptor molecule
C—relay molecule or second messenger, G protein

Which is a receptor through which ions would pass?

Answer D—note the channel appearance

Which of these acts as a second messenger?

D acts as the second messenger

Hormones differ in structure and solubility.

Protein/peptide hormones are released by exocytosis, steroid hormones are able to leave their secretory cells by way of diffusion. Once in the bloodstream, both travel to their target cells. Upon arrival at the target cell, these two types of hormones have different methods of communicating with the target cells.
Receptor location varies with hormone type. Notice that the water soluble hormones, such as epinephrine or insulin, bind with a membrane bound receptor protein while the lipid soluble hormone can pass directly through the membrane of the target cell to dock with an intracellular receptor.

Receptor location varies with hormone type.

The animation should play once you show this slide.

Go through the numbered steps in this pathway emphasizing the presence of a second messenger and the amplification of the response inside the cell. Click the blue tip of the arrow to link to a video clip that explains the process of amplification. (The link will only be active in “presentation” mode). Once the video has been viewed ask students to discuss the role of the second messenger and the value of amplification.
The response to a lipid-soluble hormone is usually a change in gene expression. Steroids, thyroid hormones, and the hormonal form of vitamin D enter target cells and bind to protein receptors in the cytoplasm or nucleus. Protein-receptor complexes then act as transcription factors in the nucleus, regulating transcription of specific genes.

The animation should play once you show this slide.

Explain the pathway of a steroid hormone using testosterone as an example. Pick a male student with a moustache as your example and explain how testosterone from the testes is secreted and moves into the blood stream. The testosterone would move around the male’s body. However, follicular cells have testosterone receptors and respond to the presence of this hormone. Once inside the follicle cell of the lip, the testosterone stimulates the cell to produce keratin by “turning on” the segment of DNA that codes for the protein.”

In this case the protein produced could be keratin.
Have students take turns explaining the action of a steroid hormone using the model provided. (Pig hair from a paint brush can serve as the keratin produced in this pathway). Hold students accountable for the activity by having them write a list of steps in the pathway from secretory cell to keratin produced.

Students should complete the chart on their own or working with a partner.

Compare their responses to these suggested responses.

The same hormone can cause different reactions depending upon the cell it has targeted.

For example, epinephrine can be stimulatory in some parts of the body and stimulatory in others.
Epinephrine inhibits the glycogen synthesizing work of a liver cell while promoting the breakdown of glycogen.

One hormone, different effects.

Did you know...

- One reason that kittens sleep so much is because a growth hormone is released only during sleep.
- The levels of two stress hormones, cortisol and epinephrine which suppress the body's immune system, will actually drop after a dose of laughter.
- Chocolate is associated with the release of serotonin, the hormone that makes you feel relaxed, calm, and happy. So are hugs.

Just for fun!

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