The Workshop Project Newsletter

PROGRESSIONS:
PEER-LED TEAM LEARNING

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Module 13: Endocrine System: Hormones and Receptors

Nichole McDaniel, Ph.D.

I. Introduction

The endocrine system combines many of the concepts that you've already encountered in the course: integration and control, cell-to-cell communication, homeostasis and feedback, membrane transport, cell signaling, and transcription and translation. In addition, the endocrine system connects with and controls numerous systems in our body: from digestive to cardiovascular and from nervous to musculoskeletal. In this module you'll begin to put these pieces together to see how one system can connect to and integrate so many other systems. To understand how the endocrine system functions, you'll explore the various hormone pathways, the types of hormones and receptors, and the ways that hormone signals are regulated.

Prepare for your workshop by reading in your textbook (Chapter 17: 636-670) and completing the Pre-Workshop Activities below, ***really!*** Show your work in these pages.

II. Pre-Workshop Activities

Activity A. Define the following terms.

gap junctions

paracrine

endocrine

target cell

steroid hormones

peptide

Activity B. Cell Communication.

Define and then come up with analogies for the following methods of cell-to-cell communication (think about how you might relate these to every-day activities in order to explain them to someone else who isn't taking this class…radio? telephone? something else?).

Gap junctions:

Neurotransmitters:

Paracrine hormones:

Endocrine hormones:

III. Workshop Activities

Activity A. Cell communication.
Share your analogies from Pre-workshop Activity B with the group. Write down any good ones below.

Activity B. Nervous and Endocrine Systems.
The function of the nervous and endocrine systems has a great deal of overlap. Both are responsible for the integration and control of other body systems, however, each is specialized for a particular style of integration and control. In this exercise, work in pairs or small groups to match the characteristics (listed below the table) to the appropriate system. Put these in the center columns Sometimes both systems will have a characteristic in common; sometimes a system will have more than one characteristic. Come up with a description of each characteristic and write it in the outer columns. As a large group share and discuss your conclusions.

	Nervous	Endocrine	
neurotransmitters are chemical messengers and the action potential is electrical	*electrical & chemical*	*chemical*	*hormones are chemical messengers*

~~chemical signaling~~	~~electrical signaling~~	ACh
monoamines	controls muscle contraction	specific
rapid on/off	neurotransmitters	intracellular receptors
lipids	peptides	persistent
estrogen	integration and control	precise
membrane receptors	global	hormones
controls menstruation, growth	norepinephrine	

Activity C. Overview of the major endocrine system pathways.
In this exercise you will work together as a group to create a map of the endocrine pathways on the blackboard.

1) As a group, **draw** (or write the name of) each organ in the table below on a piece of newsprint. Use the pictures in your textbook as a guide to make a *rough* sketch. Cut out the organ and place tape on the back so that the organs can be mounted on the board.
2) Start with the first hormone on the following table (thyrotropin-releasing hormone). Draw an arrow from the organ that secretes it (hypothalamus) to the organ that responds to it (pituitary). Write the name or abbreviation (TRH) for the hormone on the arrow line.
3) The next person will draw the next step in the pathway (pituitary secretes thyroid stimulating hormone which binds to receptors on the thyroid) in the same manner.
4) The process continues until the hormone reaches the end of the pathway (thyroid hormone is released into the body where it affects all cells). The person that draws this final pathway should also write the ultimate effects on the board (like "increases metabolism"). Finish all of the hormones within a functional grouping (dark border) before you erase the board and start the next group of pathways.
5) Once the group agrees that the pathway is correct, copy the pathway into your own notes.

Note: *In the case of hormones that inhibit their target organs, instead of using an arrow, use a dotted line that ends in an "X."*

Originating Organ	Hormone	Target Organ	Response	Target Organ	Response
hypothalamus	thyrotropin-releasing hormone	pituitary	secretes thyroid stimulating hormone	thyroid	secretes thyroid hormone
		thyroid	secretes thyroid hormone	global	increases metabolism etc.
hypothalamus	growth hormone-releasing hormone	pituitary	secretes growth hormone	global	increases growth and metabolism
hypothalamus	somatostatin	pituitary	stops secreting thyroid stimulating hormone & growth hormone	thyroid, muscle	
hypothalamus	corticotropin-releasing hormone	pituitary	secretes adrenocorticotropin hormone	adrenal cortex	secretes cortisol
		adrenal cortex	secretes cortisol	global	stress response
adrenal medulla	epinephrine, norepi, dopamine	global	sympathetic-like response		
thyroid	calcitonin	bone	reduces blood Ca^{++} level, stimulates bone deposition		
parathyroid	parathyroid hormone	bone, kidneys	increases blood Ca^{++}, bone reabsorption, urinary Ca^{++} excretion		
pancreas	insulin	global	stimulates glucose uptake, lowers blood glucose		
pancreas	glucagon	global	stimulates glycogen breakdown, increases blood glucose		

Activity D. Endocrine hormones and receptors.

The hormones of the endocrine system fall into two major categories: lipid-soluble, and lipid-insoluble. The lipid soluble hormones like steroids and their derivatives can move freely across the cell membrane. All of the others cannot cross the membrane. This has an important impact on the events that follow the hormone release. Hormones that can cross the membrane have specific receptors inside the cell—usually at the DNA—which act to increase or decrease transcription and translation of relevant proteins. Hormones that cannot cross the membrane instead bind to membrane receptors which can trigger any number of secondary events (transcription and translation, activation of enzymes, changes in cell membrane permeability).

Work in pairs. In the table below, indicate whether a hormone uses an intracellular receptor or a membrane receptor (use your textbook…table 17.6). Then **PICK 5** hormones and indicate what sorts of cellular activities (transcription and translation *of what kinds of genes…for what proteins?*, activation of *what kinds of* enzymes, changes in cell membrane permeability *to what?)* the hormone likely causes based on the effect that it has on the target organ(s). Use your imagination…what do you *think* happens?

Hormone	**Receptor type** (intracellular or membrane)	**Possible cellular effects**
follicle-stimulating hormone		
corticosterone		
oxytocin		
estrogen		
testosterone		
antidiuretic hormone		
aldosterone		
gonadotropin-releasing hormone		
calcitriol		
thyroid stimulating hormone		
thyroid hormone (thyroxin)		

How do the two different types of hormones get out of the cell where they are formed? What implication does this have for the storage of the two types of hormones?

Activity E. Regulation in Health and Disease.

The strength of the endocrine system is its ability to regulate organ system function within rather narrow limits. It does this using a variety of mechanisms. Briefly, the endocrine system can increase or decrease the level of a specific hormone, the number of receptors, or the sensitivity of receptors. Let's use basketball as an analogy. Let's say that the team is practicing free throws. There are two baskets (receptors) on the court, and two balls (the hormone molecules). On average, the players are making two shots per minute. There are several ways that we can increase the number of shots that they make:

1) increase the number of balls (more hormone)
2) increase the number of baskets (more receptors)
3) lower the height of the basket (increase receptor sensitivity)

We can also do the opposite to decrease the number of shots that they make by taking a ball and a basket away, and raising the height of the basket. It is not necessary to do all three in order to drastically affect the outcome of the hormone, but it is possible for more than one of these mechanisms to be taking place simultaneously. In a normal healthy system, we tend to rely most on the first two mechanisms. Also, many systems are regulated by more than one hormone, so there is balance on even more levels (one hormone increases blood pressure, another lowers it). In many endocrine diseases we can point to malfunctions in one or more of these mechanisms as the underlying cause. For the diseases below, come up with at least three ways that the disease could result. Then look in your book to see which of those causes is correct. Circle that explanation.

Disease 1: Gigantism…excessive growth (growth hormone)

Disease 2: Diabetes mellitus… high blood sugar (glucose in blood)

Disease 3: Hypothyroidism…low metabolism (thyroid hormone)

Disease 4: Hyperinsulinism…low blood sugar (insulin)

Disease 5: Graves disease…high metabolism (thyroid hormone)

Disease 6: Diabetes insipidus…watery urine (antidiuretic hormone)

Disease 7: Dwarfism…inhibited growth (growth hormone)

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David Gosser, Consulting Editor, gosser@sci.ccny.cuny.edu
AE Dreyfuss, Editor, aedreyfuss@aol.com
Nichole McDaniel, Co-Editor, Anatomy & Physiology Modules, nichole.mcdaniel@bcc.cuny.edu

The City College of New York
Marshak Science Building MR-1024
160 Convent Avenue, New York NY 10031
Phone: 212-650-5704 Fax: 212-650-8339
Email: info@pltl.org Website: www.pltl.org

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