Lesson 1: Helpful Hormones

Created for SPICE by scientist Dimitri Blondel
& teacher Eugenia Campbell
2009

Key Questions:
What are some of the important hormones in the human body?
What are their functions?

Science Subject: Life Science

Grade Level: 6-8

Science Concepts: Human physiology, endocrine system

Time Estimate: one-two 50 minute period (s)

Basic Vocabulary:

1. Endocrine system – A group of organs called glands and the hormones they produce that help regulate conditions inside the body.
2. Gland – An organ in the body that produces a specific substance, such as a hormone.
3. Homeostasis – Stable, constant condition.
4. Hormone – A chemical that is made in one organ and travels through the blood to another organ.

Background:

Mammalian bodies need to maintain homeostasis, and need regulation of processes like growth, development and reproduction. To accomplish this, along with the nervous system, the **endocrine system** serves as an internal regulator and messenger service. **Glands** secrete **hormones**, which then are carried by the circulatory system to target areas of the body, and attach to specific receptors. The hormones are acting as messengers; the target areas then react as appropriate. Teachers should be familiar with the following aspects of the endocrine system in preparation for teaching this lesson:

Adrenal glands: These are adjacent to the kidneys. They produce hormones in response to stress. Hormones secreted include **epinephrine, norepinephrine, glucocorticoids, and mineralocorticoids.** The glucocorticoids produced include **cortisol**, which acts on skeletal muscle, restoring homeostasis by making more glucose available to the body as fuel.

Anterior pituitary: On the underside of the brain, at the base of the **hypothalamus**. Secretes, among others, **growth hormone**. Growth hormone acts on a variety of target tissues to stimulate bone and cartilage growth.

Pancreas: Located near the kidneys, beneath the stomach; it is part of both the digestive system and the endocrine system. Secretes, among others, **insulin** and **glucagon**. These regulate the levels of glucose in the blood. Glucose is what our body's cells use for fuel, and it's important that we have just the right amount circulating in the blood, not too much, and not too little. Insulin decreases glucose level, and glucagons increases glucose level.

Thyroid gland: Located near the Adam's apple. Secretes, among others, **thyroxine**. Thyroxine acts throughout the body to help maintain normal blood pressure, heart rate, muscle tone, digestion, and reproductive functions.

Testes: Located between the legs. Secretes, among others, **testosterone.** Testosterone stimulates development of and maintains male secondary sexual characteristics such as increase in muscle and bone size, hair growth and a low voice.

Ovaries: Located near the groin. Secretes, among others, **estrogen**. Estrogen stimulates development of and maintains female secondary sexual characteristics, and maintenance of the female reproductive system.

Hypothalamus: Attached to the pituitary gland. Connects the nervous and endocrine systems. Secretes, among others, **growth hormone releasing hormone (GHRH)**, which acts on the pituitary to stimulate release of growth hormone.

Materials:

-Seven hormone "sets" will be enough for a class of 28 students. Students will end up working in groups of four, each group using one set. Each set consists of:

- 1 gland card, which lists which hormone it produces
- 1 hormone key
- 1 hormone receptor lock, which is locking a recipe box

Inside the box is a slip of paper with the effect.

- 1 effect card
- 4 info cards specific to each hormone set

The locks and keys can be different types of baggage locks. Each key should be able to open only one lock.

- Worksheet for part II

The worksheet contains the following questions:

1. What gland produces your hormone?
2. Where in the body is this gland located?
3. When is this hormone produced?
4. What is the effect of this hormone?
5. What would happen if there were too much of the hormone?
6. What would happen if there were too little of the hormone?
7. Can anything in the environment affect the hormone or its physiological effects? How?

-The 7 sets are as follows:

1. – Adrenal gland
   - Cortisol
   - Cortisol receptor
   - Restoration of homeostasis

2. – Anterior pituitary
   - Growth Hormone
   - Growth Hormone receptor
   - Growth and cell reproduction

3. – Pancreas
   - Insulin
   - Insulin receptor
   - Regulates glucose levels of blood

4. – Thyroid gland
   - Thyroxine
   - Thyroid receptor
   - Increase metabolic rate

5. – Testes
   - Testosterone
   - Testosterone (Androgen) receptor
   - Muscle growth, sexual development

6. – Ovaries
   - Estrogen
   - Estrogen receptor
   - Sexual development, reproduction

7. – Hypothalamus
   - Growth-hormone releasing hormone (GHRH)
   - GHRH receptor
   - Release of Growth Hormone from anterior pituitary


Reuters

Introduction of module to students

1. First, show the students the above images of Leonid Stadnyk, who stands 8'5" tall and weighs 440 pounds. The man he is talking to is ~6' tall.
2. Point out to the students that, due to his large size, Stadnyk has many health problems, and it is hard for him to move around without holding on to things for support.
3. Ask the students to hypothesize how he got to be so tall.
4. After discussing some of the student's hypotheses, tell them the reason: he had too much of a type of chemical called a "hormone" in his body. The particular hormone is called growth hormone. Tell the students that in this lesson we will learn about hormones and what they do in our body, and that if the amount of hormone is too small or too large, things go wrong – but if the amount is just right, our bodies

function as normal. Tell them that hormones are necessary for our bodies to function normally, and without them we would not be able to grow, have kids, or recover from any kind of stress.

Procedure:

Part I

1. Divide the class into 4 groups, sending each group into a different area of the classroom.
2. Distribute the gland cards to group 1, the hormone keys to group 2, the receptor lockboxes to group 3, and the effect cards to group 4.
3. Each member of group 1 should read their card to see which hormone their gland produces. They should then find this hormone in group 2. (Ask? Keys w/labels?)
4. Now in pairs, the gland/hormone duo should go to the receptor group (group 3), and the hormone should try their key with different receptors, until they find the correct one.
5. Now in groups of 3, the receptor should look in their lockbox, and find out what the effect of the hormone is. They should find this effect in group 4. (Ask? Wear effect around their neck?)
6. Now in groups of 4, the new groups should then go to a table and start the next phase of the lesson.

Part II

1. The instructor should now pass out 1 card to each team member in the group.
2. Each card had critical information on it to completing the task. Students are **not** allowed to look at or exchange cards with other group members and must communicate by reading what is printed on their card.
3. Working together, the students should complete their worksheet.

Optional Part III (Probably a second day)

1. Students should go online and find two facts about their hormone that were not on their info cards.
2. Students should now create a poster that conveys the information from their worksheets and from their internet research
3. Students should present their posters to the rest of the class.

Sunshine State Standards:

SC.F.1.3.1: The student understands that living things are composed of major systems that function in reproduction, growth, maintenance, and regulation.

SC.F.1.3.4: The student knows that the levels of structural organization for function in living things include cells, tissues, organs, systems, and organisms.

SC.B.1.3.1: The student identifies forms of energy and explains that they can be measured and compared.

SC.B.1.3.2: The student knows that energy cannot be created or destroyed, but only changed from one form to another.

Worksheet for part II

Name:_____ Period: _____Teacher: _____

8. What gland produces your hormone?

9. Where in the body is this gland located?

10. When is this hormone produced?

11. What is the effect of this hormone?

12. What would happen if there were too much of the hormone?

13. What would happen if there were too little of the hormone?

14. Can anything in the environment affect the hormone or its physiological effects? How?

Lesson 2: Bioaccumulation in the Singing Mouse

Created by Dimitri Blondel and Dr. Steven Phelps
2009

Key Questions:

What is bioaccumulation?
How is it related to food chains and trophic levels?
How could bioaccumulation be applied specifically to the singing mouse and its ecosystem?
What are potential solutions to the problem of bioaccumulation?

Science Subject: Life Science

Grade Level: 6-8

Science Concepts: Ecology; physiological and species-wide effects of pollution; process skills including graphing and interpretation of raw data.

Time Estimate: One 50 minute period

Basic Vocabulary:

5. **Bioaccumulation** – Accumulation of substances (pesticides or other toxic chemicals) in an organism at a rate greater than that at which the substance is lost. Bioaccumulation occurs at an increasing rate at higher trophic levels, essentially getting magnified at a rate approximating 10% with each step up to the next trophic level.
6. **Endocrine System** – A group of organs called glands and the chemicals (hormones) they produce that help regulate conditions inside the body.
7. **Endocrine Disrupter** – A chemical substance from outside the body that acts like a hormone and disrupts normal endocrine function.
8. **Vinclozolin** – A common fungicide used in agriculture; a known endocrine disrupter.

Plus, all vocabulary from Lesson 1.

Materials:

- Twenty artificial leaves
- Twenty red circular stickers
- Velcro to add to leaves and stickers so that they are removable
- Signs assigning roles (we are using construction paper and yarn), to be worn around the neck.

  There should be:

  20 plants

  6 insects (2 mealworm, 2 crickets, 2 beetles)

  3 mice

  1 hawk

  1 farmer

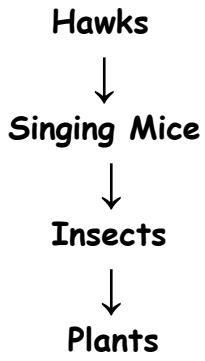
Introduction of module to students

5. Ask the students if they remember whether there is a sex difference in singing mouse calls.
6. After re-establishing that males call more than females, report to the students that we have field data from two different populations of singing mice. The males in one population call less frequently than the males in another population.
7. Lead a brief discussion on what could be causing this. Students should share their hypotheses. Lead the students to the hypothesis that a chemical in the environment, specifically a fungicide, Vinclozolin, could be causing this. Explain briefly hormones and endocrine disrupters, and that Vinclozolin may be feminizing the males, causing them to display characteristics that are more feminine. Ask the students if they think this is healthy for the reproductive biology of the singing mice, and for that population as a whole.
8. Assuming the fungicide were causing this problem, how could the chemical be accumulating in the mice? Alert the students that the goal of today's lesson is to understand how toxic chemicals can accumulate in organisms, a process called **bioaccumulation**.

Review

1. Lead the students in a review from lesson 1; ask students first about what organisms eat what other organisms in the singing

mouse ecosystem. Draw on the board the following food chain:



2. Remind the students that this is a simplification of real life, since hawks eat other types of prey, singing mice eat different types of insects, and eat about 20% plant matter as well. This is a nice opportunity to point out that in science we frequently simplify concepts in order to better understand how the world works.
3. Ask the students to label the **producers** and **consumers** on the food chain.
4. Ask a student do diagram how energy flows through the ecosystem, adding "energy arrows" to the figure. If necessary, guide the student into adding a sun somewhere in the diagram.
5. Tell the students that, similar to energy, chemicals can also flow through an ecosystem. We will now run a "simulation" game that tracks chemicals as they flow through the system.

Bioaccumulation Simulation Game - Procedure:

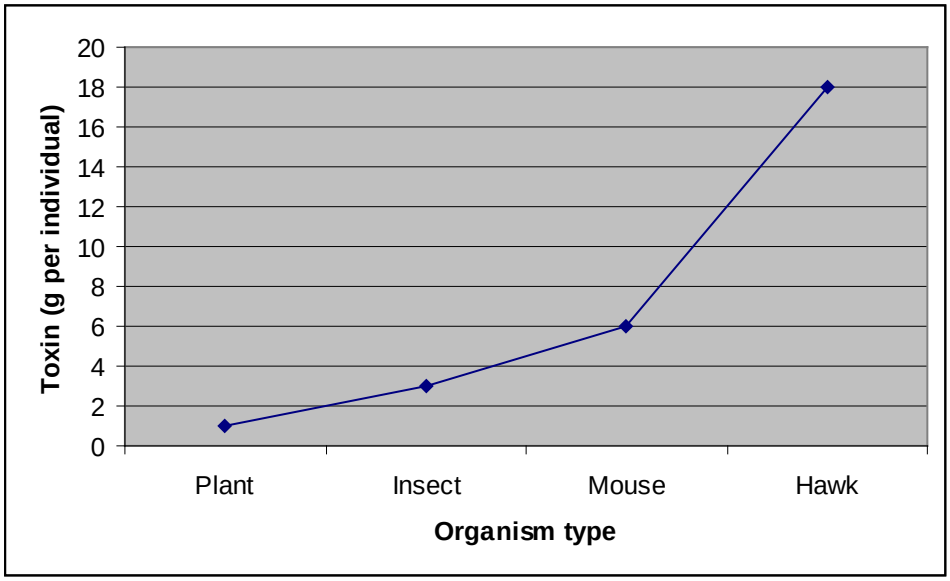
Part I – Role Playing

1. Assign roles to each student; all roles should be filled to max capacity except for plants, which can change according to class size. Grams of toxin listed below may change slightly depending on class size.
2. Show the students the red dots, and tell them each represents 1 g of a fungicide.
3. Have each plant hold one leaf.
4. The farmer should come and "apply the fungicide" by sticking one red dot on each leaf.

5. At this point, show the students on the board how many grams of toxin there are per organism (1 g per plant).
6. Have the insects each pick 3 leaves to eat. They take the leaves.
7. Have the insects take the red dots off their leaves, and hold them in their hands. This symbolizes the toxin present in their bodies.
8. Add to the table from #5, first asking the insects how many grams they each have: 3 g toxin per insect.
9. The mice should each pick 2 insects to eat. When they eat an insect, the insect should give red dots to the mice, then lie on the ground.
10. Add to the table: 6 g toxin per mouse.
11. The hawk should eat all three mice.
12. Add to the table: 18 g toxin per hawk.

Part II – Data analysis

4. The class should break up into groups of four.
5. Using the "raw data" table on the board, each group should create a graph.
6. Half the groups should create a graph (on the white board) showing organism type as the independent variable and toxin-per-individual as the dependent variable, as follows:



When students share their graphs, point out that the trophic levels can be overlaid on the X-axis as well. Also point out that in

nature the biomass (prey consumed, etc) tends to increase exponential from trophic level to trophic level, but we had to simplify since we only have ~25 students.

4. The other groups should show a visual representation of the number of grams of toxin per individual next to each organism type, as follows:

5. Have students share their graphs. Lead a discussion on how to interpret these. Points to help the students to consider:

- In the graph from # 3, what if small doses of the toxin are not harmful, but at a certain cut-off (say, 5 g), it causes harmful effects? Draw a horizontal line on the graph showing this.
- The graph from #4 is essentially a reverse biomass/energy pyramid. Show this graphically.

6. Also discuss the history of DDT and raptors, as an example of bioaccumulation.
7. End the lesson with a discussion on possible solutions to the problem of bioaccumulation.

Sunshine State Standards:

SC.7.E.6.6: Identify the impact that humans have had on Earth, such as deforestation, urbanization, desertification, erosion, air and water quality, changing the flow of water.

SC.7.L.17.1: Explain and illustrate the roles of and relationships among producers, consumers, and decomposers in the process of energy transfer in a food web.

SC.7.N.1.1: Define a problem from the seventh grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

Lesson 3: Ripe Bananas – Testing a Proximate Hypothesis

Created by Dimitri Blondel and Eugenia Campbell
2009

Key Questions:

How do bananas become ripe?

What are some proximate and ultimate explanations for why bananas might ripen simultaneously rather than sequentially?

Do plants have hormones? Can they exist as a gas?

How could we design an experiment to test this?

Science Subject: Life Science

Grade Level: 6-8

Science Concepts: Plant physiology; scientific method; ecology; ultimate vs. proximate questions

Time Estimate: One week.

Basic Vocabulary:

9. **Plant Hormones** – Chemicals used as signals by the plant to coordinate and regulate growth, development and metabolism.
10. **Ethylene** – A plant hormone that stimulates ripening, leaf and flower aging, and leaf dropping. Unlike most hormones, ethylene is a gas.
11. **Ultimate questions** – "Why" questions. A biological question that asks about the fitness benefit of a particular trait – how does help increase number of offspring and survival, thereby passing genes on to the next generation?
12. **Proximate questions** – "How" questions. A biological question that asks about the mechanistic reason for a particular trait. *How* does it occur?

Summary:

This lesson provides an opportunity for students to learn about the gaseous plant hormone ethylene while designing an experiment. Students will gain a new appreciation for the history of the domesticated banana and its wild relatives; the concepts of "domesticated" and "wild" should be explained in

detail if the students have not been previously exposed to these terms. It is expected that students will have previously covered the scientific process; in this lesson, they will experience the process first-hand. They will also be exposed to the concepts of proximate and ultimate explanations for biological phenomena. The experimental design is somewhat open-ended (within certain constraints), since the students themselves will be creating the experiment.

Materials:

-An assortment of ripe and unripe bananas.

- Paper and plastic bags

- Other items as necessary (depending on the student's eventual experimental design)

Introduction of module to students

9. Lead a discussion about fruit, specifically how and why fruit ripens.
10. Allow students to share general observations on fruit ripening. Guide the discussion to the topic of whether fruit tends to ripen sequentially or simultaneously.
11. Bring up the example of bananas and their simultaneous ripening.
12. Ask the students to come up with ultimate hypotheses for why this might occur for the bananas. Help if needed. Guide the students into thinking about seed dispersal and frugivores. One hypothesis could be that it is easier to see the ripe fruit if they are all ripe at the same time than if just a few are ripe. Another hypothesis could be that frugivore visits are relatively rare, and the plant takes advantage of the disperser's presence by maximizing the number of fruit that are ready for dispersal during a single visit. Point out to the students that wild bananas are many different colors (the yellow color is a mutation during domestication). Explain that most wild bananas are dispersed by bats. Since bats are nocturnal, possible hypotheses from this information could be that the olfactory signal from simultaneously ripened fruit would be easier for the bats to find than sequentially (and thus less intense) ripened fruit; alternatively, it could be hypothesized that ripe bananas reflect UV light (since some bats are sensitive to UV wavelengths), and bunches of ripe bananas would be more obvious.

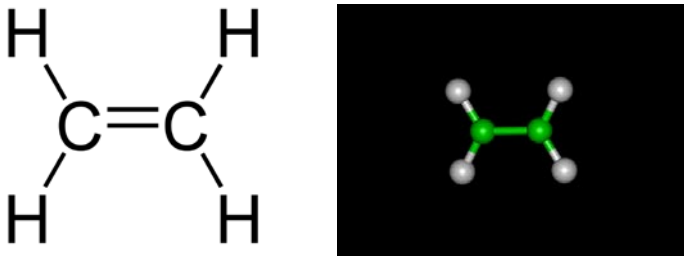
13. Ask the students to come up with proximate (mechanistic) hypotheses for simultaneous ripening. Lead them to the hypothesis that it is something released into the air by the fruit themselves. This will be the hypothesis tested in this lab. Emphasize that the proximate and ultimate explanations, while different, may both be correct, since they are answering different questions.

Ripe banana experiment - Procedure:

13. Divide students into teams of four. Each team will design their own experiment to test the hypothesis.
14. Each time should follow all the steps of the scientific process: ask question, generate hypothesis, make prediction, test prediction, draw conclusion.
15. The experiments can last several days, and can include ripe and unripe bananas. Provide all supplies necessary for experimental design (within means; if the designs are not financially possible, help the students come up with a more realistic design).
16. The students should be clear on an objective way to measure "ripeness" (e.g. number of spots, % of banana that is brown, size of largest spot, number of spots that are larger than some defined minimum).
17. Examples of some potential experimental designs:
    a. Bananas inside paper/plastic bag vs. bananas outside paper/plastic bag
    b. Unripe bananas alone vs. unripe bananas with 1 ripe banana.
    c. Different combinations of: green, yellow with no spots, yellow with spots
18. Students should collect data over the next three days.
19. Students should spend one day performing data analysis (including graphing their data) and drawing conclusions.

Concluding Discussion

1. Lead students in a discussion interpreting their results.
2. Explain to the students that the process they witnessed is due to a plant hormone called **Ethylene**, and that it is unlike most hormones in that it exists as a gas.
3. Show them what it looks like:



4. Explain that it is responsible not only for stimulation of fruit ripening, but also plays a role in the aging ("scenescence") and shedding ("abscission") of leaves and flowers.