Lesson #15: Comparing Mental Models on Waste

This lesson is an exerpt from a larger teacher resource available on-line at http://www.eenorth.com/eenorth/documents/nwhp.html
It consists of a teacher guide (includes student handouts) and 3 powerpoint presentations that guide students through the research at Nunavut Wildlife Health Project. Ideally, you would have students complete all of the lessons within this teacher resource package (which include a simple but effective demonstration of the “grasshopper effect”) In my opinion, these lessons are very well thought-out with

*emphasis on vocabulary about contaminants
*use of real-life and relatively recent (2005) data on contaminants in the north
*photos of the people and the landscape embedded in the 3 powerpoint presentations
*meaningful connection to the local people
*emphasis on students thinking of themselves as scientists and introduction to what scientists actually do
*visual (multiple intelligences!)

This teacher resource itself is only one of many found on the website http://www.eenorth.com/eenorth/. If you are a grade 9-12 science teacher (any area- check out the physics of the Qamutiit (dog sled)) you need to check out the website and do your own search to find precisely what you need.

At minimum, it is hoped that students could view all 3 powerpoint presentations (the handout provided here includes questions for all 3) and the laboratory activity included herein should definitely be done. Note that students will not truly understand the grasshopper effect unless you do the quick demonstration included in the teacher resource package.

<table>
<tr><th colspan="2">Stage 1 – Desired Results</th></tr>
<tr><td colspan="2">Established Goals: SLO A2: Recognize both the power and the limitations of science as a way of answering questions about the world and exploring natural phenomena.</td></tr>
<tr><td>Understandings:
Students will understand that…1. 1 ppm is a very small amount but can still cause health problems in humans and wildlife.</td><td>Essential Questions:
SLO A3: How do history and culture (mental models) influence creation and use of technology (how we TAKE-MAKE-WASTE goods)?</td></tr>
<tr><td>Students will know… 1. How to show 1 ppm
2. Solve problems involving the dilution of solutions (C11-4-16)
3. …give examples of various representations of concentration. Include: ppm (C11-4-13)</td><td>Students will be able to…
1. Complete a lab activity safely
2. Make the distinction between two groups of hormonally active agents – hormone mimics and hormone blockers</td></tr>
<tr><th colspan="2">Stage 2- Assessment Evidence</th></tr>
<tr><td>Knowledge:
1. Assess designs of how the students plan to demonstrate 1 part per million using the supplies provided
2. Assess answers to the questions from the lab activity</td><td>Skills: Assess lab safety skills
Assess knowledge of distinction between hormone mimics and hormone disruptors</td></tr>
</table>

Materials Required

Powerpoint Presentation "Examining Our Mental Models"

Access to powerpoints from NWHP (minimum suggested is first 6 slides of "Understanding the Findings of the NWHP" **(Source: Nunavut Wildlife Health Project: WWF and Trent University. Retrieved March 28, 2009 from http://www.eenorth.com/eenorth/documents/nwhp.html)**
(alternately, print the slides for your reference as you describe the NWHP)

HANDOUT: How Much is Too Much? Nunavut Wildlife Health Project **(Source: Nunavut Wildlife Health Project: WWF and Trent University.** Retrieved March 28, 2009 from **http://www.eenorth.com/eenorth/documents/NWHP_TeachersResourcePackage.pdf, p. 33)**

Supplies for design-a-laboratory activity "How Much Is Too Much?" (per group)
- 6 test tubes
- 1 25mL graduated cylinder
- 1 mL food coloring

HANDOUT: of Laboratory Report Outline (if having students design the lab) **(Source: Manitoba Education and Training. (1997). Senior Years Science Teacher Handbook. Manitoba: Manitoba. (p. 11.26-11.30, 11.38, 11.39))**
OR Handout: Lab: How Much is Too Much?

HANDOUT: Concept Relationship Frame **(Source: Manitoba Education and Training. (1997). Senior Years Science Teacher Handbook. Manitoba: Manitoba. (p. 10.15–10.18))**
Case Study: Are Hormonally Active Agents a Human Health Threat? **(Source: Miller, G. (2005). Living in the environment (14th ed.). CA, USA: Brooks/Cole (p.416-417).**

Stage 3 – Learning Plan

1. **Slide 39 –** Revisit the display boards and discuss students' present thoughts about mental models on waste. Try to determine whether they perceive there is such a thing as "too much" and if so, how do we determine how much is TOO much? Introduce/define "precautionary principle". The question as to whether "chemicals" should be "innocent until proven guilty" or "guilty until proven innocent" is a helpful way to frame the issue.
2. Introduce the slide shows, directing students to make notes on the sheet provided.
   *Locate Arviat, Coral Harbor, and Panirtung on a map, emphasizing that these lands are directly above Manitoba.
   *Inform students that WWF is the World Wildlife Fund
   *Students will pretend that they have just been hired by the NWHP. They are first responsible to know what the project has accomplished so far and then they will be a scientist working on the research team.
   *Direct students to complete the questions as they proceed through the 3 powerpoint presentations so that they have notes on the project. (if time is short, the absolute minimum suggested is slides #1-6 of Understanding the Findings of the NWHP) as this details the effects of the contaminants that the students will likely run across in their projects. PROJECT LINK
3. Ideally, have students go to the website on their own (or in pairs) and complete the handout. If not possible, SHOW and DISCUSS at least slides #1-6 of the NWHP.
4. INFORM students that many compounds are measured in parts per million (ppm)
5. BRAINSTORM ways that students could show 1 part per million using the provided supplies (test tubes, graduated cylinder, water, food coloring)
   Use the **Laboratory Report Outline** (Purpose: To model 1 ppm, Hypothesis: (students design this with guidance) You might begin with idea of how one could show 1 part per ten. You may want to collect their plans and review them (formative

assessment), completing the lab activity the following day.
(Alternately, handout and complete laboratory activity "cookbook" style)

6. COMPLETE the lab activity (dilution) and describe what is expected on the lab report.
7. DISCUSS the mental model of trying to decide "How much is TOO Much?"
   -assumption that we can predict natural systems
   -assumes that we can push natural systems to their limit and they will bounce back (ie resilience of nature) (An example of a case in which nature can bounce back is a bulldozed area to which pioneer species return – but this takes time. Also, when ecosystems are pushed beyond their limits, they may not "bounce back" at all. They may be converted to an entirely different ecosystem)
   -assumes that if a natural system is pushed to its limit we can always STOP the activity and the natural system will bounce back. The slides from the powerpoint demonstrate biomagnifications and bioaccumulation (there are also good simulation activities to show these two principles in the NWHP teacher resource guide.
8. READ as a class "Chemical Hazards: What are Toxic and Hazardous Chemicals?" **(Source: Miller, G. (2005). Living in the environment (14th ed.). CA, USA: Brooks/Cole (p.416-417).** To ensure that students are
   *connecting their projects to the readings (ie dioxins are mentioned)
   *understanding that with endocrine disruption, the effects are seen AT VERY LOW LEVELS of the chemicals – so their perceptions of how much is TOO much might change here. See also (Educator's Guide to Project: TAKE-MAKE-WASTE article #10 Hormone Hell from Discovery On-Line)
9. Direct students to read the Case study Are Hormonally Active Agents a Human Health Threat? **(Source: Miller, G. (2005). Living in the environment (14th ed.). CA, USA: Brooks/Cole (p.416-417).** Direct students to use the "Concept Relationship Frame" to make the distinction between hormone mimics and hormone blockers. Review it with students or have them submit it so that you can review it.

Extension Learning Activities

It would be **GRAND** to more deeply a research project perhaps with the title "For/Against the Precautionary Principle" as many real-life examples can be found in which some innovation has unintended consequences that are unforeseen or not predicted or simply ignored.
The point here is to recognize that science has contributed to many disasters and ethically questionable occurrences (though many factors obviously come into play, not only the science innovation). It is REDUCTIONIST science that is to be questioned – the application of science "in a vacuum" – in a way that is not holistic, not conducive to systems thinking. An exerpt from my thesis is included for your information/interest.

Have a "gas sniffing machine" come to check for gas leaks in the school's labs. Explore how the machine "knows" how many parts per million are present (ie how does the machine work?)

How Much is TOO Much?
The Nunavut Wildlife Health Project

Since you have recently been hired to work for the World Wildlife Fund, we are sending you the link for the website for the Nunavut Wildlife Health Project. Below are the items that you should be familiar with. (Source: Nunavut Wildlife Health Project: WWF and Trent University. Retrieved August 28, 2007 from http://www.wwf.ca/satellite/wwfkids/nwhp_trk.html)
(Use your own original words (ie do not copy directly from the screen)).

Powerpoint 1: Understanding NWHP

1. The letters in NWHP stand for….
2. The main reasons for starting the NWHP were…
3. The two concerns of the hunters/elders were…
4. The NWHP aims to achieve 3 goals. They are…
5. What are the roles of Susan and Gord? What is the official name for their type of science specialty?
6. List the 6 steps of the project and a few words to describe what happened at each step

Powerpoint 2: Northern Contaminants

1. Define contaminant.
2. What are 3 types of contaminants found in the north?
3. Give one example of a) a local source of contaminants

   b) a global source of contaminants
4. How do contaminants get to the arctic?
5. How do contaminants get into the wildlife?
6. What is the difference between biomagnification and bioaccumulation?

Powerpoint 3: Understanding the Findings of the NWHP

1. Name the five main contaminants studied and give the effect of each one.

2. True or False: Once a contaminant is in the body of an animal, it will be found in all of its organs in the same amounts.

3. True or False: Contaminant levels are higher in animals in the Arctic than they are in the Great Lakes.

4. If the arctic contaminant levels are low, give 5 reasons why we are still concerned about the effects.

5. Why is the health of wildlife described as a balancing act?

6. List 3 action items that need to be done to protect wildlife health and add a few words to describe them.

7. Do you believe that the arctic contaminant levels are TOO high? Why/why not?

Chemical Hazards: What Are Toxic and Hazardous Chemicals?
Case Study: Are Hormonally Active Agents a Human Health Threat? (p.417-418)

From: Living in the Environment: Principles, Connections, and Solutions (with CD-ROM and Info-Trac) 14th edition by MILLER, G. 2005. Reprinted with permission of Brooks/Cole, a division of Thomson Learning: www.thomsonrights.com. Fax 800 730-2215.

standards. But citizens, lawmakers, and regulatory officials must recognize the huge uncertainties involved in all such studies.

19-3 CHEMICAL HAZARDS

What Are Toxic and Hazardous Chemicals? Causing Death and Harm

Toxic chemicals can kill, and hazardous chemicals can cause various types of harm.

A **toxic chemical** is a chemical, which through its chemical action on life processes, can cause temporary or permanent harm or death to humans or animals. Its toxicity is often measured in terms of its medium lethal dose (Figure 19-5). A **hazardous chemical** can harm humans or other animals because it is flammable or explosive or because it can irritate or damage the skin or lungs, interfere with oxygen uptake, or induce allergic reactions.

There are three major types of potentially toxic agents. One consists of **mutagens,** chemicals or ionizing radiation that cause or increase the frequency of random *mutations,* or changes, in the DNA molecules found in cells. An example is nitrous acid (HNO_2) formed by digestion of nitrite preservatives in foods. *Most mutations are harmless.* One reason is that organisms have biochemical repair mechanisms that can correct mistakes or changes in the DNA code.

But harmful mutations occurring in reproductive cells can be passed on to offspring and to future generations. It is generally accepted that there is no safe threshold for exposure to harmful mutagens.

A second type consists of **teratogens,** chemicals that cause harm or birth defects to a fetus or embryo. Ethyl alcohol is an example of a teratogen. Drinking during pregnancy can lead to offspring with a low birth weight and a number of physical, developmental, and mental problems. Thalidomide is also a potent teratogen.

The third group is **carcinogens,** chemicals or ionizing radiation that cause or promote **cancer**—the growth of a malignant (cancerous) tumor, in which certain cells multiply uncontrollably. An example is benzene, a widely used chemical solvent. Many cancerous tumors spread by **metastasis** when malignant cells break off from tumors and travel in body fluids to other parts of the body. There they start new tumors, making treatment much more difficult. Typically, 10–40 years may elapse between the initial exposure to a carcinogen and the appearance of detectable symptoms. Partly because of this time lag, many healthy teenagers and young adults have trouble believing their smoking, drinking, eating, and other lifestyle habits today could lead to some form of cancer before they reach age 50.

What Effects Can Some Chemicals Have on Immune, Nervous, and Endocrine Systems? Possible Harm from Small Doses

Long-term exposure to some chemicals at low doses may disrupt the body's immune, nervous, and endocrine systems.

Since the 1970s a growing body of research on wildlife and laboratory animals, along with some epidemiological studies of humans, indicates that long-term exposure to low doses of some chemicals in the environment can disrupt the body's immune, nervous, and endocrine systems.

The *immune system* consists of specialized cells and tissues that protect the body against disease and harmful substances by forming antibodies that make invading agents harmless. Ionizing radiation and some chemicals can weaken the human immune system and leave the body vulnerable to attacks by allergens, infectious bacteria, viruses, and protozoans. Examples are arsenic and dioxins.

Some natural and synthetic chemicals in the environment, called *neurotoxins,* can harm the human *nervous system* (brain, spinal cord, and peripheral nerves). For example, many poisons and the venom of poisonous snakes are neurotoxins, which inhibit, damage, or destroy nerve cells (neurons) that transmit electrochemical messages throughout the body. Effects can include behavioral changes, paralysis, and death. Other examples of neurotoxins are PCBs, mercury, and certain pesticides.

The *endocrine system* is a complex network of glands that release very small amounts of *hormones* in the bloodstream of humans and other vertebrate animals. Low levels of these chemical messengers turn on and off bodily systems that control sexual reproduction, growth, development, learning ability, and behavior.

Each type of hormone has a specific molecular shape that allows it to attach only to certain cell receptors (Figure 19-7, left). Once bonded together, the hormone and its receptor molecule can signal cell mechanisms to execute the chemical message carried by the hormone.

Case Study: Are Hormonally Active Agents a Human Health Threat? Serious Concern but Inconclusive Evidence

Exposure to low levels of certain synthetic chemicals may disrupt the effects of natural hormones in animals, but more research is needed to determine the effects of these chemicals on humans.

There is concern that human exposure to low levels of certain synthetic chemicals can mimic and disrupt the effects of natural hormones. Over the last 25 years, experts from a number of disciplines have been piecing together field studies on wildlife, studies on labora-

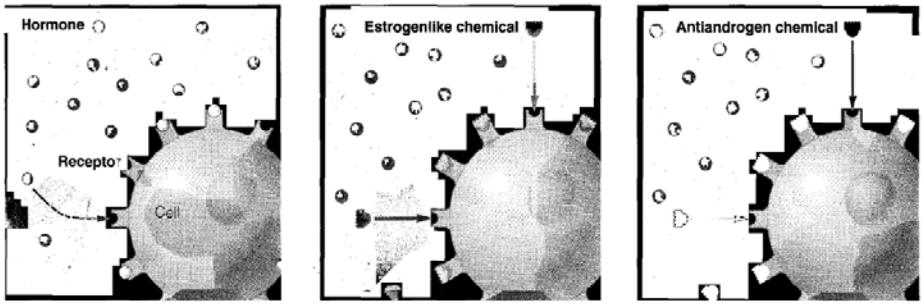

Figure 19-7 Hormones are molecules that act as messengers in the endocrine system to regulate various bodily processes, including reproduction, growth, and development. Each type of hormone has a unique molecular shape that allows it to attach to specially shaped receptors on the surface of, or inside, cells and to transmit its chemical message (left). Molecules of certain pesticides and other synthetic chemicals have shapes similar to those of natural hormones and can affect the endocrine system in people and various other animals. These molecules are called *hormonally active agents* (HAAs). Some HAAs, sometimes called *hormone mimics*, disrupt the endocrine system by attaching to estrogen receptor molecules (center) and giving too-strong, too-weak, or mistimed signals. Other HAAs, sometimes called *hormone blockers*, prevent natural hormones such as androgens from attaching to their receptors (right) so that no signal is given. Some pollutants, called *thyroid disrupters*, may disrupt hormones released by thyroid glands and cause growth and weight disorders and brain and behavioral disorders. Because of the difficulty in determining the harmful effects of long-term exposure to low levels of HAAs, there is uncertainty over their effects on human health.

tory animals, and epidemiological studies of human populations. This analysis suggests that a variety of human-made chemicals can act as *hormone* or *endocrine disrupters*, known as *hormonally active agents (HAAs)*. Examples of hormone disrupters are DDT, PCBs, and certain herbicides.

Some, called *hormone mimics*, are chemicals similar to estrogens (female sex hormones). They can disrupt the endocrine system by attaching to estrogen receptor molecules (Figure 19-7, center). Others, called *hormone blockers*, disrupt the endocrine system by preventing natural hormones such as androgens (male sex hormones) from attaching to their receptors (Figure 19-7, right). Estrogen mimics and hormone blockers are sometimes called *gender benders* because of their possible effects on sexual development and reproduction. There is also growing concern about still another group of HAAs—pollutants that can act as *thyroid disrupters* and cause growth, weight, brain, and behavioral disorders.

Is long-term exposure to low levels of HAAs a threat to human health? A 1999 study of the possible effects of hormonally active agents on humans by a U.S. National Academy of Sciences panel of scientists came to three major conclusions. *First*, "adverse reproductive and developmental effects have been observed in human populations, wildlife, and laboratory animals as a consequence of exposure to HAAs." *Second*, "there have been only a few studies of the effects of HAAs in humans, but the results of laboratory and wildlife studies suggest that HAAs have the potential to affect human immune functions." *Third*, greatly increased research is needed to come to a more definitive conclusion about whether low levels of most HAAs in the environment pose a threat to human health.

Bottom line: We do not know whether exposure to trace amounts of various hormonally active chemicals introduced into the environment have harmful effects on humans and other animals. Some scientists say there is no definitive evidence for harm from HAAs to humans and dismiss it as a minor threat. But others say there is enough preliminary evidence to warrant greatly increased research on their possible effects. This will take decades.

Some scientists say we need to wait for the results of more research before banning or severely restricting HAAs. Other scientists believe that as a precaution, we should sharply reduce the use of potential hormone disrupters.

Why Do We Know So Little about the Harmful Effects of Chemicals? Establishing Guilt Is Difficult

Under existing laws most chemicals are considered innocent until shown to be guilty, and estimating their toxicity to establish guilt is difficult, uncertain, and expensive.

According to risk assessment expert Joseph V. Rodricks, "Toxicologists know a great deal about a few