Tox in a Box™

K-12 Education Tool Kit for Environmental Health Professionals

Ambassador's Guide

Ambassador’s Guide to *Tox-in-a-Box™*

This guide has been developed to accompany the Tox-in-a-Box™ classroom kit. It provides guidance for the Tox Ambassador when using the kit in the kindergarten through twelfth grade classroom.

“School-age children constitute what may be the most important audience you’ll ever address. They are eager to learn more about you and your work as a representative of the scientific community. Moreover, teachers welcome the opportunity to have professionals come into their classrooms to talk about medicine and the excitement of science and research.”

-- from *Communicating Science and Medicine to Children*
American Medical Association

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How to Use This Kit

The Ambassador's Guide is divided into four levels. Each level has a materials list, a presentation overview chart, and a script. Once the classroom level of interest is determined, it is best to review materials for that level before the presentation. The script is intended to be a guide for the ambassador in the classroom and may be changed and tailored to the specific needs of the audience and the interests of the presenter. You may wish to begin the presentation by giving background information about yourself. Include what you do and why you became interested in the field of environmental health sciences. Have students ask questions about you and your job.

The five key principles of toxicology and environmental health are introduced in the curriculum. Each of the concepts below is explicitly addressed in the upper levels (Grades 4-6, Grades 7-9, and Grades 10-12). The K-3 unit stresses slightly different aspects of environmental health in order to accomodate the developmental differences of that age group.

Living in a Chemical World: The world is made up of chemicals which can be either man-made or naturally-occurring. Neither type is inherently safe or unsafe.

Dose Makes the Poison: Any substance can be toxic depending on its amount or dose, and certain individuals may be more susceptible.

Toxicology—An Application of Basic Science: Connections between basic science (e.g. biology, chemistry, physics, earth sciences) and the principles of toxicology.

Risks and Benefits: Assessing options: risk is part of our daily lives, and assessing our risks can help us make wiser decisions concerning our health and safety.

Tox Tales: Toxicological principles that are seen in everyday events or cultural references, and how these principles shape the world around us.

The *Tox-in-a-Box*™ kit encourages incorporation of environmental health science concepts into current lesson plans. In our experience, teachers have found guest presenters to be motivating and valuable resources for their students. Each *Tox-in-a-Box*™ kit comes with two print publications. This **Ambassador's Guide** explains the contents of the box and guides you, the Ambassador, through each of the four presentation levels. A sample copy of the **Teacher's Resource Manual and Guide to *Tox-in-a-Box*™** is also included. This book is designed to facilitate the teacher's continued use of environmental health content following your visit. After each visit, we ask that you:

- Complete an Ambassador's Evaluation Form (yellow) describing your experience in the classroom. This form also allows you to request your free copy of our CD-ROM, Essentials of Cell Biology: Toxicology in Action.
- Leave a Teacher's Evaluation Form (green) with the instructor whose class you visit. This form allows the teacher to request a free copy of both the Teacher's Resource Manual and Guide to *Tox-in-a-Box*™ and CD-ROM.

One of the goals of this kit is to provide teachers with continued access to toxicologists and other environmental health science professionals. We encourage you to keep in contact with teachers after you have been in the classroom. Thank you for participating. If you have any comments, please e-mail Chetana Acharya at *cacharya@u.washington.edu*.

Presentation Tips

From the time children enter school, they begin to develop decision-making skills regarding their health and the health of the environment. Environmental health sciences and toxicology are seldom addressed in K–12 or even college education. Your presentation can help meet state requirements regarding environmental education and health education, while introducing toxicology to a new generation.

- Remember this may be the only opportunity for students to hear from a scientist about toxicology and how it relates to them. Your enthusiasm may motivate them to pursue a career in toxicology and science!
- Remember that K–12 teachers are extremely overworked. Be respectful of their time and thank the teachers for their willingness to make time for your presentation.
- As a backup you may want to bring a slide projector with you even if the teacher has one. There are no transparencies so you do not need an overhead projector.
- Students love seeing a stir plate, so if you have access to one -- it is worth the trouble.
- Dress casually and use vocabulary appropriate for the class level. The script should have language that works for the particular level, for example use "rules" for regulations, "bad" for adverse, and "interested people" for stakeholders.
- Introduce yourself. You can begin the presentation in any way you feel comfortable. You may wish to talk about your background, what you do in your free time, or why you like coming and speaking to classes. There is no wrong way to begin. Act friendly, smile, and make eye contact, and the students will be excited to hear what you have to say.
- You may wish to begin the presentation by asking a question such as:
(Younger Groups) *How many of you like science? Who's Bill Nye?*
How many of you know what you want to be when you grow up?
(Older groups) *How many of you are going to college? What will you study?*
How many of you work? Does environmental health have anything to do with your job?
(Any age) *Have you had other scientists visit your class? What did they talk about?*
- Encourage students to ask any questions during the presentation. The more interactive the better! Don't be afraid to say, "I don't know."

- Involve the teacher in the presentation as you feel comfortable. They may wish to help you during the presentation or they may sit with the students and make a few comments. The key is to **have fun!** The students may not remember much but the more enthusiastic you are the more memorable it will be for them!
- Bring real-life examples to the students' attention. The more personal you can make it, the more interesting the presentation will be.
- Students learn best when they can relate the information they have to their own experiences. As much as possible, encourage them to ask questions, share experiences, and bounce ideas around in small groups.
- Conclude the presentation with time for questions. Your conclusion can be a brief summary of the presentation. No need to present new information. The conclusion could also be as simple as you telling the students why you enjoy the field of toxicology and the impact it has had on your personal life.

LEVEL ONE: Kindergarten—3

Materials

- Environmental and Health concept cards (#1A-B)
- Concept card of chemicals surrounding human (#2)
- Bag of candy
- Rubber slug and salt packages
- Blue or green food coloring
- Six beakers (three100ml and three10 ml)
- Dust mite card (#3)
- Routes of exposure concept cards (#4A-C)
- Diagram of wastewater treatment plant (#5)
- Cocktail-coffee stirrer
- Water Quality items: strainer, coffee filter, 2 beakers, examples of pollutants, plastic spoon
- What's Your Risk? game cards (#6A-E)
- Pop culture and everyday life concept cards (#7-10)
- Mystery fairy tale cards (#11A-C)
- Coloring page (needs to be copied by teacher)

Overview

The following presentation can be used in a 65 minute period or modified if less time is available. The presentation begins with a discussion with the students about environmental health and what environmental health means to them. This will lead to a more specific discussion on toxicology and toxicants. The discussion on toxicology will highlight the concepts that we and the world around us are comprised of chemicals (**Living in a Chemical World**), and that some chemicals can affect our health and we can affect the environment around us. Next, the concept that everything has the potential to be toxic (**Dose Makes the Poison**) will be explained. This section will include a demonstration showing the susceptibility of children to poisons. Finally, how toxicology relates to people on a daily basis will be explored (**Tox Tales**). Cards depicting characters from books, television, and movies who have been affected by toxic chemicals will be used to relate toxicology to everyday life of a kindergarten to third grade student.

Presentation Overview

Level 1 Presentation (Total Time ~ 65 minutes)

Activity	Grouping	Time	Materials
A. Living in a Chemical World			
Class "brainstorms" on environmental health and chemicals	Class	5 min	Environmental and Health concept cards (#1A-B)
The chemicals around us	Class	5 min	Concept card of chemicals surrounding human (#2)
B. Dose Makes the Poison			
Discussion of toxic chemicals, dose-response	Class	10 min	Bag of candy, rubber slug and package of salt
Dose-response demonstration	Class	5 min	Food coloring, beakers with water (App. A)
Routes of exposure, susceptibility	Class	5 min	Dust mite card, routes of exposure cards (#3, #4A-C)
C. Environmental Health			
Air Quality	Class	5 min	Coffee-cocktail stirrers
Water Quality	Class	15 min	Strainer, coffee filters, beakers, pollutants, spoon, diagram of treatment plant (#5)
D. Risks and Benefits: Assessing Your Options			
Game comparing the risks associated with common activities	Class	5 min	What's Your Risk Game cards (#6A-E)
E. Tox Tales			
Discussion of how toxicology plays a role in the students' lives and their entertainment	Class	5 min	Cards of spider, household chemicals, Mad Hatter, Snow White (#7-10)
Mystery fairy tale	Class	5 min	Coloring sheet and cards (#11A-C)

Grades Kindergarten - 3

A. Living in a Chemical World (10 min.)

Begin by "brainstorming" with the students about environmental health. First, hold up the **environment card (#1A)** and ask the class what comes to mind when they think of the environment. As students answer, make a list on the board. The list might include:

- air
- land/water/oceans
- plants/trees
- animals/wildlife
- work/school surroundings
- home surroundings
- recycling
- pollution

Hold up the **health card (#1B)** and ask the class what comes to mind when they think of health. As students answer, make a list on the board. The list might include:

- medicine
- doctors/nurses
- hospital
- sickness

Ask the class how the environment and health tie together. Finally, give a definition of environmental health, indicating the relationship between humans and the environment:

> **For example:** *How factors in our environment make us healthy or sick, and how we and what we do, affect the health of the environment.*

Write this on the board and give an example of each type of interaction. For example: how a toxic chemical or microorganism that someone eats or drinks can make them sick, or how pollution that humans make can hurt the fish in the water. If toxic substances are managed correctly they can be prevented from affecting the environment. The output from a well designed sewage treatment system may well be acceptable as drinking water.

Next, discuss with the students that people who work in the field of environmental health study the effects of many different substances (chemicals, bacteria, radiation etc.) in the environment. Explain that the science of 'toxicology' is the part of environmental health that deals with the toxic (poisonous) effects of chemicals. Ask the students if they know what a chemical is. Show the **concept card that has examples of chemicals surrounding a person (#2).** Begin with complex chemicals such as drugs they take when they are sick, bug spray that people put on themselves and plants to get rid of bugs (i.e., pesticides), and paint, and then move on to compounds that the students might not think of as chemicals, such as the food we eat and the water we drink.

Ask students if they know what our bodies are made of. Point out to the students that there is nothing in this world that is not composed of chemicals, including the human body. Explain that the human body is made up of many organs and cells all of which are made of small "pieces" that cannot

Script: Level 1

even be seen but are called chemicals. The point behind this is to demonstrate that everything in the world, including our bodies, is composed of chemicals - i.e., we live in a chemical world.

B. Dose Makes the Poison (20 min)

Now that the students know that everything is made up of chemicals, ask if they can think of some good uses of chemicals. Some possible answers may be:

- Doctors give us drugs to make us feel better
- Plastic is made of chemicals (bike helmets, video tapes)
- We need food, water, and air to live
- Pesticides that help make our food supply plentiful and wholesome

Explain to the class that all chemicals can cause harm to people, animals and plants if enough is taken in. This is true even of chemicals that are necessary for life. When a chemical causes harm, it is called a toxic chemical (i.e., something that can make people, animals, or plants sick). Have the students provide examples of toxic chemicals. List the chemicals on the board as they say them. Some chemicals that may be mentioned are:

- paints
- pesticides
- household cleaning supplies
- alcohol
- compounds in cigarettes
- bleach

Use candy to demonstrate how the greater the dose, the more toxic something can be. Hold up one **piece of candy** from the bag and ask the students if it is toxic. The students will probably say that candy is not toxic since they can eat it. Next, hold up the **bag of candy** and ask the students if they have ever eaten too much candy, for example, on Halloween, and if they felt sick after eating so much candy. Point out to the students that that is an example of how the dose (how much) of a compound (candy) you are exposed to (eat) determines whether it has an adverse effect (upset stomach) on you. You can also mention that the same thing would occur with apples or other foods.

Next, ask the students if a small amount of salt is toxic. (Show the **package of salt.**) The students will probably respond that such a small amount of salt is not toxic. Then ask the students what happens to a slug if you pour salt on it, and if this amount of salt might be toxic to a slug. (Hold up the **rubber slug.**) Most of the students will probably respond that salt is toxic to slugs, since pouring salt on a slug will make it shrivel up and die. A slug must maintain a moist outer skin and the salt pulls out the moisture and cause the slug to die. If a person ingests a large amount of salt, it could be toxic because it throws the internal system off. Again, like the candy, salt may not seem toxic but at small doses, it is toxic to slugs, and at high doses, it can be toxic to humans.

Grades Kindergarten - 3

To demonstrate the effect of size on dose, do the **demonstration with blue/green food coloring,** which is explained in more detail in *Appendix A.* Briefly, have three 100ml beakers and three 10ml beakers filled with water. Have a volunteer from the class add one drop, three drops, and five drops of blue or green food coloring to each of large beaker and then stir. Ask students what could cause this response. They may answer alcohol, smoking, oil pollution, medicine, etc. The point to make is that a small dose may have a small effect or response, but the larger dose will have a much greater response. Give other examples they might not think of such as chocolate and dogs. If dogs ingest a huge amount of chocolate, they can die.

Next, have another volunteer add one drop, three drops, and five drops to the small beakers. The smaller beakers, which can represent a small child, or a small lake will be a much darker shade of blue or green than thelarger beakers even though both have been exposed to the same amount of food coloring. This illustrates how a child and an adult may have been given the same amount (similar exposure to a chemical) but the effect can be very different (one much darker). This is due to the size difference between a child and an adult (other factors are significant as well but are too complicated for this age group). An example that students may relate to is that when they take cough medicine they take a smaller dose than that recommended for an adult.

Ask the students if they can think of other things in their environment that might harm children and babies more easily than adults. Some possible answers are:

- Babies and very old people can catch colds easier.
- Some children are allergic to peanut butter and nuts and have to be careful not to eat those items.
- People who are sick or have asthma can be sensitive to air pollution (such as cigarette smoke, smog, dust mites). Show the students the **concept card of the Dust Mite (#3).** Ask them if they know what it is. Mention that dust mites are everywhere (especially in beds and couches because their diet consists of shed scales from human skin) and that some people are allergic to dust mites. Using mattress covers helps reduce the number of dust mites in a bed and thus helps to reduce asthma (lower dose, lower response).

Discuss the different possible routes of exposure to chemicals. The slug is being exposed to salt dermally, i.e., through the skin (show the **dermal exposure card #4A**), whereas people are normally exposed to salt orally, i.e., by eating or drinking it (show the **oral exposure card #4B**). Ask the students what the other main route of exposure is (which is through inhalation, i.e., breathing in chemicals, **inhalation exposure card #4C**).

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C. Environmental Health (20 min)

Mention that the **next activity** will be about breathing (one of the three main routes of exposure to toxic substances). Hand out a cocktail-coffee stirrer to each student. Have each student stand up and do jumping jacks or jump in place for 10 seconds. Then ask them to try breathing through the stirrer for a few seconds. (Students can actually do this activity without first doing any exercise. If you use straws instead of stirrers, have them hold their nose while breathing through the straw to get the same effect). Ask them if it's difficult to breathe. Tell them this is how a person with asthma may feel. And if they are breathing "bad" or polluted air, it may be even harder to breathe. Ask them if they can list sources of air pollution (wood-burning, motor vehicles, agricultural fires) and what they can do to reduce air pollution (burn less wood, bike, walk, bus, or car-pool).

Background on asthma to discuss with students:

Asthma is a chronic lung disease (which cannot be caught from someone else!) that affects people of all ages. If a person who has asthma is around something they are allergic to, such as dust mites, pollens, molds or pet dander, the lining of their airways will become swollen. Sometimes exercise can contribute to asthma because of the increased repiration and heart rate. The muscles around the airways may also tighten up and mucous may form making it very hard to breathe. To breathe freely again, some people use an inhaler, which is a medicine prescribed by their doctor. This will relax the muscles around the air passages and decrease the swelling so the airways will open. Sometimes during a very serious asthma attack, the inhaler will not work. If this happens to you, it is very important to get to a hospital as soon as possible. There, doctors will give you a stronger medicine so you can breathe normally again. But mostly, asthma attacks are not this serious and your inhaler and other prescribed medicines (if used properly) will work perfectly fine. Kids with asthma can lead the same kind of fun, sports-filled life as any kid.

Quick Facts about Asthma:

- 15,000,000 people in the United States have asthma, including 100,000 kids in Washington (check with your local chapter of the American Lung Association for data in your state or region).
- In many areas, asthma is the second most common cause for hospitalization of children, after accidents.
- Running in a polluted area for 30 minutes is the equivalent of inhaling the carbon monoxide from smoking a pack of cigarettes in one day.
- More than 20% of the American athletes in the 1996 Summer Olympic Games had asthma.

- Our air can become unhealthy when there is not enough breeze to move daily pollution around.
- Each day, you breathe about 35 pounds of air - that's over 20,000 breaths!
- We create air pollution by driving, heating with wood or burning yard waste.

What you can do to help reduce air pollution:

- Burn small hot fires rather than slow smoldering fires in your stove or fireplace, or instead of burning wood rely on natural gas, electricity or solar heat!
- Drive less! Instead, car-pool with a friend, ride the bus, walk, bike or skate.
- Use manual lawn tools and compost (pack together) your yard waste.

Background on water pollution:

Human activities can have impacts on water quality in three ways:

- Effects on **habitat**, or the environment, where fish and other critters live.
- **Point Source Pollution**, or pollution that comes from a specific point or source such as discharge from a poorly designed sewage treatment plant or industrial site. Often from the drain inside your home.
- **Non-point source pollution**, or pollution that runs off the surface of the land. It is pollution from many different sources all mixed together and can be created from runoff from yards, overflowing septic systems, and hazardous wastes discarded on lands.

Pollution Soup: Would you drink the water?

Polluting the water: Have 4-8 students come up to the front of the classroom. Have each student pick an item they would like to pour/place into the pollution jar (a beaker filled about 1/4 to 1/2 way with water). Tell the kids that each item may seem small but all of the items add up to what we call wastewater. Explain each item from the list and what it represents as they place the item in the pollution jar. Have one student stir the wastewater. Wastewater is the same as sewage. Wastewater has to be cleaned before it can return to the water supply. It contains many pollutants (substances that are not part of clean water, like soap and human waste) that could cause people to be sick if they drank the water. In past centuries many people died because they didn't know pollutants in water could make them sick. When people found out that the wastewater was hazardous to their health, they began to treat the wastewater to make it cleaner. Some poor, underdeveloped countries can't afford to treat the water and people still get sick. Wastewater not only comes from homes but also from water runoff from watering gardens and lawns, washing cars, roadways and melting snow.

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Pollutant list: You can add many other pollutants to the ones supplied with the kit. One easy addition is hot water to demonstrate how organisms are affected with temperature change.

- **Fecal Matter** (chocolate raisins) - leading to bacteria and viruses in water affecting human and animal health (point source: toilet or dairy farm runoff).
- **Oil and Grease** (cooking oil) - are major pollutants which create a film on the surface of water that can smother larvae of some shellfish and other aquatic animals (point source: homes, restaurants, industries).
- **Household cleaners: tub, toilet bowl cleaners, oven cleaner** (baking soda) - which can contain acids or bases or hazardous ingredients (point source: homes).
- **Toothpaste** - (personal hygiene products) - e.g., shaving cream, shampoo, etc. (point source: drain at home).
- **Acid** (vinegar) - e.g., sulfur dioxide from coal-burning power plants, which can change the pH of the water and can be deadly to plants and animals. **Pollution can be colorless!** (point source: industries).
- **Antifreeze** (green food coloring and water) - the main ingredient, ethylene glycol, is poisonous to people, fish and wildlife. It is sweet tasting and pets may drink it (non-point source: through storm drains to beaches and nearby water bodies).
- **Motor Oil** (maple syrup) – more than two million gallons of motor oil are dumped into storm drains in Washington every year and only one gallon of used oil can ruin the taste of up to one million gallons of drinking water (non-point source: storm drains).
- **Soil/ Dirt** - Dirt, silt, and sediments can cloud water (habitat effects: runoff).

Cleaning the wastewater: Help one student stir the polluted water and pour it through the provided strainer or the coffee filter. The water will become a little cleaner as the “pollutants” are either caught in the strainer or slowly filtered out. It will take some time and will demonstrate how difficult it is to remove the pollutants. **Ask students if they would now drink the water.** You can get cleaner water by first using the strainer for removal of the solid waste and then purifying the polluted water again by pouring it through the coffee filter into the original beaker (or using another cup).

Explain to the kids that before water can be returned to our lakes and streams it needs to be cleaned as demonstrated with the screen and/or filter. If you want to make the water clean enough to drink the process is even longer and more costly. Show **concept card of wastewater treatment plant (#5)** while explaining steps that occur after sewage from our homes and factories enters the sewer pipe. Usually at the sewage treatment plant the steps are:

- Coarse screen removes debris
- Settling tank allows solids to settle out and oil and grease to float to top
- Machines skim top of water (scum) and scrape solids off bottom (sludge)
- Aerating tank is where good microorganisms eat organic material and use up oxygen so more needs to be added
- Settling tank removes more sludge from bacteria (sludge may go to landfill or can be reused as fertilizer)
- Layers of charcoal and sand filter the water (not in diagram)
- Chlorination tank removes microorganisms and bacteria
- Return to surface water

D. Risk vs. Benefits: Assessing Your Options (5 min)

Use the **What's your risk? game cards (#6A-E)** to demonstrate how certain activities are more or less dangerous than others, and how what some people believe are very dangerous activities, in reality are not as dangerous as some activities the students do. Show the card with the question on it, and get the students to respond to the question. The correct answer is on the back of the card, along with a brief explanation of why the answer is correct.

E. Tox Tales (10 min)

The purpose of this section is to show the students that toxicology is relevant to their daily lives.

Begin with the **spider concept card (#7)** and point out to the students that some, but not all, spiders can be toxic. Make the point that not only people-made chemicals, but also natural compounds, such as plant and animal poisons, can be toxic. The fact that something is natural does not make it safe. Then show the **household chemicals card (#8).** Ask the class if they have seen any of these chemicals in their homes or garages. Make the point that they are around natural and people-made chemicals every day.

Ask the students if they can think of any television shows, fairy tales or movies that involve something toxic. The students may be able to think of some. Next, show the cards which have examples of popular culture that involves toxicology:

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- **Mad Hatter (#9)** - the mad hatter from *Alice in Wonderland* was exposed to mercury, a heavy metal used in the manufacturing of felt hats, and that is why he acts the way he does, i.e., 'mad' or 'crazy'.
- **Snow White (#10)** - the princess falls into a deep sleep after eating an apple which has been poisoned by the witch, i.e., the witch added a toxic potion to the apple to make Snow White sleep.

Now, to further illustrate the toxicological aspects of Snow White, read the following modified version of Snow White, the Mystery Fairy Tale, to the students while showing the pictures, or even act it for the students.

> *Once upon a time, in a beautiful kingdom far, far away, there lived a very smart and beautiful girl named Rebecca. One day, while out walking by the stream in the forest near her house, she came upon the charming, but not necessarily bright, Prince Joshua, the son of the friendly King and Queen who ruled the kingdom. Immediately, Rebecca noticed that something was not right since Prince Joshua was asleep when he should be home at the palace for dinner* ***(Mystery Fairy Tale Card #11A)****. When Prince Joshua would not wake up, Rebecca realized that the wicked witch who lives on the other side of the stream must have been involved, and noticed a partially eaten apple in the Prince's hand. Rebecca quickly put the apple in a bag and hurried to the palace to send people to get the Prince. While others brought the sleeping Prince back to the palace, Rebecca went to her laboratory with the apple, where she ran some tests and discovered that the apple had been poisoned with a sleeping potion, presumably by the wicked witch, which had put the Prince into an eternal sleep, only to be broken by a kiss of love. Once Rebecca knew what happened, she quickly figured out the exact composition of the poison and developed an antidote (a medicine that would reverse the effects of the poison). Rebecca then ran to the palace with the cure, gave it to Prince Joshua, who woke up right away* ***(Mystery Fairy Tale Card #11B)****. Everyone celebrated the Prince's return to health, and Rebecca returned to her job that she loved, doing toxicology research at the University of the Kingdom. The King and Queen were so happy and thankful for the safe return of their son that they granted large sums of money to the laboratory so that Rebecca could continue her excellent scientific research, and everyone lived happily ever after.* ***(Mystery Fairy Tale Card #11C)*** *The end!*

At the end of the story, give the children the coloring page, which is based on this Mystery Fairy Tale (so named for the mystery that Rebecca solved), to color some other time.

Ask the students if they have any questions.

Finally, suggest to the teacher that he/she might consider continuing the study of toxicology with the *ToxRap* or *My Health My World* curricula. The *Teacher's Resource Manual and Guide to Tox-in-a-Box*™ has information on these curricula and many others.

LEVEL TWO: Grades 4 - 6

Materials

- Environmental and Health concept cards (#1A-B)
- pH indicator dye (BPB), HCl, NaOH, pH 10 buffer
- Pipettes
- Beaker, distilled water (bottle provided)
- Magnetic Stir bar. (Stir plate not included).
- Concept card of chemicals surrounding human (#2)
- Package of candy
- Rubber slug with salt packages
- Blue or green food coloring
- Six beakers (three100ml and three10 ml)
- Dust mite card (#3)
- Routes of exposure concept cards (#4A-C)
- Toxicology and career concept cards (#12 & #13A-D))
- Risk concept cards (#14A-B)
- What's your risk? game cards (#6A-E)
- Pop culture concept cards (#7-10 & #15)

Overview

The following presentation can be used in a 65 minute period or modified if less time is available. The presentation begins with a discussion about environmental health and what environmental health means to the students. This will lead to a more specific discussion on toxicology and toxicants. The discussion on toxicology will highlight the ideas that we and the world around us are comprised of chemicals (**Living in a Chemical World**) and that everything has the potential to be toxic (**Dose Makes the Poison**). This section will include an experiment to demonstrate the susceptibility of children to poisons. This will be followed by a discussion of toxicology as it relates to other sciences and careers that the students may be more familiar with (**Toxicology: An Application of Basic Sciences**). Next, the concepts of risk assessment and weighing risks versus benefits will be addressed (**Risks and Benefits - Assessing Your Options**). There will be a brief game to demonstrate the risks associated with various activities. Finally, how toxicology relates to people on a daily basis will be discussed (**Tox Tales**). Cards depicting characters from books, television, and movies who have been affected by toxic chemicals will be used to relate toxicology to the everyday life of a fourth- to sixth-grade student.

Presentation Overview

Level 2 Presentation (Total Time ~ 65 minutes)

Activity	Grouping	Time	Materials
A. Living in a Chemical World			
Class "brainstorms" on environmental health and chemicals	Class	10 min	Environmental and Health concept cards (#1A-B)
Demonstration that pollution is caused by everyone	Class	10 min	Concept card of chemicals surrounding human (#2), Bromophenol blue I (App. B)
B. Dose Makes the Poison			
Discussion of toxic chemicals, dose-response	Class	10 min	Bag of candy, rubber slug and package of salt, Morton's salt container
Dose-response demonstration	Class	5 min	Food coloring, beakers with water (App. A)
Routes of exposure, susceptibility	Class	5 min	Dust mite card, routes of exposure cards (#3, #4A-C)
C. Toxicology: An Application of Basic Science			
Discussion of what toxicology is, its connection to basic sciences, and career opportunities	Class	10 min	Toxicology and career cards (#12, #13A-D)
D. Risks and Benefits: Assessing Your Options			
Discussion of the concept of weighing risks and benefits	Class	5 min	Risk concept cards (#14A-B)
Game comparing the risks associated with common activities	Class	5 min	What's Your Risk Game cards (#6A-E)
E. Tox Tales			
Discussion of how toxicology plays a role in history, students' lives, and entertainment	Class	5 min	Pop culture concept cards (#7-10, #15)

LEVEL TWO: Grades 4 - 6

A. Living in a Chemical World (20 min)

Brainstorm with the students about environmental health. Hold up the **environment card (#1A)** and ask the class what comes to mind when they think of the environment. As students answer, make a list on the board. The list might include:

• air	• recycling
• work/school surroundings	• animals/wildlife
• water/oceans	• industry
• home surroundings	• plants/trees
• land	• pollution

Hold up the **health card (#1B)** and ask the class what comes to mind when they think of health. As students answer, make a list on the board. The list might include:

• medicine	• illness/ well being
• hospital	• exercise
• doctors/nurses	• diet
• drugs	• alcohol, tobacco

Ask the class how the environment and health tie together, and have them try to come up with a definition of environmental health. Finally, give a definition of environmental health that indicates the relationship between humans and the environment:

> **For example:** *The study of how factors in our environment influence human health and well being, and how humans and our actions influence the health of the environment.*

Write the definition on the board, and show an example of each type of interaction, e.g., how microorganisms such as *E. Coli* or *Salmonella* in meat can harm someone if they eat it, and/or how pollution made by humans (e.g., from cars) harm the fish and plants in the water.

Next, do the **Bromophenol blue I demonstration** to show how the actions of all individuals can add up to have a large effect on the environment. (A detailed protocol for the BPB I experiment is in *Appendix B*). Have a beaker prepared with distilled water, pH 10 stock buffer, and bromophenol blue, and explain to the students that the blue solution represents a clean lake, or the clear blue sky. Stir the BPB solution vigorously by hand or on a stir plate while asking each student his/her name and as you add one drop of 0.6 N hydrochloric acid to it say, *"This drop is for Bobby, this one is for Jane, etc."* Following the addition of about 20-30 drops, the solution suddenly will turn from blue to yellow. **Ask the students who is responsible for the pollution. Is it the fault of the last person who added the pollution (chloric acid) or the combination of all the students?** Explain that it is

Script: Level 2

not only the last person who is responsible, but that all of the individuals who added the acid are responsible for the pollution.

Discuss with the students that people who work in the field of environmental health study the effects of many different substances (chemcials, bacteria, radiation etc.) in the environment. Explain that the science of 'toxicology' is the part of environmental health that deals with the toxic (poisonous) effects of chemicals. Ask the students if they know what a chemical is. Give examples of chemicals with which the students will most likely be familiar. Show the **concept card that has examples of chemicals surrounding a person (#2)**. Begin with complex chemicals such as medications, paint, and pesticides that are used to get rid of weeds and bugs. Next, move on to compounds that the students might not think of as chemicals, such as the food we eat and the water we drink. Explain to the students that there is nothing in this world around us that is not composed of chemicals, including the human body. The human body is made up of many cells which are made up of chemicals that are not even visible to the eye. The reason for this lesson is to demonstrate that everything in the world, including our bodies, is composed of chemicals. We live in a chemical world.

B. Dose Makes the Poison (20 min)

Discuss with the students that chemicals provide many benefits and can enrich our lives. They are used as drugs, fertilizers, plastic, and energy sources. Chemicals, however, can also have harmful effects if not used properly.

Ask the class to describe a toxic chemical (A toxic chemical is one that has adverse effects on a person or organism; i.e., something that can make people, animals, or plants sick). Have them provide examples of toxic chemicals. List the chemicals the students name on the board. Some chemicals that may be mentioned are:

- paints
- alcohol
- pesticides
- compounds in cigarettes
- household cleaning supplies
- bleach

Discuss how the concept that the dose makes the poison is one of the basic principles of toxicology. Point out that Paracelsus (1493-1541), one of the founding fathers of toxicology, is known by the following quote:

> *"All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy."*—Paracelsus

To impress students, you may also want to tell them Paracelsus' full name: **Philippus Aureolus Theophrastus Bombastus von Hohenheim-Paracelsus**.

To demonstrate the concept of dose makes the poison, hold up one **piece of candy** from the bag and ask the students if it is toxic. The students will probably say that candy is not toxic/poison since they can eat it. Next, hold up the **bag of candy** and ask the students if they have ever eaten too much candy, for example, on Halloween, and if they felt sick after eating so much. Point out to the students that this is an example of how the dose (how much) of a compound (such as candy) you are exposed to (or have eaten) determines whether it has an adverse effect (upset stomach). You can also mention that the same thing would occur with apples or other foods. Another example is medicine. That’s why the dosage is so critical.

Next, ask the students if a small amount of salt is toxic. (Show the **package of salt**) The students will probably respond that such a small amount of salt is not toxic. **Ask the students if this amount of salt might be toxic to a slug** (Hold up the **rubber slug**). Most of the students will probably respond that salt is toxic to slugs, since pouring salt on a slug will make it shrivel up and die (the slug must maintain a moist outer skin and the salt pulls the moisture out). A pinch of salt might not harm it, but the entire package of salt would be toxic. Show the **Morton container of salt**, which is about 750 grams. Ask the class how much of this would be toxic to humans. Discuss that if an average sized adult ate 1/3 of the salt in the container, that amount of salt would be toxic to their body because of an internal electrolyte balance problem.

Ask the students if they can think of any particular group of humans who may be more susceptible to the toxic effects of chemicals. Explain that small children are **more** susceptible to certain chemicals not only due to their smaller size, but also due to the fact that their brains are still developing and more easily affected.

To show the effect of size on dose, do the **demonstration with blue/green food coloring,** which is explained in more detail in *Appendix A.* Briefly, have the six beakers filled with water. Have a volunteer from the class add one drop, three drops, and five drops of blue or green food coloring to each of the larger beakers. **Ask students what could cause this response.** They may answer alcohol, smoking, oil pollution, medicine, etc. Make the point that the small dose may have a small effect or response, but the larger dose has a much greater response. Give other examples they might not think of such as chocolate and dogs. If dogs consume a large dose of chocolate they can die. Next, have another volunteer add one drop, three drops, and five drops to the small beakers. The smaller beakers, which can represent a small child, or a small lake, will be a much darker shade of blue or green than the large beakers even though both have been exposed to the same amount of food coloring. This illustrates how a child and an adult may have been given the same amount (similar exposure to a chemical) but the dose that each receives can be very different (one much darker). This is due to the size difference between a child and an adult and other factors such as the developing brain and immune system in a child.

Ask the students if they can think of other chemicals that children and babies might be susceptible to. Also, ask what other human populations would be particularly susceptible to toxic chemicals in the environment. Possible answers are listed below.

- Babies and young children are very sensitive to lead because their brains are still

Script: Level 2

developing.

- Pregnant women must avoid alcohol and many other drugs due to the sensitivity of the developing fetus. Sometimes exposure to illicit drugs can cause brain damage and other bad effects to the fetus.
- People with preexisting lung disease, such as asthma, are sensitive to air pollution (such as cigarette smoke, smog, dust mites) due to decreased lung capacity/function. Show the students the **concept card of the dust mite** (**#3**). Ask them if they know what it is. Mention that dust mites are everywhere (especially in beds and couches because their diet consists of shed scales from human flesh) and that some people are allergic to them. Ask the students if any of them have asthma, how that affects how they respond to exercise, and if they are taking any drugs for their asthma.
- Elderly people must be careful about many things due to chronic illness and less responsive immune systems.

Discuss the different possible routes of exposure to chemicals. The slug is being exposed to salt dermally, i.e. through the skin (show the **dermal exposure card #4A**), whereas people are normally exposed to salt orally, i.e. by eating or drinking it (show the **oral exposure card #4B**). **Ask the students what the other main route of exposure is** (inhalation, i.e. breathing in chemicals). Show the **inhalation exposure card (#4C).**

C. Toxicology: An Application of Basic Science (10 min)

Ask the students if they have heard of a science called toxicology or if they know what it is. Show the **Toxicology card (#12)**, which shows the word in two different colors, "**Toxic**" in one, and "**ology**" in another. Point out that toxicology is the "ology", or study, of "toxic" substances. Give a definition of toxicology and environmental health sciences such as:

> *Toxicology is the study of harmful effects of chemicals on living organisms. Or, more simply stated, the science of poisons.*
>
> *Environmental health sciences is the study of how our environment can affect our health. This includes not only the study of toxic chemicals (toxicology) but also how microorganisms (bacterial, viruses) in our food, water, and air can affect our health, and how changes in our environment and ecosystem can affect our health.*

Explain to the students that, in order to study and understand toxicology, many other sciences have to be used:

- **biology/ecology** - The study of life or living matter. For toxicology, you need to understand how people, other animals, and plants normally function to understand how toxic substances affect their function.

- **chemistry** - The study of chemicals, substances and their properties. For toxicology, you need to understand the chemicals that are causing the adverse effects.
- **earth science** - The study of anything that deals with the earth such as the weather or geography. For toxicology, you need to understand how wind, rain, sunlight, etc. affect where a toxic substance will go and with what it will react.

Ask the students to "brainstorm" on careers that may utilize toxicological principles. Some careers could include:

- Doctors and veterinarians when investigating poisonings or determining side effects of drugs
- Fire fighters when dealing with hazardous spills
- Marine biologists when studying fish/shellfish problems
- Lawyers when dealing with environmental issues or lawsuits
- Mechanics when they protect themselves from chemicals
- Fast food workers when dealing with food safety issues
- Teachers when teaching about the sciences and other subjects
- Painters when handling paints and solvents

Use the career concept cards (#13A-D) to show some of the occupations that use toxicology and explain how toxicology is used by these people. Discuss that another critical field in toxicology is conducting scientific research. Toxicology researchers study how, or the mechanism by which, chemicals affect the body.

D. Risks and Benefits: Assessing Your Options (10 min)

Introduce the concept that one responsibility of a toxicologist is to determine "safe" levels of exposure to chemicals. Toxicologists do this by reviewing the risks and the benefits of a particular compound. Explain that almost every decision humans make is based on weighing the risks and benefits of a particular action. Sometimes we do not always make the best decision based on these facts. Show the students the **concept card with the child reaching for the cookies (#14A)** and trying to decide whether or not to take one based on the punishment that will result. Next, show the students the **concept card with the adult reaching for the package of cigarettes (#14B)** and trying to decide whether or not to smoke one based on the adverse effects that the cigarettes have. Explain that toxicologists working for the government make decisions regarding what chemicals should be allowed in the environment for the entire population to be exposed to based on the dangers that a chemical poses, and they assess the benefits that are associated with the chemical's use.

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A real-life example is assessment of the potential risks caused by the chlorination of water. Chlorine in the water can react with organic by-products and can produce suspected carcinogens (possible cancer-causing substances). Chlorination of water thus may pose a small risk of getting cancer. The chance of developing cancer over a year from chlorine in tap water is estimated at 3 in 10 million. In comparison, the chance of developing any smoking-related disease over a year from smoking one pack of cigarettes a day is 1 in 300 - much greater! (J. Tierney. *Hippocrates*. Jan/Feb 1988, pg. 31). The benefit of having chlorine in water is to avoid outbreaks of dangerous microbial diseases, such as typhoid and cholera. Most scientists agree that the relatively small risk of cancer outweighs the much larger chance of a microbial epidemic - but there is still controversy, because there are other ways to treat water - but they usually are more expensive.

Next, use the **What's your risk? game cards (#6A-E)** to demonstrate how certain activities are more or less dangerous than others and that what some people believe are very dangerous activities, in reality, are not as dangerous as some activities the students do. Show the card with the question on it, and ask the students to respond to the question. Show the correct answer on the back of the card and give a brief explanation of why the answer is correct.

E. Tox Tales (5 min)

The purpose of this section is to show the students that even though they may think toxicology is not relevant to their lives, there are many examples of, and uses for, toxicology in their everyday life. Begin with the **spider card (#7)** and point out to the students that certain spiders can be toxic. Make the point that not only man-made chemicals, but also natural compounds, such as plant and animal poisons, can be toxic, so the fact that something is natural does not make it safe. Then show the card of the **household chemicals (#8).** Ask the class if any of these chemicals are in their homes (basement, garages, under their sinks etc.). Make the point that they are around natural and man-made chemicals every day.

Ask the students if they can think of any historical facts, television shows, or movies that involve the principles of toxicology. The students may be able to think of some. In addition, show the cards which have examples of popular culture and historical facts that involve toxicology:

- **Mad Hatter (#9)** - the mad hatter from Alice in Wonderland was exposed to mercury, a heavy metal used in the manufacturing of felt hats, and that is why he behaves the way he does, i.e., 'mad' or 'crazy.'
- **Romeo and Juliet (#15)** - "Thy drugs are quick. Thus with a kiss I die." Romeo poisoned himself after he thought Juliet was dead. Once she awoke and saw Romeo dead, she too poisoned herself.

Ask the students if they have any questions. Finally, suggest to the teacher that he/she might consider continuing the study of toxicology with the *ToxRap* or *Smile* curricula. The *Teacher Manual and Resource Guide to Tox-in-a-Box* has information on these curricula and many others.

LEVEL THREE: Grades 7 - 9

Materials

- Package of salt, rubber slug, Morton salt container
- Slides and slide projector (projector not included)
- Blue or green food coloring
- Six beakers (three100ml and three10 ml)
- pH indicator dye (BPB), HCl, NaOH, pH 10 buffer
- Pipettes
- Magnetic Stir bar (Stir plate not included)
- Beaker, distilled water (bottle provided)
- Three handouts (App. G) -- BPB Graph Worksheet (Handout 1), Risk Factors for Cancer (Handout 2), Toxicology - the Science of Poisons (Handout 3)
- Activity cards (#16A-H & #17A-F)

Overview

The following presentation can be used in a 75 minute period or modified if less time is available. The presentation begins with a discussion about what environmental health means to students. This will lead to a more specific discussion on toxicology and toxicants. The discussion on toxicology will highlight the ideas that people and the world around us are comprised of chemicals (**Living in a Chemical World**) and that everything has the potential to be toxic (**Dose Makes the Poison**). It will also include a demonstration about dose/response relationships and the susceptibility of children to poisons. This will be followed by a discussion of toxicology as it relates to other sciences (**Toxicology: An Application of Basic Sciences)**. Next, the concept of risk assessment, and weighing risks versus benefits will be addressed with a risk activity about household hazardous waste (**Risks and Benefits - Assessing Your Options**). Finally, there will be a discussion about how toxicology relates to people on a daily basis, and about how something that was once considered safe has evolved through the decades **(Tox Tales**). This will be demonstrated by comparing old and new clippings from newspapers and advertisements.

Presentation Overview

Level 3 Presentation (Total Time ~ 75 minutes)

Activity	Grouping	Time	Materials
A. Living in a Chemical World			
Class "brainstorms" on environmental health and chemicals	Class	10 min	
B. Dose Makes the Poison			
Discussion of toxic chemicals, slide show begins, differential susceptibility, routes of exposure	Class	15 min	Slides, rubber slug, package of salt and Morton's salt container
Dose-response demonstration	Class	5 min	Food coloring, beakers with water (App. A)
Students graph dose-response curve to demostrate threshold effects	Class & individual	10 min	Bromophenol blue II (prepare before class, App. C), BPB Graph Worksheet (Handout 1, App. G)
C. Toxicology: An Application of Basic Science			
Students "brainstorm" on toxicology and its connection to basic sciences, career opportunities	Class	5 min	
Cancer discussion and completion of slide presentation	Class	10 min	Slides, Risk Factors for Cancer (Handout 2, App. G)
D. Risks and Benefits: Assessing Your Options			
Shopping for household chemicals - risk perception activity	Class & small groups	10 min	Labels of products (Activity cards #16A-H)
E. Tox Tales			
Investigation of current issues in toxicology and how they have evolved over time	Class & small groups	10 min	Headlines from advertisements and articles (Activity cards #17A-F), Toxicology - the Science of Poisons (Handout 3, App. G)

Grades 7 - 9

A. Living in a Chemical World (10 min)

Begin by "brainstorming" with the students about environmental health. First, ask the class what comes to mind when they think of the environment.

As students answer have a student make a list on the board.

The list might include:

- air
- water/oceans
- land
- animals/wildlife
- plants/trees
- work/school surroundings
- home surroundings
- recycling
- industry
- pollution

Ask the class what comes to mind when they think of health.
As students answer have another student make a list on the board.
The list might include:

- medicine
- doctors/nurses
- exercise
- drugs
- hospital
- illness/well being
- diet
- alcohol, tobacco

Ask the class how the environment and health tie together, and have them come up with a definition of environmental health.

Finally, give a definition of environmental health, indicating the relationship between humans and the environment:

> **For example:** *The science concerning how factors in our environment influence human health and well being, and how humans and our actions influence the health of the environment.*

Introduce students to the idea that people who work in the field of environmental health study the effects of many chemicals in the environment. Discuss. Ask the students to give examples of compounds that are not chemicals (there are no compounds that are not chemicals). The point behind this is to demonstrate that everything in the world, including our bodies, is composed of chemicals. **We live in a chemical world**.

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Finally, end this section with definitions of toxicology and environmental health sciences.

- *Toxicology can be defined as the study of harmful effects of chemicals on living things (humans, other organisms, and the environment).*
- *Environmental health sciences is the study of how our environment can affect our health.*

This includes not only the study of toxic chemicals (toxicology) but also how microorganisms (bacterial, viruses) in our food, water, and air can affect our health, and how changes in our environment and ecosystem can affect our health.

B. Dose Makes the Poison (30 min)

Begin this section by discussing one of the basic tenets of toxicology. Paracelsus (1493-1541), one of the founding fathers of toxicology, is known by this quote:

> *All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy."*

To impress students, you may also want to tell them Paracelsus' full name: **Philippus Aureolus Theophrastus Bombastus von Hohenheim-Paracelsus**.

Dr. Steven Gilbert (1997) has stated, *"The sensitivity of the individual differentiates a poison from a remedy,"* to emphasize the point that not all people respond the same way to a chemical hazard. While most people respond in a smiliar way (good place to introduce the 'bell shaped curve,' or 'normal distribution concept'), occasionally, an individual may respond at a dose much lower or higher than normal. Sometimes an individual may respond in a very different manner from what is expected, for example, the person who has an allergy to penicillin or is allergic to bee stings. Explain that these concepts, the "dose makes the poison," and "individual sensitivities," are the key to understanding the principles of toxicology. Substances can be poisons to some and not to others because of individual differences.

Discuss with the students the fact that chemicals provide many benefits and can enrich our lives. They are used as drugs, fertilizers, plastics, and energy sources. Chemicals, however, can also have harmful effects.

Ask the class to define a toxic chemical (a toxic chemical is one that has adverse effects on the body), and have them provide examples. Some chemicals that may be discussed are:

- paints
- pesticides
- dioxins
- mercury
- alcohol
- compounds in cigarettes
- polychlorinated biphenyls (PCBs)
- lead

Compliment the students on their examples and explain that now some slides will illustrate some of these, and other, toxic substances.

BEGIN SLIDE SHOW

Plane spraying pesticides. Pesticides kill insects and other unwanted pests and are very important for the production of an abundant and wholesome food supply, and for the control of diseases carried by insects (e.g. malaria). However, if used inappropriately, pesticides can harm humans and animals living and working nearby. Exposure to pesticides can be an important health concern for agricultural workers if the “dose” is high enough. **Ask students how a farm worker might get too high a dose.** You can discuss this in detail further when you talk about routes of exposure. It is important to remember that, although pesticides have a risk to health associated with them, they also benefit human health by preventing disease and helping to ensure an adequate supply of food. This balancing of risks and benefits occurs with most chemicals, including medical drugs.

Shelves full of pesticides, paints, etc. in a home garage. This is what many garages look like inside. These chemicals may have lids, but often the fumes can still seep into the air, or the cans might rust and leak. It is important to take the items to a special hazardous waste site for disposal, and keep them in a locked storage bin away from the house. There are also many alternatives to toxic chemicals.

Mold on wall. This picture shows mold on a wall that was behind a couch. There was a lot of moisture behind the couch, making it ideal for mold, which likes to grow in damp, humid places.

Ask the students which are more toxic, natural compounds or human-made chemicals. The answer is that both can be toxic (i.e., natural and human-made designations say nothing about the toxicity of a chemical). This is demonstrated by the existence of numerous toxic animals and plants.

CONTINUE SLIDE SHOW

Atelopus (Panamanian Golden frog). Poison dart frogs secrete toxins from their skin and this secretion was used by native tribes to coat their darts with poison. They would rub the tip of the dart along the back of the frog. One frog may have enough toxin to provide a lethal dose to 10 adult humans. The colors warn predators of their poison. If humans touch or lick the frog, they may get very sick. Atelopus frogs, as seen in this slide, are from Panama; the skin toxins have evolved for protection from predators.

Script: Level 3

Barracuda (tropical fish). The flesh of the barracuda can be poisonous. The barraduda is also a good illustration of biomagnification of natural substances. There are toxic algae which live on aquatic plants. Small fish eat these plants, including the algae, and then the barracuda eats these small fish. The more small fish the barracuda has eaten, the more toxins it accumulates, and the more toxic it becomes. People eat barracuda, but if it is too large (old) and has eaten too many small fish, it may be toxic enough to make a person sick. Sometimes people would cut off a piece of the fish and if ants would eat it, they would assume it was safe to eat. Other fishes, such as the puffer fish, can make their own poisons. Although the flesh is good to eat, ingestion of even a small amount of the poison-containing parts of the puffer fish (liver, gonads) can kill a person.

Local Sea Anemone. The Sea Anemone uses special toxin as a defense mechanism against predators. The tentacles close around predators and the urchin stings them.

Lionfish. Lionfish can be very beautiful but also very deadly. They are found in warm tropical water and are deadly because of their venom which they use to stun or kill their victims. If humans are punctured by the spines, they feel pain immediately, swelling occurs and they may be unable to move their arms or legs. This paralysis is temporary and they usually recover after several months.

Scallops. Like other shellfish, scallops can be toxic due to algae blooms in the water. There is regular testing of the seafood to determine if it is safe to sell to consumers or serve in restaurants. People who catch them and don't check to see if it's a safe time can die. An example is red tide, which is a naturally-occurring, higher than normal concentration of microscopic algae. The algae grow fast and appear reddish. Some produce neurotoxins which can be transferred through the food web (scallops to humans).

Pacific Rattlesnake. The pacific rattlesnake is found from British Colombia to Mexico, from California to Iowa. Rattlesnake venom is toxic to humans, and can be deadly. However, death is rare and usually occurs only in places where people can not get medical care.

Pacific Rattlesnake II. Here's another photo of the pacific rattlesnake. Here, you can clearly see the sharp teeth which the snakes use to inject their venom.

Amanita Muscaria. This mushroom contains a toxin that affects the body. Some mushrooms affect the brain with neurotoxins, but many of these type of mushrooms have hepatotoxin. Does anyone know what a hepatotoxin is? It is a toxin that affects the liver. There have been many instances when people have identified mushrooms incorrectly, eaten them and become sick. In some cases people have died after eating poisonous mushrooms.

Rhododendrons. These everyday shrubs are in gardens throughout the United States. They contain grayanotoxins, which affect the heart and can be poisonous if eaten. Fortunately, our bodies have a defense mechanism which makes us vomit this toxin.

Next, ask the students if some common household items, such as salt, are toxic, and show the **package of salt**. The students will probably respond that salt is not toxic. Then ask the students if salt is toxic to a slug, and hold up the **rubber slug**. Most of the students will probably respond that salt is toxic to slugs, since pouring salt on a slug will make it shrivel up and die. Slugs must maintain a moist outer layer and the salt pulls out moisture. A pinch of salt might not harm it, but that entire package of salt would be toxic.
To continue, introduce the idea that if an average size adult weighing about 60 kg (132 lbs) were to eat 240 grams of salt (4 grams per kg body weight) it would be toxic. Show the **empty container of Morton's Salt** which is about 750 grams and say that if an average adult ate 1/3 of the salt in this container, it would be toxic to their body because internal electrolyte balance may fail.

Ask the students if they can think of who may be more susceptible to the toxic effects of chemicals. Prompt them to talk about children by asking them to calculate the quantity of salt which would be toxic to a child weighing 30 kg (60 lb); the answer would be 120 grams (4 grams per kg body weight). They would only need about 1/6 of the salt in the container to be toxic to their smaller body.

To illustrate the effect of size on dose, use the **demonstration with blue or green food coloring**, which is explained in more detail in *Appendix A.* Briefly, have the six beakers filled with water. Have a volunteer from the class add one drop, three drops, and five drops of blue or green food coloring to each of the large beakers and then stir. Ask students what could cause this response. They may answer alcohol, smoking, oil pollution, medicine, etc. The point is that the small dose may have a small effect or response, but the larger dose has a much greater response. Give other examples they might not think of such as chocolate and dogs. If dogs consume a large dose of chocolate, they can die. Next, have another volunteer add one drop, three drops, and five drops to the small beakers, close and shake. The smaller beakers, which can represent a small child, or a small lake will be a much darker shade of blue or green than thelarger beakers even though both have been exposed to the same amount of food coloring. This illustrates how a child and an adult may have a similar exposure to a chemical but the amount or dose that each receives can be very different. This is due to the size difference and other factors such as the developing brain and immune system in a child.

Now **point out that children are more susceptible to certain chemicals** not only due to their smaller size, but also due to the fact that their organs are immature and still developing. For example, children have smaller airways that are more sensitive to many air pollutants. **Ask the students if they can think of other chemicals that children and babies might be susceptible to.** Also, what other human populations would be particularly vulnerable to toxic chemicals in their environment.

Possible answers are:

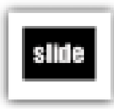
- Babies and young children are especially susceptible to serious health effects from lead poisoning because their brains are still developing.

Script: Level 3

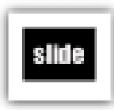
- Pregnant women must avoid alcohol and many other drugs due to the sensitivity of the developing fetus. Sometimes exposure to illicit drugs can cause brain damage and other bad effects in the fetus.
- People with preexisting lung disease, such as asthma, are sensitive to air pollution (such as cigarette smoke, smog, dust mites) due to decreased lung capacity/function. Ask the students if any of them have asthma and how that affects their response to exercise, and if they are taking any medications for their asthma.
- Elderly people must be careful about many things due to their weakening bodies and immune systems.

Discuss different routes of exposure. The slug is being exposed dermally, i.e., through the skin, whereas people are normally exposed to salt orally, i.e., by eating or drinking it. Ask the students what the other main route of exposure is (which is through inhalation, i.e., breathing in chemicals).

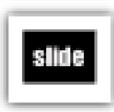
CONTINUE SLIDES



<u>Too young to smoke</u>. Not only does cigarette smoke cause cancer in people who smoke, but also in those exposed to secondhand smoke (the smoke exhaled by the smoker and the burning end of the cigarette or pipe). People who smoke get the highest dose (firsthand along with secondhand smoke).



<u>Good Air Day</u>. This is the type of day that we hope we can have more of in Seattle, and other cities around the country.



<u>Bad Air Day</u>. This shows a similar view on a day in Seattle, Washington when the particulate levels are high. Particulates are caused by outdoor burning, industry, wood-burning, and motor vehicles. It not only reduces visibility but also causes adverse health effects, especially in children, the elderly, and those with lung disease (such as asthma). Some of these health effects are listed on the slide.

Next, distribute the **BPB Graph Worksheet (Handout 1, *Appendix G*)** and conduct the **bromophenol blue II (BPB II) demonstration** to further explore the concept of dose-response. A detailed protocol for the BPB II experiment is given in *Appendix C*. Briefly, add drops of acid to a large beaker, while stirring vigorously (by hand or a stir plate). Have students record the dose (i.e., cumulative number of drops added) and the magnitude of the response (i.e., from 0-10 in color change) on their worksheets.

Once the students have completed the data collection, have the students plot the **dose or concentration (X-axis)** versus **response (Y-axis)**. You can have one student record for the class and one student draw a graph on the board as an alternative to handing out worksheets. The results should yield a sigmoid dose-response curve, with an apparent "threshold." The threshold is the dose just below where a change (response) was first noted and is called the No Observed Effect Level" or

NOEL. You can draw this on the board or use one of the student's graphs as an example. This can then be discussed using real world examples of alcohol and degree of inebriation, workplace exposure to toxic chemicals and ill health, etc.

Concepts to be discussed with respect to the students' graphs include:

- **Differences between student graphs** - discuss with the students how not everyone agreed exactly on the same "observed" response. Some may have thought 2, 3, or 4 for the same dose. In science, sometimes scientists don't agree on things, or can interpret the same observation somewhat diffferently. That's why its important for experiments to be repeated many times before being certain of the results.
- **Threshold** - the concept that there is a level of a chemical at which no effect or response occurs. The dose at or above which there is a response is termed the **Threshold Dose**.
- **NOEL** - The No Observable Effect Level is the dose at or below which there is no change or effect seen. Note that different people may have different 'thresholds' or 'NOELS' - not everyone will respond exactly the same way.

C. Toxicology: An Application of Basic Science (15 min)

Discuss the connection between toxicology and basic sciences. Toxicology is an applied science which uses most of the basic sciences the students may have already studied:

- **biology** - one needs to understand how the body and ecosystems normally function in order to understand how toxicants alter their function.
- **chemistry** - one needs to understand chemistry to understand the processes that take place in the body and the environment.
- **earth science** - one needs to understand weather patterns since sunlight, rain, wind, etc. affect the distribution of toxic substances and pollution.

Ask the students to "brainstorm" careers that may utilize toxicological principles. Some careers could include:

- Doctors, veterinarians, other health care workers, when determining poisons and drug interactions
- Fire fighters, when dealing with hazardous spills
- Marine biologists, when studying fish/shellfish problems
- Lawyers, when dealing with environmental issues or lawsuits
- Chemical engineer/industrial hygienist who ensure worker safety
- Fast food workers, when dealing with food safety issues

Script: Level 3

- Mechanics, to protect themselves adequately from fumes
- Painters (both house and fine arts), when handling paints and solvents
- Educators, when teaching about the sciences and other subjects

Point out that conducting toxicological research is critical. Toxicology researchers study not only if chemicals affect the body, but the mechanisms underlying these effects. This is a perfect opportunity to discuss your current research.

CONTINUE SLIDES

Some aspects of this research are highlighted below:

Rat embryo. One way to study toxic effects is to look at the whole animal. These pictures show two rat fetuses. The left (large) fetus is the control, while the right was exposed to aflatoxin (a toxin produced by a fungus that grows on peanuts). You can see that the brain is much smaller and deformed, and the neural tube is not closed in the exposed fetus.

Healthy cell vs. unhealthy cell. You can also look at specific organs, or study the level of the individual cell, such as in this slide. The left section of the slide shows a single, smooth layer of healthy epithelial cells. The right section of the slide shows cells which are undergoing cell death (apoptosis) – you can see the "blebs" or bulges on the cells which are characteristic of some types of cell death.

Now is a good time to introduce the topic of cancer and to use the remaining slides to illustrate certain concepts. Discuss the role of toxicologists in cancer research and then begin to cover a few broad questions related to cancer.

First, ask students "What is cancer?" Let them offer their ideas, but be sure to define cancer as a chronic disease process characterized by the uncontrolled growth of cells (tumors) that may spread (metastasize) throughout the body, ultimately causing death. State that cancer arises when the DNA in a cell is altered during a process called mutation. The mutations that occur in DNA have affects on different organs in our bodies, thus, cancer is described as a disease process that affects different organs rather than simply a single disease.

Discuss with students the presence of cancer in the world population. It occurs in all ages and races as well as both genders, although cancer onset is more frequent in "old age." Mention the following statistics:

- 1 out of 4 people in the U.S. will die from cancer. (American Cancer Society)
- In the U.S., nearly 500,000 people will die from cancer this year; it is the second leading cause of death. (American Cancer Society)

CONTINUE WITH THE SLIDES

Toxicologists also study the mechanisms by which chemicals cause their toxic effects on humans and the environment. The two slides about DNA mutation introduce the ideas that explain how chemicals cause cancer. Fortunately, our bodies have repair mechanisms that often remedy damaged DNA. However, when the damage is excessive and beyond repair, the DNA mutation may be left unrepaired. When this happens, the altered genetic information is passed on to all future cells after the mutated cell divides. Thus, the unrepaired mutations may become permanent. Permanent mutations in certain parts of the DNA may lead to chronic diseases such as cancer. Even "aging" is a result of irreparably damaged DNA.

slide Normal DNA (from Essentials of Cell Biology CD ROM). DNA is a vast chemical information database. It resides in the nucleus of each of the body's trillions of cells, and it carries the complete set of instructions for making all the proteins a cell will ever need. Every human cell within an individual contains the same DNA.

slide Mutated DNA (from Essentials of Cell Biology CD ROM). This slide shows a compound binding to the DNA, which will lead to a mutation. Some mutations can lead to cancer. Genes that control the replication of cells become damaged, allowing the cells to reproduce without restraint. Mutations refer to irreversible changes in the DNA (our "genes") of a cell. Mutations arise when reactive molecules bind to and damage DNA – and if the damage is not repaired or is repaired incorrectly a permanent change in DNA occurs.

Ask the students if they can think of chemicals in the environment that may interact with DNA and cause mutations (i.e., cigarette smoke, polluted water, chemicals in the workplace, UV radiation, and sunlight). Even oxygen, which is essential for life can damage DNA.

*Most Cancer is **not** inherited.* Even though all cancer is triggered by altered genes, only a small portion is inherited. Most cancers come from random mutations that develop in cells during one's lifetime – either as a mistake when cells are going through cell division in response to injuries from environmental agents such as radiation and chemicals, or from 'oxidative' damage to DNA that results from normal cellular metabolism (burning of sugar and oxygen to make energy for the cells). You can also discuss the important role of "antioxidants" in reducing risks of cancer such as from vitamins, fruits and vegetables, and even some drugs.

Give each student a copy of **Risk Factors for Cancer (Handout 2, *Appendix G*)**. Explain to students that cancers are attributed to various factors, also called "risk factors." It is important to note that diet, something we can largely control, can impose an important risk factor for both developing and preventing cancer. Discuss the importance of eating a balanced diet that includes fruit and vegetables. Reinforce that two of the major risk factors, tobacco and diet, are attributable for almost 65% of cancer deaths.

Script: Level 3

Choose other factors from the list to discuss, such as occupational risks. Ask the students if they can identify different hazards that some people face in the workplace. Since the topic of risk is discussed in the next section, this is a good time to mention that there is a relationship between exposure and risk. Risk is defined as the probability of injury, disease, or death for an individual or population exposed to a hazardous substance or situation. The more exposure to certain cancer risk factors, the greater the likelihood of experiencing adverse effects. However, it is critical to revisit the concept of dose when discussing risk. The greater the dose, the more risk and the greater our chance of disease.

END SLIDE SHOW

D. Risks and Benefits: Assessing Your Options (10 min)

Introduce the concept that one responsibility of a toxicologist is to determine "safe" levels of exposure to chemicals, as well as to identify what benefits these exposures may produce. Point out that almost every decision we make is based on weighing the risks and benefits of a particular action, although we do not always make the best decision based on these facts. While toxicologists are not usually involved in evaluating the benefits of chemicals, they provide the scientific information and analysis that is necessary to assess the risks of chemicals. Government agencies (i.e., EPA, FDA), the courts, Congress, public health officials and citizens use this information to make decisions about the balance between risks and benefits. This is a way to manage the risk in a community and is often referred to as risk management. Their decisions are based on the results from scientific studies, along with the policy and financial implications. Suggest that in order for a toxicologist to determine what level of a chemical is acceptable in the environment, the risk posed by a particular amount of a chemical must be determined and weighed against the benefits of the chemical's use.

A real-life example is assessment of the potential risks and benefits caused by the chlorination of water. Chlorine in the water can react with organic by-products and can produce suspected carcinogens. Chlorination of water thus may pose a small risk of getting cancer. The chance of developing cancer over a year from chlorine in tap water is estimated at 3 in 10 million. In comparison, the chance of developing any smoking-related disease over a year from smoking one pack of cigarettes a day is 1 in 300 - much greater! (J. Tierney. *Hippocrates*. Jan/Feb 1988, pg. 31). The benefit of having chlorine is to avoid outbreaks of dangerous microbial diseases, such as typhoid and cholera. Most scientists agree that the relatively small risk of cancer outweighs the much greater chance of a microbial epidemic if the water were not treated, but there is still controversy because there are other ways to treat water - but they are usually more expensive.

SHOPPING FOR HOUSEHOLD CHEMICALS - RISK PERCEPTION ACTIVITY

Ask the students how they can determine whether a product is toxic (by reading the label most likely). Pass out tootsie rolls to students and ask them to read the wrappers. While they are eating, read aloud one of the **activity cards (#16A-H)** that is included with the kit. Mention the fact that food and household products are regulated differently, which is why the food labels have different information on them. Tell the class that for the next few minutes they are going to be focusing on hazardous household products, how they affect humans and the environment, and how people can choose safer products and practices. Ask them to brainstorm a list of common household products that are considered hazardous. You can categorize their responses according to the following categories: Cleaners, Pesticides, Automotive Supplies, Home Maintenance Supplies, and Others.

Some information you may want to discuss prior to beginning the activity:

Signal words (poison, danger, warning, and caution) must appear on the front label. Consumer products are regulated by three federal agencies. Pesticides by the U.S. EPA, food and drugs by the FDA, and all other products by the Consumer Product Safety Commission (CPSC). Each agency has its own set of labeling requirements and all of them require that short-term health effects be listed. Pesticide labels do not list possible long-term health hazards such as cancer. Manufacturers are also not required to list any potential environmental hazards. Many labels do not identify the ingredients. Sometimes they list general category names or just list what is not found in the product. Some labels say, "environmentally safe" which may be misleading to the consumer.

> **Optional Questions:** What are the active ingredients listed? What are the inactive or inert ingredients listed? Are there hazard or warning words or symbols? Are there any directions that help protect people's health? Are there environmental warnings? What is a less toxic alternative to this product?

Background information on questions and relevant information:

Active ingredients - make the product both useful and potentially harmful. Inert ingredients "carry" the active ingredient.

The signal words below for pesticides and other household products are required by law. You know a product is hazardous if it has any of the signal words, "caution, warning, danger, or poison." However, it doesn't mean it definitely causes harm if used properly or according to the directions (something often overlooked by consumers). You know a product is safe only if you DO NOT see one of those signal words. Safe does not mean it's food or a lotion!

Background on Signal Words for Pesticides:

> **"Poison"** - means highly toxic, toxicity is the primary hazard.
>
> **"Danger"** -means highly toxic; corrosive, flammable or reactive
>
> **"Warning"** means moderately toxic; corrosive, flammable or reactive.
>
> **"Caution"** signals slight toxicity; corrosive, flammable or reactive.

Script: Level 3

Background on Signal Words for Other Household Products:

> **“Poison”** - means highly toxic, toxicity is the primary hazard.
>
> **“Danger**” -means extremely flammable or corrosive, or highly toxic
>
> **“Warning”** or **“Caution”** appear on all other hazardous substances. There is no distinction between hazard levels. These words are usually followed by the phrase “keep out of reach of children.”

Next, ask the class to **form five groups** for the risk perception activity. (This activity can also be done as a class activity if it is too difficult to break up into groups). This exercise should make the students think about how decisions about a particular chemical depends on many factors. Hand out one or two included labels of products **(activity cards #16A-H)** to each group and have the groups do the following activity:

Read the information on the label and answer the following questions:

- What is the most important reason you can see why you **wouldn’t** want to use your particular chemical?
- What is the most important reason you can see why you **would** want to use your particular chemical?
- Would you buy this product? (Yes or No)
- What important information was **missing** from the label?
- If you knew the answer to your question about what was missing would this make it easier for you to decide to use or not use this product?

End with a discussion about how the risks and benefits of products can often depend on who you are and what information you are given. There may be different risks and benefits depending on if you are pregnant, a child, or someone with asthma. Discuss what type of products you can substitute for many cleaners. Baking soda, Murphy’s Soap, vinegar, and water can be used for cleaning the oven, floors, windows, bathrooms, and kitchens with minimal toxicity to children or adults, although they may be somewhat less effective. You can then discuss the concept of ‘trade-offs’ between risks and benefits.

E. Tox Tales (10 min)

Explain to the students that toxicology plays a role in their everyday life. Ask the students if they can think of times they have been exposed to toxic substances, or have seen toxicology in television shows, movies, or books.

Some examples are:

- **Alice in Wonderland** - the Mad Hatter was exposed to mercury, a heavy metal used in the manufacturing of felt hats, and that is why he acts the way he does, i.e., 'mad' or 'crazy.'
- **Episodes of *E.R.*** have portrayed poisoning incidents, and the doctors have consulted a toxicologist for advice.
- Ask if anyone knows which play this is from, "Thy drugs are quick. Thus with a kiss I die." - **Romeo and Juliet.**
- **Vincent Van Gogh** - He cut off his ear and sent it to his girlfriend. He went a little crazy. He used to sharpen his paint brush in his mouth and he was using lead-based paints. He was perhaps poisoning himself by eating lead paint.
- **Everyday Examples** - Students may have gotten poison ivy after hiking through a forest, or may have been stung by a bee, wasp, or ant.
- **Roman emperors and aristocracy** - slowly poisoned by lead used in vessels for wine and even water. Latin for lead is "Plumbam" - Pb on periodic table, and the word "plumbing" comes from this.

Now that the students understand that toxicology is a part of their lives, show how toxicology, and the attitudes regarding the toxicity of different compounds change over time. **Have the students form five groups (they should already be in groups from the previous activity), and give each group one of the six included laminated cards of headlines from articles or advertisements.** Have the students review their cards and present their responses to the class:

- What is the compound in your handout?
- What time period (approximate years) is each side of the card referring to?
- What were the attitudes towards the compound in the two different time periods?
- Why do you think the attitudes have changed?

Following the reports from each group, discuss the concept of how use and public perception or attitudes towards compounds have changed through the years. Point out that these changes in attitudes, generally, have been due to an increased understanding of the toxicology underlying the compounds. To highlight the fact that we still do not know everything, ask the students if they can think of compounds we use today but may not in the future due to new toxicological studies.

Discussion points:

As a toxicologist or other environmental health professional, you should be familiar with the scientific issues surrounding all of these examples. It is important for you to make sure that scientific principles are upheld in these discussions (objectivity, opinions based on fact, etc.).

Script: Level 3

Smoking (activity card #17A)- In the old ad for smoking it states, "Smoking Camels found to have a positive beneficial effect upon digestion," giving the attitude that smoking was good for you. Now that smoking is known to cause many diseases, ads need to have health warnings. The recent ad on this activity card makes smoking seem forbidden (Viewer Discretion Advised), so even more enticing to the public. Tobacco companies need to be a lot more creative now to convince people to start smoking.

DDT (#17B)- In the first ad from *Time Magazine*, DDT is portrayed as being nice and as fresh as rain. The ad makes it seem like it's actually good for animals and humans. The more recent article addresses the serious concern we now have about DDT and the serious harm it can do to animals in the environment. It also describes how DDT is relentless and persistent in the environment years after it has been banned. However, DDT continues to be a very important means of controlling malaria in many developing countries. This raises very interesting and difficult ethical dilemmas about risk trade offs. See the article in the August 29,1999 *Seattle Times* article about this issue which is great for the discussion (headline is included on the DDT activity card).

Mercury (#17C)- Mercury is called the "Fighting Metal," in the article from 1942. The article describes how useful a metal it is -- from dental fillings, to predicting the weather. The recent article suggests that mercury poisoning is a severe problem. Mercury can be a dangerous source of contamination in fish; pregnant woman have to be very careful not to consume too much fish for mercury can cause central nervous system problems in their children. The articles also talk about mercury in fillings, and poisonings from liquid mercury and mercury vapor.

Asbestos (#17D)- Asbestos was once widely used for insulation because of its strength and heat-resisting quality. It was not considered hazardous at the time. In the 1970s and 1980s, scientists realized that the fibers from asbestos can become airborne and breathed deep into the lungs. Excessive exposure can cause lung cancer and other lung diseases.

Lead (#17E)- The older articles refer to "ethyl" which is another word for the kind of lead used in gasoline. Lead was used in gasoline for years and in the ad is called the "coolest" fuel. The more recent headlines discuss the serious health threat of lead, especially to children. Lead in paint is currently the most significant source of exposure for US children. Old paint that is peeling in homes may be eaten by small children. Lead can cause severe consequences to children following prolonged exposure, including a decrease in IQ and potentially serious brain damage at higher doses.

Alcohol (#17F)- The older advertisements portray alcohol as being good for you, "wholesome food and drink are necessary to have and to keep a healthy body." They also mention it is good for athletes. The more recent information talks about birth defects and drunk driving and includes the warning labels from beer. Here you can tie in the concept of drinking alcohol and how important the dose is. A small amount may give you some short term effects, however, a high dose can cause you to lose the ability to drive, and an even higher dose can give you alcohol poisoning and even cause death. In the short term you can metabolize the alcohol quickly, in the long term alcohol can cause severe liver damage.

Background information on compounds in articles and advertisements to help with discussion:

Tobacco/Smoking

- Tobacco is used in cigarettes and comes from the leaves of the tobacco plant. The leaves contain nicotine, and when burned produce hundreds of other toxic compounds.
- Cigarette smoke causes cardiovascular disease and lung cancer; cigarettes are the number one killer in the US.
- Many of the same chemicals that are in wood smoke and produced from combustion are found in cigarettes.

DDT (dichlorodiphenyltrichlorothane)

- Used as a pesticide to kill disease-carrying and crop-eating insects, no longer used in the US due to persistence in the environment. The EPA banned it in 1973. A book, *Silent Spring,* by Rachel Carson was primarily responsible for uncovering the problems with DDT, and led to the environmental movement of the 1960's and 1970's.
- Problems seen in nature, especially effects on bird reproduction (weakening of shells) and cold-blooded animals. It is also known to accumulate in the breast milk of woman and thus be transferred to the child. Many pesticides are not water soluble so they can get stored in fatty tissue such as the breast.

Mercury

- Heavy metal, was used in many industries including hat manufacturing (hence the Mad Hatter in Alice in Wonderland), the pulp and paper industry, and thermometer production.
- Has many effects, including central nervous system toxicity in adults and exposed fetuses, depending on the form of mercury to which one is exposed.
- There is a current controversy about using mercury for filling cavities in teeth. Mercury is cheap, durable, and not as tricky to use as gold. People are now questioning if the mercury released from the fillings can make people sick.

Asbestos

- Natural fiber widely used (previously) as an insulator because of its ability to retard fire, in tile and glues, and popcorn ceilings.
- Can cause lung cancer, especially in people who smoke (discuss synergistic effects), usage has greatly decreased, but there is now a problem with exposures due to damaged buildings containing asbestos, remodeling, and removal of asbestos.

Lead

- Heavy metal, has had widespread use in industry, in old paint, pipes, and previously (and still is in some places) in gasoline, leading to widespread dispersal.

Script: Level 3

- Effects depend upon the level of exposure. There is evidence that it has affected the overall IQ of populations of young children with higher than ‘background’ exposures.

Alcohol

- Women who consume high doses of alcohol during pregnancy have a very high risk of causing severe harm to the baby (fetal alcohol syndrome). Someone who took cold medications (warning label says do not mix with alcohol) can have a risk of interactions between the two drugs. Alcohol is a depressant, and many cold remedies contain depressants. The combination of two depressants can have an additive effect, leading to coma, or death, in the worst case.

Distribute the handout **Toxicology - the Science of Poisons (Handout 3, *Appendix G*)**. This is a broad overview with important terms used in toxicology and a list of careers in toxicology.

Ask the class if they have any questions. If you have time, you can talk more about yourself or a career in toxicology that might interest them.

Finally, suggest to the teacher that he/she might consider continuing the study of toxicology with *Project Greenskate* or *Essentials of Cell Biology: Toxicology in Action* (appropriate for 9th grade Biology). The*Teacher’s Resource Manual and Guide to Tox-in-a-Box*™ has information on these materials and many others.

LEVEL FOUR: Grades 10 - 12

Materials

- Package of salt, rubber slug, Morton salt container
- Slides and slide projector (projector not included)
- pH indicator dye (BPB), HCl, NaOH, pH 10 buffer
- Pipettes
- Plastic cups, spoon
- Magnetic Stir bar (Stir plate not included)
- Beaker, distilled water (bottle provided)
- Three handouts (App. G) -- BPB Graph Worksheet (Handout 1), Risk Factors for Cancer (Handout 2), Toxicology - the Science of Poisons (Handout 3)
- Activity Cards (#16A-H & 17A-E)

Overview

The following presentation can be used in a 70 minute period or modified if less time is available. The presentation begins with a discussion with the students about what environmental health means to them. This will lead to a more specific discussion on toxicology and toxicants. The discussion on toxicology will highlight the ideas that the world around us, including ourselves, is comprised of chemicals (**Living in a Chemical World**), that everything has the potential to be toxic (**Dose Makes the Poison**), and will include a demonstration which highlights dose/response relationships and the susceptibility of children to poisons. This will be followed by a discussion of toxicology as it relates to other sciences that the students may be more familiar with (**Toxicology: An Application of Basic Sciences**). Next, the concept of risk assessment, and weighing risks versus benefits will be addressed with a risk activity about household hazardous waste (**Risks and Benefits - Assessing Your Options**). Finally, there will be a discussion about how toxicology relates to people's everyday lives, and about how our understanding of something that was once considered safe has evolved through the decades **(Tox Tales**). This will be demonstrated by comparing old and new clippings from newspapers and advertisements.

Presentation Overview

Level 4 Presentation (Total Time ~ 70 minutes)

Activity	Grouping	Time	Materials
A. Living in a Chemical World			
Introduction to environmental health and chemicals	Class	5 min	
B. Dose Makes the Poison			
Discussion of toxic chemicals, slide show begins, differential susceptibility, routes of exposure	Class	15 min	Slides, rubber slug, and package of salt
Sensitive individuals, dose-response demonstration	Class	5 min	Bromophenol blue III demonstration (App. D)
Students graph dose-response curve to demostrate threshold effects	Class & individual	10 min	Bromophenol blue II (prepare before class, App. C), BPB Worksheet (Handout 1, App. G)
C. Toxicology: An Application of Basic Science			
Students "brainstorm" on toxicology and its connection to basic sciences, career opportunities	Class	5 min	
Cancer discussion and completion of slide presentation	Class	10 min	Slides, Risk Factors for Cancer (Handout 2, App. G)
D. Risks and Benefits: Assessing Your Options			
Shopping for household chemicals - risk perception activity	Class & small groups	10 min	Labels of products (Activity cards #16A-H)
E. Tox Tales			Headlines from advertisements and articles
Investigation of current issues in toxicology and how they have evolved over time	Class & small groups	10 min	(Activity cards #17A-F), Toxicology - the Science of Poisons (Handout 3, App. G)

Grades 10 - 12

A. Living in a Chemical World (5 min)

Begin by defining environmental health, indicating the relationship between humans and the environment:

> **For example**: *The science concerning how factors in our environment influence human health and well being, and how humans and our actions influence the health of the environment.*

Introduce students to the idea that people who work in the field of environmental health study the effects from many chemicals in the environment. Ask the students to give examples of compounds that are not chemicals (there are no compounds that are not chemicals). The reason for this discussion is to demonstrate that everything in the world, including our bodies, are composed of chemicals - We live in a chemical world.

Finally, end the section with a definition of toxicology and environmental health sciences.

Toxicology can be defined as the study of harmful effects of chemicals on living things (humans, other organisms, and the environment).

Environmental health sciences is the study of how our environment can affect our health. This includes not only the study of toxic chemicals (toxicology) but also how microorganisms (bacterial, viruses) in our food, water, and air can affect our health, and how changes in our environment and ecosystem can affect our health.

B. Dose Makes the Poison (30 min)

Begin this section by discussing one of the basic tenets of toxicology. Paracelsus (1493-1541), one of the founding fathers of toxicology, is known by this quote:

> *All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy."*

To impress students, you may also want to tell them Paracelsus' full name: **Philippus Aureolus Theophrastus Bombastus von Hohenheim-Paracelsus**.

Dr. Steven Gilbert (1997) has stated, *"The sensitivity of the individual differentiates a poison from a remedy,"* to empasize the point that not all people respond the same way to a chemical hazard. While most people respond in a smiliar way (good place to introduce the 'bell shaped curve,' or 'normal distribution concept'), occasionally, an individual may respond at a dose much lower or higher than normal. Sometimes an individual may respond in a very different manner from what is expected, for example, the person who has an allergy to penicillin or is allergic to bee stings.

Script: Level 4

Explain that these concepts, the "dose makes the poison," and "individual sensitivities," are the key to understanding the principles of toxicology. Substances can be poisons to some and not to others because of individual differences.

Discuss with the students that chemicals provide many benefits and can enrich our lives. They are used as drugs, fertilizers, plastic, and energy sources. However, chemicals can also have harmful effects.

Ask the class to define a toxic chemical (A toxic chemical is one that has adverse effects on the body). Have students provide examples of toxic chemicals. Some chemicals that may be discussed are:

- paints
- pesticides
- dioxins
- lead
- alcohol
- compounds in cigarettes
- mercury
- caffeine

Tell the students that they have come up with many good examples and that now some slides will show examples of some of these toxic substances.

BEGIN SLIDE SHOW

slide Plane spraying pesticides. Pesticides kill insects and other unwanted pests and are very important for the production of an abundant and wholesome food supply, and for the control of diseases carried by insects (e.g. malaria). However, if used inappropriately pesticides can harm humans and animals living and working nearby. Exposure to pesticides can be an important health concern for agricultural workers if the "dose" is high enough. **Ask students how a farm worker might get too high a dose.** You can discuss this in detail further when you talk about routes of exposure. It is important to remember that although pesticides have a risk to health associated with them, they also benefit human health by preventing disease and helping to ensure an adequate supply of food. This balancing of risks and benefits occurs with most chemicals, including medical drugs.

slide Shelves full of pesticides, paints, etc. in a home garage. This is what many garages look like inside. These chemicals may have lids, but often the fumes can still seep into the air, or the cans might rust and leak. It is important to take the items to a special hazardous waste site for disposal, and keep them in a locked storage bin away from the house. There are also many alternatives to toxic chemicals.

slide Mold on wall. This picture shows mold on a wall that was behind a couch. There was a lot of moisture behind the couch, making it ideal for mold, which likes to grow in damp, humid places.

Ask the students which are more toxic, natural compounds or human-made chemicals. The answer is that both can be toxic (i.e., natural and human-made designations say nothing about the toxicity of a chemical). Natural and human-made origins have nothing to do with toxicity. This is demonstrated by the numerous toxic animals and plants.

CONTINUE SLIDE SHOW

Atelopus (Panamanian Golden frog). Poison dart frogs secrete toxins from their skin, and this secretion was used by native tribes to coat their darts with poison. They would rub the tip of the dart along the back of the frog. One frog may have enough toxin to provide a lethal dose to ten adult humans. The frog's colors warn predators of its poison. If humans touch or lick the frog, they may get very sick. Atelopus frogs, as seen in this slide, are from Panama; the skin toxins have evolved for protection from predators.

Barracuda (tropical fish). The flesh of the barracuda can be poisonous. The barraduda is also a good illustration of biomagnification of natural substances. There are toxic algae which live on aquatic plants. Small fish eat these plants, including the algae, and then the barracuda eats these small fish. The more small fish the barracuda has eaten, the more toxins it accumulates, and the more toxic it becomes. People eat barracuda, but if it is too large (old) and has eaten too many small fish, it may be toxic enough to make a person sick. Sometimes people would cut off a piece of the fish, and if ants would eat it, they would assume it was safe to eat. Other fishes, such as the puffer fish, can make their own poisons. Although the flesh is good to eat, ingestion of even a small amount of the poison-containing parts of the puffer fish (liver, gonads) can kill a person.

Local Sea Anemone. The Sea Anemoneuses special toxin as a defense mechanism against predators. The tentacles close around predators and the urchin stings them.

Lionfish. Lionfish can be very beautiful but also very deadly. They are found in warm tropical water and are deadly because of their venom which they use to stun or kill their victims. If humans are punctured by the spines, they feel pain immediately; swelling occurs, and they may be unable to move their arms or legs. This paralysis is temporary, and they usually recover after several months.

Scallops. Like other shellfish, scallops can be toxic due to algae blooms in the water. There is regular testing of the seafood to determine if it is safe to sell to consumers or serve in restaurants. People who catch them and don't check to see if it's a safe time can die. An example is red tide, which is a naturally-occurring, higher than normal concentration of microscopic algae. The algae grow fast and appear reddish. Some produce neurotoxins which can be transferred through the food web (scallops to humans).

Pacific Rattlesnake. The pacific rattlesnake is found from British Colombia to Mexico, from California to Iowa. Rattlesnake venom is toxic to humans, and can be deadly. However, death is rare and usually occurs only in places where people can not get medical care.

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Pacific Rattlesnake II. Here's another photo of the pacific rattlesnake. Here you can clearly see the sharp teeth which the snakes use to inject their venom.

Amanita Muscaria. This mushroom contains a toxin that affects the body. Some mushrooms affect the brain with neurotoxins, but many of these type of mushrooms have hepatotoxin. Does anyone know what a hepatotoxin is? It is a toxin that affects the liver. There have been many instances when people have identified mushrooms incorrectly, eaten them and become sick. In some cases people have died after eating poisonous mushrooms.

Rhododendrons. These everyday shrubs are in gardens throughout the United States. They contain grayanotoxins, which affect the heart and can be poisonous if eaten. Fortunately, our bodies have a defense mechanism which makes us vomit this toxin.

Next, ask the students if some common household items, such as salt, are toxic, and show the **package of salt**. The students will probably respond that salt is not toxic. Then ask the students if salt is toxic to a slug, and hold up the **rubber slug**. Most of the students will probably respond that salt is toxic to slugs, since pouring salt on a slug will make it shrivel up and die. Slugs must maintain a moist outer layer, and the salt pulls out moisture. A pinch of salt might not harm it, but that entire package of salt would be toxic.

To continue, discuss the idea that if an average size adult weighing about 60 kg (132 lbs) were to eat 240 grams of salt (4 grams per kg body weight) it would be toxic. Show the **empty container of Morton's Salt** which is about 750 grams and say that if an average adult ate 1/3 of the salt in this container it would be toxic to their body because internal electrolyte balance may fail.

Ask the students if they can think of who may be more susceptible to the toxic effects of chemicals. Prompt them to talk about children by asking them to calculate the quantity of salt which would be toxic to a child weighing 30 kg (60 lb), the answer would be 120 grams (4 grams per kg body weight). They would only need about 1/6 of the salt in the container to be toxic to their smaller body.

To illustrate that some people are more sensitive than others, carry out the **bromophenol blue III demonstration (BPB III)**. A detailed protocol for the BPB III experiment is given in *Appendix D.* Take four-five plastic cups with distilled water, one of which has a few drops of 0.3 HCl. Then add three drops of BPB to each one. **The cup with the HCl will respond differently** (it will turn yellow) and represents the "sensitive" individual. Some people may respond differently to the same dose of a chemical because of genetics, diet, or other factors. You can brainstorm with the students as to why some people are more sensitive or resistant than others to chemicals.

Ask the students if they can think of any subpopulations of humans who may be more vulnerable to the toxic effects of chemicals.

Possible answers are:

- Children are more susceptible to brain damage from exposure to lead because their tissues are still developing and their blood-brain barrier is not effective.
- Pregnant women must avoid alcohol and many other drugs due to the sensitivity of the developing fetus. Brain damage can result from drug exposure to the fetus. The more alcohol the woman drinks, the greater the chance the fetus will be adversely effected.
- People with preexisting lung disease, such as asthma, are sensitive to air pollution (such as cigarette smoke, smog, dust mites) due to decreased lung capacity/function.

  Elderly people must be careful about many things because of their weakening body and immune system.

Also, discuss the different routes of exposure. The slug is being exposed dermally, i.e., through the skin, whereas people are normally exposed to salt orally, i.e., by eating or drinking it. Ask the students what the other main route of exposure is (which is through inhalation, i.e., breathing in chemicals).

CONTINUE SLIDES

Too young to smoke. Not only does cigarette smoke cause cancer in people, but also in those exposed to secondhand smoke (the smoke exhaled by the smoker and the burning end of the cigarette or pipe). People who smoke get the highest dose (firsthand along with secondhand smoke).

Good Air Day. This is the type of day that we hope we can have more of in Seattle, and other cities around the country.

Bad Air Day. This shows a similar day in Seattle, Washington when the particulate levels are high. Particulates are caused by outdoor burning, industry, wood-burning, and motor vehicles. It not only reduces visibility but also causes adverse health effects especially in children, the elderly, and those with lung disease. Some of these health effects are listed on the slide.

Next, distribute the **BPB Graph Worksheet (Handout 1, *Appendix G*)** and conduct the **bromophenol blue II (BPB II) demonstration** to further explore the concept of dose-response. A detailed protocol for the BPB 2 experiment is given in *Appendix C*. Briefly, add drops of acid to a large beaker, while stirring vigorously (by hand or with a stir plate). Have students record the dose (i.e., cumulative number of drops added) and the magnitude of the response (i.e., from 0-10 in color change) on their worksheets.

Once the students have completed the data collection, have the students plot the **dose or concentration (X-axis)** versus **response (Y-axis)**. You can have one student record for the class and one student draw a graph on the board as an alternative to handing out worksheets. The results

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should yield a sigmoid dose-response curve, with an apparent “threshold.” The threshold is the dose just below where a change (response) was first noted is called the No Observed Effect Level” or **NOEL**. You can draw this on the board or use one of the student’s graphs as an example. This can then be discussed, using real world examples of alcohol and degree of inebriation, tobacco smoking and chances of lung cancer, workplace exposure to toxic chemicals and ill health, etc.

Concepts to be discussed with respect to the students’ graphs include:

- **Differences between student graphs** - discuss with the students the fact that not everyone agreed exactly on the same “observed” response. Some may have thought 2, 3, or 4 for the same dose. This is the way science is - sometimes scientists don’t agree on things, or can interpret the same observation somewhat diffferently. That’s why its important for experiments to be repeated many times before being certain of the results.
- **Threshold** - the concept that there is either no response or a response below or above a particular level, respectively. The dose at or above which there is a response is termed the THRESHOLD DOSE.
- **NOEL** - the No Observable Effect Level is the dose at or below which there is no change or effect able to be observed. Note that different people may have different ‘thresholds’ or ‘NOELS’ - not everyone will respond exactly the same way.

C. Toxicology: An Application of Basic Science (15 min)

Now discuss the connection between toxicology and basic sciences. Toxicology is an applied science which uses most of the basic sciences the students have already studied:

- **Biology** - one needs to understand how the body and ecosystems normally function to understand what toxicants do to their functioning.
- **Chemistry** - one needs to understand chemistry to understand the processes that take place in the body and the environment. Some key concepts are solubility, volatility, and different reactions in the environment.
- **Earth Science** - for ecotoxicology, and things such as weather patterns to determine when toxic substances/pollution are going to be a problem. Also looking at the global distribution of chemicals into the food chain such as PCBs and Hg.
- **Physics**- most of the equipment which toxicology labs use are based in physics - lasers to visualize things, electrical charges to separate compounds out on a gel, robotics in assorted equipment, radioactive labeling of compounds.

Ask the students to “brainstorm” careers that may utilize toxicological principles.
Some careers could include:

- Doctors, veterinarians, other health care workers, when diagnosing and treating poisonings and drug interactions

- Fire fighters, when dealing with hazardous spills
- Marine biologists, when studying fish/shellfish problems
- Lawyers, when dealing with environmental issues or lawsuits
- Chemical engineer/industrial hygienist to ensure worker safety
- Fast food workers, when dealing with food safety issues
- Mechanics to protect themselves adequately from fumes
- Painters (both house and fine arts), when handling paints and solvents
- Educators, when teaching about the sciences and other subjects

Explain to the class specific careers in the field of toxicology:

- Water/food/air quality management
- Occupational health and safety
- Educational outreach
- Solid/hazardous waste managers
- Government regulation of food/drug/chemicals
- Consultants for industry and other occupations (e.g., lawyers)
- Pharmacokinetic and chemical industries develop and test new chemical products
- Academics
- Forensic or other toxicologist
- Toxicological research

Discuss that another critical field is conducting research. Toxicology researchers study how chemicals affect the body.

CONTINUE SLIDES

Some aspects of this research are highlighted below:

slide — Rat embryo. One way to study toxic effects is to look at the whole animal. These pictures show two rat fetuses. The left (large) fetus is the control, while the right was exposed to aflatoxin (a toxin produced by a fungus that grows on peanuts). You can see that the brain is much smaller and deformed, and the neural tube is not closed in the exposed fetus.

slide — Healthy cell vs. unhealthy cell. You can also look at specific organs, or study the level of the individual cell, such as in this slide. The left section of the slide shows a single,

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smooth layer of healthy epithelial cells. The right section of the slide shows cells which are undergoing cell death (apoptosis) – you can see the "blebs" or bulges on the cells which are characteristic of some types of cell death.

Now is a good time to introduce the topic of cancer and to use the remaining slides to illustrate certain concepts. Discuss the role of toxicologists in cancer research and then begin to cover a few broad questions related to cancer.

First, ask students "What is cancer?" Let them offer their ideas, but be sure to define cancer as a chronic disease process characterized by the uncontrolled growth of cells (tumors) that may spread (metastasize) throughout the body, ultimately causing death. State that cancer arises when the DNA in a cell is altered during a process called mutation. The mutations that occur in DNA have affects on different organs in our bodies, thus, cancer is described as a disease process that affects different organs rather than simply a single disease.

Discuss with students the presence of cancer in the world population. It occurs in all ages and races as well as both genders, although cancer onset is more frequent in "old age." Mention the following statistics:

- 1 out of 4 people in the U.S. will die from cancer. (American Cancer Society)
- In the U.S., nearly 500,000 people will die from cancer this year; it is the second leading cause of death. (American Cancer Society)

CONTINUE WITH THE SLIDES

Toxicologists also study the mechanisms by which chemicals cause their toxic effects on humans and the environment. The two slides about DNA mutation introduce the ideas that explain how chemicals cause cancer. Fortunately, our bodies have repair mechanisms that often remedy damaged DNA. However, when the damage is excessive and beyond repair, the DNA mutation may be left unrepaired. When this happens, the altered genetic information is passed on to all future cells after the mutated cell divides. Thus, the unrepaired mutations may become permanent. Permanent mutations in certain parts of the DNA may lead to chronic diseases such as cancer. Even "aging" is a result of irreparably damaged DNA.

slide Normal DNA (from Essentials of Cell Biology CD ROM). DNA is a vast chemical information database. It resides in the nucleus of each of the body's trillions of cells, and it carries the complete set of instructions for making all the proteins a cell will ever need. Every human cell within an individual contains the same DNA.

slide Mutated DNA (from Essentials of Cell Biology CD ROM). This slide shows a compound binding to the DNA, which will lead to a mutation. Some mutations can lead to cancer. Genes that control the replication of cells become damaged, allowing the cells to reproduce without restraint. Mutations refer to irreversible changes in the DNA (our "genes") of a cell. Mutations arise when reactive molecules bind to and damage DNA – and if the damage is not repaired or is repaired incorrectly a permanent change in DNA occurs.

Ask the students if they can think of chemicals in the environment that may interact with DNA and cause mutations (i.e., cigarette smoke, polluted water, chemicals in the workplace, UV radiation, and sunlight). Even oxygen, which is essential for life can damage DNA.

Most Cancer is ***not*** *inherited*. Even though all cancer is triggered by altered genes, only a small portion is inherited. Most cancers come from random mutations that develop in cells during one's lifetime – either as a mistake when cells are going through cell division in response to injuries from environmental agents such as radiation and chemicals, or from 'oxidative' damage to DNA that results from normal cellular metabolism (burning of sugar and oxygen to make energy for the cells). You can also discuss the important role of "antioxidants" in reducing risks of cancer such as from vitamins, fruits and vegetables, and even some drugs.

Give each student a copy of **Risk Factors for Cancer (Handout 2, *Appendix G*)**. Explain to students that cancers are attributed to various factors, also called "risk factors." It is important to note that diet, something we can largely control, can impose an important risk factor for both developing and preventing cancer. Discuss the importance of eating a balanced diet that includes fruit and vegetables. Reinforce that two of the major risk factors, tobacco and diet, are attributable for almost 65% of cancer deaths.

Choose other factors from the list to discuss, such as occupational risks. Ask the students if they can identify different hazards that some people face in the workplace. Since the topic of risk is discussed in the next section, this is a good time to mention that there is a relationship between exposure and risk. Risk is defined as the probability of injury, disease, or death for an individual or population exposed to a hazardous substance or situation. The more exposure to certain cancer risk factors, the greater the likelihood of experiencing adverse effects. However, it is critical to revisit the concept of dose when discussing risk. The greater the dose, the more risk and the greater our chance of disease.

END SLIDE SHOW

D. Risks and Benefits: Assessing Your Options (10 min)

Introduce the concept that one responsibility of a toxicologist is to determine "safe" levels of exposure to chemicals, as well as to identify what benefits these exposures may produce. This analysis is done by reviewing the risks and the benefits of each chemical. Point out that almost every decision we make is based on weighing the risks and benefits of a particular action, although we do not always make the best decision based on these facts. While toxicologists are not usually involved in evaluating the benefits of chemicals, they provide the scientific information and analysis that is necessary to assess the risks of chemicals. Government agencies (i.e., EPA, FDA), the courts,

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Congress, public health officials and citizens use this information to make decisions about the balance between risks and benefits. This is a way to manage the risk in a community and is often referred to as risk management. Their decisions are based on the results from scientific studies, along with the policy and financial implications. Discuss the idea that in order for a toxicologist to determine what level of a chemical is acceptable in the environment, the risk posed by a particular amount of a chemical must be determined and weighed against the benefits of the chemical's use. This process is termed risk assessment.

- **Risk—**the probability of injury, disease, or death for an individual or population exposed to a hazardous substance or situation, equals potency plus exposure
- **Benefit—**something that is advantageous or good
- **Risk Assessment—**identifying the nature and magnitude of risk

A real-life example is assessment of the potential risks and benefits caused by the chlorination of water. Chlorine in the water can react with organic by-products and can produce suspected carcinogens. Chlorination of water thus may pose a small risk of getting cancer. The chance of developing cancer over a year from chlorine in tap water is estimated at 3 in 10 million. In comparison, the chance of developing any smoking-related disease over a year from smoking one pack of cigarettes a day is 1 in 300 - much greater! (J. Tierney. *Hippocrates*. Jan/Feb 1988, pg. 31). The benefit of having chlorine is to avoid outbreaks of dangerous microbial diseases, such as typhoid and cholera. Most scientists agree that the relatively small risk of cancer outweighs the much greater chance of a microbial epidemic if the water were not treated, but there is still controversy because there are other ways to treat water - but they are usually more expensive.

Shopping for Household chemicals: risk perception activity

Ask the students how they identify if a product is toxic or not (probably by reading the label). Pass out tootsie rolls to students and ask them to read the wrappers. While they are eating read out loud one of the labels of products **(activity cards #16A-H)** that is included with the kit. Mention the fact that food and household products are regulated differently, which is why the food labels have different information on them. Tell the class that for the next few minutes, they are going to be focusing on hazardous household products, how they affect humans and the environment, and how people can choose safer products and practices. Ask them to brainstorm a list of common household products that are considered hazardous. You can categorize their responses according to the following categories: Cleaners, Pesticides, Automotive Supplies, Home Maintenance Supplies, and Others.

Some information you may want to discuss prior to beginning the activity:

Signal words (poison, danger, warning, and caution) must appear on the front label. Consumer products are regulated by three federal agencies. Pesticides by the U.S. EPA, food and drugs by the FDA, and all other products by the Consumer Product Safety Commission (CPSC). Each agency has its own set of labeling requirements and all of them require that short-term health effects be listed. Pesticide labels do not list possible long-term health hazards such as cancer. Manufacturers are also not required to list any potential environmental hazards.

Many labels do not identify the ingredients. Sometimes they list general category names or just list what is not found in the product. Some labels say, "environmentally safe" which may be misleading to the consumer.

Optional Questions: What are the active ingredients listed? What are the inactive or inert ingredients listed? Are there hazard or warning words or symbols? Are there any directions that help protect people's health? Are there environmental warnings? What is a less toxic alternative to this product?

Background information on questions and relevant information:

Active ingredients - make the product both useful and potentially harmful. Inert ingredients "carry" the active ingredient.

The signal words below for pesticides and other household products are required by law. You know a product is hazardous if it has any of the signal words, "caution, warning, danger, or poison." However, it doesn't mean it definitely causes harm if used properly or according to the directions (something often overlooked by consumers). You know a product is safe only if you **do not** see one of those signal words! Safe does not mean it's food or a lotion!

Background on Signal Words for Pesticides:

- **"Poison"** means highly toxic, toxicity is the primary hazard.
- **"Danger"** means highly toxic; corrosive, flammable or reactive
- **"Warning"** means moderately toxic; corrosive, flammable or reactive.
- **"Caution"** signals slight toxicity; corrosive, flammable or reactive.

Background on Signal Words for Other Household Products:

- **"Poison"** means highly toxic, toxicity is the primary hazard.
- **"Danger"** means extremely flammable or corrosive, or highly toxic
- **"Warning"** or **"Caution"** appear on all other hazardous substances. There is no distinction between hazard levels. These words are usually followed by the phrase "keep out of reach of children."

Next, ask the class to **form five groups** for the risk perception activity. (This activity can also be done as a class activity if it is too difficult to break up into groups). This exercise should make the

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students think about how decisions about a particular chemical depends on many factors. Hand out one or two of the included labels of products **(activity cards #16A-H)** to each group and have the groups do the following activity:

Read the information on the label and answer the following questions:

- What is the most important reason you can see why you **wouldn't** want to use your particular chemical?
- What is the most important reason you can see why you **would** want to use your particular chemical?
- Would you buy this product? (Yes or no)
- What important information was missing from the label?
- If you knew the answer to your question about what was missing, would this make it easier for you to decide to use or not use this product?

End with a discussion about how the risks and benefits of products can often depend on who you are and what information you are given. There may be different risks and benefits depending on if you are pregnant, a child, or someone with asthma. Discuss what type of products you can substitute for many cleaners. Baking soda, murphy's soap, vinegar, and water can be used for cleaning the oven, floors, windows, bathrooms, and kitchens with minimal toxicity to children or adults, although they may be somewhat less effective. You can then discuss the concept of 'trade-offs' between risks and benefits.

E. Tox Tales (10 min)

Explain to the students that toxicology plays a role in their everyday life. Ask the students if they can think of times they have been exposed to toxic substances, or have seen toxicology in television shows, movies, or books. Some examples are:

- **Alice in Wonderland** - the Mad Hatter was exposed to mercury, a heavy metal used in the manufacturing of felt hats, and that is why he acts the way he does, i.e., 'mad' or 'crazy.'
- **Episodes of *E.R.*** have featured patients who have been oisoned, and the doctors have consulted a toxicologist for advice.
- Ask if anyone knows which play this is from, "Thy drugs are quick. Thus with a kiss I die." - **Romeo and Juliet.**
- **Vincent Van Gogh** - He cut off his ear and sent it to his girlfriend. He went a little crazy. He used to sharpen his paint brush in his mouth and he was using lead-based paints. He was perhaps poisoning himself by eating lead paint.

- **Everyday Examples** - Students may have gotten poison ivy after hiking through a forest, or may have been stung by a bee, wasp, or ant.
- **Roman emperors and aristocracy** - slowly poisoned by lead used in vessels for wine and even water. Latin for lead is "Plumbam" - Pb on periodic table, and the word "plumbing" comes from this.

Now that the students understand that toxicology is a part of their lives, show how toxicology, and the attitudes regarding the toxicity of different compounds change over time. **Have the students form five groups (they should already be in groups from the previous activity), and give each group one of the six laminated activity cards of headlines from included articles or advertisements**. Have the students review their cards and present their responses to the class:

- What is the compound in your handout?
- What time period (years) are mentioned in one either side of the card?
- What were the attitudes towards the compound in the two different time periods?
- Why do you think the attitudes have changed?

Following the reports from each group, discuss the concept of how use and public perception or attitudes towards compounds have changed through the years. Point out that these changes in attitudes, generally, have been due to an increased understanding of the toxicology underlying the compounds. To highlight the fact that we still do not know everything, ask the students if they can think of compounds we use today but may not in the future due to new toxicological studies.

Discussion points:

As a toxicologist or other environmental health professional, you should be familiar with the scientific issues surrounding all of these examples. It is important for you to make sure that scientific principles are upheld in these discussions (objectivity, opinions based on fact, etc.).

Smoking (activity card #17A)- In the old ad for smoking it states, "Smoking Camels found to have a positive beneficial effect upon digestion," giving the attitude that smoking was good for you. Now that smoking is known to cause many diseases, ads need to have health warnings. The recent ad on this activity card makes smoking seem forbidden (Viewer Discretion Advised), so even more enticing to the public. Tobacco companies need to be a lot more creative now to convince people to start smoking.

DDT (#17B)- In the first ad from *Time Magazine*, DDT is portrayed as being nice and as fresh as rain. The ad makes it seem like it's actually good for animals and humans. The more recent article addresses the serious concern we now have about DDT and the serious harm it can do to animals in the environment. It also describes how DDT is relentless and persistent in the environment years after it has been banned. However, DDT continues to be a very important means of controlling malaria in many developing countries. This

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raises very interesting and difficult ethical dilemmas about risk trade offs. See the article in the August 29,1999 *Seattle Times* article about this issue which is great for the discussion (headline is included on the DDT activity card).

Mercury (#17C)- Mercury is called the "Fighting Metal" in the article from 1942. The article describes how useful a metal it is -- from dental fillings, to predicting the weather. The recent article suggests that mercury poisoning is a severe problem. Mercury can be a dangerous source of contamination in fish; pregnant woman have to be very careful not to consume too much fish for mercury can cause central nervous system problems in their children. The articles also talk about mercury in fillings and poisonings from liquid mercury and mercury vapor.

Asbestos (#17D)- Asbestos was once widely used for insulation because of its strength and heat-resisting quality. It was not considered hazardous at the time. In the 1970s and 1980s, scientists realized that the fibers from asbestos can become airborne and breathed deep into the lungs. Excessive exposure can cause lung cancer and other lung diseases.

Lead (#17E)- The older articles refer to "ethyl" which is another word for the kind of lead used in gasoline. Lead was used in gasoline for years and in the ad is called the "coolest" fuel. The more recent headlines discuss the serious health threat of lead, especially to children. Lead in paint is currently the most significant source of exposure for US children. Old paint that is peeling in homes may be eaten by small children. Lead can cause severe consequences to children following prolonged exposure, including a decrease in IQ and potentially serious brain damage at higher doses.

Alcohol (#17F)- The older advertisements portray alcohol as being good for you, "wholesome food and drink are necessary to have and to keep a healthy body." They also mention it is good for athletes. The more recent information talks about birth defects and drunk driving and includes the warning labels from beer. Here, you can tie in the concept of drinking alcohol and how important the dose is. A small amount may give you some short term effects, however, a high dose can cause you to lose the ability to drive, and an even higher dose can give you alcohol poisoning and even cause death. In the short term you can metabolize the alcohol quickly, and in the long term, alcohol can cause severe liver damage.

Background information on compounds in articles and advertisements to help with discussion:

Tobacco/Smoking

- Tobacco is used in cigarettes and comes from the leaves of the tobacco plant. The leaves contain nicotine, and when burned produce hundreds of other toxic compounds.
- Cigarette smoke causes cardiovascular disease and lung cancer; cigarettes are the number one killer in the US.
- Many of the same chemicals that are in wood smoke and produced from combustion are found in cigarettes.

DDT (dichlorodiphenyltrichlorothane)

- Used as a pesticide to kill disease-carrying and crop-eating insects, no longer used in the US due to persistence in the environment. The EPA banned it in 1973. A book, *Silent Spring*, by Rachel Carson was primarily responsible for uncovering the problems with DDT, and led to the environmental movement of the 1960’s and 1970’s.
- Problems seen in nature, especially effects on bird reproduction (weakening of shells) and cold-blooded animals. It is also known to accumulate in the breast milk of woman and thus be transferred to the child. Many pesticides are not water soluble so they can get stored in fatty tissue such as the breast.

Mercury

- Heavy metal, was used in many industries including hat manufacturing (hence the Mad Hatter in Alice in Wonderland), the pulp and paper industry, and thermometer production.
- Has many effects, including central nervous system toxicity in adults and exposed fetuses, depending on the form of mercury to which one is exposed.
- There is a current controversy about using mercury for filling cavities in teeth. Mercury is cheap, durable, and not as tricky to use as gold. People are now questioning if the mercury released from the fillings can make people sick.

Asbestos

- Natural fiber widely used (previously) as an insulator because of its ability to retard fire, in tile and glues, and popcorn ceilings.
- Can cause lung cancer, especially in people who smoke (discuss synergistic effects), usage has greatly decreased, but there is now a problem with exposures due to damaged buildings containing asbestos, remodeling, and removal of asbestos.

Lead

- Heavy metal, has had widespread use in industry, in old paint, pipes, and previously (and still is in some places) in gasoline, leading to widespread dispersal.
- Effects depend upon the level of exposure. There is evidence that it has affected the overall IQ of populations of young children with higher than ‘background’ exposures.

Alcohol

- Women who consume high doses of alcohol during pregnancy have a very high risk of causing severe harm to the baby (fetal alcohol syndrome). Someone who took cold medications (warning label says do not mix with alcohol) can have a risk of interactions between the two drugs. Alcohol is a depressant, and many cold remedies contain depressants. The combination of two depressants can have an additive effect, leading to coma, or death, in the worst case.

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Distribute the handout **Toxicology - the Science of Poisons (Handout 3, *Appendix G*)**. This is a broad overview with important terms used in toxicology and a list of careers in toxicology.

Ask the class if they have any questions. If you have time, you can talk more about yourself or a career in toxicology that might interest them.

Finally, suggest to the teacher that he/she might consider continuing the study of toxicology with *Project Greenskate* or *Essentials of Cell Biology: Toxicology in Action* (appropriate for 9th grade Biology). The*Teacher's Resource Manual and Guide to Tox-in-a-Box*™ has information on these materials and many others.

APPENDIX A

Blue Food Coloring Demonstration

Materials/Equipment:

- three 100ml beakers filled with water
- three 10 ml beakers filled with water
- blue underpad
- blue or green food coloring
- coffee stirrer
- plastic dropper
- blank sheet of white paper
- lab coat and gloves are recommended (lab coat not included)

PREMISE:

The small dose has a small effect or response, but the larger dose has a much greater response (darker color). An equal amount of food coloring will make the water in the small plastic cup much darker than the same amount of food coloring in the larger plastic cup.

PREPARATION:

NOTE: the food coloring may stain clothes, tables, etc. Blue underpads are provided to protect counter tops. Be careful not to get the solution on clothing.

Place three plastic cups and three vials filled with water ready at the front of the class. Have a white background (a blank piece of white paper) ready to hold up behind the cups to help the students to see the difference.

CLASS DEMONSTRATION:

<u>Set the scene</u>: Imagine that the larger (100ml) beakers are the bodies of adults/teens. Ask the class how much of our bodies are composed of water (about 70%). Have them imagine that the food coloring is a chemical they are getting exposed to.

<u>Activity</u>: Have a volunteer from the class add one drop, three drops, and five drops of blue or green food coloring to each of large beakers and then stir them with the stirrer. Ask students what happened to cause this response and have them give examples of chemicals that may have this effect.

Next have another volunteer add one drop, three drops, and five drops to the small (10ml) beakers. The smaller beakers, which can represent a small child, or a small lake will be a much darker shade of blue or green than the larger beakers even though both have been exposed to the same amount of food coloring. Point out to the students that the same amount of chemical (food coloring) had a much greater effect on the small child (small beaker) than on the adult (largebeaker).

APPENDIX B

Bromophenol Blue Experiment I (BPB I)

Materials/Equipment:

- lab coat, safety glasses, gloves (lab coat and glasses not included in kit)
- 500 ml beaker, or large clear glass container
- distilled water (dH_2O) (approximately 400 ml) (plastic container included)
- blue underpad
- 50 cc tube containing 35-50 mg bromophenol blue free acid (BPB) or 15 cc tube containing 17-25 mg BPB
- 0.1 N NaOH
- pH 10 stock buffer (2 ml)
- 0.6 N HCl (approximately 30-40 drops)
- spoon for stirring
- pipettes
- blank sheet of white paper
- stir bar and stir plate (plate not included, but recommended). Use a spoon to stir if a stir plate is unavailable.

Premise:

The dye/buffer solution will resist color change until the buffer capacity is exceeded. After the capacity is exceeded, the solution will rapidly change color (from blue to yellow) due to the pH sensitivity of BPB.

Preparation:

NOTE: the BPB solution is a dye and will stain clothes, tables, etc. Blue underpads are provided to protect counter top. Be careful not to get the solution on clothing.

CAUTION: If your skin or eyes come in contact with 0.6 N HCl you need to wash the skin **immediately.**

1. For a large amount of BPB solution, add 20 ml of 0.1 N NaOH to 35-50mg BPB. For a smaller amount add 10 ml of 0.1 N NaOH to 17-25mg BPB.

NOTE: BPB is not stable in solution for more than a day or two. Do not use tap water in this experiment, as it is often quite alkaline; use only distilled water which should be made fresh the day of the presentation or a few days prior.

2. Add 400 ml dH_2O to the beaker (or clear container), and add **15 drops** of the BPB solution, and **2 ml** pH 10 stock buffer solution.

APPENDIX B

Class Demonstration:

Set the scene: Imagine that the pretty blue color in this beaker represents a clean lake, river, ocean or sky. "This bottle that I have here has a pollutant in it, and each of you is going to contribute to this pollution (hold up the bottle of 0.6 N HCl)."

Activity: First have one student or the teacher come up as a helper and stir with the stir stick or spoon continuously (if a stir plate is available this is the recommended way to do this demonstration, but not necessary). If the student is a helper have them put on the glasses and gloves and caution them about the chemicals. Take out a clean dropper and as you ask each student his/her name, add one drop of the pollutant (0.6 N HCl) as you say, "This is for Bobby...," etc. The helper is stirring while each student adds a drop. (If you have a stir plate, you will not need a helper). Ask the class if the pollutant had an effect. It will not have had any noticeable effect. Continue calling out the student's names and putting a drop in for each. After about 20 students, some change will occur, but the solution will recover. By the addition of about 30 drops the solution will have totally changed to yellow. Then discuss with the class who is responsible for polluting the water. Is it just the last few students whose drops had a visible effect, or is it all of the drops that contributed? Make the point that it is all of the students who contributed.

Depending on the grade level, you can also discuss how biological systems (e.g. cells, organs, organisms) and environmental compartments (e.g. ponds, lakes, microcosms etc.) usually have some ability to withstand 'chemical insults' - it is only after protective mechanisms are 'used up' or saturated' that changes become evident, e.g. the threshold is exceeded. However, the ability of a system to withstand such 'chemical insults' can vary a lot.

NOTE: At these concentrations, these compounds will be similar to table salt and thus are not toxic and will not harm the environment. The waste, therefore, can be poured down the drain. (See *Appendix E* for more safety information on these compounds.)

APPENDIX C

Bromophenol Blue Experiment II (BPB II)
Dose-Response Demonstration

Materials/Equipment:

- lab coat, safety glasses, and gloves (lab coar and glasses not included in kit)
- 500 ml beaker, or large clear glass container
- distilled water (dH_2O) (approximately 400 ml)
- blue underpad
- 50 cc tube containing 35-50 mg bromophenol blue free acid (BPB) or 15 cc tube containing 17-25 mg BPB
- 0.1 N NaOH (20 ml)
- pH 10 stock buffer (3 drops)
- 0.3 N HCl (approximately 30-40 drops)
- spoon for stirring
- pipettes
- 2 clear plastic cups/ 2 100ml beakers
- blank sheet of white paper
- BPB Graph Worksheet (Handout 1, App. G)
- stir bar and stir plate (plate not included, but recommended). Use a spoon to stir if a stir plate is unavailable.

Premise:

The dye/buffer solution will resist color change until the buffer capacity is exceeded. After the capacity is exceeded, the solution will change color (from blue to yellow) rather quickly with each additional drop due to the pH sensitivity of BPB.

Preparation:

NOTE: the BPB solution is a dye and will stain clothes, tables, etc. Blue underpads are provided to protect counter top. Be careful not to get the solution on clothing.

CAUTION: If your skin or eyes come in contact with 0.6 N HCl you need to wash the skin **immediately.**

1. For a large amount of BPB solution, add 20 ml of 0.1 N NaOH to 35-50mg BPB. For a smaller amount add 10 ml of 0.1 N NaOH to 17-25mg BPB.

NOTE: the BPB solution is not stable for more than a day or two. Do not use tap water in this experiment, as it is often quite alkaline; use only distilled water, and make it fresh the day of or a few days prior to the presentation.

APPENDIX C

2. Add 400 ml dH_2O to the beaker (or clear container), and add **15 drops** of the BPB solution, and **3 drops** pH 10 stock buffer solution.
3. Fill the two plastic cups/100ml beakers with dH_2O and add approximately 10 drops of dye solution to each. To one of these cups, add enough acid to completely change the color from blue to yellow.

Background with Students:

Give students BPB Graph Worksheet (Handout 1) so that they can collect the data. Tell each student to imagine that the beaker with the blue water is their body, and that blue is an indicator of good health, and yellow is an indicator of poor health (completely yellow, you are dead). Students must keep track of the "dose" of toxicant added to the body (number of drops of toxicant (0.3 N HCl) to the blue beaker), and also record their observation as to the degree of "illness" or response, after each dose. This is determined by the magnitude of change from blue to yellow following each dose, on a scale of 0 (all blue) to 10 (all yellow). A purple-reddish color can be judged to be about a five. Show the "reference" range of colors (all blue = 0, all yellow = 10) in the two plastic glasses.

Experiment:

Note: Holding the blank sheet of white paper behind the beaker and cups helps the students to be able to see the color changes.

Begin adding drops (could have a student volunteer) of acid (0.3 N HCl) to the beaker, one by one, while stirring vigorously with the stir stick (if a stir plate is available, this is the recommended way to do this demonstration, but not necessary). After each dose (drop), ask the students to record the cumulative dose in column A on their work sheet (we have written in the doses on the work sheet to make it faster), and the magnitude of response (from 0-10) for each increment dose in Column B on the work sheet. Continue adding doses until the beaker has completely changed from blue to yellow (i.e. until the student dies!).

Once the data are collected, have each student plot dose (X-axis) versus response (Y-axis). You can also have one student make a graph on the board. The results should yield a sigmoid dose-response curve, with an apparent "threshold" (the dose just below which a change was first noted - in toxicology, this is the "**N**o **O**bservable **E**ffect **L**evel", or **NOEL**). This can then be discussed using real world examples of alcohol and degree of inebriation, tobacco smoking and chances of lung cancer, workplace exposure to chemicals and ill health, etc.

You can also discuss how biological systems (i.e., cells, organs, organisms) and environmental compartments (i.e., ponds, lakes, microcosms etc.) usually have some ability to withstand 'chemical insults' - it is only after protective mechanisms are 'used up' or saturated' that changes become evident, e.g. the threshold is exceeded. However, the ability of a system to withstand such 'chemical insults' can vary a lot.

APPENDIX C

NOTE: At these concentrations, these compounds will be similar to table salt and thus are not toxic and will not harm the environment. The waste, therefore, can be poured down the drain. (See *Appendix E* for more safety information on these compounds.)

APPENDIX D

Bromophenol Blue Experiment III (BPB III)
Variability in Response Demonstration

Materials/Equipment:

- lab coat, safety glasses, and gloves (lab coat and glassess not included in kit)
- distilled water (dH_2O) (approximately 400 ml)
- blue underpad
- 50 cc tube containing 35-50 mg bromophenol blue free acid (BPB) or 15 cc tube containing 17-25 mg BPB
- 0.1 N NaOH (20 ml)
- 0.3 N HCl (approximately 3 drops)
- spoon for stirring
- pipettes
- 4-5 clear plastic cups
- blank sheet of white paper

Premise:

The dye/buffer solution will resist color change until the buffer capacity is exceeded. After the capacity is exceeded, the solution will change color (from blue to yellow) rather quickly with each additional drop due to the pH sensitivity of BPB.

Preparation:

NOTE: the BPB solution is a dye and will stain clothes, tables, etc. Blue underpads are provided to protect counter top. Be careful not to get the solution on clothing.

CAUTION: If your skin or eyes come in contact with 0.6 N HCl you need to wash the skin **immediately.**

1. For a large amount of BPB solution add 20 ml of 0.1 N NaOH to 35-50mg BPB. For a smaller amount add 10 ml of 0.1 N NaOH to 17-25mg BPB.

NOTE: the BPB solution is not stable for more than a day or two; do not use tap water in this experiment, as it is often quite alkaline. Use only distilled water.

2. Fill four or five clear plastic cups with distilled water (dH_2O).

APPENDIX D

Experiment:

Take four or five glasses each filled with distilled water, one of which has a few drops of 0.3 HCl. Then add three drops of BPB to each one. Stir each cup with the spoon provided. The cup with the HCl will respond differently (it will turn yellow) and represent the “sensitive” individual. Some people may respond differently to the same dose of a chemical because of genetics, diet, or other factors. You can brainstorm with the students why some people are more sensitive or resistant than others to chemicals.

Holding the blank sheet of white paper behind the cups helps the students to be able to see the color changes.

NOTE: At these concentrations, these compounds will be similar to table salt and thus are not toxic and will not harm the environment. The waste, therefore, can be poured down the drain. (See *Appendix E* for more safety information on these compounds.)

APPENDIX E

Short Summary of MSDS on Bromophenol Blue*

Acute effects: May be harmful by inhalation, ingestion, or skin absorption. May cause irritation. First Aid: in case of contact, immediately flush eyes or skin with amounts of water for at least 15 minutes. If inhaled, remove to fresh air. If not breathing, give respiration. If breathing is difficult, give oxygen. If swallowed, wash out mouth with water. Emits toxic fumes under fire conditions. Personal Protection Equipment: wear appropriate NIOSH/MSHA approved respirator, gloves, safety goggles, other protective clothing. Do not breathe dust, avoid all contact, wash thoroughly after handling, keep tightly closes, store in a cool dry place.

Short Summary of MSDS on pH 10 Buffer Solution*

Caution: May be harmful if swallowed. May cause irritation to skin, eyes, and respiratory tract. Potential health effects – inhalation: may cause mild irritation to the respiratory tract. Ingestion: may cause mild irritation to the gastrointestinal tract. Skin contact: may cause mild irritation and redness. Eye contact: may cause mild irritation, possible reddening. First Aid: not expected to require first aid measures. Fire fighting measures: not considered to be a fire or explosion hazard. Handling and Storage: keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage, direct sunlight, and freezing. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid). Personal Protection Equipment: wear protective gloves and clean body-covering clothing. Eye Protection: safety glasses. Disposal considerations: dilute with water and flush to sewer if local ordinances allow.

**For full MSDS e-mail dlowen@u.washington.edu, or call VWR Scientific Products or SIGMA Chemical Co.*

APPENDIX F

Credits

We would like to thank the following people and organizations who contributed to Tox-in-a-Box.

SLIDES

Plane Spraying Pesticides - Lucio Costa, PhD, University of Washington
Shelves Full of Paint and Pesticides - Debbie Lowenthal, University of Washington
Mold on Wall - Dan Morris, Healthy Buildings
Panamanian Golden Frog - Biology Program at the University of Washington
Barracuda - Seattle Aquarium
Local Sea Anemone - Biology Program at the University of Washington
Lionfish - Biology Program at the University of Washington
Scallops - Biology Program at the University of Washington
Pacific Rattlesnake - Biology Program at the University of Washington
Pacific Rattlesnake II - Biology Program at the University of Washington
Amanita muscania mushroom - Center for Urban Horticulture at the Univ.of Washington
Rhododendrons - Biology Program at the University of Washington
Too Young to Smoke - American Lung Association
Good Air Day - Puget Sound Clean Air Agency
Bad Air Day - Puget Sound Clean Air Agency
Rat Embryo - Jesara Schroeder
Healthy Cell vs. Unhealthy Cell - Francisco Dieguez-Acuna
Normal DNA – Essentials of Cell Biology, UW HERE Program
Mutated DNA - Essentials of Cell Biology, UW HERE Program
Most Cancer Is NOT Inherited – National Cancer Institute

MATERIALS

Salt and salt containers - contributed by Morton Salt Company

SOME IDEAS AND ACTIVITIES WERE ADAPTED FROM THE FOLLOWING CURRICULA:

Pollution Soup Activity – adapted from *Down the Drain*, Massachusetts Water Authority, Massachusetts.

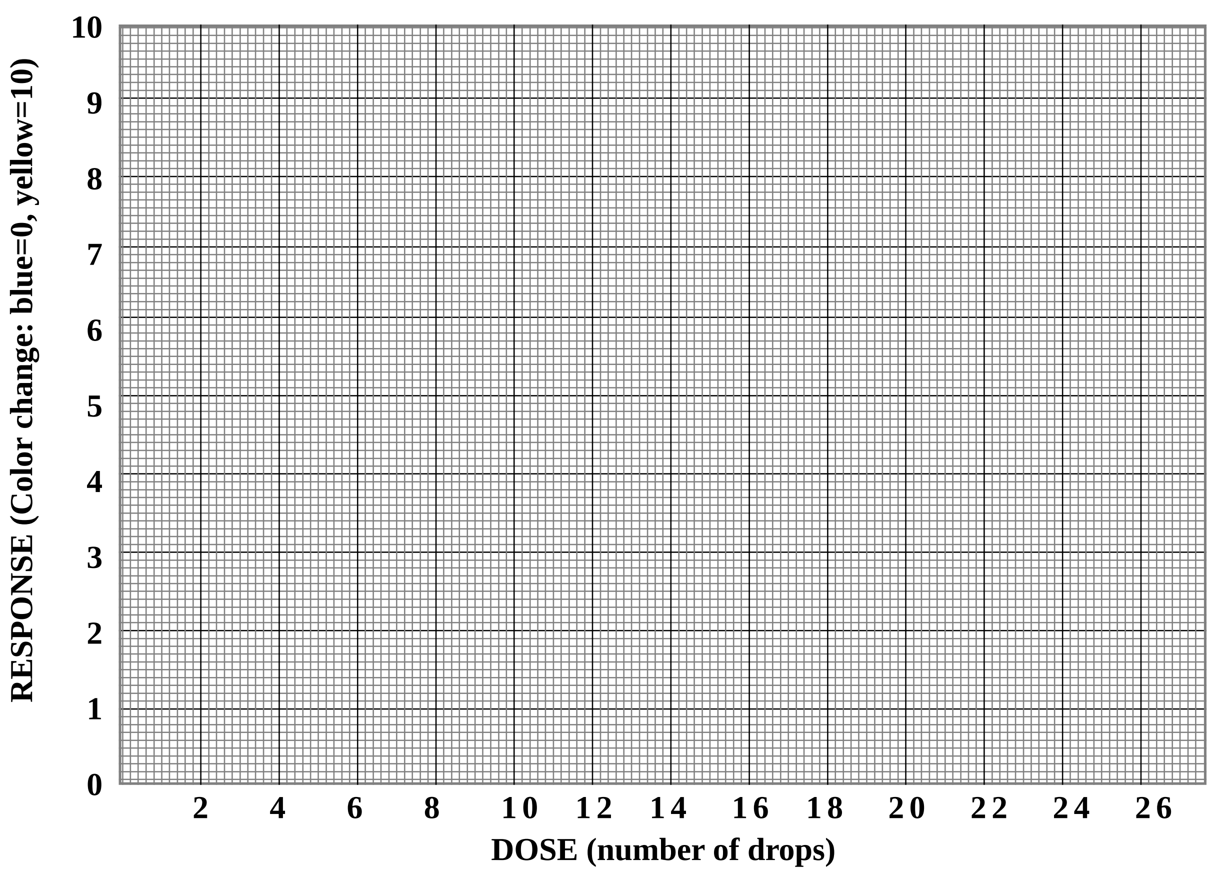
Slug and salt activity – adapted from *Toxicology, an Environmental Education Unit for Secondary Schools*, Alberta, Canada.

Household Hazardous products activity – adapted from *Hazards on the Homefront*, King County Hazardous Waste Management, WA.

APPENDIX G

HANDOUT #1
BPB Graph Worksheet
(to accompany Bromophenol Blue II Demo)

Column A DOSE	Column B RESPONSE	Column A DOSE	Column B RESPONSE
1 Drop		14 Drops	
2 Drops		15 Drops	
3 Drops		16 Drops	
4 Drops		17 Drops	
5 Drops		18 Drops	
6 Drops		19 Drops	
7 Drops		20 Drops	
8 Drops		21 Drops	
9 Drops		22 Drops	
10 Drops		23 Drops	
11 Drops		24 Drops	
12 Drops		25 Drops	
13 Drops		26 Drops	



APPENDIX G

HANDOUT #2

Major Risk Factors for Cancer

The table represents the proportion of cancer deaths attributed to the various factors listed. For example, 30% of all cancer deaths are attributed to tobacco. Tobacco and diet combined are responsible for 65% or cancer deaths.

This data is adapted from Doll, R. and Peto, R., " The causes of cancer: quantitative estimates of avoidable risks of cancer in the United States today," *Journal of the National Cancer Institute*, 1981 June; 66(6): 1191-308.

Factors	Best Estimate	Range (%)
TOBACCO	30	25-40
ALCOHOL	3	2-4
DIET	35	10-70
FOOD ADDITIVES	<1	-5-2
REPRODUCTIVE/ SEXUAL BEHAVIOR	7	1-13
OCCUPATION	4	2-8
POLLUTION	2	<1-5
INDUSTRIAL PRODUCTS	<1	<1-2
MEDICINES/MEDICAL PROCEDURES	1	0.5-3
GEOPHYSICAL FACTORS (E.G. RADON)	3	2-4
INFECTION	10?	1-?

APPENDIX G

HANDOUT #3

Toxicology: The Science of Poisons

Adapted from Suzanne Conklin, *Toxicology Enrichment Materials*

Paracelsus
(1493-1541)

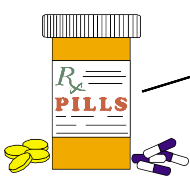
"All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy."

Some terms….
TOXICOLOGY the study of the adverse effects of chemicals on living organisms.
TOXICOLOGIST a scientist specially trained to examine the nature of these adverse effects and to assess the probability of their occurrence.
TOXICANT any agent capable of producing a deleterious response in a biological system.
TOXIN a poisonous substance of natural origin (plant, animal, bacterial, fungal).
TOXIGENIC producing toxins or poisons.
TOXOID a toxin that has been treated to destroy its toxicity.
TOXICOSIS a diseased condition resulting from poisoning.
TOXIC SUBSTANCE (regulatory term) any substance that can cause acute of chronic injury to the human body or is suspected to do so; US National Institute of Occupational Safety and Health published a list of toxic substances.
XENOBIOTIC compounds exogenous to normal metabolism of the organism, i.e., foreign compounds.
POLLUTANT a substance present in greater than natural concentration as a result of human activity and having a net detrimental effect on its environment.

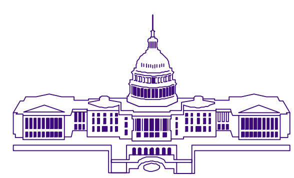
legal & criminal issues

Roles toxicologists play…

- Descriptive Toxicologist
- Mechanistic Toxicologist
- Forensic Toxicologist
- Regulatory Toxicologist
- Environmental Toxicologist
- Clinical Toxicologist



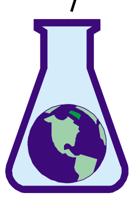
product testing



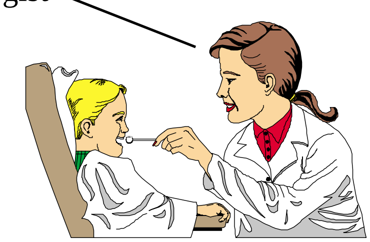
risk?

FDA	**SDWA**
EPA	**CAA**
CPSC	**CERCLA**
OSHA	**FIFRA**
DOT	**TSCA**

how?



environmental pollutants



prevention, diagnosis treatment