CDE Environmental Science

Senior, Junior full-year elective

Pre-requisites: Biology, Chemistry

Instructor: Mr. Jerry Delsol

Location: WHS Woodland High School, Woodland, Ca.

Text Environmental Science, Nebel and Wright 9th edition

Summer Reading: Silent Spring by Rachel Carson, or *A Plague of Frogs*

This course is designed to be the equivalent of a college-level semester course in Environmental Science. Environmental Science is an interdisciplinary field of study, and the goal in this class is to integrate what you know about Biology, Chemistry, Math, History, Sociology, Law, to come to an understanding of the natural world and the forces affecting it. The course will follow the curriculum recommended by the College Board, thus requiring students to take the AP exam offered by the College Board in May.

Independent work is an expectation of this course, and you will be required to master much of the content material on your own allowing more class time for laboratory and fieldwork. In addition, it will be necessary that you do long-term observations outside of class time. Another important part of the course is data analysis, measurement, statistics, dimensional analysis and other operations requiring mathematical skills.

There are several major unifying themes within this course that cut across the many academic disciplines included in the study of Environmental Science (for the College Board Course Description - go to http://www.collegeboard.com/ap/pdf/cd_env_sci_02-03.pdf for a more complete account):

Science is a process.

- Science is a method of learning more about the world.
- Science constantly changes the way we understand the world.

Energy conversions underlie all ecological processes.

- Energy cannot be created; it must come from somewhere.
- as energy flows through systems; with each step more of it becomes unusable.

The Earth itself is one interconnected system.

- Natural systems change over time and space.
- Biogeochemical systems vary in ability to recover from disturbances.

Humans alter natural systems.

- Humans have had an impact on the environment for millions of years.
- Technology and population growth have enabled humans to increase both the rate and scale of their impact on the environment.

Environmental problems have a cultural and social context.

- Understanding the role of cultural, social, and economic factors is vital to the development of solutions.

Human survival depends on developing practices that will achieve sustainable systems.

OUTLINE OF TOPICS

I. Interdependence of Earth's Systems: Fundamental Principles and Concepts (25%)

A The Flow of Energy/The Cycling of Matter

Activities: The Lorax (video): students identify the common environmental problems and concepts.

Tragedy of the Commons simulation: this simulation highlights the importance of conservation at the local, regional and worldwide levels.

Using a footprint calculator that is found on the internet students determine their ecological impact by their lifestyle.

Students research nutrient cycles and using mind map software illustrate them.

Labs: Scientific Method lab: students make a polymer using the scientific method. Buy observing the instructor make it students form a hypothesis and design experiments to gather data to support their hypothesis. They will supply problems within their conclusion and ask important questions to help the reader understand how polymers are formed.

Evaluating Ecosystem Health: This lesson is part of many exercises that the students will participate in as they learn about holistically managing the environment they live in. The specific focus of this lesson will be to check some sites for their healths and evaluate them as a class collectively. *They will be making excel spread sheets to calculate diversity and make comparsions to previous years*.

Test: Chapters 1 & 10

B Ecosystems & Biomes: What they are, how they work, how they change

Activities: Stop the Pest: This computer simulation gives students a problem to solve: how to stop a white fly infestation. *They must determine infestation rates as well as growth rates to decide what course of action to take*.

Students will choose a biome to create a series of posters allowing other students to obtain vital information from the posters. At the end of the assignment students are graded by their peers by using a gallery walk.

Create a climatograms for state biomes using the data they collect from books And Internet. In addition, they construct a table and bar graph using an electronic spread-sheet (excel).

Lab: Monitoring an ecosystem: using a grid or transect system on a plot at the school land lab students identify and construct a food web. *Using excel students calculate the percentages of living things in their plot*.

C Test: Chapters 2,3,4, 11

II. Human Population Dynamics (10%)

A History and Global Distribution

Activities: Students make an age pyramid using their family as a resource, then using the class information to create a bigger database to make another age pyramid for comparisons and to analyze treads in social and economic parameters.

Prey vs. Predator activities illustrate how populations interact with one another and how it affects population growth. Students use beads and spoons to complete the activity and *collect data then they will use a logarithmic graph to show a typical prey/predator population profile*.

Bird Island is a set of information that students use to calculate the following data:
What is the density of birds on the island?
What is the birth rate of birds on the island?
What is the death rate of birds on the island?
How many additional birds are added to the island each year?
What is the total annual growth rate of birds on the island?
How long will it take for the bird population to double?

Labs: The Duckweed Population lab is done over a period of 2 weeks with students trying to determine the effect of pH, nitrogen, phosphorous, detergent, light and salt on the growth. *They must calculate and maintain the proper ppm (i.e. 100 ppm, 200 ppm, 400 ppm, 800 ppm)*.

B Carrying Capacity

Activities: Make a graph and plot the world population data. Starting the graph at1600 *then extrapolate to the year 2050 at ten year intervals using dotted lines and three possible growth rates; low moderate and high*.Make a timeline from the 1600's to present using mind mapping software discuss the world events that made an impact on the world population.

Using iTunes, iMovie iDVD students put together video that explains why invasive species can be a threat to our ecosystems.

Labs: Mung bean over population lab: Students plant mung bean seeds into small pots of determine the effects of soil and space on the mung bean population and health.

C Test: Chapters 5, 6

III. Renewable and Nonrenewable Resources: Distribution, Ownership, Use, Degradation (15%)

A Water Quality and Pollution

Activities: Using ground water models students will do a series of (30) demonstrations on the following concepts; recharge, withdraw, overdraw, land subsidence, salt intrusion, leaching, aquifers, confining layers, confine aquifer, artesian well, zone of saturation etc.

By visiting the website site http://www.sciencecourseware.org/VirtualRiver/ students will be able to *learn how to calculate discharge from our local watershed*.

Labs: Students will use small containers and fill them with a variety of sand and gravel to *determine the % porosity, and the amount of water in an aquifer.*

Daphnia bioassays are used to check the water samples (i.e. rain gutter, local pond, waste water in vacant lot) collected by students. *They must calculate the Quality Assurance*

Quality Control QAQC to maintain quality data. The three-day lab must follow strict USDA protocols. The data is collected and then put in an excel spreadsheet so that line graphs are made to compare the data from various samples.

Students at local creek will conduct a water discharge study using the digital equipment used in the lab. They will then compare their data to the Department of Water Resources website. *Using the formulas they have learned they will calculate the area, velocity and the volume of the discharge*.

B Soils Quality

Activities: Students learn the different physical properties of soil (i.e. texture and structure, color) by collecting samples in assigned areas and conducting a variety of chemical and physical tests.

The use of simple tools such as reading lamps and funnels, students categorize organisms they collect in the soil. After the collection they will construct a soil organism food web.

Labs: Students will conduct a soil lab that analyzes soil fertility, soil moisture, percolation rate and permeability rate. Samples of the calculations follow:

*Petri dish with dry soil --- Empty petri dish = Mass of dry soil*_____________

Petri dish with moist soil --- Empty petri dish = Mass of moist soil ____________

<u>Mass of water in soil</u> x 100 = percent of water in your soil _________*Mass of moist soil*

*<u>Mass of water in soil</u> = water holding capacity of your soil*_________ *Mass of dry soil*

C Biological

Activities: Students are to create a PowerPoint presentation on genetic diversity using video podcasts from the "Eco Geeks" and prepare a quiz.

Lab: Monitoring our native plant restoration sites every year, students compare our data to evaluate our effectiveness in terms of biodiversity. *Usage of diversity indexing students can compare biodiversity before and after our projects*.

D Energy

Activities: Utilizing a mining simulation game students will learn how to apply topo map reading as well stewardship in finding the balance between economic gain and ecological stability.

Lab: Students will create diesel fuel from cooking oil that is collected from our school cafeteria that will be tested in our shop's small diesel engines.

E Land

Activities: For 5 class periods students will try to find out why the water in Fruitvale is foul. Students learn about point and nonpoint source pollution, environmental history, geological maps and plumes by using a case study format.

F Test Chapters 7, 8, 9, 12, 14,17

IV. Environmental Quality (20-25%)

Air Pollution

Activities: Students will make an Air Particulate Manual with the capturing of particulates in specified "traps" and then drawing them in the manual.

Lab: Students will collect particulates at home then identify and measure them under the microscope.

Working with the American Lung Association students will collect certain areas around our school that maybe problem areas in terms of air pollution and do a lab write up that will be presented to the administration.

B Solid Waste

Lab: A grass clipping lab will allow students to learn of the decomposition process.

Students will compare a variety of decomposition rates for different materials.

C Impact on Human Health

Lab: Test the toxicity of a few household chemicals using daphnia. *Students will use differing ppms to determine the LD-50.*

D Test: Chapters 15, 18, 19, and 20

V. Global Changes and Their Consequences (15-20%)

A First-order Effects (changes)

Activities: After watching the movie, "Inconvenient Truth" students will develop a fact and react sheet for each section of the movie.

After watching selected parts of the movie, "Who stole the electric car" students will debate," who stole it!"

Lab: Students will analyze DNA maps using digital image processing of various (restored versus native) silver sword plants from Hawaii. They will learn the importance of bio diversity within a species and how genetic bottlenecks reduces the genetic pool and how we can overcome it.

Design a solar car lab. Students working in pairs are given are variety of parts to make the fastest or most powerful solar car in the class.

B Test Chapter 21

VI. Environment and Society: Trade-Offs and Decision Making (10%)

A Economic Forces/Cultural and Aesthetic Considerations

Activity: All students are required to participate in the *Adopt-A-Topic* program. Students pick any topic they want within the field of environmental science. Then research and investigate topic. They are to contact one or two professional adults who are experts on their topic. Remember, students will become the classroom "expert" concerning a particular topic. They will present the information to the class.

Students research and design a solar oven.

B Environmental Laws and Regulations (International, National, and Regional)

Activity: Students are to develop a timeline of environmental law from 1960s to current.

C Issues and Options (conservation, preservation, restoration, remediation, sustainability, mitigation)

Lab: After the last restoration day students are to combine their monitoring data (photo, GPS and diversity) and working in teams will research a portion of the data (i.e. one team does the photo data, another does the GPS data etc.). *When all the data has been processed* students will present it at the year-end BBQ. It should be done on PowerPoint and excel. A full scientific paper will be required.

ATTENDANCE

To make the most out of the course, students should try to attend every single class and always be on time. They are considered late if they are not in their seat and ready for the class when the bell rings. All students must get a planned absence form signed at least a week in advance. Credit for the course may be denied if attendance is less than 80%. Please review the student handbook for more information.

DEADLINES

Also, essential to making the most of the course is submission of all assignments on time. If an assignment is not in on the due date, the grade will be reduced according to the importance of the assignment and the number of days late. In general, the grade will be reduced by 5% of the point value of the assignment for each day late (whether the class meets or not, including weekends and vacation days). *If students are absent, it is their responsibility to get the assignment and any missed notes from a classmate. Students must see me within two days after your return so that I can give you an appropriate date for the missed material* .If they miss a quiz or test, it is their responsibility to make sure that you make up that quiz or test, not your teacher's. You will receive a zero if the work is not made up in a reasonable amount of time. If there are extenuating circumstances, make sure that I am aware and bring a written note from a parent, guardian, or advisor. I am always willing to work with you if you have a problem.

CONFERENCES AND HELP

Even the most bright and eager students have questions and confusion. Please don't hesitate to come in for help. My office is on the first floor of the Hardy building, and my name and schedule is posted on the door. If students need help, stop after class and arrange a time to meet, or feel free to drop by the office. **I can't emphasize enough how coming to see students' teacher when they have a question can clear things up and make the class easier and more enjoyable. It may be for 5 minutes or for 55 minutes, but taking that initiative will serve students well in the long run.**

Students may also contact us by e-mail: jdelsol315@hotmail.com

GRADING AND EVALUATION

Students will be graded according to the following guidelines:

Tests – Each test is approximately 100 points. Complex concepts will not be included until they have been discussed in class, but I do expect students to learn straightforward ideas independently when reading students' assignments, so students should expect occasional quizzes on reading assignments at the beginning of class. Tests accounts for 20% of the class grade.

Labs – This class will perform on average two labs per week. Students will be asked to write lab reports, and I will give students detailed instructions as to the format and point value of each assignment. If students miss a lab, students must see me as soon as possible to arrange a make-up or alternative assignment. **Even if s student misses a lab, they are responsible for knowing the procedure, results, and conclusions of the experiment.** Labs count for 15% of the grad**e.**

Homework – If the assignment is answering a reading guide, it is very important that students read carefully, as students may be quizzed on reading, and we will base our class activities on the assumption that they have read the assignment. When written homework is assigned, it may be checked and graded. Most of the homework can be found on the following website: http://wps.prenhall.com/esm_wright_envisci_9/.

Homework count for 30% of the grade.

Class work will be graded and points awarded will depend on the difficulty of the task. Labs count for 15% of the grade.

Field Investigation will be assigned and will vary in scope. Every year we work with the Center for Land based

Learning and help a local landowner restore a piece of their property. Working with SLEWS (Students, Landowners, Education, Watersheds and Stewardship), we will be taking 5 field trips throughout the school year to plan, design, install, maintain and monitor our site, it will represent 10% of the course grade. An explanation of this field trip will be given the first week of class.

Class Participation –each student is expected to participate fully during class. There is no such thing as a stupid question, and won't be downgraded for giving the wrong answer, so take the risk! Thoughtfulness, curiosity, and intellectual energy are all appreciated, and will contribute to the grade. If students don't feel comfortable speaking in class, talk to the teacher outside of class. We also enjoy sharing any current events or special material to which students have access. Many of students have parents, relatives, or friends who may have something to offer the class. Please let me know if this is the case. Participation accounts for 10% of the grade. Good class participation is characterized by the following standards:

- Asks questions either in class or outside of class when a concept or process is not understood
- Asks questions and makes comments that show insight into the material
- Asks questions and makes comments that indicate careful preparation for class
- Asks questions and makes comments that indicate mastery of the material
- Behaves in a manner that promotes learning for everyone attending
- Respects the right of others to verbalize their thoughts
- Works in a cooperative manner when in a group setting
- Helps members of the group to learn
- Show intellectual curiosity
- Takes responsibility for tasks
- Takes responsibility for self-learning
- Completes assignments carefully and accurately

No extra credit assignments will be offered, but extra effort is valued and will contribute to the class participation grade.

AP EXAM INFORMATION

The AP Environmental Science Exam is three hours long and divided into two sections: multiple-choice (100) and free-response (4 questions). All students in the course are required to take the exam.
I will be assigning practice questions (both multiple-choice and free-response) throughout the year within the context of homework, tests, class activities, etc. If students take a conscientious approach to this class, they will be prepared to take the AP exam. I do not, however, consider the primary goal of this course to be exam preparation. Much of what we will be doing is designed to give students an appreciation for the practice of Environmental Science.

INTEGRITY

I expect complete honesty and integrity from each student. There will be occasions when students will be allowed to share information, and the teacher will tell students this clearly. Homework may be done with another students but are not allowed to just copy another student's work. Please see the student handbook for a more complete discussion of the honor code of our school. I hope this handout makes my policy and expectations in this class clear. If students have any questions, please let me know. I look forward to an exciting and enriching year as we learn about the world around us together.

LAB SAFETY

During lab activities, students may be learning the use of new equipment and substances and working with different energy sources. It is important that students approach the work seriously, following all the guidelines and safety rules.

LAB COMPONENT

The labs we do in AP Environmental Science ROP fall into three categories:

- Indoor labs. Typically we will do these on Tuesdays and Wednesdays. If we need more time we sometimes will work through Thursday. Long term labs that require daily maintenance and routine measurements must be done as soon as students arrive so as not to take too much class time.

- Outdoor labs. Tuesday and Wednesday are also the days we will use to collect water or soil samples or take

GPS readings or even set out transect lines.

•Field Investigations. Are prescheduled in September and are intra-curricular which means they are a graded part of this class. If students choose not to attend one or more of the 5 days students will not earn 10% of the grade. These days are fun and students will be applying what students have learned in class, it's a great opportunity to get outside.

STUDENT ACTIVITIES

ACTIVITY 1: DUCKWEED LAB

A bioassay is an experiment that uses living things to test the toxicity of chemicals. One kind of bioassay is a dose/response experiment in which students expose organisms to various doses of a chemical and then measure their responses. In this protocol, duckweed is used as the bioassay organism. After placing duckweed plants in beakers containing various concentrations of a chemical, students monitor their growth and health over a five-day period.

ACTIVITY 2: PREY VS PREDATOR

Observing the relationship between predators and prey is both fascinating and complex. Previously, ecologists had thought that the relationship between predators and prey was both simple and direst: the predator fed upon the prey thus keeping the prey's population in check while maintaining and increasing its own population. We now know that the relationship between predators and prey is not so simple and that many other factors affect population swings in an ecosystem. In addition, the direction of cause and effect is more subtle than it first appears. These are some of the things that students should think about while doing this activity and answering the questions.

DOSE/RESPONSE EXPERIMENTS USING DUCKWEED

Objective
To conduct a dose/response bioassay using duckweed.

Background
A bioassay is an experiment that uses living things to test the toxicity of chemicals. One kind of bioassay is a dose/response experiment in which students expose organisms to various doses of a chemical and then measure their responses. In this protocol, duckweed is used as the bioassay organism. After placing duck-weed plants in beakers containing various concentrations of a chemical, students monitor their growth and health over a five-day period.

Duckweed is a small aquatic plant that floats on the surface of ponds, wetlands, and nutrient-rich lakes. Worldwide, there are over 40 species of duckweed (family Lemnaceae), with 20 species found in the United States. Lemna minor is the species most commonly used for bioassays. Each Lemna plant consists of one or more fronds. The fronds look like little leaves but actually are a combination of leaf and stem, attached to a rootlet that dangles down in the water.

Although duckweed is a flowering plant, it rarely flowers. Usually it reproduces through budding—new fronds grow from buds on the parent plant. Eventually these new fronds grow their own roots and break off to become independent plants. When students conduct a bioassay using duckweed, students measure growth rate by counting how many new fronds develop over a five-day growth period.

In this protocol, students will carry out a dose/response experiment to test the sensitivity of duckweed to the serial dilutions students created in Protocol 1.

Materials (per student group)
☼ Fluorescent or plant grow lights
☼ 105 duckweed plants
☼ 21 beakers or clear plastic cups
☼ Miracle-Gro Liquid Houseplant Food Drops
or similar fertilizer solution (N:P:K = 8:7:6)
☼ Eye dropper (for fertilizer)
☼Tweezers or paper clips (for handling duckweed)
☼Clear plastic film such as Saran Wrap
☼90 ml. of each of the chemical solutions made in Protocol 1
☼90 ml. spring water from source used in Protocol 1
☼100 mL distilled water (for rinsing)

Procedure

1. Label beakers or cups with students name, the date, and the solution concentrations listed in Table 2.1. Label the final three beakers "control" (threebeakers per concentration).

2. Pour 30 mL solution into each of the beakers, following the labels for solution concentrations. In the control beakers, use spring water instead of a chemical solution. Add one drop of liquid fertilizer to each beaker.

3. Using tweezers or an unfolded paper clip, gently transfer five duckweed plants into each beaker. (Avoid using students fingers because that could introduce other chemicals into students culture solutions.) Choose only green, healthy-looking plants that have two fronds apiece and are approximately the same size.

4. Cover the beakers with clear plastic film, and place them under 24-hour fluorescent or plant grow lights. (Artificial lighting is optimal because it provides consistent conditions from one experiment to another. Indirect natural lighting is an acceptable alternative. Avoid placing the beakers directly in a sunny window because overheating may cause the duckweeds to get scorched.)

5. Let the beakers sit undisturbed for five days. Keep them covered with plastic, and do not add water to them during this time.

6. At the end of the five-day growth period, count the number of fronds in each beaker. It may be difficult to decide which fronds are real, and which are too small to count. The important thing is to be consistent so that studentsr results will be comparable across treatments.

7. Record studentsr data in Table 2.3 and make notes about any plants that are yellow, rootless, or sinking, or that otherwise appear unhealthy.

Using Figure 2.3, graph the mean (average) for each treatment. Then analyze studentsr data using the guidelines below.

Analysis

Comparison to the Control

The first thing to check is studentsr control (the beakers that contain just spring water and fertilizer solution). The purpose of the control is to identify how well the duckweed will grow under uncontaminated conditions.

Students can expect the number of fronds to roughly double in the control beakers during the five-day incubation period. If studentsr control plants did not grow much or do not look healthy, something may have gone wrong in studentsr experiment. Perhaps the nutrient solution was too strong or too weak, or the plants were not healthy to begin with. Or maybe a problem developed with the environmental conditions. Did the solutions get too hot, too dry, or contaminated in some way?

Analysis of Trends

Looking at studentsr graph (Figure 2.3), do students notice any trends? For example, does the toxicity of studentsr test chemical appear to increase as the concentration increases, or does it stay the same from one concentration to the next? Are there any data that don't seem to make sense?
If so, make a note of these and try to think of any possible explanations for why they are different from studentsr expectations.

A Look at Variability

The means for each treatment tell only part of the story. It is also useful to take a look at the individual data points (the number of fronds in each of the three beakers) to get an idea how much variability exists within each treatment. Try graphing individual data points for each treatment. The wider the spread between data points, the greater the variability within that treatment. The more variability there is within each treatment, the less confident students can be that one treatment is different from another, even if the means appear different on studentsr bar graph (Figure 2.3).

Because of individual differences among organisms, students shouldn't expect each plant to respond in exactly the same way. However, it is reasonable to expect that the groups of individuals in each treatment will follow predictable trends. Did replicate beakers have similar numbers of duckweed fronds at the end of the five-day growth period? If studentsr data are more variable than students think is reasonable, students could look into the potential sources of this variability. For example, did the plants appear to be healthy at the beginning of studentsr experiment, or were they already stressed? Were the serial dilutions carefully made according to directions? Did one person do all the counting of duckweed fronds, or did two or more people share this task? Based on studentsr experience with this bioassay protocol, what ideas do students have for reducing variability caused by measurement techniques?

Estimating the TC_{50}

The next step in studentsr data analysis is to figure out how to answer the question:

> How toxic is the solution or sample to the type of organism students tested?

In bioassays there are two ways to report results: LC_{50}, the lethal concentration that kills 50% of the test organisms, and TC_{50}, the toxic concentration that causes organisms to grow 50% as well as a control group. In duckweed bioassays, the plants don't necessarily die— they may just grow more slowly than they would in a less toxic solution. So in this case use the TC_{50} to represent the concentration at which the duckweed in the treatment grow approximately half as well as those in the control group.

Using Figure 2.3, students can estimate at what concentration the duckweed has grown roughly half as much as the plants in the control group. If none of studentsr concentrations produce rates that are close to half those of the control, it makes sense to report the TC_{50} as a range rather than a single number. For example, students might have to say that the TC_{50} is greater than or less than all the concentrations students tested, or that it lies somewhere between two of studentsr tested concentrations.

Drawing Conclusions about Toxicity

After students have estimated the TC_{50} for studentsr experiment, students will be able to use this number to make a statement about the toxicity of the substance students were testing. Usually this statement will be something like:

The TC_{50} for chemical X and duckweed growth is in the range of__ to __

If students have TC_{50} values for duckweed exposed to other chemicals, students can use these numbers to rank which chemicals are most toxic to duckweed. For example:

The TC_{50} for chemical X is a smaller number than the TC50 for chemical Y This means that chemical X can affect duckweed growth at lower concentrations than chemical Y Therefore, I conclude that chemical X is more toxic to duckweed growth than chemical Y

It is important to remember that duckweed bioassays are not designed to help students reach conclusions about toxicity to humans because duckweed plants and humans are likely to respond very differently to chemical exposures. In order to use bioassays to predict toxicity to humans, students would need to use organisms such as laboratory rats that are known to provide a better model of human response to toxic chemicals.

Name____

Date__________

Chemical tested__________________ 100% concentration _______ mg/L

Length of experiment ____days Constants (such as temperature and light)

TABLE 2.3
Duckweed Bioassay Data

Solution Concentration	# Duckweed Fronds/Beaker			Avg. # Fronds	Comments about Plant Health
Control					
0.001%					
0.01%					

0.1%					
1%					
10%					
100%					

FIGURE 2.3
Duckweed Bioassay Results

Control 0.001 0.01 0.1 1 10
100

Concentration (%)

Some questions to consider: *(Please use full sentences.)*

1. Did the duckweed colonies grow well in the control beakers? Do studentsr control plants appear healthy? If not, what would students recommend trying differently for the next round of experiments?

2. Did duckweed growth respond in a predictable way to concentration? Describe any trends students observed.

3. Do any of studentsr data not fit the trends students observed? If so, can students think of any reasons why these data might lie outside the range students would expect?

4. What TC50 would students estimate based on studentsr duckweed data?

TC_{50} =

If it is impossible to estimate the TC_{50} from studentsr data, please explain why.

5. What can students conclude about the toxicity of the substance students tested? Is this what students expected? Was studentsr hypothesis supported by the data?

6. If other students carried out a dose/response experiment using the same chemical, did their data follow the same trends as studentsrs?

7. Based on this experiment, would students say that duckweed would be a useful bioassay organism for water samples from the environment? Why or why not?

8. If students were going to repeat this experiment, what would students do differently? How might students improve the experimental design to reduce the variability of studentsr data or lead to more reliable results?

ACTIVITY 2: PREY VS PREDATOR

Observing the relationship between predators and prey is both fascinating and complex. Previously, ecologists had thought that the relationship between predators and prey was both simple and direst: the predator fed upon the prey thus keeping the prey's population in check while maintaining and increasing its own population. We now know that the relationship between predators and prey is not so simple and that many other factors affect population swings in an ecosystem. In addition, the direction of cause and effect is more subtle than it first appears. These are some of the things that students should think about while doing this activity and answering the questions.

The round plastic beads represent the prey. In this case we will pretend that the beads are rabbits. Studentsr small plastic bowl should have about 100 "rabbits" that students should transfer to the plastic cup before the activity begins.
The plastic spoon represents the predators. Today we will imagine that our predators are coyotes.
The small plastic bowl will represent the habitat in which the rabbits and the coyotes encounter one another.
To get the activity going, place 10 "rabbits" in the bowl. These ten "rabbits" represent the initial population for the first generation. Each new generation will always begin with at least 10 "rabbits" either through reproduction or by migration. In other words, students should always make sure that there are 10 plastic beads in the bowl at the start of each generation.
Now take the plastic spoon, and without looking directly into the bowl, sweep it through the bottom of the bowl in an attempt to catch rabbits. Students have to catch five o more rabbits in order to survive. If that predator does not catch five or more rabbits then it is dead. If there are only one predator and it dies, then we will assume that a new predator will wander into the habitat for the generation.
If the predator captures five rabbits, then it will survive ***and*** produce on offspring. One offspring is produced for each five rabbits captured. For example, if one coyote captures 13 rabbits, she will survive herself plus she will produce two offspring. If another coyote captures 15 prey, she will survive plus produce three offspring. All of the surviving coyotes plus their offspring will be hunters in the next generation.
Remove the prey from the "habitat" as the predators capture and eat them. Once the coyotes are finished hunting, subtract the dead prey from the amount that students started the generation with to figure out how many prey survived. For the generation, double the amount of prey and put that number at the top of the next column. Note: the number of rabbits in the habitat can never exceed 100. In other words, 100 is the habitat's carrying capacity for rabbits.
Complete 20 generations of hunting, making sure to carefully record studentsr data. Once students are finished hunting, it is time to plot studentsr data and complete studentsr predator-prey graph. When graphing, use one color for the prey and a different color for predators.

Our scenario takes place in the desert of the Southwestern United States between two indigenous species: the Desert Cottontail Rabbit (Sylvilagus audubonii) and the Coyote (Canis Latrans). When students are finished graphing the results of the simulation pleas answer the following questions on a separate piece of paper.

From looking at the graph that students have just created, is it possible to know for sure whether the coyote population controls the rabbit population or vice versa?
What factor appears to determine the size of the coyote population in the desert at any given time?
What factor appears to control the rabbit population in the desert?
Does the predator-prey graph that students have created show a correlational relationship or a cause and effect relationship?
Does a peak in coyote population come at the same time as or after a peak in the rabbit population? What is the explanation for this?
What other factors could be controlling the population of the rabbits besides the coyotes?
Why does the maximum number of coyotes never exceed the maximum number of rabbits?
Why did we have to put the results of this activity onto the semi logarithmic scale using a semilog graph?
What would happen to the coyote population if the rabbits were eliminated from the ecosystem due to a viral disease?
Is predation a density dependent or density independent factor?
Is it possible for a species to be both a predator and prey? Explain.
In this activity, environmental resistance was demonstrated by the _______,
while the number of __________ was an illustration of a limiting factor.
Is it possible that climate could be responsible for the oscillatory nature of predator-prey graphs? Explain.
Look at the graph at the bottom of this page. On average, how often do the hare and lynx populations reach their peaks?

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Initial Prey																				
Total Prey Captured																				
Surviving Prey																				
Initial Predators																				

Number of Surviving Predators (Must capture 5 prey to survive)																				
Predator Offspring (One offspring is born for each 5 prey captured)																				

Predator-Prey Activity