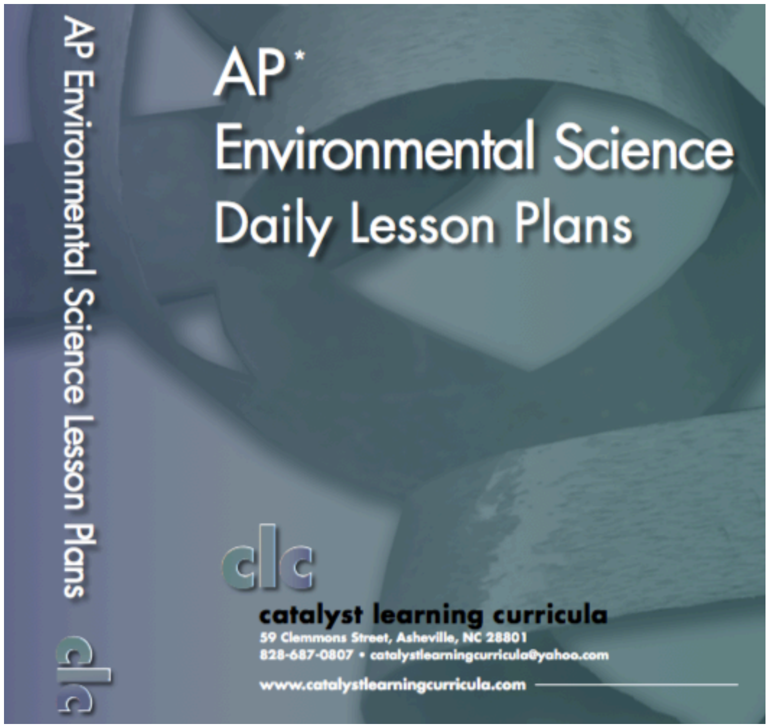

AP® Environmental Science Daily Lesson Plans

(Sample Week of Lesson Plans)

This full-year curriculum includes:

- 142 sequential lesson plans covering the entire College Board curriculum including laboratory skills and test preparation
- A pacing calendar, a materials list, student handouts and grading rubrics
- 100% hands-on learning so the teacher can provide a student-centered classroom environment with no lecture
- Lab experiments, games, model building, debates, projects and other activities designed to promote critical thinking

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AP® Environmental Science
Daily Lesson Plans Curriculum

Table of Contents
(with one week of sample lesson plans to follow)

AP* Environmental Science
Daily Lesson Plans
Ecology Unit
(Samples of Week One)

**Note: This is an except so references to other parts of the full-year curriculum may be mentioned but are not part of this sample.

Day 1 - Extended Lab Day

I. Topic: Field Collections

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Prepare to go outside (bringing with you a field journal and a pen) and be ready to answer the question: Why do scientists categorize organisms?

III. Activity One: Creating Dichotomous Keys 20 minutes

Objectives:

a) The learner will (TLW) create their own dichotomous key using familiar objects and descriptors.
b) TLW discover how to categorize items in terms of their similarities and differences.

Materials:

The students will each need a field journal and pen.

Procedure:

1. Take the students out to the shade of the tree you plan to use for Activity Two, below.
2. Ask each student to place one of their two shoes in a pile in the middle of the group.
3. Tell the students that the shoes represent a group of similar organisms that can be found in your area. Tell the students that they are the scientists responsible for creating a dichotomous key to identify each species of shoe. You will probably need to discuss the definition of a dichotomous key. As with any new terms, first ask the students if there is anyone who knows what this is and can explain it to the class. Ask someone to give an example. If they are at a loss, give them a very brief description or example to see if that jogs anyone's memory, then return the work of explaining the term to one of the students, if possible.

4. Let them know that for this exercise they will be making the assumption that similar features represent homologous characteristics or features that have a similar evolutionary origin.
5. Ask the students to take a closer look at the species in the pile and start sorting them according to similarities and differences. Tell them they must start the process by creating a question that, when answered, will help sort the organisms into two different piles.
6. After they have made some significant observations and seem to be finding ways to sort out the group, ask the students to suggest one concise question that will clearly divide the organisms into two different piles with at least two shoe types in each pile. As students share their ideas, point out that this question must address a feature that is shared by all the organisms, so that each species can be easily sorted into one pile or the other with a simple "yes" or "no" to the question. For example, "Does the organism close over the toes or leave the toes open to the elements?" Point out that a question that is not specific could cause a person to make the wrong turn at an early point in the identification process. For example, "Is the organism used for recreation or business wear?" is not a good dichotomous key question because it is subject to opinion. Ask the class to choose the best question from the ones suggested.
7. Ask the students to write this question down in their notebooks and number it "1." On the line after the question, tell the students to write the phrase, "If yes, go to question 2" and "If no, go to question ___." Tell the students that they will fill in the question number in a few minutes.
8. Ask a student to go ahead and sort the organisms into the two piles based on question 1. This person should check with the class as they sort each organism.
9. Now ask the students to suggest a question that can be used to subdivide one of the two groups. When they decide on the best question, they should record it in their notebooks with the phrases, "If yes, go to question 3" and "If no, go to question ___." Have them continue this process until they have created questions to subdivide the group to the point that only one species is a logical answer to the final question.
10. When the students have gotten to the end of a line of questions and have singled out a particular species of shoe, they should give that shoe a genus and species name typical of the Linnaean system of nomenclature, (but with a silly spin of course, because after all, they are classifying shoes!). The genus name is capitalized, the species name is lower case and both are either italicized or underlined. The genus name should be shared with other shoes of the same lineage (the students can decide where the genera are divided), and the species name should reflect a specific, identifying ecological, morphological or behavioral feature, or the area in which this species is typically found.
11. After the activity, lead a short Socratic discussion to draw out the main points of the exercise:

a. Can you now explain what a dichotomous key is?
b. What is the purpose of this type of key?
c. Is a dichotomous key representative of the common evolutionary origin of the species being classified or simply a representation of the common features of those species?

IV. Activity Two: Using Dichotomous Keys 30 minutes

Objectives:

a) The learner will (TLW) use a dichotomous key to identify species.
b) TLW discover how to decipher unfamiliar vocabulary and terms used in scientific field guides.

Materials:

For each student: one field guide with dichotomous keys to identify North American trees (do not get color picture identification guides—they do not use dichotomous keys); a field journal and pen. For the class: dichotomous field guides for as many other groups as possible—insects, fungi, birds, amphibians/reptiles, mammals, fish, rocks, seashells, etc.

Procedure:

1. Prior to class, find a tree species near the classroom that is native to North America and can be easily identified with the field guide your students will be using. It's a good idea to familiarize yourself with the guide, so that you can answer questions when the students get stuck.
2. Take the students to the tree you selected, but before you get there ask them not to reveal the name of the tree to anyone, if they know what the tree is.
3. Give the students the field guide and introduce them to the parts of the guide they will be using. Point out the location of the glossary, the keys to each of the major groups, the species descriptions, the anatomy diagrams and the plates with pictures of trees, leaves, fruit and flowers.
4. Spend some time going over the anatomy diagrams of opposite, alternate, simple and compound leaf structures as well as any other terms you know will come up immediately for this particular species.
5. With the students working in pairs, ask them to gently remove one sample that includes a leaf, a leaf node and a fruit or flower, if there are many present. You can also ask them to sit very near the tree and not remove any part of it. However, if tree collections are one of the projects your students will be doing, this would be a great time to teach them how to select an informative sample while incurring the least amount of damage.
6. Start by working the keys aloud as a class, until you feel the students are doing fine. Ask the student pairs to continue working their way through

the dichotomous key until they can identify the tree down to genus and species. Circulate to help any students that get stuck.

7. After they have completed this challenge, allow the student pairs to each choose another tree. Be sure they choose native trees so that the species will be in the field guide.
8. If time allows, let the students browse through some of the other field guides so they can see how different guides are set up in roughly the same way.

V. Activity Three: Begin a Natural History Collection 20 minutes

Objectives:

a) The learner will (TLW) notice the similarities and differences in the organisms found in their region.
b) TLW develop techniques to identify, collect and preserve organisms for study and display.

Special note: This lesson plan instructs teachers on how to begin a natural history collection using insects, although you may choose to collect some other group of organisms, such as plants, birds, etc. The collections do not need to involve killing the organisms, but can instead be comprised of drawings (or tracings from a field guide), which would give students the opportunity to sharpen their observation skills. If your students would like to capture insects for a live collection, they will need to take into account compatibility of species and the appropriate duration for keeping insects captive. If they want to kill and mount the insects they catch, any good field guide will describe the best techniques for killing, preserving and mounting insects in a display box. If your students are collecting plant samples (trees are easiest to identify), you can use an old phone book to press the fresh leaves or flowers between weighted pages and then mount them when they have dried. Perhaps some of your students will want to collect insects and others will want to collect trees (leaves, fruit and flowers), or you may require that all students collect a particular type of taxa. (To reduce the number of field guides needed, you can ask the students to work on a project in pairs or groups.)

Materials:

For each student: a field guide for the local area, for the topics your class will be studying (insects and trees are easiest, if you are requiring that a physical collection be turned in); and one copy of the "Insect Collection Project" handout (or provide a handout pertinent to the organisms they're studying). If possible, have an insect collection (or dried plant specimens, etc.) to show the students.

Procedure:

1. Distribute the "Insect Collection Project" (or other pertinent) handout and discuss the project with the class.
2. Show them an example of a scientific collection that is well-preserved and well-labeled.
3. Alert them to the due dates for this project, in which they'll be collecting 10 different samples a week for a weekly grade. The final project grade will take into account the diversity of their collection, and the preservation, identification, labeling and mounting of each specimen.
4. The next activity will allow them time to brainstorm ideas for refining their sample collection techniques.
5. All lesson plans from this point on will refer to this activity as an insect collection. (If your students are collecting trees or another group of organisms, or if your students are collecting drawings of captured and released organisms, simply change the activity to suit your particular project.) There will be class time scheduled on Day 22 of this unit and on Day 5 of the Population Dynamics unit for completion of this project. (The scheduled due date for this project is Day 6 of Population Dynamics.)

VI. Activity Four: Begin Fruit Fly Collection 15 minutes

Objectives:

a) The learner will (TLW) catch a fruit fly to begin a population study.
b) TLW become familiar with a common scientific study organism.

Materials:

For each student: one fruit fly growth tube; 1 inch of fruit fly growth media (instant mashed potatoes with blue fungicide and water) to be put at the bottom of each student's tube; and a foam stopper for each tube.

Procedure:

1. Give each student a fruit fly culture tube. Ask the students to each catch a fruit fly at home this weekend by placing a ripe banana beside the tube and placing the stopper into the tube when a fly enters it. It would help to pass around a fruit fly that you have already caught, so the students are able to identify the type of organism they want to catch. It might be helpful to award bonus points for each fly caught, to help insure that you have a large enough starting population.
2. When the students bring in their fruit flies, knock the flies out by refrigerating them for a few hours or using Fly Nap©. Place 3-5 flies in each tube, being sure to make at least one tube for each lab group. Keep the knocked out flies from falling into the wet potato culture by storing the

tubes on their sides until the flies wake up. You can right the tubes when they are awake.

3. During the first week, you should see eggs along the walls of the tube (they look like small dried salt crystals). When this occurs, take a minute during class to pass the tubes around, so the students can note the number of eggs laid compared to the number of females in the tube. Point out the high biotic potential of this species.
4. By the beginning of the second week, the larvae will have emerged from the eggs and traveled down to live in the potato culture. You will notice their dark mouths and white bodies making trails through the culture. Again, when this occurs pass the tubes around so that your students can observe the life cycle of this species.
5. By the end of the second week, the larvae will form cysts on the walls of the tube to metamorphose into adults. Take a minute to let the students make observations and notes during this stage, discussing the egg to cyst ratio of survivorship for this species.
6. When the adults emerge from the cysts, your students can begin counting them each week at a regular interval. Make this a part of your weekly routine or a weekly homework assignment. Students should take turns performing this task with their lab group members.

HW: Ask the students to continue their field collections so that they have 10 organisms representing different orders (if the students are collecting insects) or families (if they are collecting plants).

HW: Remind the students to look at the year calendar for reading and video assignments.

Insect Collection Project

Due on:

Purpose:

- To learn to use a dichotomous key with accuracy and efficiency.
- To become familiar with the habits, morphology and classification of insects.
- To practice collecting, preserving and mounting biological specimens.

Requirements:

1. You will be expected to create a display box containing 40 insects arranged and labeled by taxonomic order.

2. In your collection of 40 insects, there must be 7 or more of the following major orders represented:

Lepidoptera	Odonata	Orthoptera	Isotera	Hymenoptera
Hemiptera	Coleoptera	Diptera	Homoptera	Siphonaptera

3. All insects must be identified to the level of order and placed in the section of the box that contains other taxa of the same designation.

4. Duplicate insects of the same species will not be counted.

5. All insects will need to be dead and pinned neatly in the display box in a manner that allows someone to view them for identification (they must have all their anatomical parts in a three-dimensional form). All insects that are too small to be pinned directly to the base of the display box must be mounted on a triangular piece of paper so that the paper can be pinned.

6. There will be graded weekly check points every Friday, in which you will be expected to have 10 new insects. Bring your weekly insect collections to class in separate zipper baggies, each labeled with your name.

7. Final collection display boxes will be graded on neatness and completeness.

8. Extra work, extra specimens or keying out the insects to genus or species will be appreciated only if the basic requirements of the collection have been met first.

AP* Environmental Science
Daily Lesson Plans
Ecology Unit

Day 2

I. Topic: Nutrient Cycles and Thermodynamics

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Draw the water cycle. Label all parts of your diagram.

III. Activity One: Biogeochemical Nutrient Cycles 30 minutes

Objectives:

a) The learner will (TLW) use their understanding of the water cycle to make conclusions about the flow of nutrients in a biosphere.
b) TLW analyze the movement of a particular nutrient, taking note of the physical and chemical changes and the influences organisms have on this nutrient.

Materials:

For each student: a paper cup half-full of distilled water; a copy of the "Biogeochemical Nutrient Cycle Poster Presentation" handout; plus, each student will need to bring to class their own piece of poster board and set of wide-tipped markers.

Procedure:

1. Begin by discussing the diagram the students have drawn for the warm-up. Ask about the transitions they have included (condensation, evaporation, precipitation, transpiration, percolation, infiltration, run-off, etc.), reminding them to use the correct terminology as they explain how each transition occurs. Remember, to increase the degree of critical thinking, ask specific questions and then allow the students to teach one another by explaining and defending their responses.
2. After establishing the cyclic nature of water, ask a few questions to point out problems that can occur with nutrient cycles:
    a. Is there an equal quantity of water in each part of the cycle at any given time? *(No, the majority of the water on the planet at any given time lies in the oceans. The proportion of water held in the ground or in the air is relatively small in comparison.)*

b. Does the proportion of water held in each part of the cycle remain constant—i.e., is there generally the same amount of water in the oceans/hydrosphere, the air/atmosphere and underground/lithosphere at all times? *(The answer to this depends on the time scale. During the last few thousand years, the answer to this question would be yes. However, there have been times in the earth's history when the proportions of water in each region of the biosphere were different. For example, after formation, the planet was so hot that no liquid water could fall to the surface without immediately evaporating again into the atmosphere. Therefore, at that time, the proportions were very different from what we see today.)*
c. Does the amount of water on earth—in the lithosphere, hydrosphere and atmosphere combined—ever fluctuate? *(Not significantly. The amount of water has remained constant due to gravity and the elemental composition of the planet.)*

3. Ask the students to look into their paper cups. Let them know that the liquid in each of their cups is pure H_2O made by removing all other elements during distillation. Ask them to drink a sip of this water. Ask them how long this water has been on the planet? *(The elements that make up the water, hydrogen and oxygen, have been on the planet since its formation ~4.5 billion years ago.)*
4. Continue to check your students' understanding of these concepts:
    a. Why is there any reason to not waste water if water is always cycling and will not leave the planet? *(Water is cleaned during the evaporation part of the water cycle, when only H_2O can evaporate without added impurities. That part of the water cycle cannot be sped up on demand, and the precipitation that brings the water back down to the earth's surface cannot be counted on to distribute fresh, liquid water evenly to all parts of the planet that need it.)*
    b. Which parts of the water cycle are relatively faster and which are relatively slower? *(Withdrawal of groundwater and surface water for use happens relatively quickly, and the water does not always get replaced through evaporation, condensation and precipitation as fast as it is being withdrawn. Moreover, the cleaning process of evaporation is relatively slow compared to how quickly the water can become impure through air pollution, surface contaminants or salinity.)*
    c. Besides water, what other nutrients cycle through the atmosphere, lithosphere, and hydrosphere for use by all organisms? *(All elements cycle through the biosphere. Most nutrients cycle through all three—or at least two—of the parts of the planet mentioned. The path they take through the atmosphere, hydrosphere and lithosphere and through the organisms that live in each place is called a biogeochemical nutrient cycle.)*

5. Distribute the "Biogeochemical Nutrient Cycle Poster Presentation" handout and assign each student one of the four cycles below:
   Nitrogen cycle
   Phosphorus cycle
   Sulfur cycle
   Carbon-oxygen cycle
6. Tell the students they will be expected to research their assigned cycle and prepare a visual presentation of their findings. Each student will be expected to depict on a poster board a labeled flow diagram (similar to the one they have drawn for water) in which they list the parts of the cycle that are slower, the parts of the cycle that are faster and the ways in which humans are influencing this cycle. The best posters—one for each cycle—will be displayed on the walls of the classroom, so the diagrams and information presented on each poster will be graded for accuracy, clarity and legibility.

IV. Activity Two: The Laws of Thermodynamics and Mass 15 minutes

<u>Objectives:</u>

a) The learner will (TLW) use their understanding of the water cycle to make conclusions about the laws of thermodynamics.
b) TLW apply the laws of thermodynamics to nutrient cycles and to energy flow.
c) TLW participate in a Socratic discussion using facts to support their verbal contributions.

<u>Materials:</u>

(None.)

<u>Procedure:</u>

1. Begin by asking the class if anyone knows the first or second law of thermodynamics or the law of conservation of mass. If no one does, ask them where they could find this information (their textbook glossary) and allow them time to present a definition for each law.
2. Write these laws on the board or on an overhead transparency.
3. Begin a Socratic discussion by posing one of the following questions to the class and allowing students to answer the question. You want to encourage your students to challenge and explore the limits of their understanding of each law. The goal is to get them to apply the laws to appropriate situations and utilize the terminology in a conversation. For each response, ask your students to use an appropriate example or some supporting fact to increase the validity of their response. Play the role of devil's advocate, challenging the students even if they are going in the right direction, in order to make them support their ideas. If new

terminology is introduced, ask the student using it, or another student, to define the term. Try to encourage each student to join in on the discussion, whether as a challenger of ideas or as a provider of support. Here are some questions to keep the discussion going:

a. Questions that explore the conservation of mass:
    - If the law of conservation of mass states that matter is neither created nor destroyed, why would there ever be a need to conserve resources such as aluminum or gasoline? *(There are several reasons. The first is that not all resources are of the right purity or are in the desired location. Also, most resources are scattered and so locating, extracting and purifying those resources requires an input of energy. This leads to the second law of thermodynamics: mining, purifying and the making of products requires an input of energy, and there's energy lost at each step of these processes, in the form of heat.)*
    - If the law of conservation of mass is only true for closed systems, what are the boundaries of this closed system? *(Take an example such as carbon. There are a finite number of carbon molecules that are cycling in the biosphere (earth).)*
    - Do elements, such as carbon, ever leave our planet, or do they just cycle within the confines of the biosphere (lithosphere, hydrosphere and atmosphere)? *(The carbon on our planet originated in a star somewhere and was introduced to earth during its formation; however, due to gravity, carbon remains in the biosphere and cycles there as long as the earth exists.)*
    - Does the first law of thermodynamics only hold true when one is considering the entire universe as the confines of the cycle? *(All matter in the universe is conserved; even as conservation of mass is apparent within our biosphere, new elements arise in stars through nuclear fusion of smaller masses such as hydrogen and helium.)*

b. Questions that explore the first law of thermodynamics: The first law of thermodynamics deals with energy.
    - What are the confines of energy? Does it cycle in the ecosystem, the biosphere or the universe? *(Energy appears to be a one-way flow into our biosphere and out of our biosphere. The conservation is less apparent because the energy is lost to us as a planet, even though it is maintained for cycling within the universe.)*
    - What is our primary source of energy? *(Nearly all energy on earth comes from the sun and is captured as radiant heat or light; other much less substantial sources of energy for our planet include radioactive isotopes and geothermal energy.)*
    - If the sun is continually offering energy, why would we concern ourselves with conserving energy? *(Because the conversion of solar energy to the forms of energy we use—electricity, fossil*

fuels, etc.—is costly. This discussion will lead to the second law of thermodynamics.)

c. Questions that explore the second law of thermodynamics: The second law of thermodynamics states that all systems tend toward disorder or entropy.
   - Can you think of a situation that supports this law? *(Ex: The continual effort to keep your room clean; the exothermic release of heat during cell respiration; the input of energy needed for the endothermic reactions of photosynthesis, etc.)*
   - Why does it take an input of energy to work against entropy? Use an example such as a gasoline engine or the conversion of coal into electricity to point out how entropy plagues the process.

HW: Ask the students to begin their Biogeochemical Nutrient Cycle Poster Presentations and assign a due date for this project.

HW: Remind the students to look at the year calendar for reading and video assignments.

Biogeochemical Nutrient Cycle Poster Presentation

Due date: _______

Complete the following tasks and be ready to present your work on the due date above.

1. Use your textbook, other science textbooks and the Internet to research the movement of one of the nutrient cycles (assigned to you by your teacher). Be sure to learn the following before you begin making your poster and before you give your verbal presentation:

    a. What are the most common chemical forms this nutrient takes? (Name all that apply.)
    b. How are each of these chemical forms created? Be able to describe the process of each chemical transition.
    c. How is this nutrient used by living organisms—is it part of a particular macromolecule necessary for life?
    d. Does this nutrient cycle through the lithosphere, hydrosphere and atmosphere? What are the forms it takes in each of the spheres?
    e. Where is this cycle naturally slowest? Where is the cycle naturally fastest?
    f. How have humans altered the cycling of this nutrient?
    g. What are some ways that humans can reduce the effect they have on the cycling of this nutrient?

2. Your poster should feature the information you have found in your research. Please draw a clear, large diagram using wide-tipped, dark-colored markers so that your diagram can be seen and read from across the classroom. Please include all of the following:

    a. Write the name of your nutrient cycle at the top of the poster.
    b. Next to the nutrient name write the name of the macromolecule in which this nutrient is found.
    c. Draw a large labeled diagram of the cycling of this nutrient that includes its most common chemical forms.
    d. With a yellow marker, color the part of the cycle that is slowest.
    e. With an orange marker, color the part of the cycle that is fastest.
    f. Make a list of human influences on this nutrient cycle.

AP* Environmental Science
Daily Lesson Plans
Ecology Unit

Day 3

I. Topic: Abiotic Factors

II. Warm-up: 5 minutes

Prior to class, write the following on the board: If you were a plant living in the rainforest, what nutrients would you seek from the soil, water and air (think about yesterday's nutrient cycles)? If you were a fish swimming in a fresh water lake, what nutrients would you seek from your environment? *(The answer to both questions is the same: all organisms need the atoms that make up the molecules of life—oxygen, carbon, hydrogen, nitrogen, phosphorus, sulfur, trace amounts of some metals, etc.)*

III. Activity One: Range of Tolerance Data Analysis 40 minutes

Objectives:

a) The learner will (TLW) observe how organisms can tolerate differences in abiotic factors.
b) TLW learn to analyze and graph results using experimental data.

Materials:

For each student: one copy of the "Salt Tolerance for Radish Seed Germination" handout.

Procedure:

1. When the students have completed the warm-up, ask them to share their responses. Encourage the class to correct or add to their peers' responses. Lead them through the following discussion, encouraging the students to support their ideas with examples and facts. Here are some questions to help the students consider the main ideas for today's class:
   a. How does the availability of nutrients affect the location of living organisms? *(Nutrients can be limiting factors that allow an organism to prosper or keep an organism from growing in an environment.)*
   b. What is the difference between abiotic and biotic limiting factors? *(Abiotic factors are those that influence the existence of a population but are not living and have never been alive, such as*

wind, water, nitrogen, rock, temperature, oxygen, etc. Biotic factors are those that influence the existence of a population and that are or once were alive, such as disease, food, competitors, predators, etc.)

c. Do all organisms need the same abiotic factors in the same amounts? *(No, all organisms have different requirements. Ask the students to recall the example Free Response question concerning pH.)*
d. If an organism is denied some amount of or all of an abiotic factor for a period of time will it die? *(Not necessarily. It depends how important that factor is and for how long it is unavailable.)*

2. Distribute the "Salt Tolerance for Radish Seed Germination" handout. Ask the students to graph the data using a histogram (review this if necessary) and answer the reflection questions for homework.
3. Use this homework assignment to determine the level of your students' graphing skills. Collect and keep the results of the assignment for use on Day 12 of this unit, when there will be an activity centered around practicing scientific graphing techniques.

IV. Activity Two: Habitat Choice Experiment 40 minutes

Objectives:

a) The learner will (TLW) observe organisms' preferences for particular abiotic factors.
b) TLW utilize the parameters and techniques presented in this demonstration to create their own question, hypotheses and procedure for a habitat choice experiment.

Materials:

For each lab group: a one-meter piece of clear, plastic, flexible plumbing tubing with an interior diameter of at least 3cm (about 1 1/4 inches); six rubber bands; 10 live crickets in a paper bag (most pet stores keep "feeder" crickets in stock and sell them for a very low price, or you can order them from a scientific supply company); one large-mouth funnel (wide enough for a cricket to move through) that fits into the plastic tubing; and two pieces of black, flexible, plastic screen material in each of the following dimensions: 10cm x 10cm; 10cm x 75cm; 10cm x 50cm; and 10cm x 25cm; and one copy of the "Habitat Choice Lab Experiment Preparation Sheet" handout.

Procedure:

1. Prior to class, prepare all of the plastic tubes by poking small holes in each tube every 2cm using a heated skewer or some other pointed tool.

The holes must be large enough for fresh air to flow in and out of the tube, but not large enough to allow the crickets to escape.

2. Here is a general overview of the preliminary habitat choice experiment you will prepare, followed by detailed instructions: To prepare your habitat choice demonstration, you are going to take one of the clear plastic tubes and put layers of screen (of increasingly smaller dimensions) on top of one another, such that the tube ends up having gradations of darkness—i.e., it'll be completely uncovered (and therefore let in maximum light) on one end, and become increasingly darker toward the opposite end (where the layers of screen become thickest). Because you must be able to see the crickets during this experiment, you'll need to leave a long, skinny viewing "window" that runs along the bottom of the tube. To accomplish this, you'll wrap the screens around the tube tightly, such that they lie directly against the tube, BUT you'll trim the screen edges with scissors, such that when they are wrapped around the tube, their ends don't meet completely (this will leave a skinny strip of the clear plastic tube uncovered, which will enable you to see the crickets). Now, here are specific directions for accomplishing all of the preceding: Take one of the tubes you prepared in step 1 above. Lay the two pieces of 10cm x 75cm screen on top of one another and wrap them around one end of the tube (the other end of the tube will remain uncovered). As mentioned above, you'll want to trim the screens so that they wrap around the tube but their edges don't meet (leaving a skinny strip of tube uncovered, so that the crickets can be seen and counted). The screens can be offset from one another so that light is partially blocked out in this 75cm section. Secure the screens with rubber bands. Repeat these steps by adding the two 50cm pieces on top of the 75cm sections. Line the 50cm pieces up with the covered end of the tube so that the 75cm sections of screen are partially covered by this third and fourth layer of screen. Fifty centimeters at one end of the tube should now be darker than the rest. Again, trim the screens so that there is a seam that can be used to observe the crickets, and secure the screens with rubber bands. Repeat the same process with the 25cm sections of screen so that one end of the tube is now darkened by a total of 6 layers of screen. This set-up allows a gradation of light within the tube. When the crickets are released into the tube, they will seek the environment that is most conducive to their survival. Secure one 10cm x 10cm screen on the end of the tube to cap it. This cap allows ventilation but will keep the crickets in the tube during the experiment. Slide four desks together so the tube can be placed on a flat surface with the viewing seam on the bottom. Allow the viewing seam to lie at the place where the desks meet (albeit with a little space between them) so that the students can crawl under the desks to observe the crickets and count them. Repeat this procedure to make a habitat choice tube for each lab group.
3. Ask the students to stand around the habitat choice chambers you have created.

4. Ask a few questions to help the students connect the previous activity to the preliminary habitat choice experiment they are about to conduct:
    a. What would happen to a population of animals if they were in an environment that did not offer the optimal range of abiotic factors? *(If possible, those animals would move toward another location that contains the optimal abiotic factors.)*
    b. What do we call the innate drive of an animal to move in a specified direction? *(Taxis. The movement may be toward or away from heat, light, gravity, a chemical, a sound, etc.)*
    c. How is taxis different from kinesis? *(Taxis refers to movement in a specific direction, kinesis is the term used for generalized movement. For example, kinetic activity for a species often increases when temperatures are warmer and decreases when temperatures are colder.)*
5. Tell the students that, in a moment, 10 crickets will be placed in each tube. Ask them what question you are testing in this experiment? *(Ex: Do crickets have positive or negative phototaxis (i.e., do they move toward or away from light? Another example question: Which amount of light is optimal for crickets?)*
6. Ask the students what they think will occur in this experiment. Review the concept of hypotheses at this time. Ask the students what the null hypothesis is for this experiment. *(Ex: "Light has no effect on the direction of cricket movement." Or: "Light is not a factor for crickets in habitat selection.")*
7. Explore the students' ideas about how to formulate a good scientific procedure, using this experiment as an example:
    a. How long do you think it will take for the crickets to make a choice about their preferred habitat?
    b. Would it be best to take multiple readings at intervals or use only a final reading?
    c. Do you think the crickets will choose a habitat and remain in that habitat permanently? Does it matter if they move around between readings?
8. When the lab groups have a clear idea of how they will collect their data, give them the crickets for their experiment: Using a funnel, shake 10 crickets from the paper bag into the first lab group's tube. Cap the end of the tube with the second piece of 10cm x 10cm screen and secure it with a rubber band. Place the tube on a flat surface with the viewing seam face-down and visible where the desks meet. Now repeat this for each lab group, as they become ready. Allow one person from each lab group to draw their group's data chart on the board and fill it in as their data becomes available.
9. While the students are collecting their cricket data, distribute the "Habitat Choice Lab Experiment Preparation Sheet" handout. Point out to the class that this preliminary experiment they've been conducting gives them an idea of how crickets select habitats. Now tell them that they will design

an experiment with their lab group in which they test for an assigned or chosen abiotic factor, using the cricket and plastic tubing set-up (minus the screens that provide gradations of light). Try to allow the students as much freedom as possible in designing an experiment. Remind them that they must not intentionally kill their crickets. Here are some ideas and techniques for testing abiotic factors: test for dry/moist habitat preference using a misting bottle to moisten the inside of one end of the tube; test for cold/room temperature/warm habitat preference using a zippered baggie of ice or a bag of hot water under the tube; test for noise or vibration preference by placing a music speaker at one end of the tube, etc.

10. When the students are finished working with the crickets for the preliminary experiment, dump all of the crickets into a terrarium (or a container with breathing holes in the lid) that has a dish of drinking water, wet paper towels and cricket food (such as pieces of potato or apple).
11. Tell the class they must bring their completed “Habitat Choice Lab Experiment Preparation Sheet” to class tomorrow as well as any supplies that they listed in their experiment design procedure.

HW: Ask the students to complete the graphing activity on the “Salt Tolerance for Radish Seed Germination” handout and bring it to class tomorrow for grading.

HW: Ask the students to work with their lab groups to complete their experiment design on the “Habitat Choice Lab Experiment Preparation Sheet” for class tomorrow.

Salt Tolerance for Radish Seed Germination

Procedure:

1. A 3cm x 3cm piece of paper towel holding 5 radish seeds was placed in each well of a Styrofoam egg carton.
2. The seeds in each well were watered with a particular solution ranging in salinity from 0% salt content to 2% salt content.
3. The egg carton was closed all day each day except for the time it took to water the seeds and measure the length of the seed radicle (the embryonic root that emerges during germination).
4. Data was gathered and compiled in the chart below:

Results:

Length of radicle after four days of watering with saline solutions.

Concentration	≤0.5cm	0.5cm-1.0cm	1.0cm-1.5cm	1.5cm-2.0cm	≥2.0cm
0%	7	4	13	21	255
0.2%	3	6	37	96	158
0.4%	218	80	2	0	0
0.6%	293	7	0	0	0
0.8%	298	1	1	0	0
1.0%	300	0	0	0	0

Use the graph paper on the page that follows to graph the above data.

Reflection Questions:

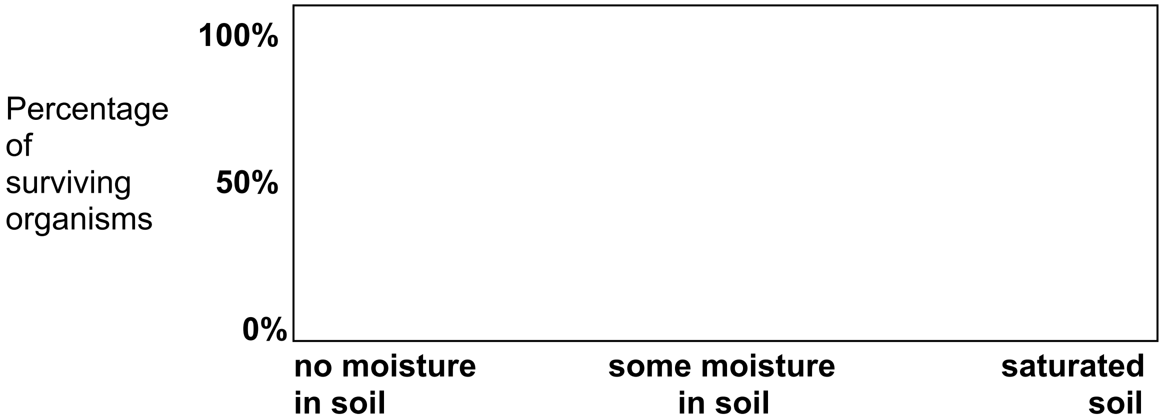
1. Which solution allowed the best growth for the radish seeds?

2. How would you describe the radishes' range of tolerance for salt?

3. Soil moisture is an abiotic factor for which most plants have an upper and lower limit of tolerance. Use the chart space on the next page to depict the number of organisms in a population that would survive in the differing amounts of soil moisture.

4. Use three different colors to shade in the portions of the chart that represent the following: the optimal range of moisture for this plant species, the zone of physiological stress and the zone of intolerance.

Range of Tolerance for a Plant Species



Use the graph space below to create a clear visual summary of the radish seed germination data.

Salt Tolerance for Radish Seed Germination

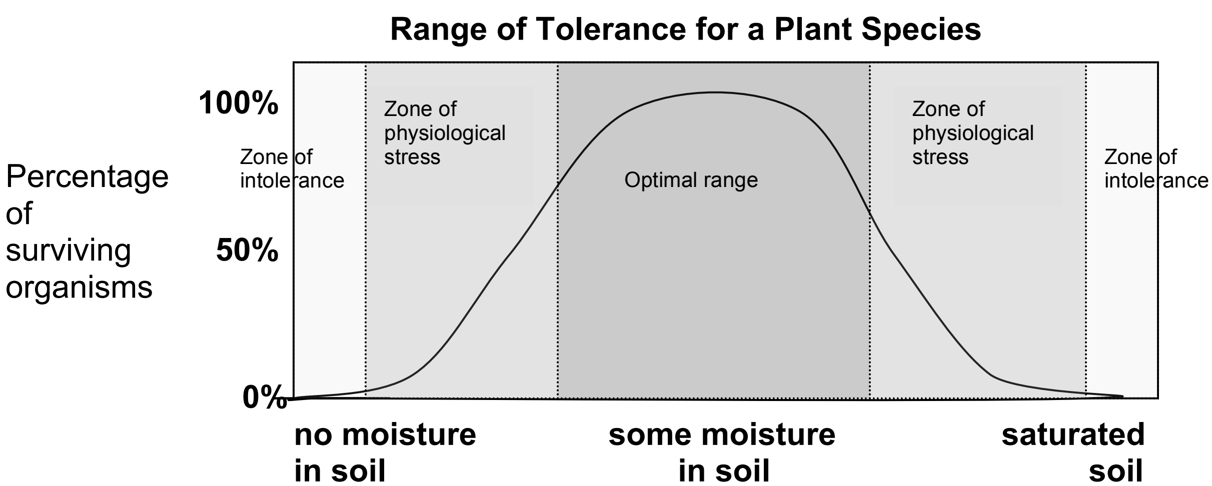
Teacher's Version

Reflection Questions:

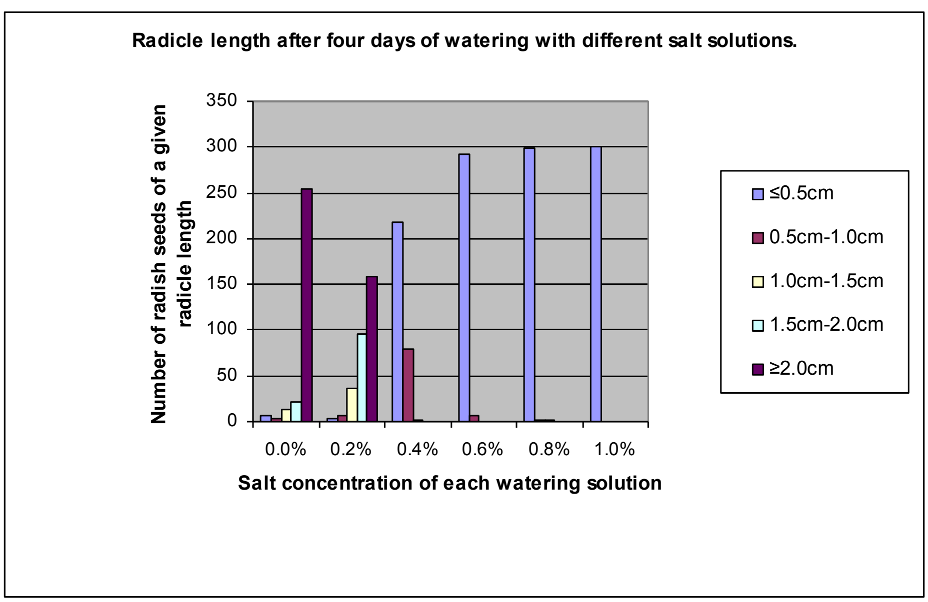
1. Which solution allowed the best growth for the radish seeds? *0.0% salt solution (the water that contained no salt).*

2. How would you describe the radishes' range of tolerance for salt? *The seeds can germinate fairly well in a solution of up to 0.2%, but by 0.4% the seeds are in the zone of physiological stress.*

3. and 4. The students' graph should be similar to the following:



The students' graph of radish seed data should be similar to the following:



Habitat Choice Lab Experiment Preparation Sheet

1. The abiotic factor I will be testing is: ________________________.
2. My experimental question is:
3. My hypothesis is:
4. My null hypothesis is:
5. The materials I will need to perform this lab are:
6. The procedure for this lab is:
    a.
    b.
    c.
    d.
    e.
    f.
7. The chart I will use to gather my data looks like this:
8. This is what I expect will occur during the experiment:

AP* Environmental Science
Daily Lesson Plans
Ecology Unit

Day 4

I. Topic: Student-designed Lab Experiments

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Divide into lab groups and share your experiment designs. Choose the question and procedure that is best in terms of the scientific process (the experiment features a large sample size, an adequate time frame, testing of only one variable, minimization of other factors, etc.).

III. Activity One: Critiquing Student-designed Experiments 45 minutes

Objectives:

a) The learner will (TLW) be able to communicate an idea to an audience.
b) TLW analyze the strengths and weaknesses of an experiment.

Materials:

For each lab group: one sheet of flip chart tablet paper and one set of wide-tipped markers.

Procedure:

1. Ask each lab group to draw a sketch of the set-up for their proposed lab experiment.
2. Ask each lab group to come to the front of the class, one group at a time, to present to the class their experimental question, hypotheses (regular and null), procedure and data collection chart.
3. Ask the class to pay close attention to each presentation. Tell the students their job is to improve upon the lab experiment being proposed (you may want to grade them on their comments and helpfulness). Ask the audience to be helpful by communicating their improvements in one of two ways:
    a. The audience member can ask a question to help lead the lab group towards an improvement.
    b. The audience member can provide a solution to a problem they detect in the experiment.

4. Remind the audience that good communication skills are necessary if they are to become scientists.
5. As each lab group proposes their ideas, try to stay out of the critique as much as possible so that the student audience rises to the occasion. If necessary, ask the audience a leading question, even if only to fool them (for the purpose of challenging them). For example, you might ask, “Does this question have only one variable?” even when an experiment does, in fact, have only one variable. Conversely, you can ask this same question when an experiment design features too many variables.
6. After all the experiment designs have been critiqued, allow the groups time to revise their experiments as needed.
7. Ask each group to give you a list of materials that will be needed for their experiment.
8. Tell them that they will perform their lab experiment during the next extended lab period.

HW: Ask the students to finish their Biogeochemical Nutrient Cycle Poster Presentation projects to be turned in tomorrow.

HW: Remind the students that they have a Plotkin Ch. 2 quiz tomorrow at the beginning of class.

HW: Remind the students to look at the year calendar for reading and video assignments.

AP* Environmental Science
Daily Lesson Plans
Ecology Unit

Day 5

I. Topic: Biogeochemical Nutrient Cycles

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Take the quiz. When you are finished, turn it over, so that it's face-down on your desk.*

*The students are assigned reading from *Tales of a Shaman's Apprentice* by Mark Plotkin during the first semester of this course as an Amazonian case study of ecological concepts.

III. Activity One: Plotkin Ch. 2 Quiz and Discussion* 15 minutes

Objectives:

a) The learner will (TLW) demonstrate what they have retained from the Plotkin book.
b) TLW express and generate interest in the book they are reading.
c) TLW have a chance to ask questions about how research science is performed at the graduate level.

Materials:

For each lab group: a copy of the quiz.

Procedure:

1. Allow the students 5-6 minutes to complete the reading quiz.
2. Ask the students to trade papers with someone who has another color of pen.
3. Go over each question, allowing the students to provide answers and discuss the book, to build interest in it as they go.

IV. Activity Two: Biogeochemical Nutrient Cycles 40 minutes

Objectives:

a) The learner will (TLW) review and critique visually presented information.
b) TLW practice presenting information in front of the class.

Materials:

Each student will need their completed Biogeochemical Nutrient Cycle Presentation Poster.

Procedure:

1. Ask the students to gather together at a table with peers who researched the same nutrient cycle.
2. Ask them to take turns sharing their work.
3. After each person has shared their poster with their group, ask that each group decide which poster features the clearest and most accurate information.
4. Tell the students that each person in the group must present one of the components a.-g. from step one of the handout. Each person in the group should present nearly equal amounts of information, but the students can decide for themselves who will present what information. Let them know that all members will receive the same grade for the oral and visual presentation based on a composite grade for their group.
5. Ask the students to rehearse what they intend to say, so that their group can help them edit or improve their oral presentation.
6. Allow each group to take turns presenting the chosen poster. Encourage the audience to ask questions of the group members who are presenting so they can clarify their understanding of each biogeochemical nutrient cycle.

HW: Remind the students that tomorrow they should have a total of 10 organisms for their insect collection.

HW: Remind the students to look at the year calendar for reading and video assignments.

Special note: Remember to purchase the supplies needed for the student-designed habitat choice lab experiments tomorrow.

Tales of the Shaman's Apprentice by Mark Plotkin
Ch. 2 - "The Search for the Black Caiman"

1. What country did Plotkin visit in Ch. 2? _______________________.

2. What was the purpose of the trip?

3. Who traveled with him? ___________________________________.

4. Describe the two cultures of people who live in this country.

5. Give an example from this chapter of the saying, "Diversity begets diversity."

6. Describe two of the following creatures that Plotkin encountered on the Amazon:

    a. Hoatzin

    b. Matamata

    c. Capybaras

    d. Ibis

7. What keystone role does the caiman play in the river ecosystem?

8. Describe one example from this chapter of a relationship between two species that is permanent and interdependent (symbiotic).

9. and 10. Name two abiotic limiting factors of a rainforest ecosystem.

Tales of the Shaman's Apprentice by Mark Plotkin
Ch. 2 - "The Search for the Black Caiman"

Teacher's Version

1. What country did Plotkin visit in Ch. 2? *French Guiana.*

2. What was the purpose of the trip?
   To find out if black caiman crocodiles were left in this country, and if so, to measure and record them so the area could be protected as a preserve.

3. Who traveled with him? *Russ Mittermier and Georges.*

4. Describe the two cultures of people who live in this country.
   On the coast live the Maroons, who are descendents from Africans brought over as slaves. Inland in the jungle are indigenous tribes who are descendents from people who crossed the Bering Straight.

5. Give an example from this chapter of the saying, "Diversity begets diversity."
   Possible answers to this question include: Mites live in the nasal passages of parrots only found in this forest; buttress roots of trees have moss and small pools with hundreds of insects, larvae and amphibians that breed there; epiphytes on a fig tree that is home to 250 different species of larvae and eggs.

6. Describe two of the following creatures that Plotkin encountered on the Amazon:
   a. Hoatzin – *A bird that climbs trees with wing claws.*
   b. Matamata – *A turtle that looks like dead leaves and has a snapping mouth.*
   c. Capybaras – *A rodent that weighs more than 100 pounds.*
   d. Ibis – *An elegant scarlet bird that looks like a heron.*

7. What keystone role does the caiman play in the river ecosystem?
   Concentrations of the crocodile's excrement provide nutrients for plankton and serve as egg-laying sites where hatchlings can graze on plankton. A reduction in the caiman population caused the fish population to plummet, because the plankton, which is the base of the food chain, did not have the nutrients to grow.

8. Describe one example from this chapter of a relationship between two species that is permanent and interdependent (symbiotic).
   Leaf-cutter ants and the fungus they grow; the Gongora orchid that intoxicates bees into pollinating it; orchids that look like female insects get pollinated by the male insect that tries to mate with one flower after another and disperse pollen in the process; fleshy seeds that are ready to germinate after moving through the digestive tract of an animal; heliconid butterflies and passion fruit vines, etc.

9. and 10. Name two abiotic limiting factors of a rainforest ecosystem.
   Soil nutrients and sunlight.

AP* Environmental Science
Daily Lesson Plans
Ecology Unit

Day 6 - Extended Lab Period

I. Topics: Habitat Choice Lab Experiments

II. Warm-up: 5 minutes

Prior to class, write the following on the board: Begin your Habitat Choice Lab Experiments.

III. Activity One: Habitat Choice Lab Experiments 5 minutes

Objectives:

a) The learner will (TLW) develop their laboratory experimentation skills.
b) TLW practice accuracy and perceptiveness in observation.

Materials:

The supplies needed will vary depending on the experimental design of each lab group. For the class: one copy of Free Response question #1 from the 2003 AP Environmental Science Exam (to be assigned as homework, below). All past AP Exam Free Response essay questions and grading rubrics can be found at the www.apcentral.collegeboard.com website. Sign in, then choose the title "Exam Questions" that appears when you roll over the green button that says "AP Courses and Exams." Simply click on "Environmental Science" on the "Exam Questions" page to find the FR questions for past exams.

Procedure:

1. Ask the students to complete their lab experiments within the class period.
2. If they finish their lab experiments before the class period is over, have them clean up then ask them to begin writing the methods section and the results section of their lab report. Ask them to discuss what will be included in the conclusion and introduction sections of their lab report.

HW: Ask the students to write a rough draft of their entire lab report and bring it to the next class.

HW: Ask the students to write an essay for Free Response question #1 from the 2003 AP Environmental Science Exam.

Special note: Tell the students to try using a main-point-plus-three-supporting-details structure whenever a question asks for an elaboration. The main points will be the "answer" portion of the question that was asked. The three supporting details might be additional information about that main point, such as giving a definition of each of the terms used in the main point, a more detailed description of the process or the idea of the main point, a statistic, a percentage or numerical detail that is associated with the main point, or an example of the point that is being made. For this particular question, part "a" asks for support, but it does not specify how many pieces of supporting evidence to give. Students should always give three pieces of supporting evidence. In this case, all three pieces should pertain to the role of leaf litter in a deciduous forest ecosystem.

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