Appendix C

Labs

Common Labs

In this section are some of the common labs used on the AP Environmental Science exam. Keep in mind that there are no specific labs for the exam and that labs may vary from year to year. Review the labs and consider the basic principles behind each lab. The labs will help to strengthen your knowledge and understanding of the AP Environmental Science curriculum.

Acid Deposition

Acid deposition, also known as acid rain, is commonly caused by sulfur and nitrogen compounds emitted by burning fossil fuels. Sulfur dioxide and nitrogen dioxide each react with water to form their corresponding acid, reducing soil and groundwater pH. The basic setup for this lab uses a combustion chamber to collect the gases from burning fossil fuel and to test the pH of the gas. The net result is a lower pH.

Air Quality

The following tests are commonly used in lab settings to evaluate air quality:

- **Particulates:** There are several ways to collect particulates from the air, including attaching a white sock to the tailpipe of an older car or diesel vehicle. Another method of trapping particulates in the air is to hang a sticky paper outside and collect it after a few days. In both cases, observe the inside of the sock or the sticky paper with a magnifying glass or microscope to view the particulate material. The particulate may include pollen, dust, soot, or other large particles.
- **Ozone:** In this lab, you can use a commercial ozone detector, an ecobadge, or a homemade potassium iodine gel to collect data on ground-level ozone (troposphere ozone). The ecobadge or KI gel will become more intensely colored as the concentration of ozone increases.
- **Carbon dioxide:** A commercial sampler is needed to test car exhaust, burning charcoal or other biomass, or another potential source of carbon dioxide.

Biodiesel from Vegetable Oil

In this lab, students learn to convert vegetable oil into biodiesel that can be used as an alternative fuel in cars and generators. Used or new oil can be used, with the procedure varying only slightly. At the end of the procedure, the students will have created diesel fuel, called "biodiesel" because the source is vegetable—from biomass.

Biodiversity of Invertebrates (Shannon-Wiener Diversity Index)

This lab determines the biodiversity of insects in a given area. A trap is set up and insects are captured. The insects are counted and the species are identified; calculations are made based on the total number of species and the total of each species. The Shannon-Wiener Index is then calculated most commonly by the equation: $H = -\text{sum}\ (pi \cdot ln\ pi)$. H represents the Shannon-Weiner Index, pi is the ratio of the number of organisms of a particular species to the total number of organisms, and $ln\ pi$ is the natural log of pi. Traps may include fall traps, sticky paper, or bait traps like tuna or sugar.

Composting with Worms

Students can complete this lab at home or in the classroom. Students monitor the results of their composting on a weekly basis, keeping track of how much biomass they add by weight (wet weight) and the type of biomass. Students then collect the compost, analyze it for nutrient content, and develop a procedure to test it using growing plants.

Coriolis Effect

This simple activity requires a lazy Susan, three pieces of paper cut into the shape of the lazy Susan's circle, and markers. Mark the center of each paper. Set the first sheet of paper on the lazy Susan and draw a line from the center to the edge. Rotate the paper one-third turn and draw another line from the center to the edge. Rotate one-third turn and draw a final line from the center to the edge. Because the lazy Susan is not moving, there will be three straight lines (as shown in Figure C-1). Label the paper "No Earth rotation."

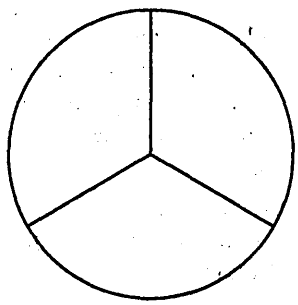


Figure C-1: No Earth rotation.

Now, place a second piece of paper on the lazy Susan and, this time, rotate the platter counter-clockwise. Draw three lines from the center while the platter is moving. The lines will come out curved as you draw the lines on the paper (see Figure C-2). Label this paper "Earth rotation Northern Hemisphere." Repeat this procedure, except rotate the lazy Susan clockwise (see Figure C-3). Label this paper "Earth rotation Southern Hemisphere."

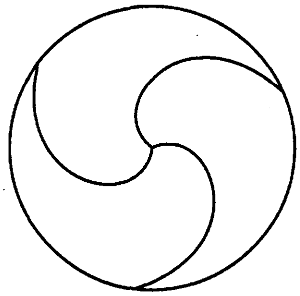


Figure C-2: Earth rotation Northern Hemisphere.

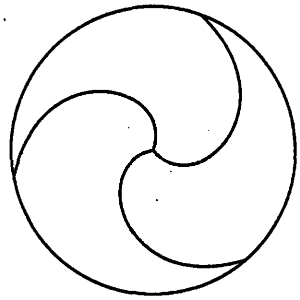


Figure C-3: Earth rotation Southern Hemisphere.

Eco-Columns

Eco-columns (like the one shown in Figure C-4) are mini ecosystems made up of three chambers. The bottom section is an aquatic chamber containing a fish and plant to replicate photosynthesis and cellular respiration. This chamber has a small slit to allow the students access to test the water for changes. The middle section is usually a decomposition section, but it can be reversed with the top, terrestrial section. The decomposition section contains worms and organic matter that, when broken down, move to the aquatic section. The terrestrial section usually has a small plant and sometimes a small animal. The top has a small cap with holes to allow watering if needed. Usually, after a few weeks, the system seldom needs water. The water cycle is very visible in the column. Other biogeochemical cycles are also found, and students learn to identify which cycles are in the column. This activity also teaches observation skills.

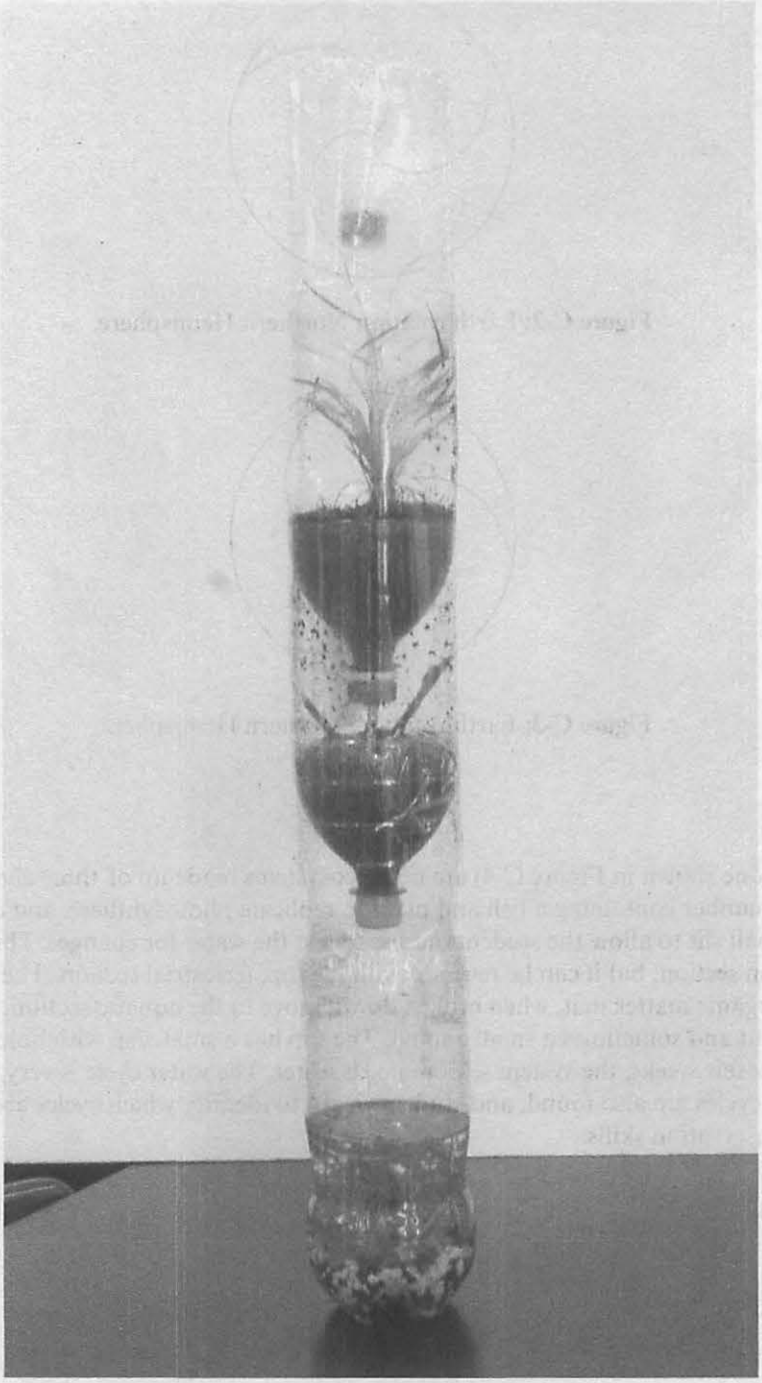


Figure C-4: An eco-column.

Ecological Footprint

Students take an online survey answering questions about their lifestyles and then, based on their answers, see their calculated impact on the Earth—often referred as their footprint. Students can take the survey multiple times to see how hypothetical changes in their lifestyles may affect their footprints.

Ecosystem Ecology

This field experiment examines the biotic and abiotic components of a local ecosystem and gives students the opportunity to learn how to use common environmental measurement instruments such as barometers, hygrometers, and thermometers. Students observe and note plants, consumers, decomposers, elements, and compounds. Depending on design, data is recorded over a period of time, possibly two to four different times. The flow of energy throughout the ecosystem, species interactions, and human impacts on the ecosystem are noted.

Energy Audits

Students examine energy usage at home or school and determine ways to make changes to save energy. This may include looking at the home energy bill to determine how much energy is used in kWh. Surveys may be conducted to see the number of light bulbs in the house, wattages of bulbs already in use, dimmer switches used, how many are compact fluorescent lights (CFLs), or how many incandescent bulbs can be converted to CFLs or replaced by lesser-wattage incandessent bulbs. Students may watch a meter to compare energy use when an appliance is turned on to energy use when the same appliance is turned off. From the results, the students develop a plan to use less energy.

Field Studies

Field studies study natural areas and might include determining the types of plants and animals in the areas, and the role of the water, weather, terrain, and human influences. Additional studies may include determining water quality, air quality, soil studies, and transects. (See "Ecosystem Ecology," earlier, as an example of a field-study lab.)

Food Webs

There are several activities showing food webs in action. Students identify producers, primary consumers, secondary consumers, tertiary consumers, and decomposers. Students set up the various links between species, show energy flow from the lower to the higher trophic level, and to decomposers. Finally, exploring webs can help students discuss the ramifications if one species is removed.

Mining

Students construct a model of a mine, illustrating different layers of the Earth and the location of the desired ore. Then students trade models with a partner and try to mine the partner's model. The goal is to maximize the ore collected and minimize the damage done to the mine. This activity can also be done using chocolate chip cookies.

LD_{50}: Bioassay

Although this lab is often referred to as lethal dose (LD), most labs for AP Environmental Science are actually lethal concentration (LC) labs, in which test organisms are placed in a known concentration of the test medium. LD is the lethal dose that the organisms receive. The 50 refers to the number of the test organisms that die, in this case 50 percent. The number can be changed for different criteria. Often, copper sulfate is used with brine shrimp. The brine shrimp are placed in a range of copper sulfate solutions. After 24 hours, a count of live and dead brine shrimp is made and the number of dead shrimp is plotted on a graph. From the graph, you can determine the threshold and the lethal concentration that causes 50 percent of the test organisms to die.

Oil Spill Cleanup

This activity involves cleaning up a simulated oil spill in water. Vegetable oil is poured into a pie tray containing water. A straw blows the oil around to simulate waves and wind in the oceans. Then students try a variety of methods to remove the oil and leave the water behind. String and small straws can be used as booms to surround the water. Cotton balls and pads, cloth, newspaper, and a variety of other material can be used to absorb the oil. At the end, the water is dumped out and students can feel how much oil remains on the pie tray.

Predator-Prey Simulation

This lab demonstrates the relationship between population sizes of predators and prey, usually mice and coyotes. When predator numbers decline, prey numbers increase, and when predator numbers rise, prey numbers decrease. Similarly, more prey leads to more predators, and fewer prey leads to fewer predators. This lab is conducted with pieces of paper representing mice and coyotes. Data is recorded after each round, representing generations, and a cyclical pattern of population numbers should emerge.

Productivity

In this lab, grass captures energy from the sun through the process of photosynthesis, resulting in a measured increase in the biomass of grass (the net primary productivity). The gross primary productivity is the amount of biomass produced by photosynthesis per unit of area over time. The net primary productivity is the production of glucose during photosynthesis minus the energy from glucose used to complete cellular respiration in the plant during photosynthesis.

Population Growth in *Lemna minor*

Lemna minor, also known as duckweed, is commonly used as an aquatic test plant for new pesticides and removes nitrates and phosphates in wastewater. It also can be harvested, dried, and used as feed for animals, especially chickens. In AP Environmental Science, this lab involves measuring the growth of duckweed in waters containing varying concentrations of nitrates, phosphates, pesticides, or salts.

Porosity

In this lab, different soil samples are collected in tubes capped on the bottom end. Samples usually include gravel, sand, and fine sand. Water is then poured into the sample and the length of time it takes for water to reach the bottom is recorded. The activity illustrates the fact that porosity and permeability increase with larger particle size. Soil that has tighter pore spaces and smaller particles has a greater chance of runoff and flooding because water cannot permeate easily.

To calculate percent porosity, use the following formula:

$$\text{Percent Porosity} = \text{Volume of Voids} \div \text{Total Holding Volume} \times 100$$

Salinization

The buildup of salts in soil is an increasing problem in areas where there is heavy crop irrigation, as in the Central Valley of California. In this lab, students germinate seeds in increasing concentrations of salt to determine the point at which the seeds cease sprouting. Any seeds can be used, but fast-germinating seeds such as Mung beans are commonly used because you can see results in about five days. Salt concentrations begin at 0 percent (as the control) and are increased up to about 4 percent, usually in 0.5 percent increments. The data can be graphed to show results.

Soil Analysis Labs

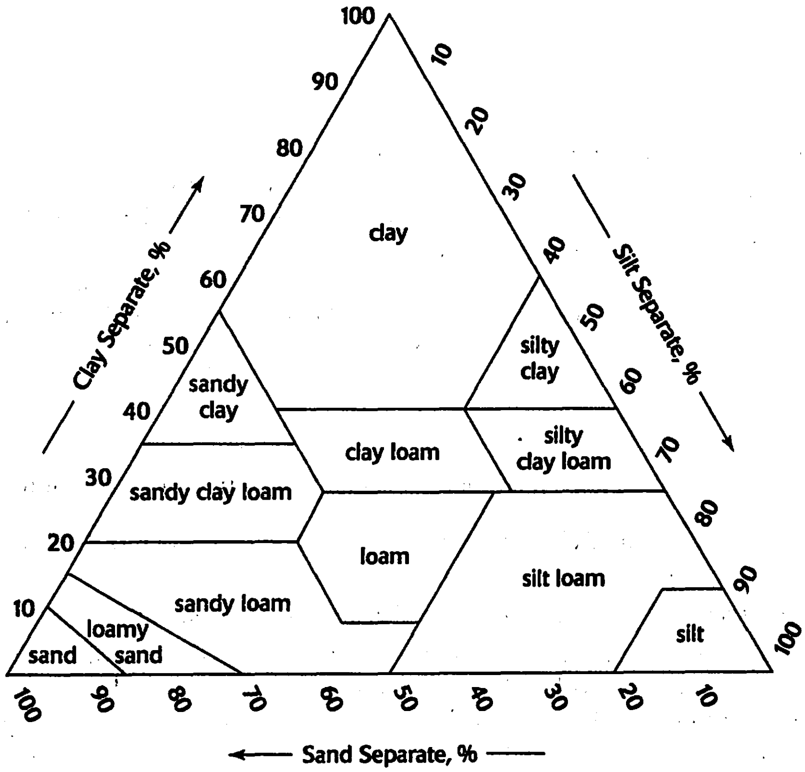
During this series of labs, students conduct both chemical and physical tests on soil samples. The results help determine the suitability of the soil to grow crops. The lab directs students to construct an assortment of buildings, bury septic systems, and conduct additional activities.

Chemical properties:

- **pH:** measures the concentration of H^+ and OH^- ions. The pH scale ranges from 1 to 14, with 7 being neutral. Values below 7 are acidic, and values above 7 are basic. Some soil types require additives to help neutralize the soil. In low-pH soils, some nutrients will not be available to be used by plants.
- **Nitrogen:** Common plant nutrient; major component of most commercial fertilizers.
- **Phosphorus:** Common plant nutrient; major component of most commercial fertilizers.
- **Potassium:** Common plant nutrient; major component of most commercial fertilizers. Also called potash.

Physical properties:

- **Color:** Moist soils are darker than dry soils and commonly contain many nutrients from decaying organic material. Other soil colors may indicate the presence of iron and/or other minerals.
- **Friability:** This is the ability of the soil to crumble into smaller pieces with little pressure. This is important for the roots of plants to grow. The greater the friability, the easier it is for plant roots to grow.
- **Percent humus:** This test determines the soluble organic component of the soil. The higher the percent, the better the water-holding capacity.
- **Permeability:** This is the measure of how much fluid can flow through soil. This can be determined by investigating pore size and the connection between soil particles.
- **Ribbon test:** Roll a sample of moist soil beneath your fingers; the longer the roll of soil, the greater the percentage of clay.
- **Soil type (particle size distribution):** Determines the percentage of clay, silt, and sand by placing a mixture of soil in a cylinder, allowing the soil sample to settle, and then determining the percentage of each. Sand, being heaviest, settles first; then silt; and finally clay. The percentages of each are then used to determine the soil type, according to the soil texture triangle shown in Figure C-5.
- **Water-holding capacity:** How much water is held by the soil. Sand has the least, while clay has the greatest.



Source: U.S. Department of Agriculture

Figure C-5: Soil texture triangle.

Solar Cooker/Solar House

This activity allows for creativity and innovation while designing a solar house or solar cooker that uses the sun's rays to magnify and/or trap heat. Lab objectives include defining the difference between active and passive solar energy, learning how both can be utilized, and discovering how to identify the important components of each. Active solar power uses the sun's radiation as energy to power electrical or mechanical equipment (equipment that moves). Passive solar power does not use another energy source or active mechanical systems. Active systems use fans, pumps, and other technology, while passive systems are simple and have minimal moving parts.

Specific Heat: Solar Absorption

With the increasing use of solar energy, it is important to understand how this energy is best captured. All substances absorb heat, and their capacity to do so is called their "specific heat." Specific heat is the amount of heat needed to raise the temperature of 1 gram of a substance by 1°C. Different materials have different specific heats, which affects the amount of solar radiation needed to heat a particular substance. In this lab, the heat-holding capacity of various substances is tested.

The principle of specific heat also applies to the atmosphere and climate. This particular lab compares the specific heat of soil to that of water and then relates the results to effects on climate.

Tragedy of the Commons

The *commons* is any resource that is shared by a group. This includes the air we breathe, water we drink, and fish taken from the oceans. It also refers to city parks and many other things that are shared by a group or are used by the public.

In this activity, students "fish" from a common ocean of fish (goldfish crackers, M&M's, or other similar products may be used) and usually all the "fish" are taken on the first round. In subsequent games, students learn to cooperate to avoid depleting the ocean.

Transects

Frequently, instead of studying entire areas, scientists sample small sections and then extrapolate the data to represent likely conditions in the area as a whole. One method of sampling is to run a 100m tape transect line. At every 10m interval, a 1-square-meter area is placed, first on the left side of the tape and then on the right side, alternating sides every 10m. In each square-meter area, the percentage of ground cover is estimated. Then the plant species are identified and the percentage of each is determined. Next, any animal present in the square or evidence of animals in the square is recorded. Finally, the information is tallied and compared to other transects in the study area. This is an excellent activity to repeat on a regular basis to examine seasonal variation.

Water Quality

A variety of tests can be conducted to test water quality. A brief description of each is noted below:

- **pH:** Measures the concentration of either free H^+ or OH^- ions. Normal pH for freshwater is between 6.5 and 8. The pH of saltwater is 8.2.
- **Temperature:** Measures the heat content of the water usually in °C (sometimes °F).
- **Dissolved oxygen (DO):** A measure of the amount of oxygen dissolved in the water. The concentration of DO is temperature-influenced, with higher temperatures able to hold less DO. Other factors that can influence the concentration of DO in water include the amount of organic waste, the plant and animal communities present, the water depth, and the flow rate of rivers and streams. Average needed DO concentration is 4 ppm for freshwater fish, 5 ppm for saltwater fish.

- **Percent saturation:** Measures the amount of oxygen dissolved in the sample water compared to the maximum that could be present at that temperature. One hundred percent saturation is the maximum amount of DO that the water can hold at that temperature. DO percent saturations between 80 percent and 120 percent are considered excellent.
- **Turbidity:** Measures the clarity of the water. The test can be conducted using a Secchi disk, usually divided into quarters with opposite black and white quadrants. A colored disk also can be used in areas where the water is very clear, usually in the open ocean water. A turbidity test is a measurement of the dissolved solids in the water. High turbidity means much suspended solid material in the water, which results in the water being less clear. This reduces the penetration of sunlight and reduces photosynthesis in the water, which, in turn, can affect the food chain.
- **Phosphate:** Phosphate is an important nutrient for plant growth, usually found in fertilizers and runoff from agricultural lands. Excessively high phosphate levels can lead to excessive growth and ultimately eutrophication. Phosphate levels should be 0.05 mg/L in flowing water, 0.025 mg/L in still waters.
- **Nitrates:** Nitrates are important for plant growth, usually found in fertilizers and runoff from agricultural lands. Excessively high nitrogen levels can lead to excessive growth and ultimately eutrophication. A concentration greater than 0.1 mg/L is considered high and the Environmental Protection Agency (EPA) limit is 10 mg/L.
- **Alkalinity:** Measures compounds that can change the pH toward the alkaline (basic). The normal range is between 100 ppm and 250 ppm. The EPA has no standards for alkalinity.
- **Biological oxygen demand (BOD):** Required for aerobic organisms in a body of water. Unpolluted waters have a concentration less than 5 mg/L. High nutrient levels are associated with high BOD.
- **Fecal coliform:** Bacteria that ferments lactose and produces gas when grown in a lactose broth. New tests have been developed that produce a color change in addition to gas.
- **Total solids:** Weight of the suspended solids and dissolved solids. All water contains some solids, but problems can arise from suspended sewage, industrial waste, soil erosion, and excess amounts of algae.
- **Total dissolved solids:** Occur naturally in water but may be objectionable in drinking water due to taste. At high levels of dissolved solids, water may be unsuitable for irrigation, because salts may leave residue and can accumulate over time. The EPA standard is 500 mg of dissolved solids per liter of water, but the range is 20 mg/L to 2,000 mg/L.
- **Chlorine:** The EPA standard caps chlorine concentration at 250 mg/L. NaCl is applied to roads in the winter to make driving on snowy and icy roads easier and safer. These salts can run off into the streams, increasing local chlorine concentrations. Other sources of chlorine include animal waste, potash fertilizers, and septic-tank effluent. Chlorine also may leach out of limestone formations.
- **Hardness:** Measures dissolved salts that include calcium, magnesium, or iron. Hard water is 121 ppm, and soft water is less than 20 ppm.
- **Iron:** Normal range is 0.1 ppm to 0.5 ppm.

Weathering

There are two types of weathering labs:

- **Chemical weathering:** This lab tests the effects of acid rain on different types of rock. Rock such as limestone, granite, and marble is exposed to dilute hydrochloric acid (HCl) and observations are made to see the effect of the acid on the rock. Additionally, the mass of the rock can be measured before and after exposure to dilute acid. This activity can be repeated to see the long-term effects on rock of the exposure to dilute acid. Chemical weathering may include hydrolysis, oxidation, or dissolving reactions.
- **Mechanical weathering:** In this lab, shaking rock samples in a container of water simulates mechanical weathering. Rock is weighed, placed in a container with water, and shaken; then the water is drained. The rock is rinsed and dried and then weighed a second time, and the difference in mass is calculated. Mechanical weathering may include wind, water (erosion), ice, plant growth, and human-related actions.

Analysis of Past Exams

Analyzing past exams can help you prepare for the AP Environmental Science exam. In this section, we provide information is provided on the labs used in free-response questions and experimental-design questions in the past. Review these sections to get a sense of how labs have been used on the exam in years past.

Free-Response Questions

Information from labs is frequently used in the free-response questions. Here is a brief description of the labs or parts of labs that have been used in past free-response questions:

- In 1998, students were asked to determine the pH range for a fish species, explain how to determine that a lake's pH has changed, and explain how to remediate the acidification.
- In 1999, students were asked to list three water quality tests and explain what information each water quality test provides.
- In 2001, students were asked to draw a small food web from given information. In addition, points were awarded for correct connections and energy flow between the species.
- Also in 2001, an information table was provided for four water quality tests and students were asked to interpret the data. In addition, they had to provide two more water tests and the expected outcomes.
- In 2002, data from an LD_{50} test on brine shrimp was provided, and students had to graph the data and determine the threshold concentration and the concentration where 50 percent of the test species died.
- In 2003, students were asked to describe what changes might occur if worms ate all the leaf litter. Some of the changes would involve soil quality.
- In 2004, students were asked to describe one physical soil test and one chemical soil test.
- In 2005, students were asked about surface mining, especially regarding the replacement of the removed soil.
- In 2007, students were asked about primary and secondary sewage treatment and disinfection.

Experimental-Design Questions

Labs are also used in experimental-design questions. Review the labs and develop a detailed approach to answering this type of question. You will also find it helpful to review the introduction of this book for more information regarding experimental-design questions.

Here is a brief description of the labs or parts of labs that have been used in past experimental-design questions:

- In 1999, students were given a study and asked to describe the hypothesis, identify the variable being manipulated, outline a procedure including what data they would collect, discuss the results, and relate the results to the distribution of an insect population.
- In 2001, students were asked to define a hypothesis and design a controlled experiment testing the production of acorns and the gypsy moth population.
- In 2003, students were asked to design a controlled experiment that demonstrates cause and effect in a forest ecosystem. The experiment had to include the environmental factor that would be tested, the hypothesis that would be tested, and the data that would be collected.