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To the Student

What is inquiry?
Inquiry can come in many forms. Sometimes it is very structured, such as when a scientist is searching for a cure for cancer and follows an exact plan for his research. Sometimes it can be very open, such as when a researcher designs her own methods for observing and investigating the social patterns of elephants.

As a student, you may not always get to choose the topic you will be studying, but through inquiry, you can often choose the way you will investigate the topic at hand. You can choose your materials, plan, and execute your own procedure. If you are really curious about something you have observed, your teacher may encourage you to investigate that question further.

How to Use This Lab Manual
Glencoe’s Guided Inquiry Lab Manual provides you with a variety of activities about a range of biology topics. Each lab provides you with background material about a topic, offers suggestions for questions to explore, encourages you to form your own questions and hypotheses, and provides you with suggestions for testing your hypothesis. The questions at the end of the lab give you an opportunity to analyze your data and draw conclusions about what you found.

Suggestions for Successful Inquiry in Biology
Conducting inquiry in biology is challenging but it can also be a lot of fun. Here are some ideas for how you can make each inquiry a success:

• **Explore safely.** Always check your plan with your teacher before you get started.
• **Ask questions.** Think about what the activity is asking you to do and make sure you understand it before you begin.
• **Keep an open mind.** Experiments don’t always turn out the way you plan them. Use the data you have to draw conclusions. If the result is completely unexpected, try to figure out what you can change to get the results you expected.
• **Be creative.** Think of new ways to explore the concepts rather than the ones that are suggested. This will keep you more interested in the process and can result in some interesting findings.
• **Ask more questions.** Really interesting things can happen throughout an experiment. Ask questions such as how, why, and what if, to learn more. Explore on your own, or get permission from your teacher.
Laboratory and Safety Guidelines

Emergencies
- Inform the teacher immediately of any mishap—fire, injury, glassware breakage, chemical spills, and so forth.
- Know the location of the fire extinguisher, safety shower, eyewash, fire blanket, and first-aid kit. Know how to use this equipment.
- If chemicals come into contact with your eyes or skin, flush with large quantities of water and notify your teacher immediately.

Preventing Accidents
- Do NOT wear clothing that is loose enough to catch on anything. Do NOT wear sandals or open-toed shoes. Remove loose jewelry—chains or bracelets—while doing lab work.
- Wear protective safety gloves, goggles, and aprons as instructed.
- Always wear safety goggles (not glasses) in the laboratory.
- Wear goggles throughout the entire activity, cleanup, and handwashing.
- Keep your hands away from your face while working in the laboratory.
- Remove synthetic fingernails before working in the lab (these are highly flammable).
- Do NOT use hair spray, mousse, or other flammable hair products just before or during laboratory work where an open flame is used (they can ignite easily).
- Tie back long hair and loose clothing to keep them away from flames and equipment.
- Eating, drinking, chewing gum, applying makeup, and smoking are prohibited in the laboratory.
- Do NOT inhale vapors or taste, touch, or smell any chemical or substance unless instructed to do so by your teacher.

Working in the Laboratory
- Study all instructions before you begin a laboratory or field activity. Ask questions if you do not understand any part of the activity.
- Work ONLY on activities assigned by your teacher. NEVER work alone in the laboratory.
- Do NOT substitute other chemicals/substances for those listed in your activity.
- Do NOT begin any activity until directed to do so by your teacher.
- Do NOT handle any equipment without specific permission.
- Remain in your own work area unless given permission by your teacher to leave it.
- Do NOT point heated containers—test tubes, flasks, and so forth—at yourself or anyone else.
- Do NOT take any materials or chemicals out of the classroom.
- Stay out of storage areas unless you are instructed to be there and are supervised by your teacher.

Laboratory Cleanup
- Keep work, lab, and balance areas clean, limiting the amount of easily ignitable materials.
- Turn off all burners, water faucets, probeware, and calculators before leaving the lab.
- Carefully dispose of waste materials as instructed by your teacher.
- With your goggles on, wash your hands thoroughly with soap and warm water after each activity.
Safety Symbols

These safety symbols are used in laboratory and field investigations in this book to indicate possible hazards. Learn the meaning of each symbol and refer to this page often. Remember to wash your hands thoroughly after completing lab procedures.

<table>
<thead>
<tr>
<th>SAFETY SYMBOLS</th>
<th>HAZARD</th>
<th>EXAMPLES</th>
<th>PRECAUTION</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISPOSAL</td>
<td>Special disposal procedures need to be followed.</td>
<td>certain chemicals, living organisms</td>
<td>Do not dispose of these materials in the sink or trash can.</td>
<td>Dispose of wastes as directed by your teacher.</td>
</tr>
<tr>
<td>BIOLOGICAL</td>
<td>Organisms or other biological materials that might be harmful to humans</td>
<td>bacteria, fungi, blood, unreserved tissues, plant materials</td>
<td>Avoid skin contact with these materials. Wear mask or gloves.</td>
<td>Notify your teacher if you suspect contact with material. Wash hands thoroughly.</td>
</tr>
<tr>
<td>EXTREME TEMPERATURE</td>
<td>Objects that can burn skin by being too cold or too hot</td>
<td>boiling liquids, hot plates, dry ice, liquid nitrogen</td>
<td>Use proper protection when handling.</td>
<td>Go to your teacher for first aid.</td>
</tr>
<tr>
<td>SHARP OBJECT</td>
<td>Use of tools or glassware that can easily puncture or slice skin</td>
<td>razor blades, pins, scalpels, pointed tools, dissecting probes, broken glass</td>
<td>Practice common-sense behavior and follow guidelines for use of the tool.</td>
<td>Go to your teacher for first aid.</td>
</tr>
<tr>
<td>FUME</td>
<td>Possible danger to respiratory tract from fumes</td>
<td>ammonia, acetone, nail polish remover, heated sulfur, moth balls</td>
<td>Make sure there is good ventilation. Never smell fumes directly. Wear a mask.</td>
<td>Leave foul area and notify your teacher immediately.</td>
</tr>
<tr>
<td>ELECTRICAL</td>
<td>Possible danger from electrical shock or burn</td>
<td>improper grounding, liquid spills, short circuits, exposed wires</td>
<td>Double-check setup with teacher. Check condition of wires and apparatus.</td>
<td>Do not attempt to fix electrical problems. Notify your teacher immediately.</td>
</tr>
<tr>
<td>IRRITANT</td>
<td>Substances that can irritate the skin or mucous membranes of the respiratory tract</td>
<td>pollen, moth balls, steel wool, fiberglass, potassium permanganate</td>
<td>Wear dust mask and gloves. Practice extra care when handling these materials.</td>
<td>Go to your teacher for first aid.</td>
</tr>
<tr>
<td>CHEMICAL</td>
<td>Chemicals that can react with and destroy tissue and other materials</td>
<td>bleaches such as hydrogen peroxide; acids such as sulfuric acid, hydrochloric acid; bases such as ammonia, sodium hydroxide</td>
<td>Wear goggles, gloves, and an apron.</td>
<td>Immediately flush the affected area with water and notify your teacher.</td>
</tr>
<tr>
<td>TOXIC</td>
<td>Substance may be poisonous if touched, inhaled, or swallowed.</td>
<td>mercury, many metal compounds, iodine, poinsettia plant parts</td>
<td>Follow your teacher’s instructions.</td>
<td>Always wash hands thoroughly after use. Go to your teacher for first aid.</td>
</tr>
<tr>
<td>FLAMMABLE</td>
<td>Open flame may ignite flammable chemicals, loose clothing, or hair.</td>
<td>alcohol, kerosene, potassium permanganate, hair, clothing</td>
<td>Avoid open flames and heat when using flammable chemicals.</td>
<td>Notify your teacher immediately. Use fire safety equipment if applicable.</td>
</tr>
<tr>
<td>OPEN FLAME</td>
<td>Open flame in use, may cause fire.</td>
<td>hair, clothing, paper, synthetic materials</td>
<td>Tie back hair and loose clothing. Follow teacher’s instructions on lighting and extinguishing flames.</td>
<td>Always wash hands thoroughly after use. Go to your teacher for first aid.</td>
</tr>
</tbody>
</table>

Eye Safety
Proper eye protection should be worn at all times by anyone performing or observing science activities.

Clothing Protection
This symbol appears when substances could stain or burn clothing.

Animal Safety
This symbol appears when safety of animals and students must be ensured.

Radioactivity
This symbol appears when radioactive materials are used.

Handwashing
After the lab, wash hands with soap and water before removing goggles.
Activity 1
What is inquiry?

Inquiry activities may be structured, guided, or exploratory. During a structured activity, you follow instructions and observe the results. In a guided activity, you are given a problem or question. Then, you work with other students to determine a process for solving that problem. Exploratory activities allow you to investigate a topic in any way you choose. You will use each of these methods to explore how food scraps and leaves decompose.

Possible Materials

<table>
<thead>
<tr>
<th>Everyday Materials</th>
<th>Lab Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>• dry soil</td>
<td>• distilled water</td>
</tr>
<tr>
<td>• small slices of banana peel, apple peel, and potato</td>
<td>• thermometer</td>
</tr>
<tr>
<td>• plastic wrap</td>
<td>• goggles</td>
</tr>
<tr>
<td>• rubber bands</td>
<td>• protective gloves</td>
</tr>
<tr>
<td>• newspaper</td>
<td>• mask</td>
</tr>
</tbody>
</table>

Background

Food scraps, grass clippings, leaves, and paper can decompose into useful organic waste. One way to decompose these items is to combine them into a compost pile. Properties of a compost pile aid decomposition. Brainstorm some factors that might help the items above decompose.

Question

How do properties of the compost pile affect the rate of decomposition?

Form a Hypothesis

Think about what you already know about decomposition in a compost pile. Now, make a hypothesis to answer the question above. Write your hypothesis in your Science Journal.

Safety

Always wear goggles, gloves, and a mask when handling decomposing material.

Do not use meat or dairy products in any of your experiments.

Test Your Hypothesis

Part 1: Structured Inquiry—Does moisture affect the decomposition of food scraps?

1. Fill two large beakers or jars with dry soil. Use a wax pencil to label one beaker Moist and the other Dry.

2. Obtain small slices of banana peel, apple peel, and potato from your teacher. You will need two of each type of food scrap. Copy the data table on page 9, and record the initial appearance of the food scraps.

3. Place one of each type of food scrap into each beaker. Cover the food scraps with 2 cm. of soil.

4. Slowly pour 100 mL of water into the beaker labeled Moist. Cover both beakers with plastic wrap held tight with rubber bands. Place the beakers in a dark, warm location.
What is inquiry? continued

5. After one day, remove the plastic wrap. Pour the contents of the beaker onto cardboard and record the appearance of the food scraps in your data table. Be sure to wear protective goggles, gloves, and a mask while handling the food scraps.

6. Place the food scraps and soil back in the beakers. Add 10 mL of water into the beaker labeled Moist. Replace the plastic covering on the beakers and put the beakers back in the dark, warm location. Wash hands thoroughly after science activities.

7. Repeat steps 5 and 6 every day for a week. Afterward, dispose of the materials as directed by your teacher.

Part 2: Guided Inquiry—Do all leaves decompose at the same rate?

1. Discuss decomposition of leaves with your lab partner. Recall times when you have seen decomposing leaves. What did the leaves look like? Did some leaves seem to decompose faster than others? Write your hypothesis.

2. Work with your partner to design an experiment to test your hypothesis. Use a variety of leaves in your study, including deciduous leaves and evergreen leaves. Include leaves from the ground as well as leaves from trees. Make a list of the different materials you will need for your lab. Think about how you will make your observations. Create a data table for recording your observations and measurements. In your plan, be sure to include any necessary safety measures.

3. Have your teacher approve your plan before you begin.

4. Gather the materials you need for your lab.

5. Carry out your investigation according to your plan.

Part 3: Exploratory Inquiry—How does the rate of decomposition in a compost pile depend on its properties?

1. Think about other properties you brainstormed at the beginning of the lab. Are there any properties you could investigate for their effect on decomposition? Are there other tests you could perform to explore the effects of moisture? Remember to limit your variables when designing your experiment.

2. Make a list of possible experiments you could conduct. Think about whether the materials required are easily available. How long would each experiment take to complete?

3. Work with your lab partner to choose an experiment from your list. Write out the steps that you will follow, and include a list of materials and a data table for recording your observations and measurements. In your plan, be sure to include any necessary safety measures.

4. Have your teacher approve the plan for your experiment.

5. Gather the supplies you need for your investigation. Perform the experiment according to your plan.
Interpret Your Data

1. Look at the observations that you made for Part 1, the effect of moisture on decomposition of food scraps. Describe how the appearance of the food scraps in dry soil and moist soil changed throughout the week.

2. What variable did you test in Part 2? How does that variable relate to the rate of decomposition?

3. Look at the data that you collected for Parts 2 and 3. If possible, make a graph using your data. Remember that the independent variable (the factors you changed) will be on the $x$-axis, and the dependent variable (your observations) will be on the $y$-axis.
Conclude and Apply

1. How did moisture affect the rate of decomposition of the food scraps you tested in Part 1?

2. Would making the soil in Part 1 very wet increase the rate of decomposition? Design an experiment to test your hypothesis.

3. Write a conclusion about how the property of compost piles that you tested in Part 3 affects the rate of decomposition.

4. Discuss the results you obtained in Part 3 with your classmates. Compare the different properties each group in your class tested. Draw conclusions about the best conditions for a compost pile.

5. Explain how an exploratory activity, such as the one you performed in Part 3, allows you to investigate a topic in more depth.

Going Further
Look back at the procedures that you used in Part 3. How could you improve your design?
## Activity 2

### Monitoring a Plankton Bloom

Plankton are organisms that are found in both freshwater and marine ecosystems. The word *plankton* is derived from the Greek word *planktos*, which means “wandering.” Plankton do not have the ability to move against water currents. Plankton drift with existing water movements. Phytoplankton, such as diatoms and dinoflagellates, are primary producers that use carbon dioxide, nutrients, and light to make food. Zooplankton, such as the copepod (copepods are small crustaceans that are usually shorter than 1 mm) shown below, are free-floating animals that feed on phytoplankton.

![Figure 1](image)

<table>
<thead>
<tr>
<th><strong>Possible Materials</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Everyday Materials</strong></td>
</tr>
<tr>
<td>• nylon stocking</td>
</tr>
<tr>
<td>• scissors</td>
</tr>
<tr>
<td>• small plastic container with lip on the top</td>
</tr>
<tr>
<td>• heavy-duty string</td>
</tr>
<tr>
<td>• rubber band</td>
</tr>
<tr>
<td>• plastic tie</td>
</tr>
<tr>
<td>• wire/wire hanger</td>
</tr>
<tr>
<td>• wire cutter</td>
</tr>
<tr>
<td>• pliers</td>
</tr>
<tr>
<td>• thread</td>
</tr>
<tr>
<td>• needle</td>
</tr>
<tr>
<td>• stapler</td>
</tr>
<tr>
<td>• watch</td>
</tr>
<tr>
<td>• medium-size plastic container with lid</td>
</tr>
<tr>
<td>• tap water</td>
</tr>
<tr>
<td>• heavy-duty tape (duct or mailing tape)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Lab Materials</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• thermometer</td>
</tr>
<tr>
<td>• pH test strips</td>
</tr>
<tr>
<td>• nitrate test kit</td>
</tr>
<tr>
<td>• phosphate test kit</td>
</tr>
<tr>
<td>• rubbing alcohol</td>
</tr>
<tr>
<td>• compound microscope</td>
</tr>
<tr>
<td>• heavy-duty tape</td>
</tr>
<tr>
<td>• microscope slide/depression slide</td>
</tr>
<tr>
<td>• coverslip</td>
</tr>
<tr>
<td>• references for phytoplankton and zooplankton identification</td>
</tr>
<tr>
<td>• 1-mL pipette</td>
</tr>
</tbody>
</table>

### Background

In temperate regions, seasonal cycles cause changes in the water temperature of lakes and ponds. These changes lead to mixing between surface water and deeper layers of water. This process of mixing, which occurs in both the spring and the fall, is known as turnover. Brainstorm factors that might be present in surface water, deeper waters, or both, that might affect plankton populations and growth.
Monitoring a Plankton Bloom, continued

Plankton Cycles  Plankton exhibit a seasonal cycle that can be monitored using a variety of tools. These tools reveal information about the biological, chemical, and physical characteristics of the water. Plankton cycles are affected by both abiotic and biotic factors, including water temperature, light intensity, nutrient concentrations, and predator-prey relationships. High nutrient concentrations and increasing light intensity in the spring help phytoplankton flourish, resulting in a plankton bloom. Zooplankton populations also will increase after a lag period. To a lesser extent, this process is repeated in the fall, but a fall bloom is usually smaller than a spring bloom because of the decreasing intensity of light.

Collecting Plankton  Plankton blooms can be monitored by collecting plankton samples with a plankton net. A plankton net, shown in Figure 2, consists of fine-mesh netting with a collecting cup on one end and a towline on the other end. Acting like a filter, it is pulled through the water. Water passes through the mesh netting, but any organisms larger than the size of the mesh will be collected in the sampling cup. The sample is then analyzed under a microscope and the numbers and types of organisms can be determined. Other measurements, such as water temperature, pH, nitrate and phosphate concentrations, and oxygen concentrations, can be taken as well. In this activity you will construct a plankton net. You will use your net to monitor a fall or spring plankton bloom in a nearby area of water by doing a plankton tow once a week for at least six weeks or longer, if possible.

Safety

Wash hands immediately after collecting a sample or working in the laboratory. Do not drink any of the water that you collected. Dress appropriately and wear a personal flotation device if necessary. Use caution while collecting samples. Use all laboratory materials appropriately.

Test Your Hypothesis

1. Think about the materials that have been provided for you. How will you test your hypothesis?

2. Make a list of the steps you will take to monitor a plankton bloom. There are several stages to consider. First, you will have to construct your own plankton net to use for sampling. Think about how you will use the materials provided to make a plankton net. How will you ensure that it will be structurally strong?

3. Construct your plankton net. Use Figure 2 as a reference.

4. Using your knowledge of plankton, make a list of steps you will follow to monitor a plankton bloom.
   - Consider the variables in your experiment.
   - How will you ensure the quality of your data as you make your collections?
Consider how variations in the following could affect your data:

- method by which sample is collected
  (For example: will you have to drag the net through still water, or will the current be strong enough to allow you to hold the net in one place while water passes through it?)
- length of time of plankton tow
- time of day sample is collected
- exact location sample is taken

5. After you collect your data and complete your plankton tow each week, how will you store your sample? Consider the length of time between collection and viewing under the microscope.

Plankton only live for about 24 hours. Store the plankton in the refrigerator or preserve them by adding one part 70% isopropyl alcohol to six parts of water. CAUTION: Keep all sources of ignition away from the alcohol.

6. How will you make an accurate count of the organisms in your sample? How will you identify whether an organism is zooplankton or phytoplankton?

7. How will you clean and store your net between uses? Does your net need to be repaired or reconstructed?

8. Read the MSDSs in the test kits and follow the safety guidelines. Review your plan with your teacher before you proceed with each step.

### Interpret Your Data

1. On graph paper, construct graphs that show how the variables of water temperature, pH, nitrate and phosphate concentrations, and the average number of phytoplankton and zooplankton changed over the weeks of sampling. You should also make graphs showing time (week 1, week 2, and so on) on the x-axis and the number of phytoplankton and zooplankton on the y-axis.

2. Analyze your graphs. How do the seasonal changes correlate to the changes in the number of plankton you collected? Is there a correlation between any other data collected and the number of plankton?
Conclude and Apply

1. Do your data support your hypothesis? Explain why or why not.

2. Compare your data to those of your classmates. Are there any differences? What could account for these differences?

3. Explain the relationship between seasonal changes and plankton blooms. How are the concentrations of nitrate and phosphate related to plankton blooms?

4. Predict how nitrates and phosphates from runoff could affect a plankton bloom.

Going Further
If you were to do this project again, how would you improve your methods? What additional studies could be conducted?
Plasma Membranes

The plasma membrane of a cell maintains the structure of the cell by enclosing the cell’s organelles. It also controls which molecules may enter and leave the cells. In this activity, you will investigate how environmental changes may affect plasma membranes.

Background
Under normal conditions, the plasma membrane protects the cell contents and controls which substances enter and leave the cell. Changes in the environment may alter the structure of the plasma membrane. Brainstorm some environmental changes that might affect the plasma membrane. How might these changes affect the cell?

Question
How can environmental changes affect the plasma membranes of a cell?

Form a Hypothesis
Think about what you already know about plasma membranes. Now, make a hypothesis to answer the question above. Write your hypothesis in your Science Journal.

Safety
Wash your hands thoroughly after handling plant material. Be sure not to eat or drink any substances in a lab. Handle glass objects carefully and report any breaks to your teacher immediately.

Test Your Hypothesis
1. Work with your lab partners to make a list of ways that environmental factors can affect plasma membranes. For example, orange crops may be lost when freezing temperatures cause water in the plants to form ice crystals that rupture the plasma membranes.
2. What environmental factors can you test? Consider variables that are both naturally occurring and those that are of human origin. How could you recreate these factors in the lab?

3. One method you might use to study the environmental effects on plasma membranes uses beet roots. Beet cells contain a red chemical. If the plasma membranes are altered or damaged, the red coloring will escape. You can also observe effects on the plasma membranes by looking at yeast cells under a microscope. The chemical stain Congo red normally can’t penetrate the membrane of yeast cells. If a solution of yeast cells is stained with Congo red, the cytoplasm will remain clear. However, if the plasma membranes are damaged, the stain will enter the cell and the cytoplasm will appear red.

4. Decide with your lab partner which environmental condition you wish to investigate. Also decide which method you think is best for studying the effect that a change in an environmental condition would have on plasma membranes.

5. Make a list of the steps that you will follow for your investigation. Have your teacher approve your plan.

6. Discuss with your partner how you think your environmental change will affect the plasma membranes you test. Based on the environmental condition you have decided to test, restate your hypothesis below:

   Prediction: ______________________

   ______________________

7. Carry out your investigation. You may wish to use a data table similar to the one below. If possible, create a graph of your data.

<table>
<thead>
<tr>
<th>Environmental Condition (variable)</th>
<th>Observations/Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Interpret Your Data**

1. Describe the environmental condition that you changed.
2. Explain the procedure you used to test this environmental change.

3. Using the data table(s) you prepared, describe any changes you observed or measured during your investigation.

4. Describe any problems you may have encountered during your investigation. Did this affect your results? If so, explain how.

**Conclude and Apply**

1. Review your data table. Write a statement that summarizes your results. What other questions do you have?

2. Compare your results to those of other groups in your class. Describe other investigations that could be made about environmental effects on plasma membranes.
3. The investigations made by you and your class involved only one or a few types of cells. Do you think your results can be extended to other types of plasma membranes as well? Explain why or why not.

Going Further
Describe a way that your investigation or the investigation of another group could be applied to an everyday situation.
Predicting the Traits of Offspring

Children resemble their parents because genes are passed from generation to generation. By examining the traits of a family, you can predict which traits will most likely occur in the offspring. In this activity, you will investigate how traits can be predicted.

**Background**

Traits can be either learned or inherited. Learned traits are acquired throughout our lives. Inherited traits are determined by genes encoded on DNA in cells. Genes have two or more versions called alleles. One allele might be dominant and the other might be recessive. A child might show a trait that is not seen in either parent because the child has two recessive alleles for that trait. Make a list of human traits that are learned and a list of those that are inherited.

**Question**

How do parents’ traits affect those of their offspring?

**Form a Hypothesis**

Think about your current knowledge of inherited traits. Now, make a hypothesis to answer the question above. Write your hypothesis in your Science Journal.

**Figure 1**

```
B b
b B
```

- = Male
- = Female
B = Brown eyes
b = Blue eyes

**Safe

Safety**

If you are working with plants, be sure to wash your hands thoroughly after handling plants, fertilizer, or other related materials.

**Test Your Hypothesis**

1. Discuss with your lab partners ways that you could investigate inherited traits. You might want to examine your traits, traits of a family pet, or traits of a plant.
2. After choosing a person, animal, or plant to study, you should consider from where the traits were inherited. For example, if you choose to examine the traits of a student, you should be able to examine the traits of the student’s parents, grandparents, and other family members. If you choose a pet, you...
Predicting the Traits of Offspring, continued

should be able to examine both your pet’s parents and grandparents, as well as its brothers or sisters.

3. Work with your lab partners to write a list of steps that you will follow for your inquiry.

4. Make a list of the traits that you want to study. Remember that some traits are learned and some are inherited. For this inquiry activity, you will consider only inherited traits.

5. Have your teacher approve your plan before you begin.

6. Carry out your inquiry according to your plan. When studying the traits of people, plants, or animals, you should complete pedigrees similar to the one in Figure 1. You might also need to prepare a trait survey form similar to the one shown below. How would you create a survey for something like eye color?

<table>
<thead>
<tr>
<th>Trait Survey Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trait A</td>
</tr>
<tr>
<td>___ yes</td>
</tr>
<tr>
<td>___ no</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trait D</th>
</tr>
</thead>
<tbody>
<tr>
<td>___ yes</td>
</tr>
<tr>
<td>___ no</td>
</tr>
</tbody>
</table>

Interpret Your Data

1. Look at the trait survey forms that you completed. Note any trends in how the traits are passed on.

2. Draw a pedigree for each trait.
3. Look at the pedigrees that you drew. Which traits occurred most often? Which traits skipped a generation?

4. What percentage of the people, animals, or plants that you studied had the same form of a specific trait? Calculate the percentage by dividing the number of subjects with the same form of the trait by the total number of subjects.

Conclude and Apply

1. Based on your survey, describe the possible forms that occurred for each trait on your list. What is the probability that each trait will be passed on to the next generation?

2. Compare the results of your inquiry with those of other groups in your class. Based on what you learned, do you feel that it is possible to make a good prediction about the traits a new offspring will have if you know the traits of its recent ancestors? Explain why or why not.
Going Further
What do you think was the greatest limitation in your study of inherited traits? What are some ways that you could overcome this limitation in future studies? What are some additional studies that could be conducted?
**Activity 5**

**Discovering Your Learning Style**

Do you often repeat your notes aloud to yourself while studying? You might be an auditory learner. Do you take frequent breaks to get up and move around while studying? You might be a kinesthetic learner. Do you usually form a mental picture of the information that you are trying to remember? You might be a visual learner.

**Background**

How people process and remember incoming information has been a topic of study for many years in the fields of education and psychology. There are several theories or models that exist to help explain how people analyze and catalog new information. One theory of learning style is based on the idea that people interpret and remember information using three modes—auditory or hearing, visual or seeing, and kinesthetic/tactile or moving/touching. Most people use all three modes to process information; however, for many, one mode might be stronger than the other two. For example, some people might find it is easiest to learn new material by hearing it and then repeating it back to themselves. They might find it harder to process new information by just reading the material. People who are strongly kinesthetic might find it is easier to remember if they are moving while they learn. A strongly visual person might prefer to use flash cards or charts and graphs to help him or her learn and remember new information.

**Question**

What type of learning style(s) do you use?

**Form a Hypothesis**

Think about how you learn information in the classroom and as you study. Now, make a hypothesis to answer the question above. Write your hypothesis in your Science Journal.

**Safety**

Use all laboratory materials appropriately.

**Possible Materials**

**Everyday Materials**
- white index cards
- colored index cards
- highlighters
- colored pens or pencils

**Visual Materials**
- table of random numbers
- common household or classroom objects
- tray
- two CDs or tapes of different music

**Audio Materials**
- tape player or CD player with headphones
- dictionary
- stopwatch/watch or clock with a second hand

**Test Your Hypothesis**

1. Think about the materials that have been provided for you. Discuss with your lab partner(s) how you will test your hypothesis.

2. Think about the three types of learning listed in the introduction—visual, auditory, and kinesthetic. Design three separate experiments to test each type of learning. Consider how to set up a control for each experiment. Identify what the independent and dependent variables for each experiment will be. The experiments should be designed in such a way that the data from each should be able to be compared to the other two.
Discovering Your Learning Style, continued

3. Here is some additional information that might help you design your experiments.
   a. Visual learners often need to see the material that they are trying to learn in order to feel as though they understand it. They are encouraged to study using brightly colored flash cards to highlight important points while reading and to rewrite notes in brightly colored ink. Visual learners might learn better if they can create a drawing of a concept. They might be distracted by background movements while trying to concentrate.
   b. Auditory learners often need to repeat aloud information that they are trying to learn. They might put information into a song or rhyme to help them remember it better. They might be distracted by background noise while trying to learn.
   c. Kinesthetic learners may remember best when learning is accompanied by some kind of motion such as pacing, exercising, or even standing. They might also benefit from being able to touch any materials that are involved in learning a concept. They often learn best by physically participating in the activity.

4. Have your teacher approve your plan before you begin.

Possible Procedure

1. To test the auditory mode, create a set of index cards that has 12 random numbers (or a list of letters or words) on each card. Have one partner read the numbers in a neutral tone at one-second intervals. Repeat the reading process two more times. The subject has 30 s to repeat as many numbers as possible in the correct order. Calculate and record the percent value of how many numbers the subject can repeat in the correct order. This can be done under three different experimental conditions: a quiet background, a background of fast paced dance music with words, and a background of relaxation music with no words.

2. To test the visual mode, consider using some combination of the white and colored index cards and the highlighters and/or colored pens and pencils to present the numbers/words/letters.

3. To test the kinesthetic mode, use the same presentation that was used by the auditory mode except, this time, the three experimental conditions will be to have the subject sit still in a chair, then stand, and finally, pace the room.

4. Another experiment that can be done to test all three modes involves using a tray or list of at least 12 common objects. The visual mode can be tested by having the subject observe the tray for 30 s then removing the tray from sight and recording how many objects the subject can name correctly.
Activity 5  Discovering Your Learning Style, continued

The auditory mode can be tested by reading a list of similar objects and recording how many the subject can recall. The kinesthetic mode can be tested by allowing the subject to touch the items on the tray, then removing the tray from view, and recording how many items the subject can recall. Use a different set of items for each portion of the experiment and calculate the percent of objects that the subject was able to recall correctly.

Object Recall

<table>
<thead>
<tr>
<th>Experimental Condition</th>
<th>Percent of Objects Recalled Correctly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Looking</td>
<td></td>
</tr>
<tr>
<td>Listening</td>
<td></td>
</tr>
<tr>
<td>Touching</td>
<td></td>
</tr>
</tbody>
</table>

Interpret Your Data

1. Construct graphs that allow you to compare data collected from each experiment.

2. Is your hypothesis supported by the data? Why or why not?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Conclude and Apply

1. What conclusion can you reach about your learning style?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

2. What factors other than learning style could affect the outcome of the experiment?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

3. How can you use what you discovered about your learning styles to your advantage?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

4. Do you think the learning style you identified in this experiment is always the primary way you learn? Why or why not?

________________________________________________________________________

________________________________________________________________________

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________________________________________________________________________

Going Further

Design an experiment that will allow you to further refine your understanding of learning styles.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Activity 6

Plant Adaptations

All living things have traits known as adaptations that enable them to survive in their particular environment. In this activity, you will investigate whether a plant’s adaptations will allow it to survive in other environments also.

Background

Plants have certain adaptations that make them well suited for the environments in which they live. You can easily identify the differences between plants that live on land and plants that live in water. Aquatic plants have little strengthening tissues in their stems; their smaller root systems are for anchorage only. Why do you think aquatic plants have these adaptations? Plants that live in different terrestrial environments have different adaptations based on the characteristics of their environments, too. With a partner, brainstorm three different plants (aquatic and/or terrestrial) and list some different characteristics they have that allow them to thrive in those environments.

Question

Will a plant’s adaptations allow it to survive in a different environment?

Form a Hypothesis

Think about what you already know about plant adaptations. Now, make a hypothesis to answer the question above. Write your hypothesis in your Science Journal.

Test Your Hypothesis

1. Choose a plant from the aquatic plants, desert plants, and houseplants your teacher has provided.

Safety

Wash your hands thoroughly after handling plant material. Be careful when handling glass objects.

Possible Materials

<table>
<thead>
<tr>
<th>Everyday Materials</th>
<th>Lab Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>houseplants</td>
<td>aquatic plants</td>
</tr>
<tr>
<td>soil</td>
<td>desert plants</td>
</tr>
<tr>
<td>sand</td>
<td>aquarium or large, clear container</td>
</tr>
</tbody>
</table>

|                     |               |
|                     | small pots or polystyrene cups |
|                     | 200-watt lamp |
|                     | microscope |
|                     | microscope slides |
2. Discuss with your lab partners the type of environment for which your plant is best suited. Use reference materials to find information about your plant.

3. Observe the characteristics of your plant that you can see without harming it. Are its leaves large or small? What type of stem does it have? What adaptations can you observe that allow your plant to live in its natural environment? Are there other adaptations that you might be able to see with a microscope?

4. What effect would there be on your plant if you placed it in a different environment? Decide with your lab partners which environment you would like to provide for your plant.

5. Look at the list of materials provided for this activity. How can you use these or other materials to create the different environment? Write a plan for your investigation. Remember to include details about how long your investigation will last, how you will care for your plant, and what observations you will make.

6. Have your teacher approve your plan before you begin.

7. Carry out your investigation according to your plan. Record daily observations about your plant. You may wish to use an observation table like the one shown below. Write your prediction for how your plant will react to its new environment in the observation table.

8. At the end of the observation period, use a hand lens to look at the plant’s roots. Consider how long they are and their appearance. Next, cut apart the plant’s stem and view its cells using a microscope. Make notes on any adaptations visible from these observations.

**Data Table**

<table>
<thead>
<tr>
<th>Type of Plant</th>
<th>Normal Environment</th>
<th>Characteristics</th>
<th>New Environment</th>
<th>Predict how well your plant will survive in its new environment.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Day</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
Interpret Your Data

1. Which type of plant did you study, and what is its natural environment?

2. Name some characteristics of your plant that you feel are important adaptations enabling it to live in its natural environment.

3. Describe the new environment that you provided for your plant.

4. Explain how you cared for your plant.

5. Review the chart you made for observing your plant in its new environment. Did your plant survive well in this environment? Explain.

6. Did you prove or disprove your hypothesis? Explain.
Conclude and Apply

1. Think about your plant's adaptations and how these adaptations enable the plant to survive in its natural environment. Explain how each of these adaptations either helped or hurt the plant in its new environment.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

2. Compare your results with those of your classmates. Write a general statement that describes the class results.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

Going Further

Create a computer graphics presentation describing your experiment. If possible, include photographs showing the condition of your plant. Be sure to summarize your results.
Effects of Ozone Depletion

Earth’s atmosphere consists of many different gases, one of which is ozone. Ozone gas is formed as ultraviolet light from the sun breaks apart oxygen molecules into single oxygen atoms. These single oxygen atoms combine with molecules of oxygen to form ozone (O₃). Although ozone exists in small quantities high in Earth’s atmosphere, it plays a vital role in protecting Earth’s surface from harmful ultraviolet (UV) radiation, particularly UVB and UVC radiation.

Background
When substances such as chlorofluorocarbons (CFCs) and halons reach the stratosphere, they can destroy ozone. These gases were once used in the coolant systems of refrigerators and air conditioners as well as the manufacture of aerosol cans and fire extinguishers. Other, natural processes, such as volcanic eruptions that release aerosols into the atmosphere, can also destroy ozone. Satellite measurements of the total atmospheric ozone during the years 1974 to 1993 show an average global decrease in total ozone of about 2% per decade. The eruption of Mt. Pinatubo in the Phillipines in 1991 also had an effect on atmospheric ozone. The aerosols produced by the eruption caused a short-term decrease in globally averaged ozone by about 6% over the years 1991 to 1994. As a result of this decreased ozone coverage, more UVB radiation is reaching Earth’s surface. The Environmental Protection Agency estimates that each percent of ozone reduction results in a 1.5% to 2% increase in the amount of UVB radiation reaching Earth’s surface.

The medium-length waves of UVB radiation are known to cause damage to DNA that can result in skin cancer in humans and other animals. Exposure to UVB radiation can also increase the risk of cataract development and aggravate certain skin conditions. Immune system function may decrease.

If exposure to UVB radiation can pose a threat to humans and animals, what impacts might it have on plants? Brainstorm some ways you think plants might be impacted by increased exposure to UVB rays. Why might they experience these results? Don’t forget to include both terrestrial and aquatic plants.

Question
What effect does UVB radiation have on terrestrial plants?

Form a Hypothesis
Think about what you already know about UVB radiation. Now, form a hypothesis to answer the question above. Write your hypothesis in your Science Journal.
Safety

Always wash your hands immediately after handling plant material.

Test Your Hypothesis

1. Think about the materials that have been provided for you. How will you test your hypothesis?

2. Make a list of steps that you will follow. Consider the following questions as you design your experiment:
   - How will you identify which plants are yours and which treatment they are receiving?
   - How will you care for the plants in terms of planting, watering, and fertilizing?
   - How will you control variables such as the amount of water or fertilizer given to the plants? Do you want to monitor the temperature in the area of each experimental condition?
   - Will you set up your experiment to compare plants grown in regular sunlight to those grown under a UVB shield, or to compare plants grown with no or reduced amounts of UVB to those grown with additional exposure to UVB radiation?
   - How will you monitor the effects of UVB radiation on the plants? How will you measure growth rate? Through stem height? Number of leaves? Changes in morphology of plant/leaves? Size/length of leaves?
   - Consider measuring the total biomass of each plant at the termination of your experiment. What steps will be involved in measuring plant biomass?
   - What other observations such as leaf color, texture, or general appearance of the plant might be important?
   - Depending on the number of seeds provided to you, you could extend your experiment to determine at which point in the plant’s development the exposure to UVB radiation has the most effect—as a seedling, after germination/sprouting, or after the plant matures.
   - You could also consider extending your experiment to see if there is any interaction between increased exposure to UVB radiation and herbivore activity or disease vulnerability in the plants.
3. Review your plan with your teacher. Carry out your investigation. Keep in mind that you must carefully control for other variables in this experiment, such as temperature, moisture, soil type, and nutrients. Slight differences in any of these variables could greatly affect your results. Take careful measurements and notes about the growth and appearance of your plants. You may want to use a table, like the data table below, to help you organize your data.

### Data Table

<table>
<thead>
<tr>
<th>Week 1</th>
<th>Stem Length (mm)</th>
<th>Number of Leaves</th>
<th>Size of Leaves (mm)</th>
<th>Leaf Morphology</th>
<th>Leaf Color</th>
<th>General Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental Condition = Sunlight</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species A</td>
<td>Plant 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species B</td>
<td>Plant 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Experimental Condition = Sunlight Plus UVB Lamp</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species A</td>
<td>Plant 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species B</td>
<td>Plant 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Experimental Condition = Mesh Screen</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species A</td>
<td>Plant 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species B</td>
<td>Plant 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Interpret Your Data

1. Organize your data by making several graphs that show the differences in growth rate, leaf number, leaf size, and biomass of each plant.

2. Analyze your data. Did you prove or disprove your hypothesis? Explain.
3. Compare your data from the two species of plants grown. Did one species show more resistance to UVB radiation? What are other explanations for differences in growth between the different species?

Conclude and Apply
1. What effects can UVB light have on terrestrial plants?

2. Studies have shown that increased exposure to UVB radiation leads to decreased primary productivity in phytoplankton. Predict how this could affect all levels of the food chain in an ecosystem.

3. Describe possible solutions that could decrease the impact of increased UVB radiation on crop plants.

4. Design an experiment that would allow you to selectively breed plants that are resistant to the effects of increased exposure to UVB radiation.

Going Further
Prepare your project for presentation to another class. Include information on the current status of the ozone layer and what individuals can do to help further reduce the rate of ozone destruction.
Measuring Biodiversity

Biodiversity is defined as the total variety of life on Earth. The three levels of biodiversity are genetic diversity, species diversity, and ecosystem diversity. Genetic diversity refers to genetic differences both within and between populations. Species diversity, or the variety of species in an ecosystem, is sometimes called species richness. The variety of ecosystems on Earth, ranging from rain forests to deserts to hydrothermal vents, is referred to as ecosystem diversity. In this activity, you will focus on the species diversity of an ecosystem.

Background
Species diversity is the total number of species in an ecosystem, from familiar plants and animals to microscopic bacteria and protists. Some areas of the world, such as tropical rain forests and coral reefs, have higher species diversity than other areas do. For example, a five-square-kilometer area of rain forest in Peru contains over three times as many butterfly species than are found in the entire United States. In this lab, you will compare the species diversity of two different ecosystems in your area. You will survey small areas within each ecosystem using a quadrat similar to the one shown in Figure 1. You may choose to compare any two ecosystems in your area. Examples include a grassy park, a downtown street, a desert, a sandy beach, or a forest. You may also choose to compare any two local aquatic ecosystems, such as a small pond, a tidal pool, a stream, or a large lake.

Question
How does species diversity differ between two ecosystems in your area?

Form a Hypothesis
Think about what you already know about biodiversity and the different ecosystems in your area. Now, make a hypothesis to answer the question above. Write your hypothesis in your Science Journal.

Safety
Always wash your hands immediately after completing field or laboratory work. Wear gloves and appropriate clothing while you conduct your survey. To avoid hazards in conducting field studies, don’t reach where you can’t see. If the vegetation is higher than one foot, use a stick to check for hidden hazards ahead of you. Avoid wearing perfumed products that will attract insects. Be alert and avoid poisonous plants and animals.
Test Your Hypothesis

1. Think about the materials that have been provided for you. How will you test your hypothesis?

2. Make a list of steps that you will follow. First, you will have to choose two ecosystems in which to conduct your surveys. Then, you will have to construct your quadrat. Use Figure 1 as a basic guide for quadrat construction. How will you ensure that you are sampling an area within the ecosystem at random?

3. Once you are ready to conduct your survey, consider the following questions:
   - Will you sample the soil in each area? See Figure 2 for ideas on how to set up a soil funnel to help you further identify any organisms in the soil sample.
   - Will you be sampling any water in each area?

4. Once you have completed your list, ask your teacher to approve your plan.

5. Carry out your investigation. Take careful notes as you conduct your surveys. You might want to use a data table like the one shown below to help you organize your data and calculate species diversity.

Data Table

<table>
<thead>
<tr>
<th>Organism</th>
<th>Number of Individuals</th>
<th>Proportion of Total Organisms</th>
<th>Square of the Proportion of Total Organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Interpret Your Data

1. Calculate the biodiversity of each area surveyed using the Simpson Diversity Index.

2. Compare the Simpson Diversity Index values for the two areas that you surveyed. Which area has higher biodiversity? Do your data support your hypothesis? Explain why or why not.

Conclude and Apply

1. Compare and contrast the characteristics of the two ecosystems that you studied. How are the characteristics of each ecosystem related to the species diversity?

2. Compare your data to those of others in the class. What conclusions can be made from the similarities or differences in data?
3. Why is it important to conduct more than one survey within each ecosystem?


4. Explain why monitoring biodiversity is important.


**Going Further**
Research the influence of human activities on biodiversity. Share the results of your research with your class in the form of a multimedia presentation.
Effects of Water Quality Changes on Protists

Protists (Kingdom Protista) are an extremely diverse group of organisms. They exhibit a number of characteristics that set them apart from bacteria, plants, animals, and fungi. Protists can be one-celled organisms, like bacteria. But unlike bacteria, which are prokaryotes, protists are eukaryotes, and they can be multicellular. Many protists are too small to be seen without a magnifying lens. Others, such as slime molds and the algae that make up kelp forests, can be easily seen and may even be very large. Some protists are photosynthetic organisms, while others are heterotrophs that feed on bacteria or other protists. Living in freshwater, salt water, soil rich with decaying matter, and other moist areas, many protists use flagella, cilia, or pseudopodia to move around. Examples of protists you may be familiar with are shown in Figure 1.

Background

In freshwater ecosystems, protists are important organisms at or near the base of the food chain. Photosynthetic protists contribute to the total amount of primary production. Others provide a link between primary producers and consumers and larger, secondary consumers, such as fish.

Freshwater protists are affected by a number of variables. Freshwater protists are affected by a number of variables. Thinking about what you have learned about animals and their environments, brainstorm things that might affect a protist’s ability to survive in its environment. Why is it important that we learn this? In this activity, you will investigate the effects of water quality changes on several species of protists.

Possible Materials

<table>
<thead>
<tr>
<th>Everyday Materials</th>
<th>Lab Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>• glass jars</td>
<td>• culture media for protists</td>
</tr>
<tr>
<td>• silt/sand</td>
<td>• liquid fertilizer</td>
</tr>
<tr>
<td>• vinegar</td>
<td>• pH test strips</td>
</tr>
<tr>
<td>• hot water bath</td>
<td>• motor oil</td>
</tr>
<tr>
<td></td>
<td>• houseplant pesticide</td>
</tr>
<tr>
<td></td>
<td>• thermometer</td>
</tr>
<tr>
<td></td>
<td>• droppers</td>
</tr>
<tr>
<td></td>
<td>• protist-slowing agent</td>
</tr>
<tr>
<td></td>
<td>• microscope slides</td>
</tr>
<tr>
<td></td>
<td>• compound light microscope</td>
</tr>
</tbody>
</table>

*Euglena gracilis*
*Amoeba proteus*
*Paramecium caudatum*
*Synedra*
*Volvox globator*
*Chilomonas*
Effect of Water Quality Changes on Protists, continued

**Question**
Does a change in water quality affect protists?

**Form a Hypothesis**
Form a hypothesis to answer the question above. Write your hypothesis in your Science Journal.

**Safety**
Always wash your hands immediately after handling chemicals such as pesticides and fertilizers. Wear goggles, gloves, and appropriate clothing while you conduct your experiments using hazardous chemicals. Do not touch your face while conducting science activities.

**Test Your Hypothesis**
1. Think about the materials that have been provided for you. How will you test your hypothesis?
2. Make a list of steps that you will follow. Consider the following statements and questions as you plan your experiment:
   - Identify the independent and dependent variables of the experiment. How will you maintain a control throughout the experiment? How will you manipulate the independent variable for each experimental condition?
   - How will you monitor the number of organisms in each experimental condition? You will need an initial estimate and frequent estimates throughout the course of the experiment. How often will you determine the number of organisms? Will you return the sampled organisms to the culture after you have examined them?
   - How will you use the materials provided for you to model changes in water quality, such as the addition of nutrients, pesticides, oil, and silt; changes in pH due to acid precipitation; or increased water temperature due to thermal pollution?
3. Once you have completed your list, ask your teacher to approve your plan. Be sure to include any necessary safety measures.
4. Carry out your investigation. Make careful counts of the number of organisms for each experimental condition. You might want to organize your data in a table like the one below. Construct a similar data table for each organism used in the experiment.

**Data Table**

<table>
<thead>
<tr>
<th>Estimated Number of Organisms/mL</th>
<th>Initial</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental Condition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinegar</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutrients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pesticide</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat</td>
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Interpret Your Data

1. For each organism tested, use graph paper to make a line graph that shows how the number of organisms changed through time. Label the horizontal axis *Time (days)* and the vertical axis *Estimated Number of Organisms/mL*. Use a different color line to represent the changes through time for each experimental condition. Make a legend to identify which experimental condition each color represents.

2. Analyze your tables and graphs. Were any of the organisms affected by the changes in water quality? Which organisms were most affected? By which experimental condition? Did the results of the experiment support your hypothesis?

Conclude and Apply

1. Compare your data to those of your classmates. What additional factors were investigated? Based on the class’s pool of data, what can you conclude about the effects of water quality changes on protists?

2. Did your results prove or disprove your hypothesis? Explain. Did the class’s results prove or disprove your hypothesis? Explain.
3. Predict how changes in the protist population of a given body of water could affect other organisms.

4. Can protists be used as bioindicators of changes in water quality? Based on the results of your experiment, which organism would you choose to use as a bioindicator?

**Going Further**
Design an experiment that will allow you to determine which species of protists are useful as bioindicators.
Environmental Effects on Tadpole Upbringing

As with all organisms, the environment is critical to a tadpole’s survival as it matures into a frog. In this activity, you will investigate the best environment for raising tadpoles in captivity.

Background
The larval stage of a frog’s life is a tadpole, also known as a polliwog. Unlike a frog, a tadpole breathes through internal gills. It has no legs, and it propels itself through the water using its tail. Through metamorphosis, a tadpole matures into an adult frog. Its legs develop and, as it grows lungs for breathing out of water, its gills disappear. A tadpole usually eats only plants, but as it transforms into a frog, its digestive system changes, allowing it to eat insects and other small animals.

The successful development of a tadpole depends on its environment. A tadpole needs freshwater, mild temperatures, and the proper amount and type of food. The length of time required for a tadpole to change into a frog varies depending on the species and the tadpole’s environment.

Question
What is the best environment for raising tadpoles in captivity?

Form a Hypothesis
Think about what you already know about tadpoles. Now, make a hypothesis to answer the question above. Write your hypothesis in your Science Journal.

Safety
Ask your teacher about proper procedures for handling tadpoles before beginning the activity. Wash your hands thoroughly after handling the plants, water, or tadpoles. Exercise extra caution if your investigation requires the use of a light source near the tadpole habitat. Do not let water splash on hot lightbulbs.
Test Your Hypothesis

1. Before beginning this project, research tadpoles to learn about proper care and feeding. Contact local wildlife experts and ask about regulations regarding obtaining tadpoles and releasing frogs into ponds. Talk with your teacher about where you will obtain the tadpoles and what will happen to the tadpoles or frogs when the project is completed.

2. For this inquiry activity, you will examine the best conditions for raising tadpoles in captivity. Discuss with your lab partners which variable you want to investigate, and which conditions you want to keep constant. You might want to consider the temperature, food, lighting, or number of tadpoles kept in a container.

3. Make a list of the steps you will follow in your investigation. Think about what properties you will observe when determining the tadpoles’ response to various environmental conditions. How long will you observe your tadpoles? Remember that you must use a control group in your investigation. In your plan, be sure to include any necessary safety measures.

4. Have your teacher approve your plan for the activity.

5. Prepare the habitats that you will use for your tadpoles. Be sure to vary only one condition of the environment. When the habitats are ready, obtain the tadpoles according to your teacher’s instructions. In your Science Journal, note any differences you find in the tadpoles, for example, species or size. At the end of the experiment, you may want to examine any such differences in relation to your findings.

6. Carry out the investigation of the tadpole’s environment. Record your observations carefully. You might want to use a table like the data table below.

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<tr>
<th>Date</th>
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Interpret Your Data

1. How did the condition of the control group of tadpoles change throughout your investigation?

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2. How did the condition of your experimental group of tadpoles change throughout your investigation?

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3. Did any unplanned events occur during your investigation that might have affected your results? If so, what were they?

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4. Make a Venn diagram below comparing changes in the overall conditions of your control group and your experimental group.
Conclude and Apply

1. Compare and contrast how the conditions of your control group and your experimental group changed.

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2. Which group seemed to thrive better? Explain.

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3. Summarize the results of your investigation.

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4. If you could extend or repeat your investigation, what would you do? Why?

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5. Look over the results obtained by other groups in your classroom. Compare your group’s results to those of the other groups. Write a summary of what you think are the best environmental conditions for raising tadpoles in captivity.

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Going Further

Use computer graphics software to prepare an instructional booklet for raising tadpoles in captivity.