Miami-Dade County Public Schools

Curriculum and Instruction (Science)

Essential Labs

(Minimum Required Laboratory Activities)

Biology

May 2007

Miami-Dade County Public Schools
giving our students the world

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Table of Contents
Biology Lab Manual

Introduction

The purpose of this packet is to provide the Biology teachers with a list of basic laboratories and hands-on activities that students in any Biology class should experience. Each activity is aligned with the Sunshine State Standards (SSS). Emphasis should be placed on those activities that are aligned to the Annually Assessed Benchmarks which are consistently assessed in the grade 11 Science Florida Comprehensive Assessment Test (FCAT).

In this lab manual you will find many variations of familiar labs that are commonly seen in Biology. These enduring concepts in Biology give the students the grasp into a further depth of knowledge in Biology than they are used to in other types of courses. It is very important to know that these labs are not meant to be done as worksheets or activities. Group activities do have a place in many topics in science, as you will note in the omission of some concepts that are not included in this packet. These labs, though, are meant to be more in-depth studies requiring the student to write full page lab reports with the formulation of hypotheses and with discussion and analysis of results.

In most cases, the activities were designed as simple as possible without the use of advanced technological equipment to make it possible for all teachers to use these activities. However, it is highly recommended that technology, such as ExploreLearning's Gizmos, and the hand-held data collection equipment from Vernier, Texas Instruments, and Pasco, is implemented in the science classrooms.

This document is intended to be used by secondary science departments in M-DCPS so that all science teachers can work together, plan together, and rotate lab materials among classrooms. Through this practice, all students and teachers will have the same opportunities to participate in these experiences and promote discourse among learners, which are the building blocks of authentic learning communities.

Acknowledgement:

M-DCPS Curriculum and Instruction (Science) would like to acknowledge the efforts of the teachers who worked arduously and diligently on the preparation of this document.

Materials

- Salt
- Cups
- Beakers
- Spoons
- Sugar
- Ruler
- Potato slices
- Baker's yeast
- 50 ml beakers (3)
- 100 ml beaker
- Scissors
- Glue or transparent tape
- 3 textbooks
- 2 coins (such as pennies)
- Green, red, blue, and yellow toothpicks
- Grassy areas
- Strips of cardboard, 38 cm x 3 cm
- Toothpicks
- Crayons
- Tape
- Modeling clay
- Colored gumdrops
- Ziploc baggies
- Small (10 mL) graduated cylinders
- Beakers or cups for straining
- Cheesecloth
- Test tubes and containers or racks to hold them
- Wood splints or disposable inoculation loops
- Strawberries
- Extraction solution (10% shampoo and a dash of salt)
- Ice cold ethanol (70% pharmacy ethanol will work)
- Microscopes
- Microscope slides
- Protist identification key
- Protist cultures (Euglena, Paramecium, Amoeba, and Stentor).
- Pipettes
- Food coloring
- Petroleum jelly
- Large leaves with narrow stems intact
- Laboratory balance
- Fan
- Bright lamp
- Spray bottle
- Preserved perch (fish)
- Preserved frog
- Dissecting tray
- Dissecting kit
- Dissecting microscope
- Paper towel
- Live goldfish
- Water from aquarium
- Fish net
- Stopwatch
- Radish seeds
- pH meter
- Vinegar
- Medicine droppers
- Petri dishes
- Filter paper
- Stethoscope
- Rubbing alcohol
- Cotton balls
- Stopwatch
- Glass-marking pencil
- Metric ruler
- Bunsen burner (or candles)
- Sterile nutrient agar plates
- Plastic/Latex gloves
- Matches
- Apron
- Sterile cotton swabs or an inoculating loop

Grade 11 Annually-Assessed Benchmarks

The following lists the seventeen Annually-Assessed Benchmarks that will be tested each year of the Grade 11 Science FCAT. It should be noted that within specific benchmarks other benchmarks are embedded and could be tested annually.

- **SC.A.1.4.3**- The student knows that a change from one phase of matter to another involves a gain or loss of energy. (Also assesses B.1.4.3)
- **SC.A.1.4.4**- The student experiments and determines that the rates of reaction among atoms and molecules depend on the concentration, pressure, and temperature of the reactants and the presence or absence of catalysts.
- **SC.A.2.4.5**- The student knows that elements are arranged into groups and families based on similarities in electron structure, and that their physical and chemical properties can be predicted.
- **SC.B.1.4.1**- The student understands how knowledge of energy is fundamental to all the scientific disciplines (e.g., the energy required for biological processes in living organisms and the energy required for the building, erosion, and rebuilding of the Earth).
- **SC.C.1.4.1**- The student knows that all motion is relative to whatever frame of reference is chosen and that there is no absolute frame of reference from which to observe all motion. (Also assesses C.1.4.2 and C.2.4.6)
- **SC.C.2.4.1**- The student knows that acceleration due to gravitational force is proportional to mass and inversely proportional to the square of the distance between the objects.
- **SC.D.1.4.1**- The student knows how climatic patterns on Earth result from an interplay of many factors (Earth's topography, its rotation on its axis, solar radiation, the transfer of heat energy where the atmosphere interfaces with lands and oceans, and wind and ocean currents).
- **SC.D.1.4.2**- The student knows that the solid crust of Earth consists of slow-moving, separate plates that float on a denser, molten layer of Earth and that these plates interact with each other, changing the Earth's surface in many ways (e.g., forming mountain ranges and rift valleys, causing earthquake and volcanic activity, and forming undersea mountains that can become ocean islands).
- **SC.D.2.4.1**- The student understands the interconnectedness of the systems on Earth and the quality of life. (Also assesses SC.G.2.4.4)
- **SC.E.1.4.1**- The student understands the relationships between events on Earth and the movements of the Earth, its moon, the other planets, and the sun. (Also assesses SC.E.1.4.2 and SC.E.1.4.3)
- **SC.F.1.4.1**- The student knows that the body processes involve specific biochemical reactions governed by biochemical principles. (Also assesses SC.F.1.4.3 and SC.F.1.4.5)
- **SC.F.2.4.3**- The student understands the mechanisms of change (e.g., mutation and natural selection) that lead to adaptations in a species and their ability to survive naturally in changing conditions and to increase species diversity. (Also assesses SC.D.1.4.4 and SC.F.1.4.2)
- **SC.G.1.4.1**- The student knows of the great diversity and interdependence of living things. (Also assesses SC.G.1.4.2)
- **SC.G.2.4.2**- The student knows that changes in a component of an ecosystem will have unpredictable effects on the entire system but that the components of the system tend to react in a way that will restore the ecosystem to its original condition. (Also assesses SC.B.1.4.5 and SC.G.2.4.5)
- **SC.H.1.4.1**- The student knows that investigations are conducted to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories. (Also assesses SC.H.1.2.1, SC.H.1.2.2, SC.H.2.4.2, SC.E.2.4.6, and SC.E.2.4.7)
- **SC.H.2.4.1**- The student knows that scientists control conditions in order to obtain evidence, but when that is not possible for practical or ethical reasons, they try to observe a wide range of natural occurrences to discern patterns.
- **SC.H.3.4.2**- The student knows that technological problems often create a demand for new scientific knowledge and that new technologies make it possible for scientists to extend their research in a way that advances science. (Also assesses SC.H.3.4.5 and SC.H.3.4.6)

Parts of a Lab Report
A Step-by-Step Checklist

A good scientist reflects on their work by writing a lab report. A lab report is a recap of what a scientist investigated. It is made up of the following parts.

Title (underlined and on the top center of the page)

Benchmarks Covered:
- Your teacher should provide this information for you. It is a summary of the main concepts that you will learn about by carrying out the experiment.

Problem Statement:
- Identify the research question/problem and state it clearly.

Potential Hypothesis (es):
- State the hypothesis carefully. Do not just guess but try to arrive at the hypothesis logically and, if appropriate, with a calculation.
- Write down your prediction as to how the independent variable will affect the dependent variable using an "if" and "then" statement.
    - If (state the independent variable) is (choose an action), then (state the dependent variable) will (choose an action).

Materials:
- Record precise details of all equipment used
    - For example: a balance weighing to +/- 0.001 g, a thermometer measuring from -10 to +110^{o}C to an accuracy of +/- 0.1^{o}C, etc.
- Record precise details of any chemicals used
    - For example: 5 g of copper (II) sulfate pentahydrate $CuSO_4 \cdot 5H_2O(s)$.

Procedure:
- Do not copy the procedures from the lab manual or handout.
- Summarize the procedures; be sure to include critical steps.
- Give accurate and concise details about the apparatus and materials used.

Variables and Control Test:
- Identify the variables in the experiment. State those over which you have control. There are three types of variables.
    1. Independent variable: (also known as the manipulated variable) the factor that can be changed by the investigator (the cause).
    2. Dependent variable: (also known as the responding variable) the observable factor of an investigation which is the result or what happened when the independent variable was changed.
    3. Constant variables: the other identified independent variables in the investigation that are kept or remain the same during the investigation.
- Identify the control test. A control lest is the separate experiment that serves as the standard for comparison to identify experimental effects, changes of the dependent variable resulting from changes made to the independent variable.

Data:

- Ensure that all data is recorded.
  - Pay particular attention to significant figures and make sure that all units are stated.
- Present your results clearly. Often it is better to use a table or a graph.
  - If using a graph, make sure that the graph has a title, both axis are labeled clearly, and that the correct scale is chosen to utilize most of the graph space.
- Record all observations.
  - Include color changes, solubility changes, whether heat was evolved or taken in, etc.

Results:

- Ensure that you have used your data correctly to produce the required result.
- Include any other errors or uncertainties which may affect the validity of your result.

Conclusion and Evaluation:

- A conclusion statement answers the following 7 questions in at least three paragraphs.
  - **First Paragraph: Introduction**
    1. What was investigated?
       a. Describe the problem.
    2. Was the hypothesis supported by the data?
       a. Compare your actual result to the expected result (either from the literature, textbook, or your hypothesis)
       b. Include a valid conclusion that relates to the initial problem or hypothesis.
    3. What were your major findings?
       a. Did the findings support or not support the hypothesis as the solution to the restated problem?
       b. Calculate the percentage error from the expected value.
  - **Middle Paragraphs: These paragraphs answer question 4 and discusses the major findings of the experiment using data.**
    4. How did your findings compare with other researchers?
       a. Compare your result to other students' results in the class.
    - The body paragraphs support the introductory paragraph by elaborating on the different pieces of information that were collected as data that either supported or did not support the original hypothesis.
    - Each finding needs its own sentence and relates back to supporting or not supporting the hypothesis.
    - The number of body paragraphs you have will depend on how many different types of data were collected. They will always refer back to the findings in the first paragraph.
  - **Last Paragraph: Conclusion**
    5. What possible explanations can you offer for your findings?
       a. Evaluate your method.
       b. State any assumptions that were made which may affect the result.
    6. What recommendations do you have for further study and for improving the experiment?
       a. Comment on the limitations of the method chosen.
       b. Suggest how the method chosen could be improved to obtain more accurate and reliable results.
    7. What are some possible applications of the experiment?
       a. How can this experiment or the findings of this experiment be used in the real world for the benefit of society?

Lab Roles and Their Descriptions

Cooperative learning activities are made up of four parts: group accountability, positive interdependence, individual responsibility, and face-to-face interaction. The key to making cooperative learning activities work successfully in the classroom is to have clearly defined tasks for all members of the group. An individual science experiment can be transformed into a cooperative learning activity by using these lab roles.

Project Director (PD)

The project director is responsible for the group.

Roles and responsibilities:

- Reads directions to the group
- Keeps group on task
- Is the only group member allowed to talk to the teacher
- Shares summary of group work and results with the class

Materials Manager (MM)

The materials manager is responsible for obtaining all necessary materials and/or equipment for the lab.

Roles and responsibilities:

- The only person allowed to be out of their seat to pick up needed materials
- Organizes materials and/or equipment in the work space
- Facilitates the use of materials during the investigation
- Assists with conducting lab procedures
- Returns all materials at the end of the lab to the designated area

Technical Manager (TM)

The technical manager is in charge of recording all data.

Roles and responsibilities:

- Records data in tables and/or graphs
- Completes conclusions and final summaries
- Assists with conducting the lab procedures
- Assists with the cleanup

Safety Director (SD)

The safety director is responsible for enforcing all safety rules and conducting the lab.

Roles and responsibilities:

- Assists the PD with keeping the group on-task
- Conducts lab procedures
- Reports any accident to the teacher
- Keeps track of time
- Assists the MM as needed.

When assigning lab groups, various factors need to be taken in consideration;

- Always assign the group members preferably trying to combine in each group a variety of skills. For example, you can place an "A" student with a "B", a "C," and a "D" or an "F" student.
- Evaluate the groups constantly and observe if they are on task and if the members of the group support each other in a positive way. Once you realize that a group is dysfunctional, re-assign the members to another group.

SAFETY CONTRACT

I will:
• Follow all instructions given by the teacher.
• Protect my eyes, face, hands, and body while participating in class activities.
• Carry out good housekeeping practices.
• Know where to get help fast.
• Know the location of the first-aid and fire fighting equipment.
• Conduct myself in a responsible manner at all times in a laboratory situation.

I, _____, have read and agree to abide by the safety regulations as set forth above and also any additional printed instructions provided by the teacher. I further agree to follow all other written and verbal instructions given in class.

Signature: _____ Date: _____

Enzyme Catalyst Lab

Benchmark:

SC.A.1.4.2 Knows that the vast diversity of the properties of materials is primarily due to variations in the forces that hold molecules together**. CS**

SC.A.1.4.4 The student experiments and determines that the rates of reaction among atoms and molecules depend on the concentration, pressure, and temperature of the reactants and the presence or absence of catalysts**. AA**

Objective/Purpose:

1. Investigate the effect of variations in enzyme concentration on rate of reaction.
2. Investigate the effect of variations in substrate concentration on rate of reaction.

Background Information:

The enzyme catalase speeds up the breakdown of hydrogen peroxide (H_2O_2) into water (H_2O) and oxygen gas (O_2). The reaction is described by the following equation:

$$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$$

Problem Statement/ Engagement:

So now that we know what enzymes do, we are to answer the following question:
"How will different concentrations of hydrogen peroxide affect the reaction of an enzyme?"

Materials:

- Yeast solution
- Hydrogen peroxide
- Filter paper disks
- Forceps
- Eight 50 ml beakers
- Distilled water
- Marking pencil
- Paper towels

Procedure:

1. Make a hypothesis based on the problem statement.
2. Prepare peroxide solutions in separate test tubes as outlined in Table 1.

Table 1
Concentration Hydrogen Peroxide Solutions

Concentration	Hydrogen Peroxide	Distilled Water
0% Peroxide Solution	0 ml	35 ml
25% Peroxide Solution	9 ml	27 ml
50% Peroxide Solution	18 ml	18 ml
75% Peroxide Solution	27 ml	9 ml
100% Peroxide Solution	35 ml	0 ml

3. Using the forceps, dip a filter paper disk into the beaker containing the solution of activated yeast. Keep the disk in the solution for 4 seconds, and then remove it.
4. Place the disk on a paper towel for 4 seconds to remove any excess liquid.
5. Using the forceps, transfer the filter paper disk to the bottom of a rubber stopper.

Note: The yeast solution contains the catalase enzyme and when the enzyme soaked disk comes into contact with hydrogen peroxide, the reaction results in the formation of oxygen bubbles.

6. Insert the stopper into one of the test tubes and quickly invert the test tube. Have one person in your group measure how long it takes for the bubbles to carry the disk to the top of the test tube. Record the time in a data table similar to the one shown below.
7. Repeat steps 2-5 until you have a minimum of three trials for each peroxide solution.
8. Calculate the average rising time for each of the peroxide solutions. Record this information in your data table.
9. Construct a graph plotting the concentration of hydrogen peroxide on the x-axis (independent variable) and rising time on the y-axis (dependent variable).

Data (Tables and Observations):

	Rising Time			
Beaker	Trial 1	Trial 2	Trial 3	Average
0 % Peroxide				
25 % Peroxide				
50 % Peroxide				
75 % Peroxide				
100 % Peroxide				

Data Analysis (Calculations):
Construct and analyze the graph from your table.

Results and Conclusions:
1. Suppose you had placed a filter paper disk in a 30% peroxide solution. Using your graph, predict how long it would take this disk to rise to the top.
2. In a paragraph describe how the concentration of peroxide affects the breakdown rate of hydrogen peroxide. Use the results of this experiment to justify your answer.
3. In a paragraph explain why your hypothesis was or was not supported.

Closure Activity:
Discuss each group's results with the class as a whole. Make sure to discuss and correct any misconceptions the students have. Write down the WHOLE class's conclusions on the board and refer back to the hypotheses.

Extension:
Time permitting, the students may choose to repeat the experiment with even higher or lower concentrations.

Teacher Notes:
Before passing out the labs, have the students think about what processes in the body use enzymes to function. Be sure to discuss as a class the vital enzymes for human digestion such as protease, amylase, lipase, etc.
Review the lab information with the students and, using WHOLE CLASS discussion, have them decide on a individual hypothesis for their lab group, focusing on lower concentration effects and higher concentration effects on the rate of reaction.

Adapted from:
District Biology Activities

Potato Osmosis Lab

Benchmark:

SC.F.1.4.1 The student knows that the body processes involve specific biochemical reactions governed by biochemical principles**. AA**
SC.F.1.4.8 The student knows that cell behavior can be affected by molecules from other parts of the organism or even from other organisms.

Objective/Purpose:

1. To observe the process of osmosis and how it occurs in cells.
2. Examine and describe the different environmental conditions that can affect a cell and its processes.

Background Information:

Diffusion is the process in which there is a net movement of molecules from a high area of concentration to a low area of concentration. Osmosis is the passage of water from a region of high water concentration through a semi-permeable membrane (*Semi-permeable membranes* are very thin layers of material which allow some things to pass through them but prevent other things from passing through.) to a region of low water concentration. This is seen in cell membranes. When there is a higher concentration of one type of molecule outside of a cell, water will move through a membrane out of the cell in order to make the water concentrations equal. This causes the cell to shrink (hypertonic). If the concentration of certain molecules is higher inside of the cell, then the water will move into the cell causing it to swell (hypotonic). When the molecule concentrations are equal on both sides of the membrane, water does not move (isotonic).

In the human body, many salts and enzymes help to regulate a cell's state and the processes necessary for the human body to function such as potassium and calcium channels in the heart. These functions are carried out by having constant changes in concentration of molecules from one side of the membrane to another. Cell membranes will allow small molecules like oxygen, water, carbon dioxide, ammonia, glucose, amino acids, etc., to pass through. Cell membranes will not allow larger molecules like sucrose, starch, protein, etc., to pass through.

In this lab you are going to use the materials listed below to create your own lab that will simulate osmosis in the cell membrane and how it is affected by different solutions.

Problem Statement / Engagement:

All systems in life long to be stable or in homeostasis. Using the three different solutions you will make (salt, sugar, plain water), come up with a hypothesis for each Petri dish. Make predictions for what will happen in each.

"How will the environmental conditions affect the size of the potato?"

Materials:

- Salt
- Cups
- Beakers
- Spoons
- Sugar
- Ruler
- Potato slices

Procedure:

1. First gather all the materials necessary.
2. Cut 3 cubed pieces of potato the same length and thickness. Record these measurements.
3. Fill three Petri dishes with the same amount of water (about halfway.)
4. Add 3 tsp. of salt to beaker 1, 3 tsp. of sugar to beaker 2, and leave beaker 3 plain.
5. Drop one piece of potato into each beaker. Note the time.
6. Make a hypothesis for what will happen in each one of the Petri dishes.

Hypothesis for dish 1_____

Hypothesis for dish 2_____

Hypothesis for dish 3_____

7. Make observations of thickness, size, and flexibility every 5 minutes.
8. Write down your conclusions and discuss every hypothesis in regards to proof or disproof.
9. Write down any new hypotheses you might have and how you would repeat the experiment.

Data (Tables and Observations):

Water Type	Initial Size and Observations	5 min (mm)	10 min (mm)	15 min (mm)	20 min (mm)	25 min (mm)

Data Analysis (Calculations):

1. Draw a line graph comparing the changes in size of the three pieces of potato over time.
2. Discuss what you found in the lab and use the graph to support it.

Results and Conclusions:

1. Discuss each hypothesis. Did you prove it correct? Use your results to support your findings.
2. Plant cells always have a strong cell wall surrounding them. When they take up water by osmosis, they start to swell, but the cell wall prevents them from bursting. Plant cells become "turgid" when they are put in dilute solutions. Turgid means swollen and hard. The pressure inside the cell rises; eventually the internal pressure of the cell is so high that no more water can enter the cell. Using your findings, explain how what you saw in the lab proves that the opposite would occur in a sugary or “undiluted” environment.
3. Animals which live on dry land must conserve water and so must animals which live in the sea (the sea is very salty!). However, animals which live in freshwater have the opposite problem; they must get rid of excess water as fast as it gets into their bodies by osmosis. Explain why their cells need to do this to ensure their survival.

Closure Activity:

Have the students in the class write down their final results onto the board. Have groups average the size increase or decrease for each potato. Discuss as a class what hypotheses were proven or disproven for each "environmental condition." Make sure the students include these results in the write up of their conclusions.

Extension:

The students can repeat the experiment, using different measured concentrations of salt or sugar to prove if the level of concentration is the main factor in osmosis.

Adapted from: Potato Osmosis Lab (Many different teachers)

Investigating the Effect of Light Intensity on Photosynthesis

Benchmark:

SC.D.2.4.1 The student understands the interconnectedness of the systems on Earth and the quality of life. **AA**
SC.G.2.4.6 The student knows the ways in which humans today are placing their environmental support system at risk (e.g., rapid human population growth, environmental degradation, and resource depletion.) **CS**

Objective/Purpose:

1. To observe how light affects photosynthesis.
2. To understand how photosynthesis in important to life.
3. To understand the consequences of what can happen when plants and trees are destroyed.

Background Information:

In order to carry out photosynthesis, a plant must have light. But how much light? Some plants need a lot of light. Others seem to thrive in shade. Does more light lead to more photosynthesis? In this investigation, you will examine how the intensity of light affects photosynthesis. You will also analyze the importance of photosynthesis and its need for our environment to survive.

Problem Statement / Engagement:

"How does the destruction of forests affect the rate of photosynthesis?"
"How does this change our living environment and what consequences can a low level of photosynthesis cause to our atmosphere?"

Read the entire investigation. Then, work with a partner to answer the following questions.

1. What are the products of photosynthesis? Which of these products is released from leaves as a gas?

2. What can you tell about photosynthesis if a leaf begins to produce more gas bubbles? Fewer gas bubbles?

3. What are the manipulated and responding variables in this experiment? Identify one controlled variable.

Materials:

- Test tube
- Source of bright light
- Sodium bicarbonate solution
- Watch or clock with second indicator
- 400-mL beaker
- Plastic gloves
- Freshly cut sprig of an evergreen (such as yew)
- Hand lens
- Forceps

Procedure:

1. Working with a partner, completely fill a test tube and a beaker with a sodium bicarbonate solution. Sodium bicarbonate will provide a source of carbon dioxide.

2. Using forceps, place a sprig of evergreen about halfway down in the test tube. Be sure that the cut end of the sprig points downward in the test tube.

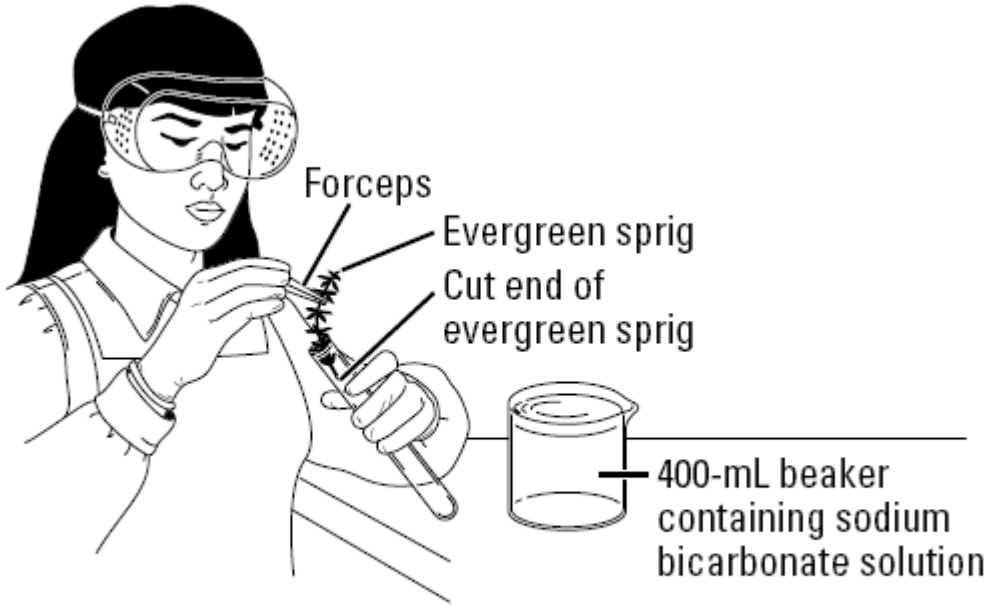


Figure 1

3. Cover the mouth of the test tube with your thumb and turn the test tube upside down. Try not to trap any air bubbles in the test tube.

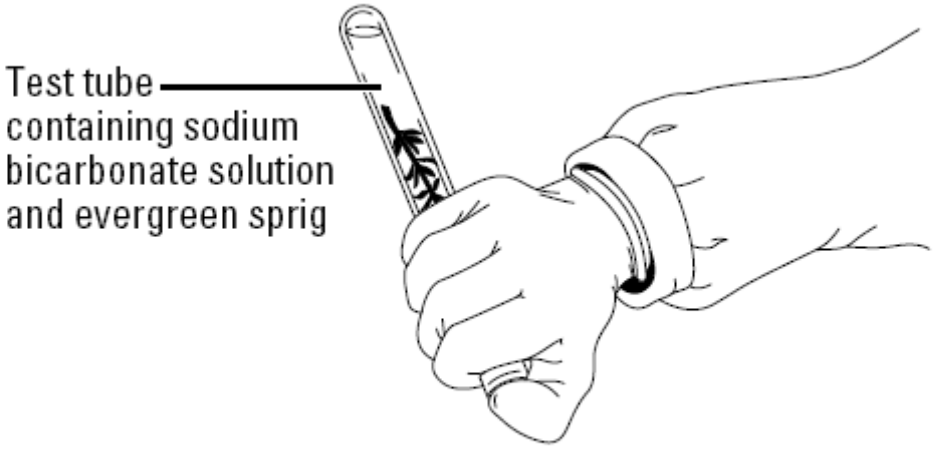


Figure 2

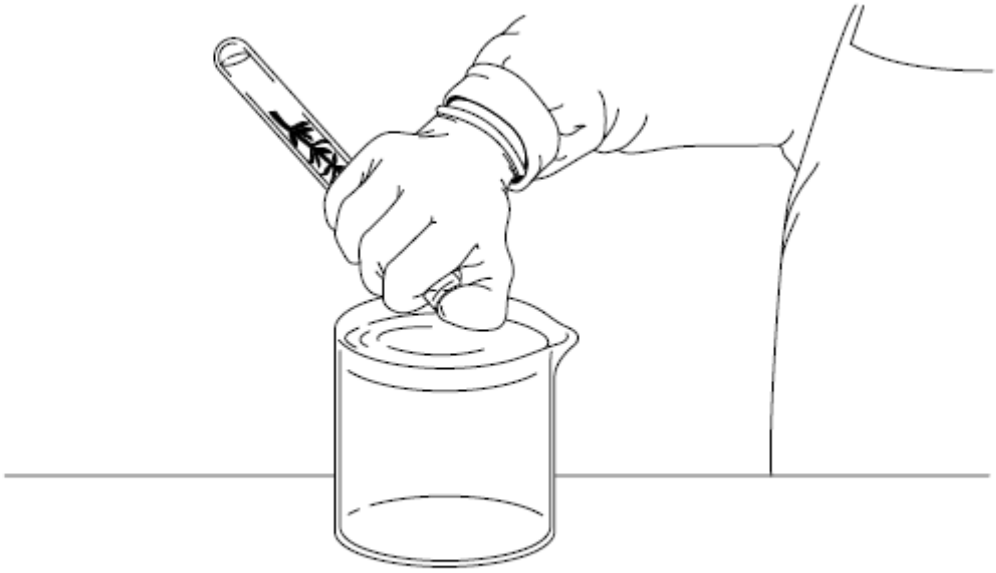


Figure 3

4. Place the mouth of the test tube under the surface of the sodium bicarbonate solution in the beaker. Remove your thumb from the mouth of the test tube.

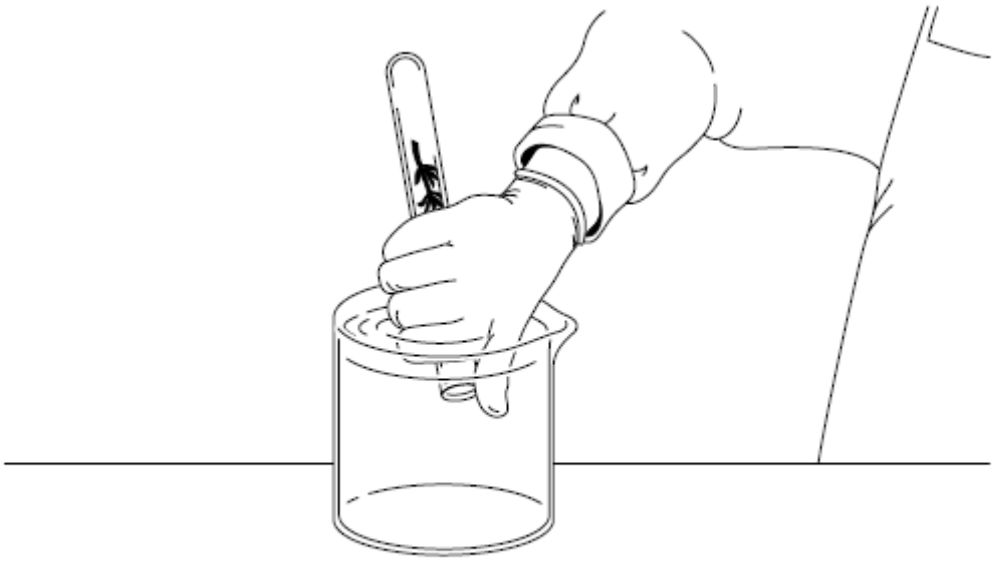


Figure 4

5. Gently lower the test tube inside the beaker so that the test tube leans against the side of the beaker.

Figure 5

6. Put the beaker in a place where it will receive normal room light. Using a hand lens, count the number of bubbles produced by the sprig in the test tube for 5 minutes. Record the number of bubbles on the Data Table below.
7. Darken the room and count the number of bubbles produced again for 5 minutes. Record the number on the Data Table.
8. Turn up the lights in the room and shine a bright light on the sprig. Count the number of bubbles produced in 5 minutes. Record the number on the Data Table.

Data (Tables and Observations):

Data Table

Light Intensity	Number of Bubbles Produced in 5 Minutes
Room light	
Dim light	
Bright light	

Data Analysis (Calculations):

1. Observing: From what part of the sprig (stem or needle leaves) did the bubbles emerge?

2. Observing: When was the greatest number of bubbles produced?

3. Expository: Explain the data produced in the experiment in relation to the levels of photosynthesis.

Results and Conclusions:

1. Drawing Conclusions: How does the intensity of light affect the rate of photosynthesis? Was your hypothesis correct or not? Explain what occurred.

2. Comparing and Contrasting: How do your results compare with those of your classmates? Are they similar? Different? How can you account for any differences in the numbers of bubbles produced? Can you identify any trends even if the actual numbers differ?

Closure Activity:

Have the students make a Microsoft Power Point presentation about the importance of plants to our atmosphere, community and future. Have them include measures that they would implement to save our forest and stop global warming.

Extension:

Perform the activity again using different colors of light. What effect does each color have on the rate of photosynthesis?

Notes for Teacher:

Students should have been introduced to the concept of Photosynthesis including the pathways and cycles such as the CAM pathway and the Calvin cycle. Students should be aware of the current debates and discussions about global warming and how the destruction of plants and trees contributes to such a problem.

Provide sprigs that are as freshly cut as possible. If possible, cut stems underwater and keep the cut ends in water until use.

Prepare a saturated solution of 7 g sodium bicarbonate per 100 mL water. Pour off the solution, leaving any undissolved solid behind.

Time required: 30 minutes

Adapted from: State Adopted – Prentice Hall (Laboratory Manual B)

Observing Respiration

Benchmark:

SC.B.1.4.1 The student understands how knowledge of energy is fundamental to all the scientific disciplines (e.g., the energy required for biological processes in living organisms and the energy required for the building, erosion, and rebuilding of the Earth). **AA**
SC.F.1.4.1 The student knows that the body processes involve specific biochemical reactions governed by biochemical principles. **AA**

Objective/Purpose:

1. To understand how photosynthesis and respiration work hand in hand.
2. To observe how respiration occurs under aerobic conditions.

Background Information:

All living things undergo respiration. During this process, food molecules are broken down. As part of this process, animals take in oxygen and release carbon dioxide by breathing, which is easily observable. Plants do not "breathe" as animals do, so respiration in plants is not as easily observable. How do we know that plants respire?

In this investigation, you will observe the release of carbon dioxide by humans. You also will perform an experiment to determine whether plants release carbon dioxide as a product of respiration.

Problem Statement / Engagement:

"How do organisms release energy from food? "

Read the entire investigation. Then work with a partner to answer the following questions.

1. What hypothesis is Part A of this experiment testing?

2. What is an acid indicator?

3. When the cabbage is mixed with the boiling water, what color do you expect the water to turn?

4. In Part B, why is nothing added to one of the test tubes containing cabbage indicator?

5. What special safety note should you observe when you blow through the straw?

Materials:

- Distilled water
- Straw
- Heat-resistant gloves
- Hot Plate
- Cotton ball
- 2 500-mL beakers
- Test tubes
- Purple cabbage leaves
- Test tube racks
- Large slotted spoon
- Stoppers
- 10 radish seedlings
- Forceps

Procedure:

1. Write a hypothesis to the problem statement above.

2. Tear the purple cabbage into small pieces. Place the cabbage pieces into one of the beakers.

3. Pour about 300 mL of distilled water into the other beaker. Using the hot plate, heat the water until it boils. **CAUTION:** *Put on safety goggles. Be careful when working with the hot plate.*

4. Put on heat-resistant gloves. Pour the hot distilled water into the bowl that contains the cabbage. **CAUTION:** *Be careful when working with heated materials to avoid burns.* Allow the water to cool. Remove the heat-resistant gloves. The water will turn purplish-blue in color when mixed with the cabbage.

5. Using the slotted spoon, remove the cabbage pieces and discard them according to your teacher's directions. Save the liquid to use as an acid indicator. Its color will change from purplish-blue to
reddish-blue when it is mixed with an acid. When carbon dioxide combines with water, it forms a weak acid called carbonic acid.

6. Pour some of the cabbage indicator into 2 test tubes so that each is half full. Cover one test tube completely with aluminum foil.

7. Use a straw to blow a few times into the uncovered test tube, as shown in Figure 1. **CAUTION:** *Be sure not to inhale any of the cabbage indicator.* Observe any changes in the color of the cabbage indicator in both test tubes. Record your observations in the Data Table.

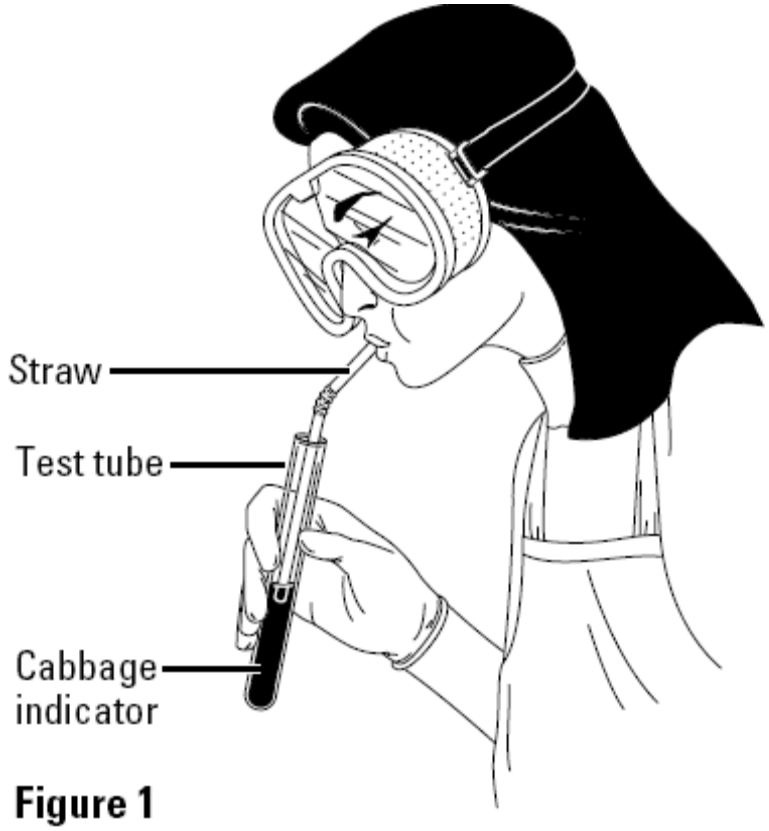


Figure 1

8. Pour some of the cabbage indicator into 2 test tubes so that they are one-quarter full.

9. Place a cotton ball and 10 radish seedlings in one test tube. See Figure 2. Place a stopper in both test tubes. Place the test tubes in a test-tube rack and set them aside for 24 hours.

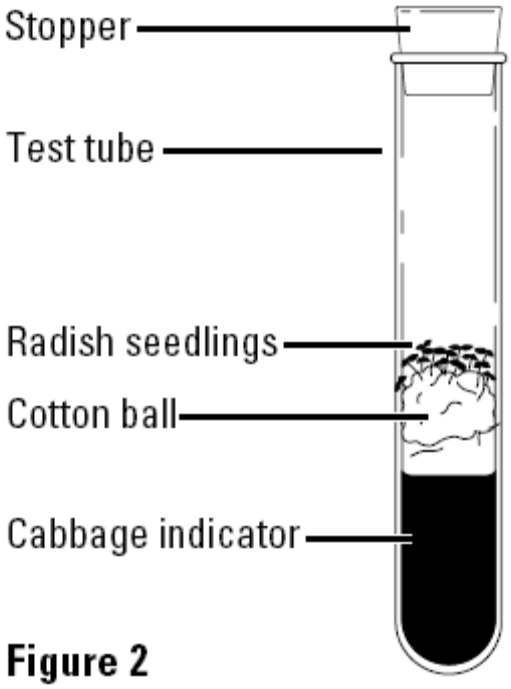


Figure 2

10. After 24 hours, observe the test tubes. Record your observations in the Data Table.

Data (Tables and Observations):

Test Tube	Description	Color of Cabbage Indicator

Data Analysis (Calculations):

1. Observing: Did the color of the cabbage indicator change when you exhaled into the test tube? Explain why.

2. Observing: Did the color of the cabbage indicator change in the test tube that contained the radish seedlings? Explain the reason.

3. Comparing and Contrasting: Compare the reaction that occurred in the test tube that contained the radish seedlings with the one that occurred in the test tube into which you exhaled. How are they similar?

4. Inferring: Did respiration occur in this experiment? Explain your answer.

Results and Conclusions:

1. **Hypothesis:** Was your hypothesis correct or incorrect? Explain your answer in detail.

2. **Drawing Conclusions:** Why is the process of cellular respiration common to all forms of life?

3. **Inferring:** Why do most living things take in oxygen?

Closure Activity:

Have the students build a 3-D model of a cell including the mitochondria, nucleus, and chloroplast. Ask students to identify the areas in the cell where glycolysis occurs, respiration occurs and where photosynthesis occurs that can be shared with their peers during class presentations. Look for creativity in the representation of the processes and cell parts. Ask them to relate them and connect them to things outside of the classroom.

Extension:

Why do we need plants? Why do plants need animals? What might happen if too many trees are destroyed? Use what you know about photosynthesis and respiration to answer these questions.

Notes for Teacher:

** Pea or bean seedlings can also be used instead of radish seedlings.

Prior to doing this lab, students should have been taught about cellular respiration including lactic acid fermentation, alcoholic fermentation, glycolysis, the Krebs cycle, and the electron transport chain. They should be familiar with the definition and purpose of ATP, ADP, NADPH, NADH, NAD^+, electrons, FAD, $FADH_2$, anaerobic and aerobic respiration, carbon atoms, carbon dioxide, and acetyl CoA, all of which are integral parts of cellular respiration.

Students should also be aware of how photosynthesis and respiration go hand in hand. The products of one process are the reactions of the other and vice versa.

Adapted from: State Adopted – Prentice Hall (Laboratory Manual B)

Making Karyotypes

Benchmark:

SC.F.1.4.1 The student knows that the body processes involve specific biochemical reactions governed by biochemical principles. **AA**
SC.F.2.4.2 The student knows that every cell contains a "blueprint" coded in DNA molecules that specify how proteins are assembled to regulate cells. CS

Objective/Purpose:

Learn how to construct a karyotype and be aware of its importance in determining genetic disorders or syndromes.

Background Information:

Several human genetic disorders are caused by extra, missing, or damaged chromosomes. In order to study these disorders, cells from a person are grown with a chemical that stops cell division at the metaphase stage. During metaphase, a chromosome exists as two chromatids attached at the centromere. The cells are stained to reveal banding patterns and placed on glass slides. The chromosomes are observed under the microscope, where they are counted, checked for abnormalities, and photographed. The photograph is then enlarged, and the images of the chromosomes are individually cut out. The chromosomes are identified and arranged in homologous pairs. The arrangement of homologous pairs is called a karyotype. In this investigation, you will use a sketch of chromosomes to make a karyotype. You will also examine the karyotype to determine the presence of any chromosomal abnormalities.

Students should already have been introduced to the terms and topics of mitosis, meiosis, chromosomes, autosomes, and homologous pairs before doing this lab.

Problem Statement / Engagement:

"Can chromosomal abnormalities be observed?"

Read the entire investigation. Then work with a partner to answer the following questions.

1. What clues to the presence of certain genetic disorders can be seen in a karyotype?

2. Why might a laboratory worker attempting to diagnose a genetic disorder prefer to work with photographs of chromosomes rather than the chromosomes themselves?

3. Why would it be much more difficult to construct a karyotype of unstained chromosomes?

4. Which pair of chromosomes can contain two very different chromosomes and still be considered normal? Explain your answer.

5. How do autosomes differ from sex chromosomes?

Materials:

- Scissors

- Glue or transparent tape

Procedure:

Part A. Analyzing a Karyotype

1. Make a hypothesis based on the problem statement above.

2. Observe the normal human karyotype in Figure 1. Notice that the two sex chromosomes, pair number 23, do not look alike. They are different because this karyotype is of a male, and a male has an X and a Y chromosome.

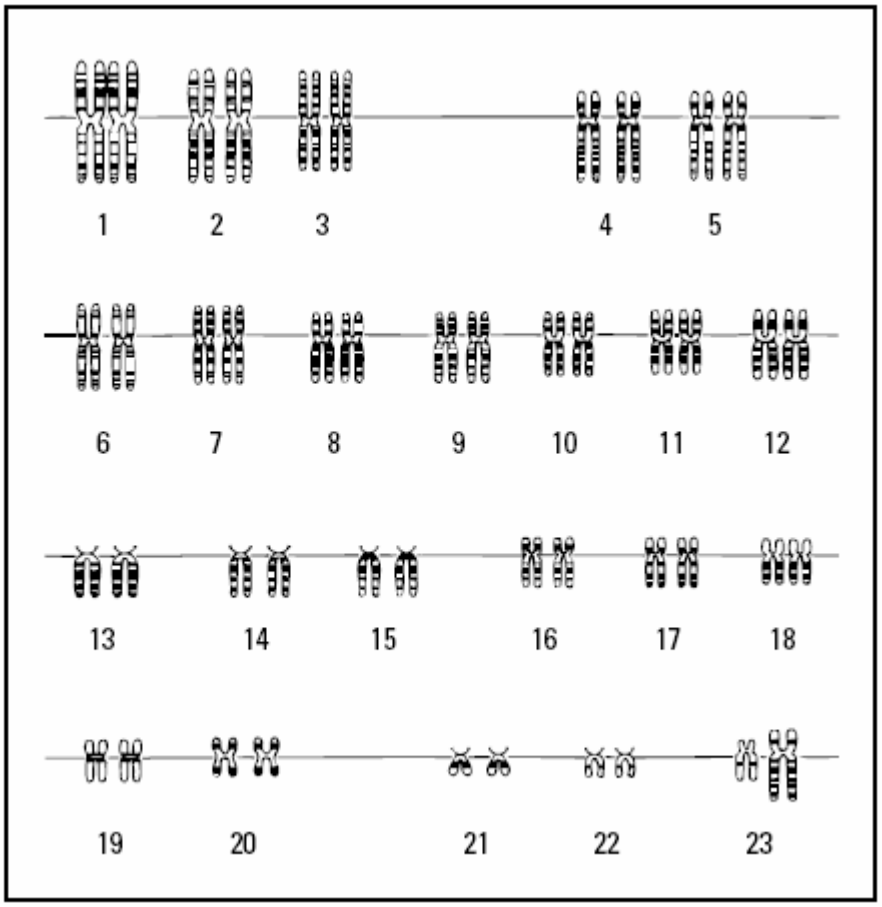


Figure 1

3. Identify the centromere in each pair of chromosomes. The centromere is the area where each chromosome narrows.

Part B. Using a Karyotype to Identify a Genetic Disorder

1. Study the human chromosomes in Figure 2 on the next page. Notice that 23 chromosomes are numbered 1 through 23.

2. To match the homologous chromosomes, look carefully at the unnumbered chromosomes. Note their overall size, the position of the centromere, and the pattern of the light and dark bands. Next to the unnumbered chromosome that is most similar to chromosome 1, write 1.

3. Repeat step 2 for chromosomes 2 through 23.

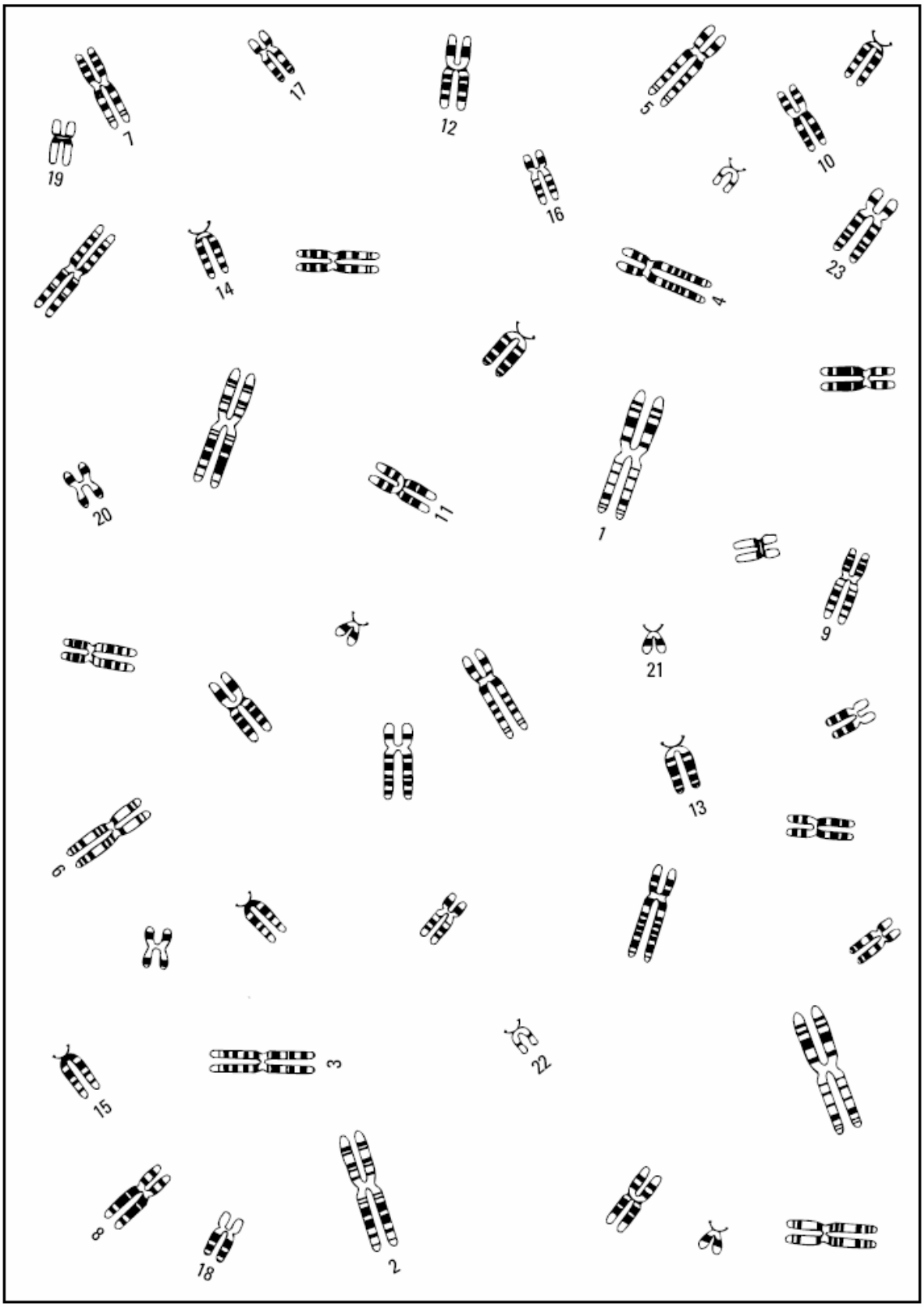


Figure 2

4. Use scissors to cut out all the chromosomes from Figure 2. Tape them in their appropriate places in Figure 3. Note any chromosomal abnormalities. **CAUTION:** *Be careful when handling sharp instruments.*

Data (Tables and Observations):

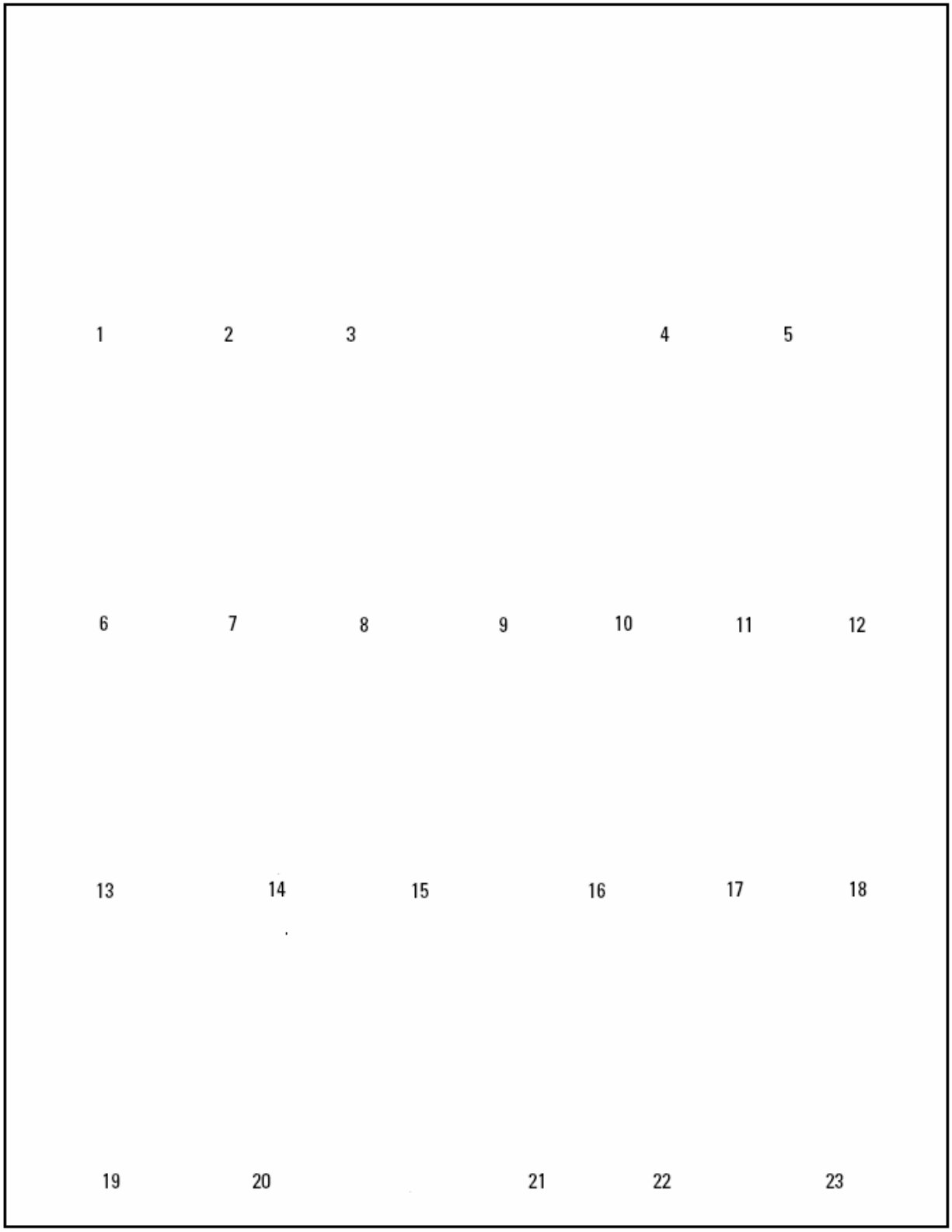


Figure 3

Data Analysis (Calculations):

1. Observe the karyotypes in Figures 4 and 5. Note the presence of any chromosomal abnormalities.

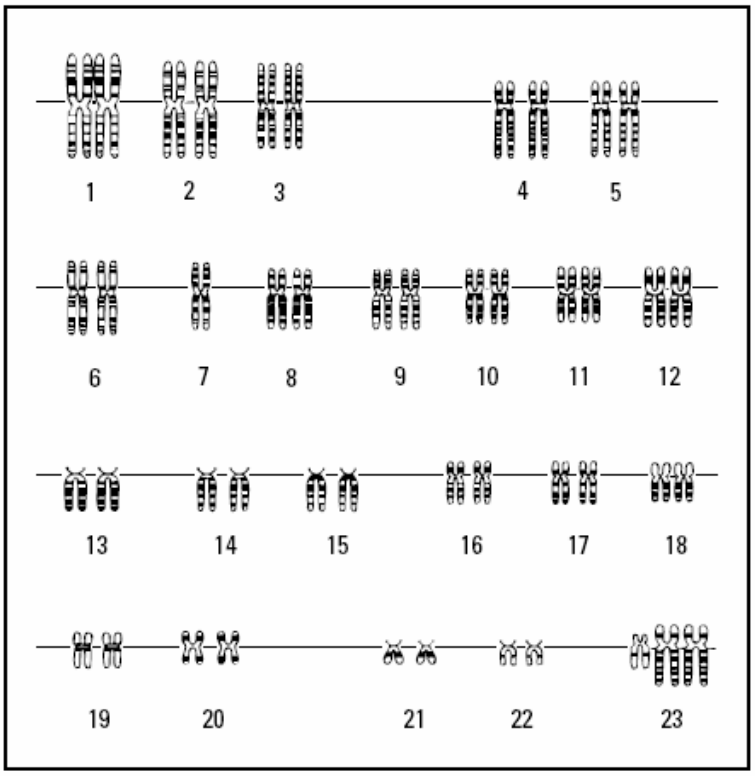


Figure 4

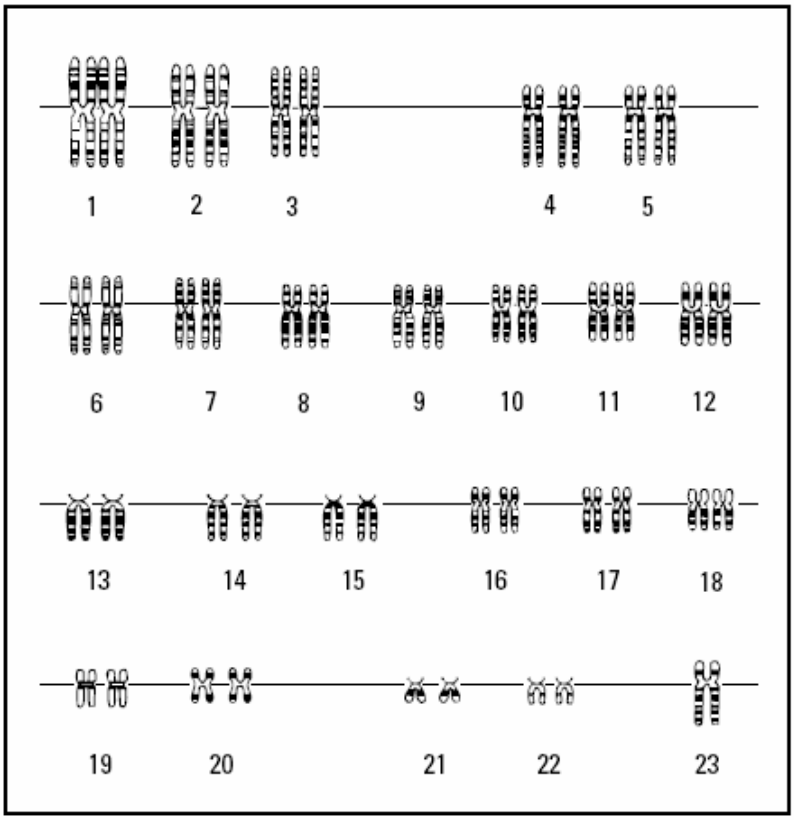


Figure 5

2. Comparing and Contrasting: Of the four karyotypes that you observed, which was normal? Which showed evidence of an extra chromosome? An absent chromosome?

3. Formulating Hypotheses: What chromosomal abnormality appears in the karyotype in Figure 4? Can you tell from which parent this abnormality originated? Explain your answer.

4. Inferring: Are chromosomal abnormalities such as the ones shown confined only to certain parts of the body? Explain your answer.

Results and Conclusions:

1. Draw a data table in the space below in which to record your observations of the karyotypes shown in Figures 1, 3, 4, and 5. Record any evidence of chromosomal abnormalities present in each karyotype. Record the genetic defect, if you know it, associated with each type of chromosomal abnormality present.

2. Drawing Conclusions: Are genetic defects associated with abnormalities of autosomes or of sex chromosomes? Explain your answer.

3. **Posing Questions:** Formulate a question that could be answered by observing chromosomes of different species of animals.

Closure Activity:

Have the students present their karyotypes to the class and explain the importance about karyotyping in determining genetic disorders.

Extension:

Using library materials or the Internet, research one type of deletion syndrome (a syndrome that results from loss of parts of chromosomes), and write a short paragraph describing the chromosomal abnormality involved and the characteristics of the disorder.

Students can also use their computers to generate a pamphlet about the syndrome which includes information about the chromosomal abnormality involved, how it affects the organism, characteristics of the syndrome. Include some relevant pictures or websites that people can refer to if they want to learn more about the syndrome.

Adapted from: Prentice Hall, Lab Manual A (District-adopted book)

Investigating Inherited Traits

Benchmark:

SC.F.2.4.3 The student understands the mechanisms of change (e.g., mutation and natural selection) that lead to adaptations in a species and their ability to survive naturally in changing conditions and to increase species diversity. **AA**
SC.F.2.4.2 The student knows that every cell contains a "blueprint" coded in DNA molecules that specify how proteins are assembled to regulate cells. **CS**

Objective/Purpose:

1. To investigate the probability of genotypes and phenotypes of an offspring.
2. To investigate the traits that are dominant, hybrid, and recessive.

Background Information:

Heredity is the passing on of traits, or characteristics, from parent to offspring. The genetic makeup of an individual is known as its genotype. The physical traits you can observe in a person are his or her phenotype. Phenotype is a result of the genotype and the individual's interaction with the environment. The units of heredity are called genes. Genes are found on the chromosomes in a cell. An allele is one of two or more forms of a gene. When the two alleles of a pair are the same, the genotype is homozygous, or pure. When the two alleles are not the same, the genotype is heterozygous, or hybrid. In nature, specific combinations of alleles happen only by chance.
Some alleles are expressed only when the dominant allele is absent. These alleles produce recessive phenotypes. Alleles that are expressed when the genotype is either homozygous or heterozygous produce dominant phenotypes. An allele that codes for a dominant trait is represented by a capital letter, while an allele that codes for a recessive trait is represented by a lowercase letter.

Sometimes when the genotype is heterozygous, neither the dominant nor recessive phenotype occurs. In this case, called incomplete dominance or co-dominance, an intermediate phenotype is produced. In humans, the sex of a person is determined by the combination of two sex chromosomes. People who have two X chromosomes (XX) are females, while those who have one X chromosome and one Y chromosome (XY) are males. In this investigation, you will see how different combinations of alleles produce different characteristics.

Problem Statement/Engagement:

"If you have both parent phenotypes for a trait, then can you accurately predict the phenotype of an offspring?"

Materials:

- 3 textbooks
- 2 coins (try to use the same kinds of coins such as pennies)**

** To reduce the noise produced by flipping coins, you can have students use plastic disks used for bingo or tiddlywinks (available at toy or hobby shops). Have students place a small piece of masking tape on each side of the two disks. Mark one side of each disk "H" (heads) and the other side of each disk "T" (tails). Remind students that the pieces of masking tape should be the same size so that both sides of the coin or disk are the same weight. (Optional)

Procedure:

1. Make a hypothesis based on the problem statement above for the resources being supplied.

2. Place the textbooks on the laboratory table so that they form a triangular well.

3. Obtain two coins. You and your partner will each flip a coin to determine the traits in a hypothetical offspring.

4. Start by determining the sex of the offspring. Flip the coins into the well. If both coins land the same side up, the offspring is a female. If the coins land different sides up, the offspring is a male. Record the sex of the offspring in the blank on page 36.

5. For the rest of the coin tosses you will make, heads will represent the dominant allele and tails will represent the recessive allele.

6. You and your partner should now flip your coins into the well at the same time to determine the phenotype of the first trait, the shape of the face. **Note:** *The coins should be flipped only once for each trait.* After each flip, record the trait of your offspring by placing a check in the appropriate box in Figure 1.

7. Continue to flip the coins for each trait listed in the table in Figure 1.

Note: *Some information in Figure 1 has been simplified. Some listed traits are actually produced by two or more genes.*

8. Using the recorded traits, draw the facial features for your offspring in the space provided on page 36.

Data (Tables and Observations):

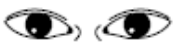
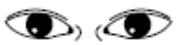
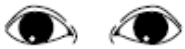
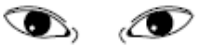
Traits	Dominant (both heads)	Hybrid (one head, one tail)	Recessive (both tails)
Shape of face	 round *RR*	 round *Rr*	 Square *rr*
Cleft in chin	 present *CC*	 present *Cc*	 absent *cc*
Texture of hair	 curly *HH*	 wavy *Hh*	 straight *hh*
Widow's peak	 present *WW*	 present *Ww*	 absent *ww*
Spacing of eyes	 close together *EE*	 medium distance *Ee*	 far apart *ee*
Shape of eyes	 almond *AA*	 almond *Aa*	 round *aa*
Position of eyes	 straight *SS*	 straight *Ss*	 slant upward *ss*
Size of eyes	 large *LL*	 medium *Ll*	 small *ll*

Figure 1

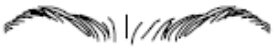
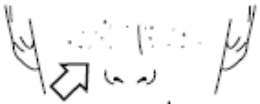
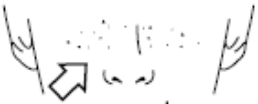
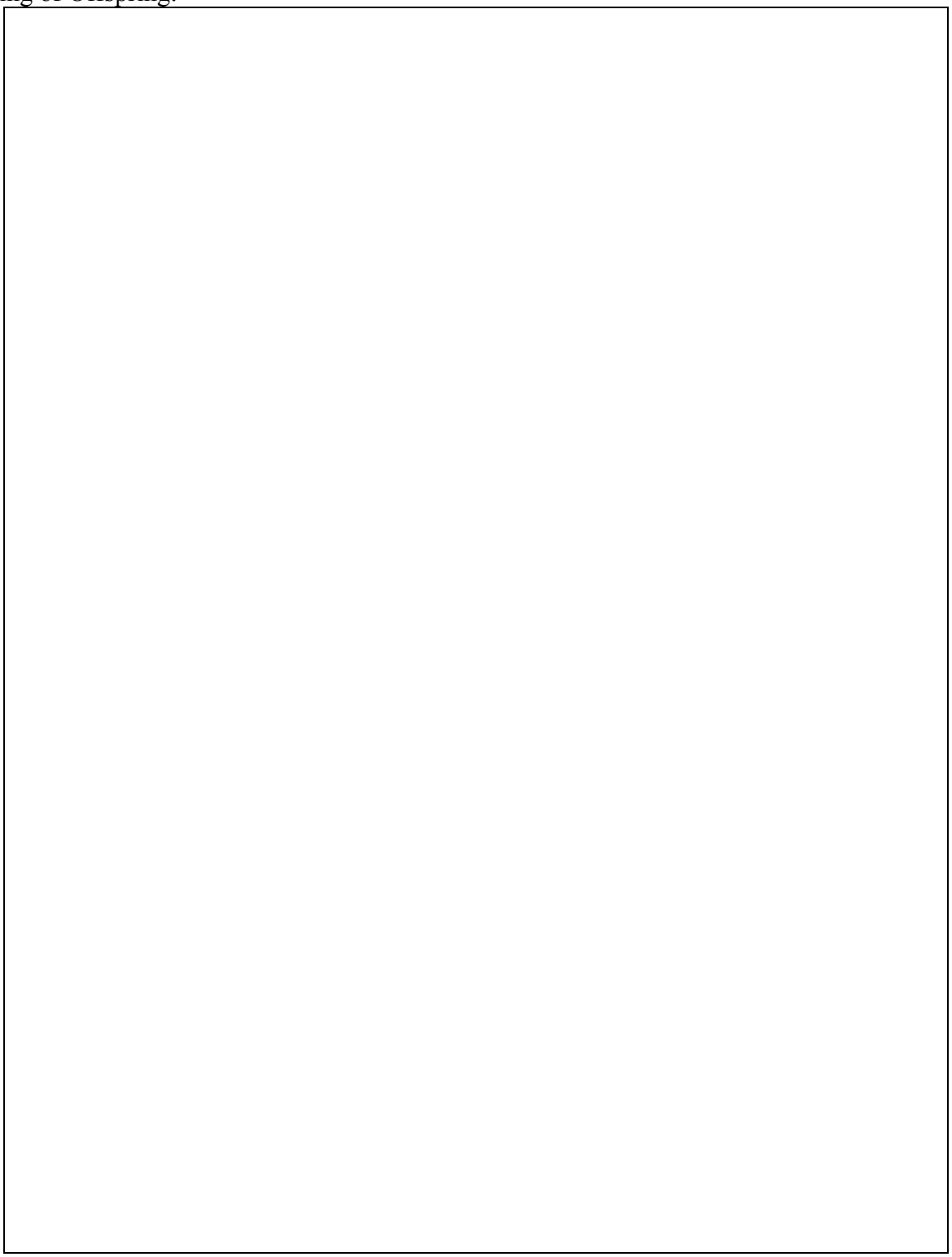
Traits	Dominant (both heads)	Hybrid (one head, one tail)	Recessive (both tails)
Length of eyelashes	 long *LL*	 long *Ll*	 short *ll*
Shape of eyebrows	 bushy *BB*	 bushy *Bb*	 fine *bb*
Position of eyebrows	 not connected *NN*	 not connected *Nn*	 connected *nn*
Size of nose	 large *LL*	 medium *Ll*	 small *ll*
Shape of lips	 thick *TT*	 medium *Tt*	 thin *tt*
Size of ears	 large *LL*	 medium *Ll*	 small *ll*
Size of mouth	 large *LL*	 medium *Ll*	 small *ll*
Freckles	 present *FF*	 present *Ff*	 absent *ff*
Dimples	 present *DD*	 present *Dd*	 absent *dd*

Figure 1 *continued*

Data Analysis (Calculations):

Sex of offspring _____

Drawing of Offspring:



What percentage chance did you and your partner have of "producing" a male offspring? A female offspring? Explain your answer.

Results and Conclusions:

1. Would you expect the other pairs of students in your class to have an offspring completely similar to yours? Explain your answer.

2. What are the possible genotypes of the parents of a child who has wavy hair *(Hh)*?

3. Which traits in this investigation showed incomplete dominance?

4. Do you think that anyone in your class has all the same genetic traits that you have? Explain your answer.

5. How might it be possible for you to show a trait when none of your relatives shows it?

Closure Activity:

Have a discussion about the results of each student and present them to the class. Make sure to discuss and correct any misconceptions the students have about phenotypes and genotypes. Make a table on the white board of each student's results and form a class analysis table to see which traits are most dominant in the class.

Extension:

Repeat this investigation with your partner to "produce" your second offspring. After completing all of your tosses, make a drawing of the offspring. What similarities exist between your first and second offspring? What differences? Would you expect a third offspring to resemble either the first or the second offspring? Explain your reason.

Notes to Teacher:

Make sure the students have covered the concepts of Punnett squares, probability, genotype, dominant traits, recessive traits, alleles, genes and phenotype. The answers to the hypothesis will vary; an acceptable answer can be that they could not accurately determine the phenotype of the offspring because of recessive traits.

Adapted from: District Adopted – Prentice Hall (Lab Manual B)

Natural Selection: "Toothpicks in Hiding"

Benchmark:

SC.F.2.4.3 The student understands the mechanisms of change (e.g., mutation and natural selection) that lead to adaptations in a species and their ability to survive naturally in changing conditions and to increase species diversity**. AA**
SC.G.1.4.1 The student knows of the great diversity and interdependence of living things**. AA**

Objective/Purpose:

1. Identify desirable variations in a species.
2. Observe the effects of different variations on a species.

Background Information:

What do a snow hare, grasshopper, and an army truck have in common? They all use camouflage or the ability to blend into their environment. This is an adaptation, a behavioral or physical characteristic that increases an organism's chance of survival in a particular habitat. By blending in with its surroundings, an animal can avoid being discovered and eaten by predators.

Using different colored toothpicks to represent prey animals, you are going to test which variation (allele) in a species is better adapted for survival in a particular habitat than individual animals of a different color. We will first need to make a **hypothesis** of what will happen to a specific toothpick population before you begin the hunt.

Problem Statement/Engagement:

"Which species variation is the most successful in the chosen environment?"

Materials:

- 20 green toothpicks
- 20 red toothpicks
- 20 blue toothpicks
- 20 yellow toothpicks
- Grassy areas

Procedure:

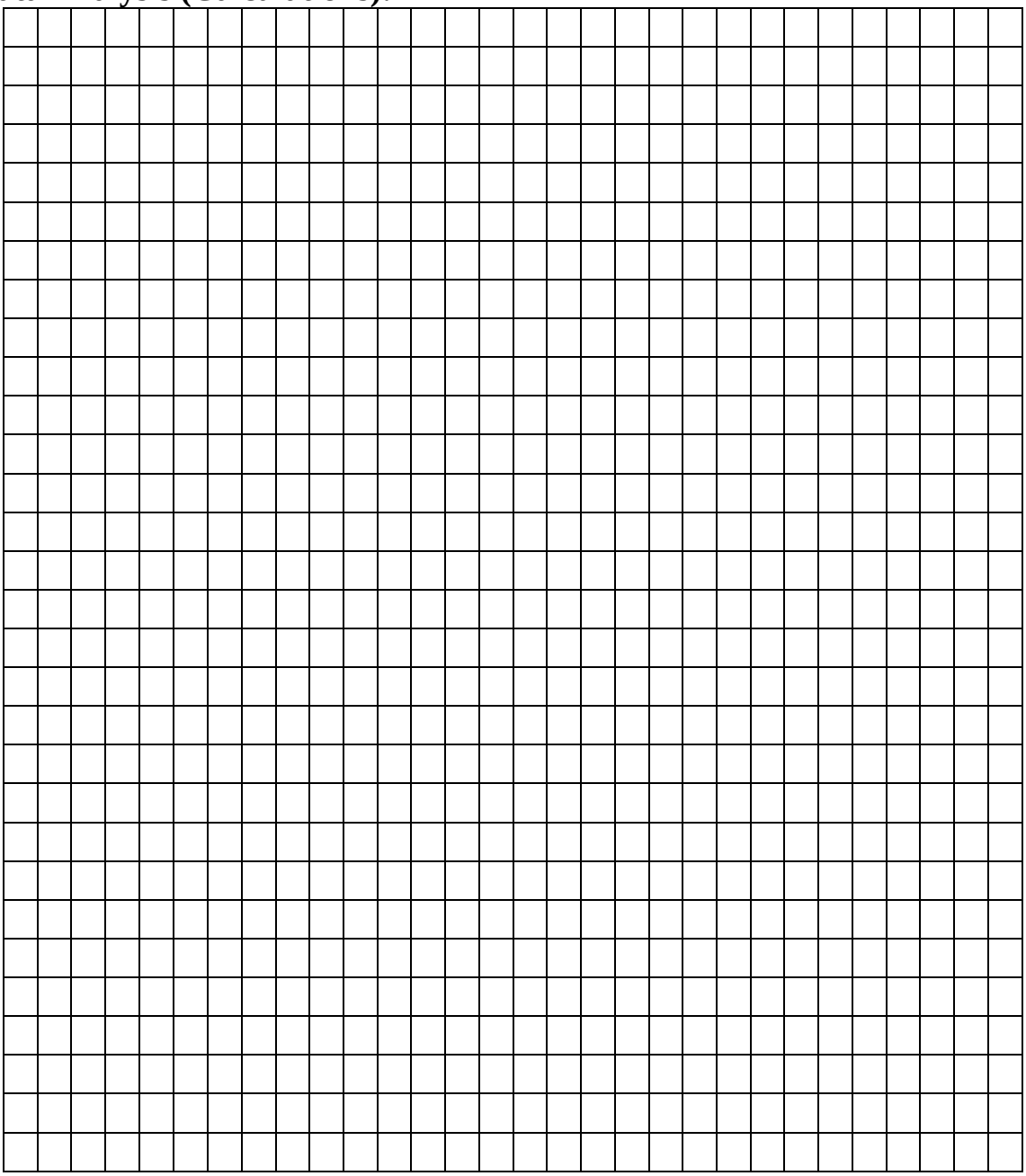
1. You will work in a team of 4-5 with one person being the timer. The rest will be the "Predators."
2. Make a few HYPOTHESES of what will happen to a particular population of toothpicks BEFORE the hunt. Write this down on your paper. (Ex: which color will do best, do worst?)
3. You should then decide on a uniform hunting tactic such as taking only one at a time, using only two fingers, etc. This "procedure" is up to you. This is your predator tactic (independent variable).
4. Once the procedure is in place, measure out a three by three-square meter area using the orange flags provided. This will designate your "hunting" area. Note the color, grass height, dirt type, or any other observations of the area to be hunted.
5. Have the timer mix the toothpicks and spread them randomly while the "predators" are not looking. The initial amount of toothpicks thrown out should be recorded and all the colors should be in equal amounts. (For example: record 20 green, 20 red, 20 blue, and 20 natural.)
6. When all is set, the timer shall signal the start of the hunt. The hunters should be given one minute to "capture" as many of the prey as they can.

7. The team will then chart the number of toothpicks for each color captured by each predator on your team. Record the total number for each color.
8. Divide the total number of each toothpick color caught, by the original number recorded and multiply by 100 ("Caught"/original) x(100) This is the percentage caught for each color.
9. Graph your raw results as a bar graph (make sure to include the four components of a graph: title, axis labels, correct distribution scale, and appropriateness). Use the total numbers for the colors found by your team.

Data (Tables and Observations):

Hunter's Name	Color: Beg. #____	Color: Beg. #____	Color: Beg. #____	Color: Beg. #____	Color: Beg. #____	Total of All Colors: Beg. # _____
Team Totals:						
Percentages of Each Color Caught						Total Caught/Total Original_____

Data Analysis (Calculations):



Results and Conclusions:

1. Was there a difference in the numbers of colors caught by other predators? Why or why not?
2. Based on what you have observed, which color toothpick was best "adapted" to its environment? Which was the worst adapted? Explain.
3. If the toothpicks were living organisms, how would you predict the population to change in your small 3X3 meter over several generations of being preyed upon? Use your results to defend your guess. Show your work and assume that the color of the toothpicks has no effect on being able to catch food or reproduce.
4. Explain how the results of this activity would differ if you were in a different habitat, for example, an asphalt parking lot? white parking lot? red carpet? sandy beach?

Closure Activity:

In the classroom, compare your results with the results from the other teams. As a class, discuss individual hypotheses and results. Decide as a group which variation of the toothpick species was the most successful and the species that was the least successful.

Extension:

Develop and discuss a new method for hunting the toothpicks in the same environment so that you will end up with approximately equal numbers of the different colors. Explain why you would use this method.

Notes to the teacher:

Make sure to get plenty of toothpicks.

Adapted from: Toothpicks in Hiding Lab (Various teachers)

Building a DNA Model

Benchmark:

SC.H.4.4.1 The student knows that investigations are conducted to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories. **AA**
SC.F.2.4.2 The student knows that every cell contains a "blueprint" coded in DNA molecules that specify how proteins are assembled to regulate cells. **CS**

Objective/Purpose:

4. To create what the structure of a DNA molecule looks like and explain its composition.
5. To describe the function of the parts which make up a DNA molecule.
6. Recognize the purpose and relationships of the nucleotide bases found in DNA.

Background Information:

DNA, deoxyribonucleic acid, is found in the chromosomes of all living things. The structure of this molecule encodes the genetic information that controls the development of each living thing. When scientists figured out the structure of DNA, they built a model. The structure of this model helped them see how DNA can carry information and be copied to make new DNA molecules. In this investigation you will examine the structure of DNA by building your own DNA model.

Students should have already been introduced to the structure of DNA including the phosphate backbone, deoxyribose sugar location, and the nucleotides found within it such as Adenine (A), Cytosine (C), Guanine (G) and Thymine (T). Students should also have knowledge of which nucleotides bind together and how DNA replicates.

Problem Statement / Engagement:

"If during replication a base pair gets substituted, then what effect might it have on the DNA molecule?"

Teacher should start the lesson by asking the students to answer the following questions.

1. Which two molecules make up the "sides" of a DNA molecule?

2. When you construct your model of DNA, which materials will you use to represent the sides of a DNA molecule?

3. Which molecules make up the "rungs" of a DNA molecule?

4. When you construct your model of DNA, which materials will you use to represent the rungs of a DNA molecule? What will the toothpicks represent in your model?

5. Which bases usually pair together to form the rungs of a DNA molecule?

Materials:

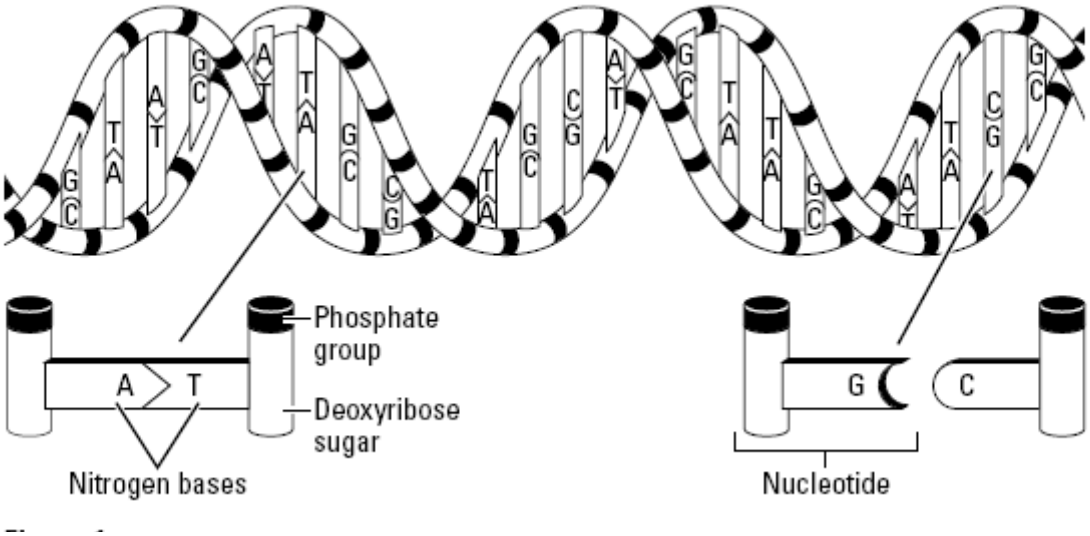
(Per group)

- 2 strips of cardboard, 38 cm _ 3 cm
- Metric ruler
- Toothpicks
- Crayons
- Tape
- Modeling clay
- Colored gumdrops
- Digital camera (optional; if available)
- Colored printer (optional; if available)

Procedure:

1. Make a hypothesis based on the problem statement above.
2. Study Figure 1. It illustrates the shape of the DNA molecule. DNA is a double helix (a helix is a spiral). The two helices of the DNA molecule form what is often referred to as a "twisted ladder." The sides of the ladder are made up of alternating sugar molecules and phosphate groups. The sugar is a 5-carbon deoxyribose sugar. Each phosphate group is a phosphate atom with 4 oxygen atoms bonded to it. Each "rung" of the DNA ladder is made up of two nitrogen bases. Together, a sugar, a phosphate group, and a base make up a nucleotide. A nucleotide is the basic unit of DNA.
3. Nitrogen bases are grouped into two classes: the purines and the pyrimidines. The purines are adenine (A) and guanine (G). The pyrimidines are cytosine (C) and thymine (T). In a DNA molecule, a purine bonds to a pyrimidine to make up each rung of the ladder. Adenine usually bonds only with thymine. Cytosine usually bonds only with guanine.
4. Now you can make a model of the DNA ladder. Choose two colored crayons and color the cardboard strips with alternating colored boxes. Use one color to represent the sugar molecules and label those boxes S. Use the other color for the phosphate groups. Label those boxes P. Remember to make a key designating what each color represents.
5. To make the rungs of the ladder, choose four different-colored gumdrops. Each color will represent a particular nitrogen base. For example, a green gumdrop might represent an adenine base. A yellow gumdrop might represent a guanine base. Be sure to make a key to explain which color represents which nitrogen base.

Figure 1



5. Stick each gumdrop onto a toothpick. Determine which nitrogen base gumdrops can be bonded together. Then join the correct gumdrops together by placing a toothpick between them.
6. Attach the nitrogen base rungs to the ladder by taping the free toothpick ends to the sugar bases.
7. Continue to add correctly paired nitrogen-base gumdrop rungs to the sugar units of the ladder.
8. When your ladder is completed, you might want to stand it up by inserting the two strips into mounds of modeling clay.

Data (Tables and Observations):

Construct a rough draft on paper of what the DNA model is going to look like, including the keys prior to constructing the final model.

Data Analysis (Calculations):

Given the following bases, predict to which base each would be bonded:

1. A ____ T ____ G ____C _____
2. G ____ A ____ T____ C_____
3. T ____ C ____ G____ A _____

4. If you changed the base on one side of the DNA molecule, what should you do to the base on the other side of the molecule? Explain your answer.

Results and Conclusions:

1. How does the model you constructed differ from an actual DNA molecule?
2. If you changed the base on one side of the DNA molecule, what should you do to the base on the other side of the molecule? Explain your answer.
3. When DNA is replicated or copied, the ladder splits as the bases separate. New units are added to each half of the DNA molecule. How does this create two identical molecules of DNA?

Closure Activity:

- Have the student groups present their DNA models and explain their illustrations. Also have the students explain the importance of DNA replication.

- Have students explain the role of DNA on the Human Genome and what it means for the future concerning medicine, diseases, and adaptations to organisms.

Extension:

- Consider the following base sequence in one DNA chain. How would you fill in the corresponding portion of the other chain?

G G C A T G A C G AA C T T A T C GG C A T T A G C C A A T T

- How could a very high fever affect DNA replication, if temperature affects enzymes in the body?

Notes for Teacher:

Students should have already been introduced to the structure of DNA including the phosphate backbone, deoxyribose sugar location, and the nucleotides found within it such as Adenine (A), Cytosine (C), Guanine (G) and Thymine (T). Students should also have knowledge of which nucleotides bind together and how DNA replicates including mitosis and meiosis.

Genetic and chromosomal mutations should also have been covered with the students including substitution, inversion, deletion, duplication, non-disjunction, frameshift mutation, and others so that the students can understand the concept of what occurs in each and how that can affect the DNA of an offspring.

Adapted from: District Adopted – Prentice Hall (Laboratory Manual A)

DNA Extraction Lab

Benchmark:

SC.F.1.4.1 The student knows that the body processes involve specific biochemical reactions governed by biochemical principles. **AA**
SC.F.2.4.2 The student knows that every cell contains a "blueprint" coded in DNA molecules that specify how proteins are assembled to regulate cells. CS

Objective/Purpose:

1. To observe DNA in an organism.
2. To compare and contrast the amount of DNA found in different individuals of a species.

Background Information:

DNA is too small to see under a regular microscope, so then how can it be studied? DNA is a large chemical molecule found in all living things, so it should be possible to extract it from cells or tissue. All we need to do is disrupt the cell's plasma membrane and nuclear envelope, make the DNA clump together and - voila! - DNA extraction is possible. Plant material is easy to use and DNA extractions from onion, bananas, liver, or wheat germ are common classroom activities or demonstrations.

Plants used in agriculture and horticulture are often artificially selected for their large flowers and fruits. Strawberries are no exception. A reason for the size of today's large supermarket strawberries is the octaploid nature of their cells. With eight sets of chromosomes, they have plenty of DNA for classroom extraction.

Problem Statement / Engagement:

We will be looking for the presence of DNA in a food source commonly eaten by humans.
"Do you think you have ever eaten DNA?"

Materials:

- Ziploc baggies
- Small (10 mL) graduated cylinders
- Beakers or cups for straining
- Cheesecloth
- Test tubes and containers or racks to hold them
- Wood splints or disposable inoculation loops
- Strawberries
- Extraction solution (10% shampoo and a dash of salt)
- Ice cold ethanol (70% pharmacy ethanol will work)

Procedure:

1. Smash several strawberries in a Ziploc baggie for 1 minute.
2. Add 10 mL extraction solution
3. Smash solution/berry mix for an additional 1 minute
4. Filter through cheesecloth
5. Pour 2-3 mL of filtrate into a test tube
6. Layer twice this volume with *ice cold* ethanol
7. Stir gently with inoculation loop and spool DNA as it clumps at the EtOH/filtrate interface.
8. Compare the amount of your extracted DNA with other groups' DNA.

Data (Tables and Observations):

Draw and describe the DNA removed from the strawberries.

Data Analysis (Calculations):

1. How is the appearance of your DNA similar or dissimilar to what you have learned about DNA structure?
2. A person cannot see a single strand of cotton thread from 30 meters away. But if thousands of threads are wound together into a rope, the rope can be seen at some distance. How is this statement an analogy to the DNA extraction you did?
3. DNA dissolves in water but not in ethanol. Explain what happened when the ethanol came in contact with the strawberry extract during the DNA extraction.

Results and Conclusions:

Compare the amount of DNA you extracted with the amounts other groups in your class were able to extract. What may be the reasons for the differences in the amounts? Discuss size, ripeness, lab method, etc.

Closure Activity:

Discuss your results and your analysis questions with the rest of the class in a whole group discussion. Determine as a class what might be the prevailing factor in the amount of DNA extracted. Design a simple experiment that would test these factors.

Extension:

Repeat the experiment with different fruits and/or different levels of ripeness and make predictions about how much DNA may be extracted from these foods.

Notes to the Teacher:

- Be sure to provide different size strawberries and to have enough strawberries.
- Be sure to make the ethanol VERY cold. If it is not, the amount of DNA extracted will be less.

Protein Transcription and Translation

Benchmark:

SC.F.1.4.1 The student knows that the body processes involve specific biochemical reactions governed by biochemical principles**. AA**
SC.F.1.4.5 The student knows that complex interactions among the different kinds of molecules in the cell cause distinct cycles of activity governed by proteins.
SC.F.2.4.2 The student knows that every cell contains a "blueprint" coded in DNA molecules that specify how proteins are assembled to regulate cells. CS
SC.F.2.4.3 The student understands the mechanisms of change (e.g., mutation and natural selection) that lead to adaptations in a species and their ability to survive naturally in changing conditions and to increase species diversity**. AA**

Objective/Purpose:

1. The student will learn the process of RNA transcription.
2. The student will understand the implication of a mistake in RNA translation.

Background Information:

Protein synthesis is the process where an mRNA strand is read at a ribosome in a cell to determine the correct structure of a protein. Within these instructions there are certain "start" and "stop" codons which signal when a protein is supposed to start or end. The instructions are very specific and usually only code for one type of protein. If a "mistake" is made, such as a deletion, inversion, or substitution, the whole protein may or may not change. This could be harmful, beneficial, or neutral change in DNA.

Given the DNA code for the hormone insulin, you will determine the correct amino acid sequence of a molecule. This exercise is divided into three strands of DNA that need to be coded for their proteins. Each strand represents the beginning, the middle, or the end of the insulin molecule. Based on the DNA code, the student will determine which segments are which. Once they have determined their segment, they will group up with the missing two segments and complete the exercise.

Problem Statement/Engagement:

"What effect would occur from the change in the exact chemical makeup of a protein?"

Materials:

- Pencils
- DNA strands

Procedure:

1. Decode the strands of DNA. Write out the resulting m-RNA in your chart below.

a. TACAAACATTTAGTTGTAAACACACCCTCAGTGGACCAACTCCGCA
ACATAAACCAAACACCGCTCGCGCCGAAAAAGATATGGGGGTTTTGG

b. TCTTCCCTCGCGCTCCTAAACGTTCAACCGGTTCAACTTAAT
CCGCCGCCAGGGCCCCGCCCCTCAGAAGTTGGTGATGCG

c. AATCTCCCATCAGACGTTTTTGCCCCGTAACAACTTGTTACAACA
TGGTCATAAACGTCAGAGATGGTCAATCTCTTAATGACGTTAACT

2. Divide the m-RNA into its codons by placing a vertical line between them.
3. Using the amino acid chart found below, determine the name of the amino acid that each codon codes for. In the chart below, write the abbreviation of the amino acids in their proper order.
4. After examining the polypeptide chains just constructed, determine if it is a beginning, middle, or an end segment of the pro-insulin molecule. (Hint: Look for a start code at the beginning, a stop code at the end, or no stop or start code.)

Data (Tables and Observations):

DNA strand	mRNA	Protein (amino acid or polypepetide chain)	Which End?

First Base in Codon	Second Base in Codon: A	G	U	C	Third Base in Codon
A	Lysine	Arginine	Isoleucine	Threonine	A
	Lysine	Arginine	Methionine	Threonine	G
	Asparagine	Serine	Isoleucine	Threonine	U
	Asparagine	Serine	Isoleucine	Threonine	C
G	Glutamic Acid	Glycine	Valine	Alanine	A
	Glutamic Acid	Glycine	Valine	Alanine	G
	Aspartic Acid	Glycine	Valine	Alanine	U
	Aspartic Acid	Glycine	Valine	Alanine	C
U	"Stop" Codon	"Stop" Codon	Leucine	Serine	A
	"Stop" Codon	Tryptophan	Leucine	Serine	G
	Tyrosine	Cysteine	Phenylalanine	Serine	U
	Tyrosine	Cysteine	Phenylalanine	Serine	C
C	Glutamine	Arginine	Leucine	Proline	A
	Glutamine	Arginine	Leucine	Proline	G
	Histidine	Arginine	Leucine	Proline	U
	Histidine	Arginine	Leucine	Proline	C

Data Analysis (Calculations):

1. Record the **entire** list of amino acids and write it in the space below. Start with the beginning segment, followed by the middle, and ending with tail.

_____

_____

_____

Results and Conclusions:

1. How many amino acids does this complete protein contain? _____
2. This protein is called pro-insulin. In order for it to operate in the body, a segment between #30 and #66 amino acids must be removed. The remaining sections are reconnected to form insulin. How many amino acids are there in the protein insulin? _____
3. Write an essay on the importance of having the exact genetic code for this protein and why mutations can cause a problem.
4. If the sixth letter in the entire strand is changed to a "G," does it change the protein? Explain your answer.
5. If the sixth letter in the entire strand is changed to "T," does it change the protein? Explain your answer.
6. What if the last letter on the DNA strand was deleted due to an environmental change? What could that do to the cell and to the individual itself as a whole?

Closure Activity:

Discuss as a class the answers to #4, #5, and #6. Compare the different responses and write a consensus for each on the board.

Extension:

Provide the students with the opportunity to research another protein and compare its structure to this one. What are the similarities in the function/structure of the additional protein?

Adapted from: Protein Synthesis Lab, Accessexcellence.org

Investigating Bacterial Growth

Benchmark:

SC.G.1.4.1 The student knows of the great diversity and interdependence of living things. **AA**
SC.F.1.4.8 The student knows that cell behavior can be affected by molecules from other parts of the organism or even other organisms. **CS**

Objective/Purpose:

1. Student will be able to make a connection between hygiene, sanitation, and bacterial diseases.
2. Students will be able to analyze the bacterial growth and make decisions on how to prevent bacterial growth in the selected areas to be tested.

Background Information:

Bacteria are prokaryotes-unicellular organisms that lack a nucleus. Bacteria are divided into two different groups: the Eubacteria and the ArchaeBacteria. Each group is now considered to be a different kingdom. Eubacteria live almost everywhere and is the larger of the two bacteria kingdoms. They are surrounded by a cell wall that protects the cell and gives it its shape. Inside the cell is the cytoplasm.

ArchaeBacteria lack a nuclei and have cell walls but they are quite different to Eubacteria. They have different membrane lipids and their DNA sequences are more like those of eukaryotes. ArchaeBacteria are found in extremely harsh environments, such as excessive salty environments, like Utah's Great Salt Lake.

Bacteria have different shapes. They can be rod-shaped (called bacilli), spherical-shaped (called cocci), and cork screw-shaped (called spirilla). Bacteria replicate through the process of Binary Fission in which the DNA of the bacteria is duplicated and an identical bacteria cell is produced.

Bacteria are essential to the living world. Some are known as producers that capture energy by photosynthesis and others are known as decomposers because they break down the nutrients in dead matter. Bacteria are also used by humans in the production of foods and beverages. Yet there are also bacteria that are harmful to organisms, such as E.coli.

This lab will help you analyze some of the bacteria that surround you.

Problem Statement / Engagement:

"Which area tested do you believe will lead to the largest percentage of bacterial growth?"

Read the entire investigation. Then work with a partner to answer the following questions.

1. Why is it important not to open sterile agar plates?

2. Why do you think it is so important to write only near the edges of the Petri dish?

3. Why is it important to use sterile techniques while inoculating the agar plates?

4. What is the purpose of the disk soaked in distilled water in each inoculated Petri dish?

5. What is the purpose of taping closed the lids of the Petri dishes?

Materials:

- glass-marking pencil
- Metric ruler
- Bunsen burner (or candles)
- Transparent tape
- 2 sterile nutrient agar plates
- Plastic/Latex gloves
- Matches
- Apron
- 2 sterile cotton swabs or an inoculating loop
- Safety goggles
- Beaker of water
- 3 areas to be tested for bacteria (can be chosen by student or teacher)
- Test-tube rack

Procedure:

Part A. Inoculating a Sterile Nutrient Agar Plate

1. Put on your laboratory apron. Obtain two sterile nutrient agar plates. Carefully turn over each plate and lay it on your worktable.

CAUTION: *Be very careful not to open the Petri dishes of sterile agar while handling them.*

2. With a glass-marking pencil, mark the bottom of each Petri dish shown in Figure 1. Draw two lines at right angles to each other so that the dish is divided into four equal areas or quadrants. Number the quadrants on each dish 1 through 4. **Note:** *Place the numbers near the edges of the dishes.* Write your initials near the top center of each dish. Carefully turn the Petri dishes right side up.

3. Put on your plastic gloves. **CAUTION:** *Use extreme care when working with bacterial cultures.* Obtain two sterile cotton swabs. Carefully read steps 4 through 8 and study Figure 2 before you proceed. Remove your plastic gloves.

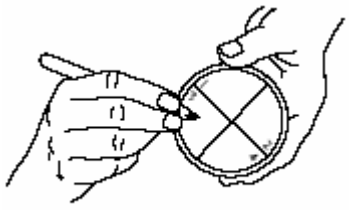
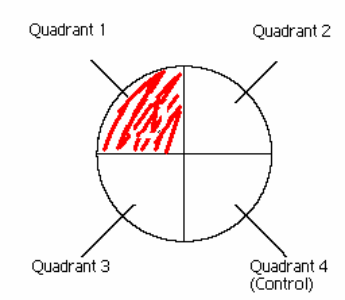


Figure 1

4. Put on your safety goggles and light the Bunsen burner. **CAUTION:** *Use extreme care when working with or near an open flame. Tie back loose hair and clothing.*

5. Pick the three test sites per group and using a sterile inoculating loop to swab the area. Using the inoculating loop, streak the pre-assigned area on the agar plate. Repeat the same steps with the other two remaining study sites using different inoculating loops or swabs. Remember to leave quadrant 4 untouched (control).



6. If using a swab, dispose of the used swab once done in the area assigned by the teacher. If using the inoculating loop remember to disinfectant it by placing it in the flame of the Bunsen burner.
7. With transparent tape, tape the Petri dishes closed as shown in Figure 6. Turn the dishes upside down. Incubate the dishes for 48 hours at 37°C. Check regularly for overgrowth of bacteria.

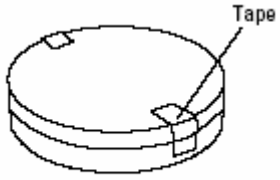


Figure 6

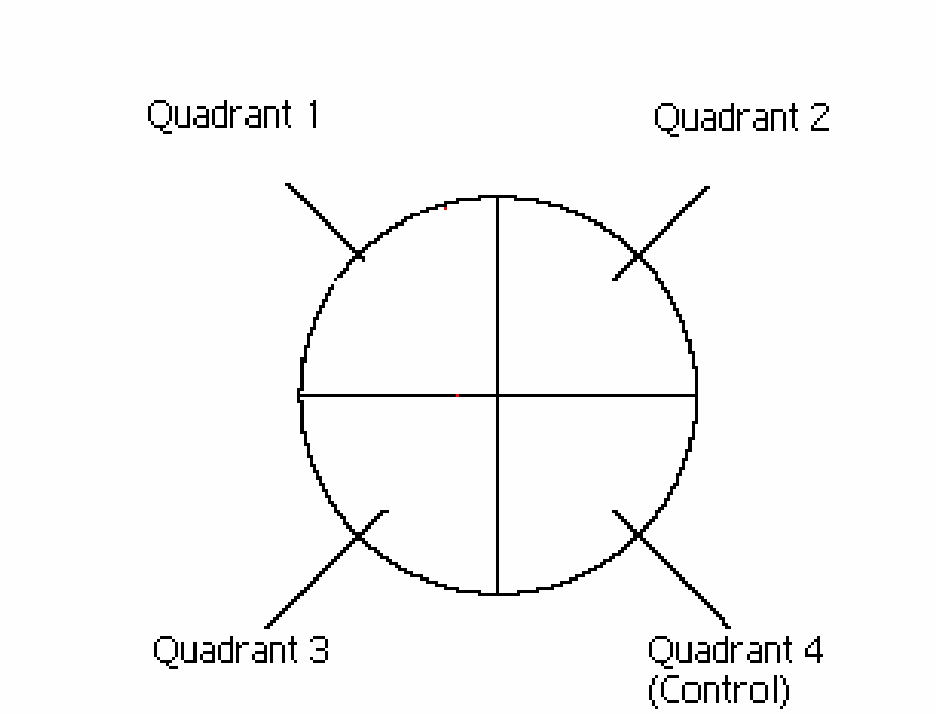
8. Observe the petri dishes after 48 hours. White or cloudy areas of the agar indicate bacterial growth.
9. Approximate the percentage of bacterial coverage for each quadrant tested.
10. Return the petri dishes to your teacher for proper disposal. Thoroughly wash your hands with soap and water.

Data (Tables and Observations):

BACTERIAL GROWTH

Areas Tested (per student)	Percentage of Bacterial Growth
1.	
2.	
3.	
4. Control	

In the following illustration draw what growth is seen in each quadrant and any distinctive characteristics (if viewable):



Data Analysis (Calculations):

1. Observing: Which area tested contained the highest amount of bacterial growth?

2. Draw: Use a bar graph to illustrate the information gathered in the data table.

Results and Conclusions:

1. Discuss if your hypothesis was correct or incorrect? Explain why using your results is evidence.
2. What do you believe is the cause of the large amount of bacterial growth in the area you tested? Explain your answer.
3. How can proper hygiene or sanitation help in decreasing bacterial growth?
4. Are all bacteria bad? Explain in detail.

Closure Activity:

1. Pretend that a serious staphylococcus infection has developed in the locker room of your school's gym. Assume that you are responsible for testing which area(s) of the locker room have the highest concentration of bacteria. How would you do so?

2. Scientists have observed that an antibiotic seems to lose its effectiveness against a particular population of bacteria after a prolonged period of time. What do you think is responsible for this phenomenon?

Extension:

Using the procedures presented in this investigation, test other species of bacteria—such as *B. subtilis*, *P. vulgaris*, *S. lutea, and E. coli.* For even further extension, check the assigned bacteria's for their resistance or sensitivity to various disinfectants and antibiotics. The types of disinfectants that can be used are chlorine bleach, household cleaner, household disinfectant, and rubbing alcohol to name a few. The antibiotic disks from which you can choose are the following: aureomycin, chloromycetin, penicillin, streptomycin, teracycline, and terramycin.

Supplemental Materials needed for the above lab extensions are:

Forceps
Disinfectants
Antibiotic disks (these disks are available from biological supply houses)
Bacteria (can be obtained from biological supply houses)

or

Suppose that your doctor diagnoses your condition as a bacterial infection and prescribes an antibiotic. Your doctor cautions you to take the antibiotic for 10 days even though you may feel fine after a few days. Explain why you should follow your doctor's orders.

Notes for Teacher:

Please refer to teacher's annotated lab manual A (Prentice Hall) *Going Further* section to learn how to prepare agar plates; otherwise, they can be purchased pre-prepared from biological supply houses.

Background Information for Extension Lab:

Chemical substances that either kill bacteria or inhibit bacterial growth are called antimicrobial agents. Antimicrobial agents are of three basic types: antiseptics or chemicals used to inhibit the growth of or kill bacteria on living tissues; disinfectants or chemicals used to inhibit the growth of or kill bacteria on nonliving things; and antibiotics or compounds that block the growth and reproduction of bacteria. The effectiveness of each type of antimicrobial agent is influenced by many factors. Some of these factors include the environmental conditions in which the agent is applied, the chemical properties of the agent, how long the agent has been stored, and the rate of deterioration of the agent. In this investigation, you will test the effectiveness of disinfectants and antibiotics in inhibiting the growth of bacteria.

Adapted from: Laboratory Manual A – Prentice Hall (District adopted)

Protist Diversity and Classification Lab

Benchmark:

SC.F.2.4.3 The student understands the mechanisms of change (e.g., mutation and natural selection) that lead to adaptations in a species and their ability to survive naturally in changing conditions and to increase species diversity. **AA**
SC.G.1.4.1- Knows of the great diversity and interdependence of living things. **AA**

Objective/Purpose:

1. The student will be able to observe different types of protists in aquatic ecosystems and compare how those living near the surface of the water differ from those living near the bottom.
2. The student will be able to construct a dichotomous key using the protists studied.

Background Information:

The Kingdom Protista includes incredible diversity. Protists differ in shape, structures, and sizes, but also in their habitats, motility, nutrition, and reproduction. Some protists are able to photosynthesize and some are heterotrophs.

Problem Statement / Engagement:

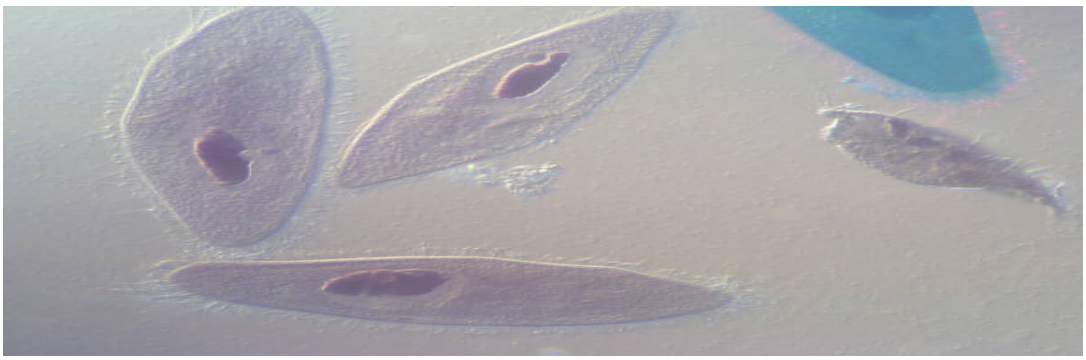
How does the presence of light affect the type of protists that inhabit an area?

Materials:

- Microscopes
- Microscope slides
- Protist identification key
- Protist cultures (Euglena, Paramecium, Amoeba, and Stentor).

Procedure:

1. Label one microscope slide “surface” and the other microscope slide “bottom.”
2. With a microscope, observe the “surface” slide under low, medium, and high power. Make sure to move the slide around the stage to survey the entire area under the cover slip.
3. Repeat step two with the “bottom” slide.
4. Describe and sketch the protists you observe on the slides. In your description, note specific characteristics, such as method of locomotion (cilia, flagella, and pseudo pod), color, shape, etc. Use a protist key to identify the different types of protists you observe.
5. Construct a dichotomous key of the protists observed using the characteristics noted.



Data (Tables and Observations):

Surface Sample

Sketch	Description	Identification

Bottom Sample

Sketch	Description	Identification

Data Analysis (Calculations):

1. Compare the anatomy of the protists in both habitats
2. Construct a dichotomous key using four protists studied in the lab.

Results and Conclusions:

1. Did the data support your hypothesis? Explain your response.
2. Did the protists share any characteristics?
3. How did habitat affect the type and characteristics of the protists that live in the area?
4. Why is it necessary to construct dichotomous keys?

Closure Activity:

Share results and discuss as a class your findings and your dichotomous key.

Extension:

Repeat the lab activity with pond water from different water samples.

Adapted from: Biology Exploring Life. Prentice Hall.

Plant Transpiration

Benchmark:

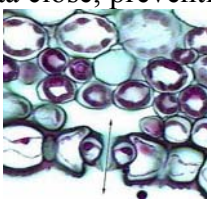
SC.F.1.4.2 The student knows that body structures are uniquely designed and adapted for their function.
SC.F.1.4.7 The student knows that organisms respond to internal and external stimuli. CS
SC.F.2.4.3 The student understands the mechanisms of change (e.g., mutation and natural selection) that lead to adaptations in a species and their ability to survive naturally in changing conditions and to increase species diversity**. AA**

Objective/Purpose:

3. To observe how different environmental factors affect transpiration.
4. To observe the structure and function of stomata in plants.

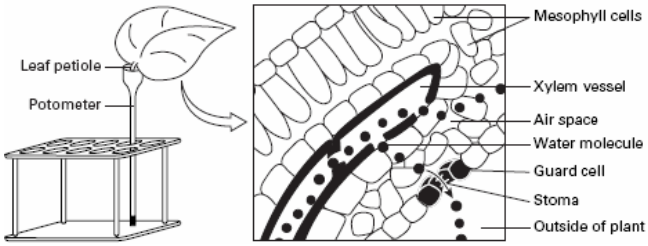
Background Information:

Stomata enable carbon dioxide to enter a plant. The openings also allow evaporative cooling, which keeps the plant enzymes from breaking down in hot conditions. Environmental conditions influence the number of stomata that are open. For example, low carbon dioxide levels in a leaf signal the guard cells to actively accumulate potassium ions. Due to osmosis, water follows the potassium ions into the guard cells, causing them to swell until gaps (the stomata) open between them. When more water has been lost through transpiration than can be replaced, the guard cells lose pressure and sag together. The stomata close, preventing more water loss to occur.



Problem Statement / Engagement:

"How will different environmental factors affect transpiration?"



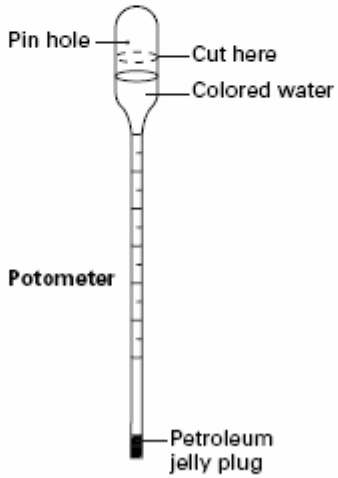
Materials:

- 4 pipettes per group
- Food coloring
- Petroleum jelly
- Scissors
- Test-tube rack
- Large leaves with narrow stems intact
- Laboratory balance
- Fan
- Bright lamp
- Spray bottle

Procedure:

Part A: Making the Potometers

1. With a permanent marker, mark the halfway point between each graduation (marking) on a transfer pipette. For example, between the 0.75 and 1 mL marks, make a mark to represent 0.875 mL. Repeat on the other three transfer pipettes.
2. Place a transfer pipette in colored water and draw up water past the 1 mL mark. Let go of the bulb before taking the pipette out of the water.
3. Open the petroleum jelly and squeeze the air out of the tip. Place the petroleum jelly tube under the tip of the pipette. Squeeze about 3 mm of petroleum jelly into the pipette to seal it.
4. Without squeezing the pipette bulb, use a safety pin to poke a hole in the bulb. (This keeps pressure from building up in the bulb.) With scissors, cut off the top of the pipette bulb. Repeat steps 1–4 for the other three pipettes. Then place the potometers in a test-tube rack.



5. Find the mass of each leaf using a laboratory balance. Enter the mass of each leaf in Data Table 1 on the next page.
6. Place Leaf 1 in the bowl of water so that its petiole or stem is underwater. Cut off the end of the petiole or stem underwater. Repeat with the other three leaves.
7. Place a leaf petiole or stem in each potometer. Label the leaf samples 1–4 on the remaining portion of the pipette bulb.

8. In Part B you will need to remove the leaves from the potometers to measure how much water has transpired. Because you are starting with only about 1 mL of water in each potometer, the water that sticks to the leaf petioles will affect your measurements. Therefore, you need to know how much water remains in the potometers when the petioles are removed. Remove the leaves and record the initial water levels of each potometer below.

   Leaf 1 potometer initial water level: _____ mL

   Leaf 2 potometer initial water level: _____ mL

   Leaf 3 potometer initial water level: _____ mL

   Leaf 4 potometer initial water level: _____ mL

9. Replace the leaves. Mark the water level on the pipette with a marker of a different color than the one you used before. This mark will help you notice when the water level changes.

Part B: Measuring Transpiration Rates

1. Place Leaf 1 and Leaf 2 in ambient conditions (existing classroom conditions—no special treatment). These two leaves will be your experimental controls. (Testing two leaves in each environment will help verify your results.) Record the time below.

   Start time for Leaf 1 and Leaf 2: _____

2. You will be assigned to test the effect of intense light, wind, or humidity. Record the variable you are testing in Column 1 of Data Table 1. As directed by your teacher, place Leaf 3 and Leaf 4 in your assigned environmental condition. Record the time below.

   Start time for Leaf 3 and Leaf 4: _____

3. To take a measurement on a leaf sample, remove the petiole from the potometer. Read the level of the water and quickly replace the petiole. Subtract the new water level from the initial water level that you recorded in Part A, Step 7. Record the *difference* in Data Table 1. You can take measurements every 10 min or at whatever intervals are appropriate. For instance, if you notice the water level has decreased before 10 min are up, take a measurement and note the time. If nothing has happened in 10 min, take a measurement at 15 min instead. Take measurements for each leaf at three time intervals before calculating the total transpiration rates. To calculate the rate, divide the third water level reading by the mass of the leaf and by the total number of minutes.

Data (Tables and Observations):

Figure 1: Data Table

	Mass of Leaf (g)	Water-Level Difference at ___ min	Water-Level Difference at ___ min	Water-Level Difference at ___ min	Total Transpiration Rate $\left(\frac{\text{mL/g}}{\text{min}}\right)$
Leaf 1 (control)		____ mL	____ mL	____ mL	
Leaf 2 (control)		____ mL	____ mL	____ mL	
Leaf 3 Variable: _____		____ mL	____ mL	____ mL	
Leaf 4 Variable: _____		____ mL	____ mL	____ mL	

Data Analysis (Calculations):

Plot 4 line graphs on the same grid. The x-axis should show time in minutes (independent or manipulated variable) and the y-axis should show the amount the water transpired (dependent or responding variable). Discuss your graph and what your results mean.

Results and Conclusions:

1. Did the data collected support your hypothesis? Explain and support your answer.
2. What can you conclude about the response of plants to wind and humidity? Explain.

Closure Activity:

In your group, provide a response to your teacher about the following scenarios:
"A gardener noticed that her plants were more wilted on sunny days, even when it wasn't very hot. Explain why this may have occurred, based on the results of your experiment."

Extension:

Test different sizes and textures of leaves for comparison and analysis of plant adaptations to different habitats.

Notes to the teacher:

- Make sure to get enough plants and also ensure that the stem of the plants to be used are small enough to fit into a pipette.
- Encourage and allow creative ideas for different manipulated variables that the students may come up with.

Adapted from: *Zip up the Xylem* Lab. Biology Exploring Life. Prentice Hall.

Fish Dissection and Behavior Study

Benchmark:

SC.F.1.4.2 The student knows that body structures are uniquely designed and adapted for their function.
SC.G.1.4.1 The student knows of the great diversity and interdependence of living things. **AA**

Objective/Purpose:

SWBAT:

1. Observe and identify the external parts of a fish.
2. Dissect and identify the internal organs of fish.
3. Observe and record the movement and breathing rate of goldfish.

Background Information:

Fishes are members of the phylum chordate and the subphylum vertebrata. The largest class of fishes, class Osteichthyes, contains fishes with skeletons made of bone. Fishes exhibit many adaptations for life in an aquatic environment. The perch and the goldfish are representative members of the Osteichthyes class.

Problem Statement / Engagement:

1. How are the structures of a fish evident of adaptations for living in an aquatic environment?
2. What is the relationship between the number of times the mouth of the goldfish opens and closes and the number of times the gill covers move?

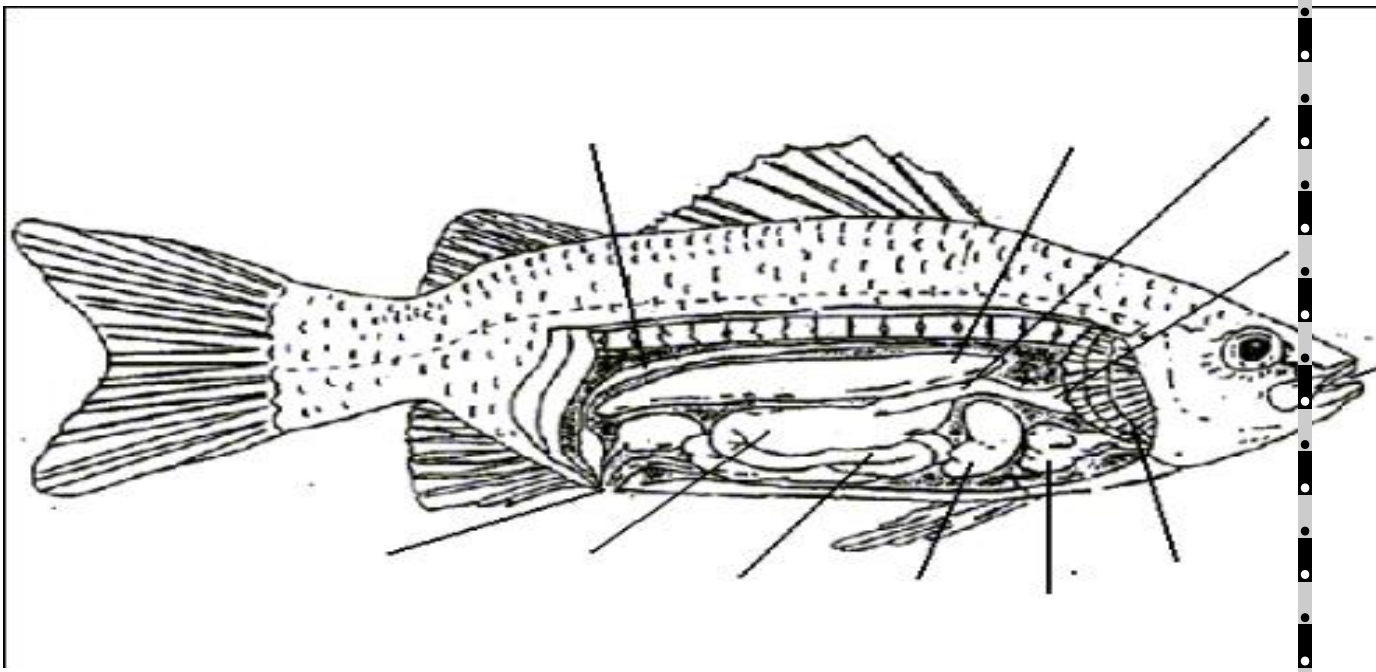
Materials:

- Preserved perch (fish)
- Preserved frog
- Dissecting tray
- Dissecting kit
- Dissecting microscope
- Paper towel
- Plastic bags
- Live goldfish
- Beaker
- Water from aquarium
- Fish net
- Stopwatch

Procedure:

1. Obtain a preserved fish and rinse under running water to remove excess preservatives.
2. Make observations of the external anatomy and fill in the observations table.
3. Fill a large glass beaker three-quarters full with water from an aquarium.
4. With a fish net, transfer one goldfish into beaker.
5. Observe the goldfish and using a stopwatch count how many times the fish opens and closes its mouth in one minute. Count how many times the gill covers move in one minute.
6. Carefully return the goldfish to its appropriate aquarium.
7. Using your thumb, lift up the edge of the operculum on the preserved fish and raise it up as far as you can. Using your scissors, cut the operculum off as close to the eye as possible. You have exposed the gills. The gills are layered one on top of another.
8. Using your probe, carefully lift each of these layers. How many layers do you find?

   _____
9. Using your scissors, remove one of these layers. Examine the feathery structure.
10. To expose the internal organs you will cut away part of its muscular wall. Grasp your preserved fish, holding it with your thumb on one side and fingers on the other. Turn your hand upward to expose the ventral surface. Using your scissors, insert the point into the skin just in front of the anus. Cut forward to the gills. Be careful not to destroy any of the internal organs, since they are mostly found in this area.
    Place your thumb into the open cut area and lift up, separating the bottom from the top. Using your scissors, cut upward near the anus and the operculum and form a flap of skin and muscle. Finish cutting along the lateral line and remove the flap of tissue. See the figure below.
11. The fish contains a 2-chambered heart. Locate this organ found just behind and below the gills.
12. Locate the tube-like digestive system. Begin just behind the mouth in the area called the pharynx. This area leads into the gullet or the opening of the esophagus. This area is very elastic and can stretch when the fish is alive.
13. Locate the rather large liver located just in front of the stomach.
14. Follow the intestine to the anus.
15. Locate the kidneys, found just below the spinal column. Their main function is to rid the body of nitrogenous waste.
16. The swim bladder is the last remaining organ to be identified. It is located between the kidneys and gonads.
17. Label the perch figure.



Data (Tables and Observations):

Data Table 1: External Anatomy

Type of Fin	Function
Anterior dorsal	
Posterior dorsal	
Anal	
Caudal	
Pectoral	
Pelvic	

Data Table 2: Goldfish Behavior

Body part	Number of times recorded in one minute
Mouth opening and closing	
Gill cover movement	

Data Table 3: Internal Anatomy

Body Part	Function
Gills	
Operculum	
Heart	
Liver	
Kidneys	
Swim Bladder	
Anus	

Data Analysis (Calculations):

1. How is the fish's body shape an adaptation to its environment?
2. What is the relationship between the number of times the mouth opens and closes and the number of times the gill covers move?
3. How are the perch's teeth adapted to their function?

Results and Conclusions:

1. What structures on the perch make it adapted for living in an aquatic environment?
2. While many invertebrates have an exoskeleton, vertebrates such as fishes have an endoskeleton. Of what advantage to the fish is the endoskeleton?
3. The perch fertilizes its eggs externally and leaves the eggs exposed on rocks. The guppy fertilizes its eggs internally and gives birth to live young. Which fish probably produces fewer eggs? Explain your response.

Closure Activity:

Have a class discussion about the data collected and whether the hypotheses were proven or not.

Extension:

1. Repeat the experiment with a cartilaginous fish for comparison.
2. Write a report on jawless fish or lobe-finned fish (coelacanth).

Adapted from: Prentice Hall Biology andvarious internet sites.

Study of Abiotic and Biotic Factors

Benchmark:

SC.G.2.4.2 The student knows that changes in a component of an ecosystem will have unpredictable effects on the entire system but that the components of the system tend to react in a way that will restore the ecosystem to its original condition**. AA**
SC.G.2.4.4 The student knows that the world ecosystems are shaped by physical factors that limit their productivity. **CS**

Objective/Purpose:

1. Identify and describe the essential components of habitat.
2. Describe the importance of good habitat for animals.
3. Define "limiting factors."
4. Recognize that some fluctuations in wildlife populations are natural as ecological systems undergo constant change.

Background Information:

A variety of factors affects the ability of wildlife to successfully reproduce and to maintain their populations over time. Disease, predator/prey relationships, varying impacts of weather conditions from season to season (e.g., early freezing, heavy snows, flooding, and drought), accidents, environmental pollution, and habitat destruction and degradation are among these factors.

Some naturally-caused as well as culturally-induced limiting factors serve to prevent wildlife populations from reproducing in numbers greater than their habitat can support. An excess of such limiting factors, however, leads to threatening, endangering, and eliminating whole species of animals. The most fundamental of life's necessities for any animal are food, water, shelter, and space in a suitable arrangement. Without these essential components, animals cannot survive.

Wildlife populations are not static. They continuously fluctuate in response to a variety of stimulating and limiting factors. Natural limiting factors tend to maintain populations of species at levels within predictable ranges. This kind of "balance in nature" is not static, but is more like a teeter-totter than a balance. This cycle appears to be almost totally controlled by the habitat components of food, water, shelter, and space, which are also limiting factors. Habitat components are the most fundamental and thereby the most critical of limiting factors in most natural settings.

Problem Statement / Engagement:

"How will resource availability affect the population of a species in an ecosystem?"

Materials:

- Students
- Open space

Procedure:

1. Make a hypothesis based on the problem statement above for the resources being supplied.
2. Obtain a number (1 through 4) from your teachers.
    a. Deer = 1
    b. Resources = 2, 3, 4
3. Go outside. Deer will all stand on one side of the sidewalk and all the resources will stand on the opposite side. Stand with backs toward other group.
4. Each student should choose a sign to make for the first round. Students 2 – 4 will decide what resource they will be and all the deer will decide what resource they are looking for. Resources will include food, water, and shelter.
5. Make the sign of the resource.
    a. Food = Rub stomach with hand
    b. Water = Raise hand to the mouth as if to drink from a cup
    c. Shelter = Raise arms over head
6. When teacher says "GO," turn around and face other group. Continue to hold sign.
7. When deer see a student in the habitat making the sign they need, they should walk quickly, but calmly, to get that student and take them back to the deer side. This represents the deer successfully meeting its needs and reproducing. Those deer who do not meet their needs remain in the environment to provide habitat for the other deer in the next round.
8. Record the number of deer in each round for graphing later.
9. Predict what will happen in the next round.
10. Continue steps 3-8 about 10 more times.

Data (Tables and Observations):

Round	Number of Deer	Prediction for Next Round

Data Analysis (Calculations):

Graph the results from your data table and discuss trends in your data.

Results and Conclusions:

To be included in your conclusions:

1. Identify and describe the essential components of habitat in regard to the lab.
2. Describe the relationship between resource availability and population growth or decline.
3. Define "limiting factors."
4. Explain how fluctuations in wildlife populations are natural as ecological systems undergo constant change.

Closure Activity:

Have a discussion about the results in your group and present them to the class.

Extension:

Repeat the experiment adding a "hunter" component. Write out the new procedure and how humans can affect an ecosystem.

Adapted from: Oh Deer! (Various teachers)

Effects of Acid Rain

Benchmark:

SC.G.2.4.6 The student knows the ways in which humans today are placing their environmental support systems at risk (e.g., rapid human population growth, environmental degradation, and resource depletion). **CS**

SC.H.1.4.1 The student knows that investigations are conducted to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories**. AA**

Objective/Purpose:

1. To determine the effects of acid rain on seed germination.
2. To simulate the human impact on the environment.

Background Information:

The burning of fossil fuels during the industrialization of the world has caused many negative environmental impacts. One, being the release of sulfur dioxide and carbon monoxide into the atmosphere, causing chemical reactions with water vapor causing acid precipitation (snow, rain, and ice). This has led to many issues with water pollution and soil pollution, causing adverse effects on plant growth and development.

Problem Statement / Engagement:

"Which acid concentration solution will have the most adverse affects on the germinating seeds?"

Materials:

- Graduated cylinders
- water
- Medicine droppers
- 5 petri dishes
- filter paper
- 25 radish seeds
- pH meter
- vinegar (acetic acid)

Procedure:

1. Label one Petri dish for each of the following treatments 100%, 75%, 50%, 25%, and 0%.
2. Place two pieces of filter paper into each dish.
3. Create the acid vinegar solutions. Use the following measurements to create the solutions:
    a) 100% = 20 mL of vinegar
    b) 75% = 15 mL vinegar, 5 mL water
    c) 50% = 10 mL vinegar, 10 mL water
    d) 25% = 5 mL vinegar, 15 mL water
    e) 0% = 20 mL water
4. Add 5 mL of acid solution to the appropriate petri dish.
5. Place 5 seeds in each treatment.
6. Place the Petri dishes in the box in the front of the room.
7. Use the pH meter to measure the acidity of each of the 5 solutions provided for testing, and record each reading in the chart.
8. After 5 days, remove the Petri dishes and check to see how many seeds have germinated (sprouted).
9. Record your data in the chart. Note any changes in the appearance of the seeds.

Data (Tables and Observations):

Percentage of Vinegar	pH	# of Seeds Germinated	Changes in Appearance
100%			
75%			
50%			
25%			
0%			

Data Analysis (Calculations):

Graph and analyze the results and discuss them in your conclusions.

Results and Conclusions:

Discuss your observations, trends, hypothesis proven or not and why, and possible applications.

Closure Activity:

Have a whole class discussion on the results from your graph, writing possible environmental causes of acid rain in the environment.

Extension:

Research areas which have issues with acid rain and discuss the possible causes and environmental impact, and provide global solutions for these areas.

Teacher Notes:

Make sure to engage the students beforehand in this unit by providing and discussing articles pertaining to current acid-rain issues. Discuss the causes before the lab and give the students opportunities to debate solutions at the conclusion of the lab.

Adapted from: District developed *Lab Intensive Summer Lab Manual*

Circulation Lab

Benchmark:

SC.F.1.4.1 The student knows that the body processes involve specific biochemical reactions governed by biochemical principles. **AA**
SC.F.1.4.2 The student knows that body structures are uniquely designed and adapted for their function**.**

Objective/Purpose:

1. The student will be able to describe how the sounds of a heart through a stethoscope relate to the stages of a heartbeat.
2. The student will be able to observe the relationship between heart rate and exercise.

Background Information:

When the ventricles in your heart contract, your atrioventricular valves, pulmonary valve, and aortic valve open and allow blood to flow through them. The valves then close, stopping blood from flowing backward. As the valves close, they make sounds that can be heard using the stethoscope. When the atrioventricular valves close, a "lub" sound is produced. When the pulmonary and aortic valves close, a "dubb" sound is produced.

Heart rate is the number of times a minute that the ventricles in your heart contract and pump blood. Each time blood is pumped, artery walls expand and then relax. This causes a surge of blood that can be felt at certain points in your body—your pulse. Heart rate can be measured without a stethoscope by measuring the pulse rate.

When you exercise, your heart rate increases. After exercise, the heart rate slows to a normal resting rate. The length of time it takes for heart rate to return to normal after exercise is a measure of the efficiency of the heart.

Problem Statement / Engagement:

"How does heart rate change with exercise?"

Materials:

- Stethoscope
- Rubbing alcohol
- Cotton balls
- Stopwatch

Procedure:

1. Use alcohol-clean earpieces on the stethoscope.
2. Listen to your heart by placing the diaphragm (flat side of the stethoscope) over your heart.
3. Describe what you hear in your data section of the lab.
4. While sitting, take your pulse for 15 seconds and multiply it by 4 to get your heart rate per hour. Record the result in your data section.
5. Run in place for 30 seconds. Immediately afterward, take your pulse for 15 seconds and calculate your pulse per hour again; then record your findings.
6. After an additional 45 seconds (to allow a total recovery time of 1 minute after exercising) take your pulse again for 15 seconds, calculate, and record it.

Data (Tables and Observations):

Describe the sounds of your heart: _____

Pulse Type	Pulse Rate
Sitting Pulse	
Peak Pulse	
Recovery Pulse	

Data Analysis (Calculations):

Make a line graph to represent how your heart responds to exercise. Plot time on the x-axis and pulse rate on the y-axis. Use the equation below to calculate your maximum heart rate:

220-your age in years = maximum heart rate per minutes

Use the equation below to calculate the lower end of your target heart rate, which is 70% of your maximum heart rate.

Maximum heart rate X 0.7 = lower end of target heart rate zone

Use the equation below to calculate the upper end of your target heart rate zone, which is 80% of your maximum heart rate.

Maximum heart rate X 0.8 = upper end of target heart rate zone

Results and Conclusions:

1. Did the data support your hypothesis? Explain your answer.
2. While listening to someone's heart, a doctor discovers that the "lub" sound is weaker than the "dubb" sound. What might this clue suggest about the functioning of the heart valves?
3. While listening to your heart, did you find that there was more time between the "lub" and the "dubb" sounds or between one "lub dubb" and the next? Suggest a possible explanation.
4. Explain why athletes often have lower resting pulse rates than non-athletes.
5. How is it useful to know your target heart rate zone? What forms of exercise do you think might increase your heart rate so that it is in your target heart rate zone?

Closure Activity:

Share results with other students and have a class discussion about data, graphs, and conclusions.

Extension:

Repeat lab activity with people of different age groups.

Adapted from: Prentice Hall. Biology Exploring Life

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