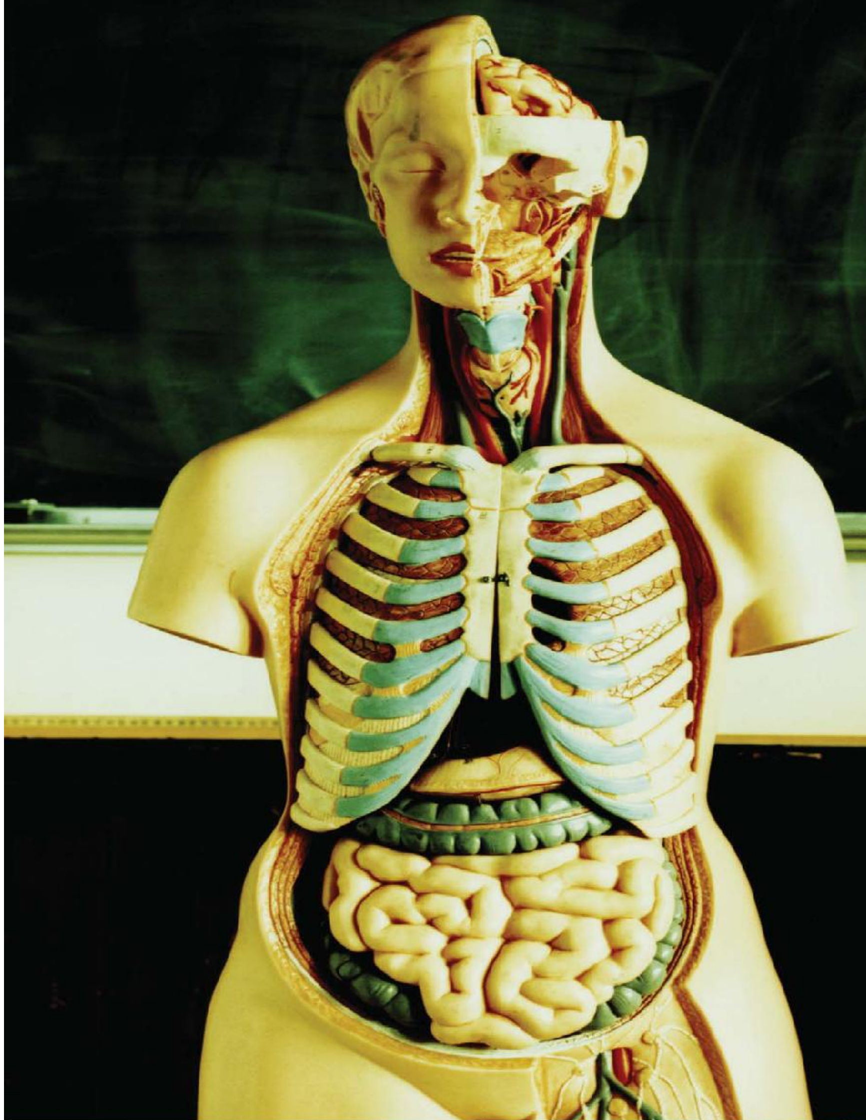
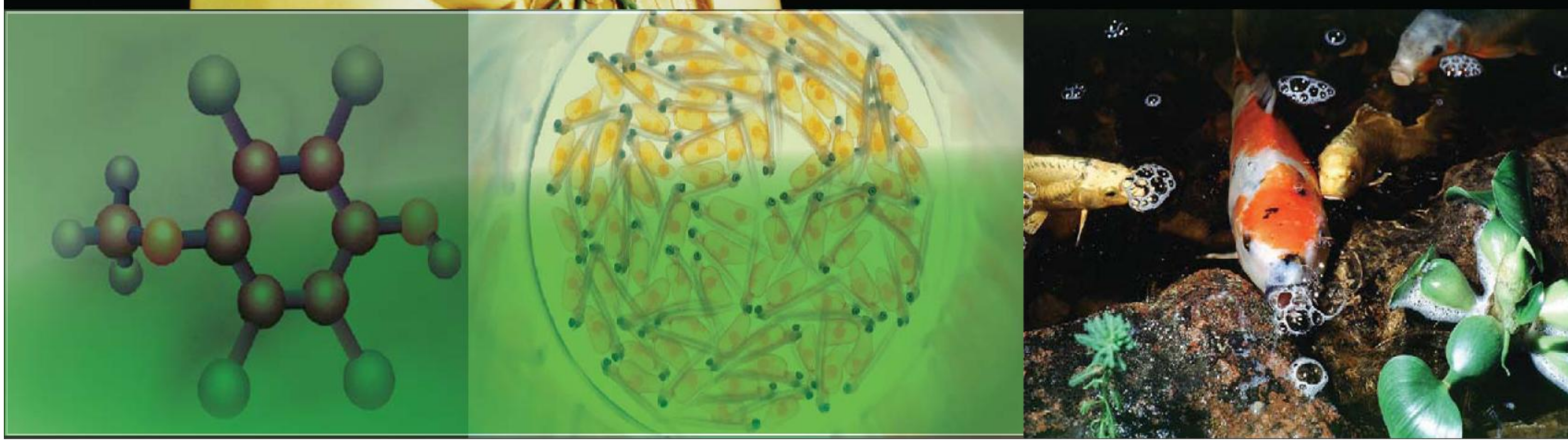
Miami-Dade County Public Schools



Biology

H.O.T. Science Labs

(High Order Thinking Science Labs)



Curriculum and Instruction

Division of Mathematics, Science, and Advanced Academic Programs

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Introduction

The purpose of this document is to provide Biology teachers with a list of basic laboratories and hands-on activities that students in a Biology class should experience. Each activity is aligned with the Biology Curriculum Pacing Guide and the Next Generation Sunshine State Standards (NGSSS).

All the information within this document provides the teacher an essential method of integrating the Science NGSSS with the instructional requirements delineated by the Course Description published by the Florida Department of Education (FLDOE) and the Biology End of Course Test (EOC). The information is distributed in three parts:

(1) A list of the course specific benchmarks as described by the FLDOE and that may be tested in the Biology EOC. The Nature of Science Body of Knowledge and related standards are infused throughout the activities. Specific Nature of Science, Language Arts, and Mathematics benchmarks may have been explicitly cited in each activity; however, it is expected that teachers infuse them frequently in every laboratory activity.
(2) Basic resources to assist with laboratory safety, organization of groups during lab activities, and scientific writing of reports.
(3) Hands-on activities that include a teacher-friendly introduction and a student handout. The teacher introduction in each activity is designed to provide guidelines to facilitate the overall connection of the activity with course specific benchmarks through the integration of the scientific process and/or inquiry with appropriate questioning strategies addressing Norman Webb's Depth of Knowledge Levels in Science.

All the hands-on activities included in this packet were designed to address important concepts found in the Biology course that will be assessed in the Biology EOC and to provide the teacher with sufficient resources to help the student develop critical thinking skills in order to reach a comprehensive understanding of the course objectives. In some cases, more than one lab was included for a specific standard, benchmark, or concept. In most cases, the activities were designed to be simple and without the use of advanced technological equipment to make it possible for all teachers to use. However, it is highly recommended that technology, such as *Explorelearning Gizmos* and hand-held data collection equipment from *Vernier*, *Texas Instruments*, and *Pasco*, is implemented in the science classrooms.

This document is intended to bring uniformity among the science teachers that are teaching this course so that all 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 Division of Mathematics, Science, and Advanced Academic Programs would like to acknowledge the efforts of the teachers who worked arduously and diligently on the preparation of this document.

Next Generation Sunshine State Standards (NGSSS)

- Annually Assessed (AA) Multiple-Choice Items are underlined followed by secondary benchmarks assessed as AA Benchmarks.
- Activities will reflect AA benchmark, but it is imperative that teachers become familiar with the secondary benchmarks and the content objectives described in the Curriculum Pacing Guides and the FLDOE Biology Item Specifications.

1. **SC.912.L.14.1:** Describe the scientific theory of cells (cell theory) and relate the history of its discovery to the process of science. (**AA**)
   a. **SC.912.N.1.3:** Recognize that the strength or usefulness of a scientific claim is evaluated through scientific argumentation, which depends on critical and logical thinking, and the active consideration of alternative scientific explanations to explain the data presented.
   b. **SC.912.N.2.1:** Identify what is science, what clearly is not science, and what superficially resembles science (but fails to meet the criteria for science).
   c. **SC.912.N.3.1:** Explain that a scientific theory is the culmination of many scientific investigations drawing together all the current evidence concerning a substantial range of phenomena; thus, a scientific theory represents the most powerful explanation scientists have to offer.
   d. **SC.912.N.3.4:** Recognize that theories do not become laws, nor do laws become theories; theories are well supported explanations and laws are well supported descriptions.
2. **SC.912.L.14.3:** Compare and contrast the general structures of plant and animal cells. Compare and contrast the general structures of prokaryotic and eukaryotic cells. (**AA**)
   a. **SC.912.L.14.2:** Relate structure to function for the components of plant and animal cells. Explain the role of cell membranes as a highly selective barrier (passive and active transport).
3. **SC.912.L.14.7:** Relate the structure of each of the major plant organs and tissues to physiological processes. (**AA**)
4. **SC.912.L.14.26:** Identify the major parts of the brain on diagrams or models. (**AA**)
5. **SC.912.L.14.36:** Describe the factors affecting blood flow through the cardiovascular system. (**AA**)
6. **SC.912.L.14.52:** Explain the basic functions of the human immune system, including specific and nonspecific immune response, vaccines, and antibiotics. (**AA**)
   a. **SC.912.L.14.6:** Explain the significance of genetic factors, environmental factors, and pathogenic agents to health from the perspectives of both individual and public health.
   b. **HE.912.C.1.4:** Analyze how heredity and family history can impact personal health.
   c. **HE.912.C.1.8:** Analyze strategies for prevention, detection, and treatment of communicable and chronic diseases.

7. **SC.912.L.15.1:** Explain how the scientific theory of evolution is supported by the fossil record, comparative anatomy, comparative embryology, biogeography, molecular biology, and observed evolutionary change. (**AA**)

   a. **SC.912.N.1.3:** Recognize that the strength or usefulness of a scientific claim is evaluated through scientific argumentation, which depends on critical and logical thinking, and the active consideration of alternative scientific explanations to explain the data presented.

   b. **SC.912.N.1.4:** Identify sources of information and assess their reliability according to the strict standards of scientific investigation.

   c. **SC.912.N.1.6:** Describe how scientific inferences are drawn from scientific observations and provide examples from the content being studied.

   d. **SC.912.N.2.1:** Identify what is science, what clearly is not science, and what superficially resembles science (but fails to meet the criteria for science).

   e. **SC.912.N.3.1:** Explain that a scientific theory is the culmination of many scientific investigations drawing together all the current evidence concerning a substantial range of phenomena; thus, a scientific theory represents the most powerful explanation scientists have to offer.

   f. **SC.912.N.3.4:** Recognize that theories do not become laws, nor do laws become theories; theories are well supported explanations and laws are well supported descriptions.

   g. **SC.912.L.15.10:** Identify basic trends in hominid evolution from early ancestors six million years ago to modern humans, including brain size, jaw size, language, and manufacture of tools.

8. **SC.912.L.15.6:** Discuss distinguishing characteristics of the domains and kingdoms of living organisms. (**AA**)

   a. **SC.912.N.1.3:** Recognize that the strength or usefulness of a scientific claim is evaluated through scientific argumentation, which depends on critical and logical thinking, and the active consideration of alternative scientific explanations to explain the data presented.

   b. **SC.912.N.1.6:** Describe how scientific inferences are drawn from scientific observations and provide examples from the content being studied.

   c. **SC.912.L.15.4:** Describe how and why organisms are hierarchically classified and based on evolutionary relationships.

   d. **SC.912.L.15.5:** Explain the reasons for changes in how organisms are classified.

9. **SC.912.L.15.8:** Describe the scientific explanations of the origin of life on Earth. (**AA**)

   a. **SC.912.N.1.3:** Recognize that the strength or usefulness of a scientific claim is evaluated through scientific argumentation, which depends on critical and logical thinking, and the active consideration of alternative scientific explanations to explain the data presented.

   b. **SC.912.N.1.4:** Identify sources of information and assess their reliability according to the strict standards of scientific investigation.

   c. **SC.912.N.2.1:** Identify what is science, what clearly is not science, and what superficially resembles science (but fails to meet the criteria for science).

10. **SC.912.L.15.13:** Describe the conditions required for natural selection, including: overproduction of offspring, inherited variation, and the struggle to survive, which result in differential reproductive success. (**AA**)
    a. **SC.912.N.1.3:** Recognize that the strength or usefulness of a scientific claim is evaluated through scientific argumentation, which depends on critical and logical thinking, and the active consideration of alternative scientific explanations to explain the data presented.
    b. **SC.912.L.15.14:** Discuss mechanisms of evolutionary change other than natural selection such as genetic drift and gene flow.
    c. **SC.912.L.15.15:** Describe how mutation and genetic recombination increase genetic variation.
11. **SC.912.L.16.1:** Use Mendel's laws of segregation and independent assortment to analyze patterns of inheritance. (**AA**)
    a. **SC.912.L.16.2:** Discuss observed inheritance patterns caused by various modes of inheritance, including dominant, recessive, co-dominant, sex-linked, polygenic, and multiple alleles.
12. **SC.912.L.16.3:** Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information. (**AA**)
    a. **SC.912.L.16.4:** Explain how mutations in the DNA sequence may or may not result in phenotypic change. Explain how mutations in gametes may result in phenotypic changes in offspring.
    b. **SC.912.L.16.5:** Explain the basic processes of transcription and translation, and how they result in the expression of genes.
    c. **SC.912.L.16.9:** Explain how and why the genetic code is universal and is common to almost all organisms.
13. **SC.912.L.16.10:** Evaluate the impact of biotechnology on the individual, society and the environment, including medical and ethical issues. (**AA**)
14. **SC.912.L.16.13:** Describe the basic anatomy and physiology of the human reproductive system. Describe the process of human development from fertilization to birth and major changes that occur in each trimester of pregnancy. (**AA**)
15. **SC.912.L.16.17:** Compare and contrast mitosis and meiosis and relate to the processes of sexual and asexual reproduction and their consequences for genetic variation. (**AA**)
    a. **SC.912.L.16.8:** Explain the relationship between mutation, cell cycle, and uncontrolled cell growth potentially resulting in cancer.
    b. **SC.912.L.16.14:** Describe the cell cycle, including the process of mitosis. Explain the role of mitosis in the formation of new cells and its importance in maintaining chromosome number during asexual reproduction.
    c. **SC.912.L.16.16:** Describe the process of meiosis, including independent assortment and crossing over. Explain how reduction division results in the formation of haploid gametes or spores.

16. **SC.912.L.17.5:** Analyze how population size is determined by births, deaths, immigration, emigration, and limiting factors (biotic and abiotic) that determine carrying capacity. (**AA**)
    a. **SC.912.N.1.4:** Identify sources of information and assess their reliability according to the strict standards of scientific investigation.
    b. **SC.912.L.17.2:** Explain the general distribution of life in aquatic systems as a function of chemistry, geography, light, depth, salinity, and temperature.
    c. **SC.912.L.17.4:** Describe changes in ecosystems resulting from seasonal variations, climate change, and succession.
    d. **SC.912.L.17.8:** Recognize the consequences of the losses of biodiversity due to catastrophic events, climate changes, human activity, and the introduction of invasive, non-native species.
17. **SC.912.L.17.9:** Use a food web to identify and distinguish producers, consumers, and decomposers. Explain the pathway of energy transfer through trophic levels and the reduction of available energy at successive trophic levels. (**AA**)
    a. **SC.912.E.7.1:** Analyze the movement of matter and energy through the different biogeochemical cycles, including water and carbon.
18. **SC.912.L.17.20:** Predict the impact of individuals on environmental systems and examine how human lifestyles affect sustainability. (**AA**)
    a. **SC.912.N.1.3:** Recognize that the strength or usefulness of a scientific claim is evaluated through scientific argumentation, which depends on critical and logical thinking, and the active consideration of alternative scientific explanations to explain the data presented.
    b. **SC.912.L.17.11:** Evaluate the costs and benefits of renewable and nonrenewable resources, such as water, energy, fossil fuels, wildlife, and forests.
    c. **SC.912.L.17.13:** Discuss the need for adequate monitoring of environmental parameters when making policy decisions.
    d. **HE.912.C.1.3:** Evaluate how environment and personal health are interrelated.
19. **SC.912.L.18.1:** Describe the basic molecular structures and primary functions of the four major categories of biological macromolecules. (**AA**)
    a. **SC.912.L.18.11:** Explain the role of enzymes as catalysts that lower the activation energy of biochemical reactions. Identify factors, such as pH and temperature, and their effect on enzyme activity.
20. **SC.912.L.18.9:** Explain the interrelated nature of photosynthesis and cellular respiration. (**AA**)
    a. **SC.912.L.18.7:** Identify the reactants, products, and basic functions of photosynthesis.
    b. **SC.912.L.18.8:** Identify the reactants, products, and basic functions of aerobic and anaerobic cellular respiration.
    c. **SC.912.L.18.10:** Connect the role of adenosine triphosphate (ATP) to energy transfers within a cell.
21. **SC.912.L.18.12:** Discuss the special properties of water that contribute to Earth's suitability as an environment for life: cohesive behavior, ability to moderate temperature, expansion upon freezing, and versatility as a solvent. (**AA**)

22. **SC.912.N.1.1:** Define a problem based on a specific body of knowledge, for example: biology, chemistry, physics, and earth/space science, and do the following: (1) pose questions about the natural world, (2) conduct systematic observations, (3) examine books and other sources of information to see what is already known, (4) review what is known in light of empirical evidence, (5) plan investigations, (6) use tools to gather, analyze, and interpret data (this includes the use of measurement in metric and other systems, and also the generation and interpretation of graphical representations of data, including data tables and graphs), (7) pose answers, explanations, or descriptions of events, (8) generate explanations that explicate or describe natural phenomena (inferences), (9) use appropriate evidence and reasoning to justify these explanations to others, (10) communicate results of scientific investigations, and (11) evaluate the merits of the explanations produced by others. (**AA**)

    a. **SC.912.N.1.4:** Identify sources of information and assess their reliability according to the strict standards of scientific investigation.

    b. **SC.912.N.1.6:** Describe how scientific inferences are drawn from scientific observations and provide examples from the content being studied.

    c. **SC.912.L.14.4:** Compare and contrast structure and function of various types of microscopes.

    d. **LACC.910.RST.1.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

    e. **LACC.910.RST.1.3:** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

    f. **LACC.910.RST.2.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.

    g. **LACC.910.RST.2.5:** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).

    h. **LACC.910.RST.3.7:** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

    i. **LACC.910.RST.4.10:** By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

    j. **LACC.910.WHST.1.2:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (1) Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. (2) Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. (3) Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts. (4) Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. (5) Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. (6) Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).

k. **LACC.910.WHST.3.9:** Draw evidence from informational texts to support analysis, reflection, and research.

l. **MACC.912.F-IF.3.7:** Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. (1) Graph linear and quadratic functions and show intercepts, maxima, and minima. (2) Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. (3) Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior. (4) Graph rational functions, identifying zeros and asymptotes when suitable factorizations are available, and showing end behavior. (5) Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.

m. **MACC.912.N-Q.1.1:** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

n. **MACC.912.N-Q.1.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

SC.912.N.2.2: Identify which questions can be answered through science and which questions are outside the boundaries of scientific investigation, such as questions addressed by other ways of knowing, such as art, philosophy, and religion. (**Not Assessed**)

Resources

Materials Hands-on Activities

1. **Perfect People**
   - Meter sticks and rulers
   - butcher paper or poster paper (for presenting)
   - markers

2. **Study of Abiotic and Biotic Factors**
   - 4 stakes
   - hammer
   - measuring rope (10 m) marked in meters
   - soil pH test kit
   - thermometer
   - wind vane
   - anemometer
   - trowel or hand shovel

3. **Limiting Factors**
   - open space

4. **Designing Food Chains and Food Webs**
   - butcher paper or poster paper
   - markers

5. **Human Impact – Effects of Acid Rain**
   - beakers (50 mL)
   - graduated cylinder
   - filter paper
   - medicine droppers
   - pH meter
   - 5 Petri dishes
   - water
   - vinegar (acetic acid)
   - 25 radish seeds

6. **Evidence for the Theory of Evolution**
   - Replica fossilized bone "casts"
   - Scissors
   - Paper
   - Tape or glue

7. **Examining the Fossil Record**
   - Chart paper
   - Scissors
   - Markers
   - Glue or tape

8. **Natural Selection**
   - Plastic spoon, knife, or fork
   - Self-sealing plastic sandwich bag
   - Food pieces (candies, unshelled nuts, beans, etc.)
   - Plastic container for nest (optional)

9. Using a Dichotomous Key for Invertebrate Phyla

- ☐ Invertebrate handouts (pictures)
- ☐ Invertebrate specimen samples
- ☐ Dichotomous key

10. Classification of Fruits

- ☐ Fruit pictures (may be substituted for real fruit)

11. Cladistics

- ☐ Organism Cards and Linnaean Table (in student packet)
- ☐ Clear (see-through) plastic bags – 7 per group
- ☐ 3 x 5 cards or sticky notes
- ☐ Scissors
- ☐ Printer paper
- ☐ Color pencils or markers

12. Plant Structure and Function

<u>Teacher Section</u>

- ☐ Tea leaves or tea bag (Leaf
- ☐ One fruit (any kind) (Flower)
- ☐ Celery plant (Stem and Leaf)
- ☐ Carrot or onion (Root)
- ☐ Live green plant (in a pot)

<u>Student Section</u>

- ☐ Student handout

Part 2A

- ☐ Plant leaves
- ☐ Clear fingernail polish
- ☐ Clear cellophane tape (clear package sealing tape)
- ☐ Microscope
- ☐ Microscope slides

Part B

- Plant roots (monocot and dicot)
- Microscope
- Microscope slides

Part C

- Plant stems (monocot and dicot)
- Microscope
- Microscope slides

13. Exploring Flower Structure

- ☐ Stereo and compound microscopes
- ☐ Brassica rapa or similar type of flowers
- ☐ Forceps
- ☐ Scissors
- ☐ index cards (4” x 6” or bigger)
- ☐ pencil
- ☐ tape
- ☐ microscope slides
- ☐ cover slips
- ☐ water
- ☐ disposable pipettes
- ☐ rubber stopper

14. Investigating the Effects of Light Intensity on Photosynthesis

- ☐ Test tube
- ☐ Source of bright light
- ☐ Sodium bicarbonate solution (Baking Soda)
- ☐ Watch or clock with second indicator
- ☐ 400-mL beaker
- ☐ Plastic gloves
- ☐ Sprig of evergreen or Elodea/*Anacharis* (Fresh Water Aquarium Plant)
- ☐ Hand lens
- ☐ Forceps

15. Cellular Respiration

- ☐ Distilled water
- ☐ Straw
- ☐ Heat-resistant gloves
- ☐ Hot Plate
- ☐ Cotton ball
- ☐ Beakers 500-mL (two)
- ☐ Test tubes (4)
- ☐ Purple cabbage leaves or Bromothymol blue
- ☐ Test tube rack
- ☐ Slotted spoon (large)
- ☐ Stoppers
- ☐ Radish seedlings (10)
- ☐ Forceps
- ☐ Aluminum foil

16. Animal-Vertebrate Fish “Perch” Dissection

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

17. Circulation Lab

- ☐ Stethoscope
- ☐ Rubbing alcohol
- ☐ Cotton balls
- ☐ Stopwatch

18. Take a Heart Hike

- ☐ 3-inch-wide masking tape, blue and red
- ☐ Large magic marker to write on tape
- ☐ Two small bowls or pans
- ☐ 20 quarter-sized red circles and 20 quarter-sized blue circles

19. The Deadly Fuchsia Disease

- ☐ test tube racks
- ☐ test tube
- ☐ distilled water
- ☐ NaOH (0.1 M)
- ☐ phenolphthalein

20. Cell Model Project

- ☐ recyclable household items

21. Diffusion and Osmosis

- ☐ Ziploc bag
- ☐ liquid starch
- ☐ forceps
- ☐ beaker (500 mL)
- ☐ water
- ☐ Iodine (Lugol’s solution)
- ☐ razor
- ☐ potato
- ☐ ruler
- ☐ balance
- ☐ graduated cylinder
- ☐ distilled water
- ☐ sucrose solution
- ☐ dissecting needle
- ☐ beaker
- ☐ aluminum foil

22. Investigating Inherited Traits
- 3 textbooks
- 2 pennies

23. Differences in Similar Phenotypes
- Metric ruler
- Meter stick

24. Making Karyotypes
- Scissors
- Glue or transparent tape

25. Building a DNA Model Project
- 2 strips of cardboard, 38 cm x 3 cm
- Metric ruler
- Toothpicks
- Crayons
- Tape
- Colored gumdrops
- Modeling clay
- Digital camera (optional; if available)
- Colored printer (optional; if available)

26. DNA Extraction Lab
- 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)

27. Candy DNA Replication Lab
- Red licorice chunks (red and black) - 24 piece each color
- Gum drops or colored marshmallows (4 different colors) - 6 of each color
- Wooden toothpick halves – about 70

28. Protein Synthesis: Transcription and Translation
- Pencils
- DNA strands worksheet

29. Building Macromolecules

Use different household or food items to represent the different elements
- Blueberries= Hydrogen
- Red Grapes= Oxygen
- Green grapes= Carbon
- Radish= Nitrogen
- Bonds= wooden toothpicks or dry spaghetti pieces

30. Enzyme Catalyst Lab

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

31. Properties of Water

- glass of water
- paperclip
- penny
- soda straw
- glass slide
- glass test tube
- a strip of jeans
- paper strip with a marker dot
- wax paper

32. Classification – Fishing for Protists

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

33. Genetic Disorders: Informational Poster and Presentation

- Construction paper
- Glue
- Poster board
- Stapler

Materials Modified Hands-on Activities

1. Genetic Disorders: Informational Poster and Presentation

- Construction paper
- Glue
- Poster board
- Stapler

Materials Additional Hands-on Activities

1. Fun with Bubbles

- 3 different kinds of clear dishwashing liquids
- commercial bubble solution
- water
- glycerin
- rulers
- straws
- plastic trash bags to cover tables

2. **Stimuli Effects on Heart Rate: Sympathetic Stimuli and Coughing**
    - *CBL2* with *TI 83* calculator
    - ice water bath
    - towel
    - *DataMate App*
    - *Vernier Respiration Rate Monitor*
    - *Vernier Hand-Grip Heart Rate Monitor* or *Vernier Exercise Heart Rate Monitor*
    - saline solution in dropper bottle for the exercise heart rate monitor

3. **Stimuli Effects on Heart Rate: Exercise and Baroreceptor Stimuli**
    - *CBL2* with *TI 83* calculator
    - *DataMate App*
    - *Vernier Respiration Rate Monitor*
    - *Vernier Hand-Grip Heart Rate Monitor* or *Vernier Exercise Heart Rate Monitor*
    - saline solution in dropper bottle for the exercise heart rate monitor

4. **Investigating Bacterial Growth**
    - 1 agar plate
    - Sample of bacteria
    - Inoculating loop or cotton swab
    - Forceps
    - Tape
    - 1 wax pencil/Sharpie
    - 1 metric ruler
    - Distilled water
    - Blank paper disk
    - 3 disks immersed in either antibiotic, antiseptic, or disinfectant solutions
    - 1 paper disk not immersed with any fluid
    - Penicillin or similar antibiotic
    - Bleach
    - Mouthwash

5. **DNA Electrophoresis Simulation**
    - Football, soccer or other large grass field (It is important to use a grass field in case students fall during the activity.)
    - 50 m or 100 m measuring tape
    - Stopwatch or other timing device

6. **Identifying Organic Compounds**
    - 10 test tubes
    - Test-tube rack
    - Test-tube holder
    - Masking tape
    - Glass-marking pencil
    - 10-mL graduated cylinder
    - Bunsen burner or hot plate
    - Iodine solution
    - 20 mL Honey solution
    - 20 mL Egg white and water mixture
    - 20 mL Corn oil
    - 20 mL Lettuce and water mixture
    - 20 mL Gelatin and water
    - 20 mL Melted butter
    - 20 mL Potato and water
    - 20 mL Apple juice and water mixture
    - 20 mL Distilled water
    - 20 mL Unknown substance
    - 10 Dropper pipettes
    - Paper towels
    - 600-mL Beaker
    - Brown paper bag
    - Sudan III stain
    - Biuret reagent
    - Benedict's solution

Laboratory Safety

Rules:

- Know the primary and secondary exit routes from the classroom.
- Know the location of and how to use the safety equipment in the classroom.
- Work at your assigned seat unless obtaining equipment and chemicals.
- Do not handle equipment or chemicals without the teacher's permission.
- Follow laboratory procedures as explained and do not perform unauthorized experiments.
- Work as quietly as possible and cooperate with your lab partner.
- Wear appropriate clothing, proper footwear, and eye protection.
- Report to the teachers all accidents and possible hazards.
- Remove all unnecessary materials from the work area and completely clean up the work area after the experiment.
- Always make safety your first consideration in the laboratory.

Safety Contract:

I will:

- Follow all instructions given by the teacher.
- Protect eyes, face and hands, and body while conducting class activities.
- Carry out good housekeeping practices.
- Know where to get help fast.
- Know the location of the first aid and firefighting 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: ____________________

Lab Roles and 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 and responsibilities:

Project Director (PD)
The project director is responsible for the group.
- Reads directions to the group
- Keeps group on task
- Is the only group member allowed to talk to the teacher
- Assists with conducting lab procedures 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.
- Picks 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.
- 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.
- 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”, “C”, and a “D” and or “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.

Writing in Science

A report is a recap of what a scientist investigated and may contain various sections and information specific to the investigation. Below is a comprehensive guideline that students can follow as they prepare their lab/activity reports. Additional writing templates can be found in the District Science website.

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

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

Benchmarks:
- A summary of the main concepts that you will learn by carrying out the experiment.

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

Hypothesis(es):
- State the hypothesis carefully, logically, and, if appropriate, with a calculation.
  1. Write your prediction as to how the independent variable will affect the dependent variable using a complete statement that is testable or an **IF-THEN-BECAUSE** statement:
     a. **(Introductory) If** (state the independent variable) is (choose an action), **then** (state the dependent variable) will (choose an action), **because** (describe reason for event).

Materials and activity set up:
- List and describe the equipment and the materials used. (e.g., A balance that measures with an accuracy of +/- 0.001 g)
- Provide a diagram of the activity set up describing its components (as appropriate).

Procedures:
- Do not copy the procedures from the lab manual or handout.
- Summarize the procedures that you implemented. Be sure to include critical steps.
- Give accurate and concise details about the apparatus (diagram) and materials used.

Variables and Control Test:
- Identify the variables in the experiment. There are three types of variables:
  1. Independent variable (manipulated variable): The factor that can be changed by the investigator (the cause).
  2. Dependent variable (responding variable): The observable factor of an investigation resulting from the change in the independent variable.
  3. Constant variable: The other identified independent variables in the investigation that are kept or remain the same during the investigation.
- Identify the control test. A control test is the separate experiment that serves as the standard for comparison and helps identify effects of the dependent variable

Data:
- Ensure that all observations and/or data are recorded.
  1. Use a table and write your observations clearly. (e.g., color, solubility changes, etc.)

2. Pay particular attention to significant figures and make sure that all units are stated.

Data Analysis:

- Analyze data and specify method used.
- If graphing data to look for a common trend, be sure to properly format and label all aspects of the graph (i.e., name of axes, numerical scales, etc.)

Results:

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

Conclusion and Evaluation:

- **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 (from the literature, or hypothesis) result.
     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) the hypothesis as the solution to the problem?
     b. Calculate the percentage error from the expected value.

- **Middle Paragraphs:** Discuss the major findings of the experiment.
  1. How did your findings compare with other researchers?
     a. Compare your result to other students' results in the class.
        i. The body paragraphs support the introductory paragraph by elaborating on the different pieces of information that were collected as data.
        ii. Each finding needs its own sentence and relates back to supporting or not supporting the hypothesis.
        iii. The number of body paragraphs you have will depend on how many different types of data were collected. They should always refer back to the findings in the first paragraph.

- **Last Paragraph:** Conclusion
  1. 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.
  2. 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.
  3. 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?

Hands-on Activities

Perfect People

NGSSS:
SC.912.N.1.1 Define a problem based on a specific body of knowledge, for example: biology, chemistry, physics, and earth/space science, and do the following: 1) pose questions about the natural world, 2) conduct systematic observations, 3) examine books and other sources of information to see what is already known, 4) review what is known in light of empirical evidence, 5) plan investigations, 6) use tools to gather, analyze, and interpret data (this includes the use of measurement in metric and other systems, and also the generation and interpretation of graphical representations of data, including data tables and graphs), 7) pose answers, explanations, or descriptions of events, 8) generate explanations that explicate or describe natural phenomena (inferences), 9) use appropriate evidence and reasoning to justify these explanations to others, 10) communicate results of scientific investigations and,11) evaluate the merits of the explanations produced by others. (**AA**)

Purpose of the Lab/Activity:
- To distinguish between qualitative and quantitative data.
- Utilize tools of measurements and emphasize importance of using the metric system.
- Practice making observations and inferences.
- Develop the steps of the scientific method by writing hypothesis and gathering data.
- Apply the scientific method to determine which bubble solution produces the largest bubble.

Prerequisites:
- Students should know laboratory safety rules and proper use of laboratory equipment.
- Students should be assigned their lab roles prior to the beginning of the activity.
- Students should know the steps of the scientific method.

Materials (per group):
- Ruler and Meter Stick

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Describe the objective of the activity and guide students in their thinking of possible problem statements as they consider their classmates square or rectangular shapes. 1. What is the problem statement? Have students synthesize their own problem statements and check for the testability. Examples may include: "Tall people have rectangular shapes. People with longer legs than torsos have rectangular shapes." 2. State the hypothesis. Again, allow time for the students to collaborate their own. Ensure the use of a complete statement or IF-THEN-BECAUSE statement. Answers will vary but should include both independent and dependent variable. 3. Identify the independent and dependent variable. Example: Independent: height of person, Dependent: length of arm to leg ratio 4. Identify the variables held constant. Example: meter stick

	5. Explain the tests conducted, identify both the experimental and control test. Experimental Test: Example: measurements of at least ten people in the class Control Test: Example: Known ratios of athletes? 6. List the number of trials per test. Example: 3 trials b. Students' misconceptions should be addressed. Some common misconceptions are: There is no universal scientific method. If a hypothesis proven to be false the experiment has failed. Quantitative data and qualitative data are the same. If two events occur repeatedly, one event causes the other. Scientific-sounding studies in tabloid magazines are true.
During activity:	**What the teacher will do:** a. Monitor students to make sure they are remaining on task and are following proper lab protocol. b. Review the experimental design diagram by asking individual students in groups to explain the different parts of the experiment. c. Follow laboratory procedural plan; making sure to model proper laboratory safety and use of equipment. d. Create class data table on board. e. Emphasize importance of data collection by groups. f. Ask the following questions: 1. Do you think the independent variable (Ex; body shape) affected the hypothesis? Why do you think? Explain your answer. 2. What factors caused differences in your data? What other variables should be tested from the results you obtained? 3. Does the number of trials affect the results you collected? Explain why or why not? 4. What other hypotheses could you have made from this problem statement? List possible ones. 5. Would you change the problem statement you came up with? Why or why not? What would have been an example of a better problem statement?
After activity:	**What the teacher will do:** a. Have the students record their group data and hypothesis on class data table, if the problem statements are the same across the groups. b. Analyze the different class data; making sure to note the importance of multiple trials, and repeatability in scientific investigations. c. Have students graph the data of their experiment; allow time to work with individual groups on what way is best to represent their data. (Example: the **D**ependent variable is the **R**esponding variable that in a graph is recorded on the **Y**-axis; the **M**anipulated variable is the **I**ndependent variable and is graphed on the **X**-axis.

Extension:

- Interactive Scientific Method Investigation: http://sunshine.chpc.utah.edu/labs/scientific_method/sci_method_main.html
- GIZMO: Growing Plants

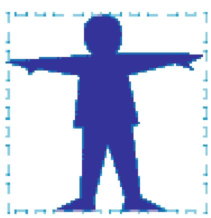
Student

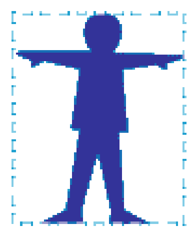
Perfect People

NGSSS:
SC.912.N.1.1 Define a problem based on a specific body of knowledge, for example: biology, chemistry, physics, and earth/space science, and do the following: 1) pose questions about the natural world, 2) conduct systematic observations, 3) examine books and other sources of information to see what is already known, 4) review what is known in light of empirical evidence, 5) plan investigations, 6) use tools to gather, analyze, and interpret data (this includes the use of measurement in metric and other systems, and also the generation and interpretation of graphical representations of data, including data tables and graphs), 7) pose answers, explanations, or descriptions of events, 8) generate explanations that explicate or describe natural phenomena (inferences), 9) use appropriate evidence and reasoning to justify these explanations to others, 10) communicate results of scientific investigations and,11) evaluate the merits of the explanations produced by others. (**AA**)

I. Arm Length and Height:

In this part of the experiment you will measure the height and length of 6 different people to determine if they are considered a "square" or a "rectangle" based on height and arm span measurements. From these observations, make a problem statement testing about the trends of body shape in a class population.





Problem Statement:
Identify the research question (problem to investigate) and state it clearly.

____

Hypothesis(es):
Write your prediction as to how the independent variable will affect the dependent variable. You may use an ***IF-THEN-BECAUSE*** statement to help you:

If <u>(state the independent variable)</u> is <u>(choose an action)</u>, **then** <u>(state the dependent variable)</u> will <u>(choose an action)</u>, **because** <u>(describe reason for event)</u>.

____

____

____

Student

Materials:

Procedures:
Using **centimeters**, measure your **height** (the distance from your head to your toes) and your **arm span** (the distance from the longest finger on your left hand to the longest finger on your right hand). If your height and arm span are about the same, then you're a square. If they're different, you're a rectangle.

Data: You may modify this data table for your own experiment.

Name of person	Height in centimeters	Arm span in (cm)	Square or Rectangle
1.____________	__________________	____________	______________
2.____________	__________________	____________	______________
3.____________	__________________	____________	______________
4.____________	__________________	____________	______________
5.____________	__________________	____________	______________
6.____________	__________________	____________	______________

Data Analysis:
Graph and analyze data to look for a common trend, be sure to properly format and label all aspects of the graph (i.e., name of axes, numerical scales, etc.)

Write an explanation for the results of your analysis.

Conclusion and Evaluation:
Write a conclusion of your findings. Follow the guidelines in the **Parts of a Lab Report: A Step-by-Step Checklist.**

Student

II. Inferring Height from Bone Length
(Adapted from pbs.org, Scientific American Frontiers)

By analyzing skeletal remains, scientists can infer all sorts of traits. For example, there is a link between the length of certain bones and height of an individual. This connection (also known as a regression) is consistent enough to allow person's height to be inferred from just a few bones.

Inferring Height
Your upper leg contains a large, single bone called the femur. This long bone stretches from the hip (pelvis) socket to the kneecap (patella). The length of this bone can be used to roughly estimate a person's height. To increase accuracy of this bone-to-height relationship, you will also need to know both the gender and race of the individual. These factors affect the relationship between long bone length and the individual's height.

Objective
This activity page will offer an experience in:
- Discovering how accurate these bone inferences are in predicting height

Materials
- Metric ruler or tape measure

Procedures
Part 1-Inferring Height from Femur Length
1. Work with a partner. Identify the placement of your partner's femur bone. It is the single large bone that extends from the hip socket to the kneecap.
2. Use a measuring tape to determine the approximate length of this bone (in centimeters).
3. Multiple the length of the femur by 2.6.
4. Add 65 to this number to arrive at the approximate height of your partner in centimeters.
5. Use a metric ruler to obtain the actual height of your partner in centimeters.
6. Switch roles.

Part 2-Inferring Height from Humerus Length
1. Work with a partner. Identify the placement of your partner's humerus bone. It is the single large bone that extends from the elbow to the shoulder socket.
2. Use a meter stick or measuring tape to determine the approximate length of this bone (in centimeters). If the bone comes from a female subject, go to step 3. If the bone comes from a male subject, go to step 5.
3. If the bone comes from a male subject, go to step 5. 3. If the bone comes from a female, multiply the measured length in centimeters by 3.06.
4. Add 64.26 to this number. This final number is the approximate height of the female based upon her humerus length.
5. If the bone comes from a male, multiply the measured length in centimeters by 3.27.
6. Add 59.41 to this number. This final number is the approximate height of the male based upon his humerus length.
7. Again, if you'd like to convert this numbers into inches, divide the result by 2.54.
8. Switch roles.

Student

Data:

Name	Actual Height	Femur Length	Inferred Height	Humerus Length	Inferred Height

Analyzing Your Results

1. How accurate were you in inferring height from femur length? Explain.
2. How accurate were you in inferring height from humerus length? Explain.
3. Were factors such as gender and race taken into account in these computations? Explain.
4. How might the accuracy of this calculation be improved?

Teacher

Study of Abiotic and Biotic Factors

NGSSS:
SC.912.L.17.5 Analyze how population size is determined by births, deaths, immigration, emigration, and limiting factors (biotic and abiotic) that determine carrying capacity. (**AA)**

Purpose of the Lab/Activity:

- Identify organisms living in the soil, plants, insects, and any other animals living within the site.
- Examine abiotic factors in the same study site.
- Compare abiotic and biotic factors in an ecosystem.

Prerequisites:

- Understand the role of photosynthesis in ecosystems.
- A general sense of the major groups of organisms in order to help determine their role and habitat.
- Knowledge of weather instrumentation and soil analysis kits.

Materials (per group):

- 4 stakes
- hammer
- measuring rope (10 m) marked in meters
- soil pH test kit
- thermometer
- wind vane
- anemometer
- trowel or hand shovel

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Select a study site. It does not have to be large (10 x 10 m) but it should show some diversity of plants and have some animal life in the area. An un-mowed corner of the campus, a section of trees behind the gym, or even a vacant lot down the street can be used. Use a different 10 x 10 m area for each lab group so that it is not so trampled. Also go over in advance and check the area for anything that could harm the students or make walking difficult. b. Tell students that today we will be looking at the schoolyard as an ecosystem. Go over expectations about gathering data and making observations in their assigned group. c. Review expectations about working within their groups. d. Assign groups and jobs within; there should be 11 groups (see procedural plan for explanation). Tell students that the schoolyard ecosystem is practice for gathering data and making observations of the ecosystem. e. Student misconceptions should be addressed. Some common misconceptions are: Ecology is just the study of pollution. f. Complete a Quick Write (literacy strategy that is designed to give students the opportunity to reflect on their learning) with the following scenario: Have students think of their favorite outdoor spot. As they recall their memory of that spot, have them list the living things that exist there. Have

	them also describe important nonliving aspects of their experience.
During activity:	**What the teacher will do:** a. Monitor students to make sure they are remaining on task and are examining their selected environment. b. Assist groups with identification of species. c. Emphasize importance of data collection by groups. d. Ask the following questions: 1. What are abiotic factors? Identify at least three abiotic factors in your ecosystem. 2. What are biotic factors? Identify at least three biotic factors in your ecosystem. 3. Predict the role of abiotic factors on an ecosystem.
After activity:	**What the teacher will do:** a. Compile class data; making sure to note the importance of multiple trials, and repeatability in scientific investigations. b. Have students return to their Quick Write and identify the abiotic and biotic factors. c. Answer Key for Results/Conclusion: 1. Show the abundance and type of producers, consumers, herbivores, carnivores, and decomposers in the food web. This may be diagrammed. Answers will vary. 2. Using the information you have, construct an energy-flow diagram for the area. Answers will vary. Remember arrows show the direction of the energy flow. 3. What ecological relationships did you observe? Give specific examples of each. Answers will vary according to the dynamics of the ecosystem observed. 4. Describe the niche of one organism to the best of your ability. Answers will vary. Niche is defined as the unique arrangement of an organism defined by its habitat, food sources, time of day it is most active, and other factors. 5. Can you see any relationship between the abundance of an organism, its size and its place in the food chain? Explain.

Extension:

- Distribute a picture of an ecosystem and have students identify biotic and abiotic factors.
- Show video clip: Abiotic vs. Biotic
- Interactive Lab: How do organisms react to changes in abiotic factors?
- Gizmo: Pond Ecosystem

Student

Study of Abiotic and Biotic Factors

NGSSS:
SC.912.L.17.5 Analyze how population size is determined by births, deaths, immigration, emigration, and limiting factors (biotic and abiotic) that determine carrying capacity. (**AA)**

Background:
An ecosystem can be divided into biotic and abiotic components. The community of the organisms living in the area comprise of the biotic components of the ecosystem. The community includes the organisms and actions such as mutualism and predation. And the environment in which the organisms thrive is the abiotic ecosystem. The abiotic components include the energy produced through the cycling of nutrients, the solar energy, and other non-living components in the ecosystem. The abiotic components of the ecosystem can be temperature, light, air current, etc.

Biotic components shape an ecosystem and are the living components in the organism's environment. In a grassland ecosystem, biotic components can be categorized as producers, consumers, and decomposers. The producers capture the solar energy, use the nutrients available, and produce energy. For example, grasses, trees, lichens, cyanobacteria, etc are producers. Consumers do not have the ability to produce or capture energy on their own and depend on the producers. They are the herbivores, carnivores, and omnivores. Decomposers break down the organic layer providing nutrients for the producers. Insects, fungi, bacteria, etc. are examples of decomposers. In the grassland ecosystem, soil is the important link between the biotic and abiotic components.

Abiotic factors affect the living organisms in a community. In a barren ecosystem new organisms start colonizing the ecosystem. They depend on the environmental components to thrive well in the system. These environmental components which facilitate the thriving of the organisms are the abiotic factors. It can be the soil, climate, water, energy, and anything helping the sustenance of the organism. The abiotic components impact the evolution cycle.

In an ecosystem, if one factor is altered, it can impact the whole system. The availability of the other resources in the system can be impacted as a whole. Human beings are capable of altering the physical environment through development, construction, farming, and pollution. As a result the abiotic components in the system change and affect the biotic organisms. Global warming affects many organisms like plants and microbes. Acid rains have resulted in the destruction of the fish population.

Problem Statement: What are the biotic and abiotic components of an ecosystem?

Safety: Do not touch poisonous plants or animals.

Vocabulary: ecosystem, environment, abiotic, biotic, temperature, pH, plant, insect, bird, mammal, reptile, amphibian, soil, wind, anemometer, wind vane

Student

Materials (per group):

- 4 stakes
- hammer
- measuring rope (10 m) marked in meters
- soil pH test kit
- thermometer
- wind vane
- anemometer
- trowel or hand shovel

Procedures:

1. Select a study site close by.
2. Groups will accomplish the following tasks: (the list gives the name of the group and the procedure for that group)
   a. **Staking** (3 students minimum). Using the measuring rope, mark a 10 m x 10 m square. Mark the corners of the square and rectangles with stakes, and then connect the stakes with string. At the end of the period rewind the string and take up the stakes.
   b. **Trees** (a plant with a stem more than 1 cm. in diameter): Count each type of tree in the 10 m x 10 m square.
   c. **Shrubs** (a plant with a stem greater that .5 cm. in diameter but less than 1 cm. in diameter): Count each type of shrub in the 10 m x 10 m square.
   d. **Primitive plants (a plant with a stem less than 0.5 cm in diameter): and Herbs (ferns, mosses, liverworts, etc.):** Count each one in the 10 m x 10 m square.
   e. **Insects:** Count and identify insects collected, then release them.
   f. **Birds:** Count and identify any birds in the vicinity of the study site.
   g. **Mammals, reptiles and amphibians:** Look for tracks, burrows, or other signs of these animals in or near the 10 m x 10 m area. Identify animal or its sign. DO NOT PICK UP ANY SNAKES.
   h. **Temperature:** Take the air temperature at head, shoulder, waist, knee, and ground level in the open, under a tree, and under a shrub.
   i. **Soil:** Take soil samples at the same location as the soil and litter group. Follow directions of the soil pH kit. Describe the color and texture of the soil.
   j. **Wind:** On the first day, set out the rain gauge in the study site at a location that is not sheltered by vegetation. Check each day for any rain. Read and record.
   k. **Description:** Describe what the study site looks like. Try to paint a picture with words.
3. Each student is responsible for finding ecological relationships and identifying it within the study area.
4. Return to classroom and share data. Some groups may need help with identifying their samples.

Student

Observations/Data:

	# Identified (divided by type)	Description (by type)	Abiotic or Biotic
Trees			
Shrubs			
Primitive Plants			
Herbs			
Insects			
Birds			
Mammals			
Reptiles			
Amphibians			
Temperature			
Soil			
Wind			

Student

Data Analysis:
Create a sketch of your ecosystem. Color code the abiotic and biotic components.

Sketch of School Yard Ecosystem

Results/Conclusion:

1. Show the abundance and type of producers, consumers, herbivores, carnivores, and decomposers in the food web. This may be diagrammed.
2. Using the information you have, construct an energy-flow diagram for the area.
3. What ecological relationships did you observe? Give specific examples of each.
4. Describe the niche of one organism to the best of your ability.
5. Can you see any relationship between the abundance of an organism, its size and its place in the food chain? Explain.
6. Write a paper describing all your results and conclusion of your observations.

Teacher

Limiting Factors

(Adapted from the "Oh Deer" activity)

NGSSS:

SC.912.L.17.5 Analyze how population size is determined by births, deaths, immigration, emigration, and limiting factors (biotic and abiotic) that determine carrying capacity. (**AA)**

Purpose of the Lab/Activity:

- Identify and describe the essential components of habitat.
- Describe the importance of good habitat for animals.
- Define "limiting factors."
- Recognize that some fluctuations in wildlife populations are natural as ecological systems undergo constant change.
- Graphing the data collected to show how population size differs over time and with changes in the environment.

Prerequisites:

- An understanding of the components of an ecosystem, organism's role and interactions that occur between them.
- The difference between abiotic and biotic factors.
- The resources necessary for an organism to survive.

Materials (per group):

- open space

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Ask the following question in order to review the basic needs of animals: 1. Identify some of the basic needs of animals. 2. Define the concept of a "limiting factors" in your own words. b. Before going outside, give directions on how to play. Impress upon the students that being honest is the only way to obtain accurate scientific data for the graphing activity. In nature, cheating is not an option! c. Explain that habitats provide: shelter, food, water, space, mates, etc. This game simulates the search for three of these: shelter, food and water. d. Once outside, students will count off in fours. 1s, 2s, and 3s are one side of the field. 4s are on the other. e. Space the two lines facing each other at least 20 yards apart. The width of the activity area should be slightly wider than the habitat line. f. The 4s will represent the deer. g. The 1s, 2s, 3s will be the habitat components.
During activity:	**What the teacher will do:** a. Monitor students during the activity to make they are not cheating by changing their sign after a round as begun. b. Assist them at the end of each round to make sure they are following the procedure. Emphasize step 7. c. Encourage students to color code organism name according to their role

	d. Remind students to collect data at the end of each round; each round symbolizes a year. e. Ask the following questions: 1. What were the limiting factors for population growth in this simulated ecosystem? Can these factors change over time? 2. Ecologists have found that no organism can experience indefinite exponential growth, yet *Homo Sapiens* have experienced exponential growth for hundreds of years. How have humans modified the limiting factors of our population growth?
After activity:	**What the teacher will do:** a. Return to classroom, to work on analysis of lab. b. Answer Key for Results/Conclusion: 1. List the basic needs of animals. food, water, shelter, and adequate space 2. Describe the relationship between resource availability and population growth or decline. When resources are available populations grow until they reach their carrying capacity. If resources become limited then the population will decline. 3. Define “limiting factors” and provide three examples. Limiting factors prevent the continued growth of a population; Examples: predators, drought, disease, habitat loss, pollution, hunting, reduced dietary items, weather, parasites, etc. 4. What is the carrying capacity for the deer population according to your graph? Answers will vary; must be determined using their group’s graph. Carrying capacity is the maximum population size a certain environment can support for an extended period of time. 5. Once the deer population goes significantly above carrying capacity, describe what happens to the deer population in the years following. The deer population naturally increases until it overshoots the carrying capacity. At this point, the environment can no longer provide for the species, due to the limiting factors which in this activity was food, water and shelter. The deer population, due to lack of resources, will begin to die out, allowing the environment to recover. As the environment recovers, the species population is able to flourish once more. c. Examine the graph. 1. What happened to the population size between years 1 and 2? declined 2. What happened to the population size between years 4 and 5? increased 3. If the environmental conditions in year 9 are the same as occurred between years 2 and 3, what can you expect to happen to the population between years 8 and 9? Why? The environmental conditions were favorable between years 2 and 3 and the population increased. The population is on the rise from years 6 to 8, but the population in year 8 is still at or below the population at year 2. With similar favorable conditions as between years 2 to 3, the population should continue to increase into year 9. d. Have groups answer the following questions: 1. How did you determine the carrying capacity?

	2. Describe how the activity modeled the significance of limited resources in regards to a species' population. 3. List some possible sources of errors and how they could affect the lab results. 4. Make suggestions for improving the lab to make the simulation more accurate and effective.

Extension:

- Repeat the experiment adding a "hunter" component. Write out the new procedure and how humans can affect an ecosystem.
- Online Activity 35.2: Population Growth of Two Different Species www.biology.com Students plot exponential growth of bacteria as they view a video. Then they plot and analyze data showing changes in a hypothetical population of grizzly bears. Then they compare exponential growth to population limited by environmental factors.
- Gizmo: Rabbit Population by Season

Student

Limiting Factors
(Adapted from the “Oh Deer” activity)

NGSSS:
SC.912.L.17.5 Analyze how population size is determined by births, deaths, immigration, emigration, and limiting factors (biotic and abiotic) that determine carrying capacity. (**AA)**

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

Vocabulary: reproduction, predator, prey, degradation, limiting factor, habitat, species, population, resource, carrying capacity

Materials (per group):
- open space

Procedures:
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.

Student

Resources will include food, water, and shelter. A deer can choose to look for any of its needs in each round, but cannot change its mind after turning around to face the "habitat".

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. Repeat steps 3 – 8, fifteen more times.

Observation/Data:

Year (round)	Deer Population (#)	Prediction for Next Round
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Data Analysis:
Graph the results from your data table and to show the rise and fall of the deer population. Create a line graph using the data from the table above; make sure to label your axis(s) and include the units of measurements.

Effects of Resources on Deer Population

Results/Conclusion:

1. List the basic needs of animals.
2. Describe the relationship between resource availability and population growth or decline.
3. Define “limiting factors” and provide three examples.
4. What is the carrying capacity for the deer population according to your graph?
5. Once the deer population goes significantly above carrying capacity, describe what happens to the deer population in the years following.
6. Write a conclusion of your findings. Follow the guidelines in the **Parts of a Lab Report: A Step-by-Step Checklist.**

Designing Food Chains and Food Webs

NGSSS:
SC.912.L.17.9 Use a food web to identify and distinguish producers, consumers, and decomposers. Explain the pathway of energy transfer through trophic levels and the reduction of available energy at successive trophic levels. (**AA**)

Purpose of the Lab/Activity:
- Differentiate between a food chain and food web.
- Identify and distinguish the main components of an ecosystem.
- Explain the pathway of energy through trophic levels.
- Analyze the reduction of energy available at successive trophic levels.

Prerequisites:
- Understand the role of photosynthesis in ecosystems.
- A general sense of the major groups of organisms in order to help determine their role and habitat.
- Know the law of conservation of energy.

Materials (per group):
- butcher paper or poster paper
- markers

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Gather materials for each group, make sure to cut butcher into 1 m^2 sections. b. Tell students that today we will be creating a shoreline food web; set a time limit. c. Review the names of the organisms listed. d. If possible, allow students to search internet for any organisms they may not be familiar with. e. Instead of just having the students write the names of the organisms you can create visuals of the organism on index cards. It is a good idea to print a set for each group and laminate them so you can reuse them. f. Student misconceptions should be addressed. Some common misconceptions are: Food chains and food webs are the same. The top of a food chain has the most energy because it accumulates up the chain. Organisms higher in the food-web eat everything that is lower in the food web. Green plants are the only producers. g. Show the students the following video clip: http://videos.howstuffworks.com/planet-green/37343-g-word-pet-pythons-gone-wild-video.htm 1. Create a visual that connects the feeding relationships shown.
During activity:	**What the teacher will do:** a. Monitor students during the group assignment to make sure they are remaining on task and are creating a food web.

	b. Assist groups with identification of organisms from list. c. Encourage students to color code organism name according to their role d. Remind students that the arrows(s) that connect the organisms represent the flow of energy. e. Set a 20 minute time limit for group assignment. f. Ask the following questions: 1. Why does the arrow in a food chain point towards the animal that eats the food? 2. What does a food chain have in common with a food web? 3. How is a food chain different from a food web? 4. Identify the following: producers, consumers, decomposers, scavenger, detrivore.
After activity:	**What the teacher will do:** a. Encourage groups to present their food webs. Check for any possible errors in identifying the organisms' role. b. Discuss the following questions: 1. What does the suffix "troph" mean? nourish 2. What do you think a trophic level is? The position the organism occupies on the food chain. 3. Compare food chains and food webs. Food webs show how organisms are connected in many ways (via the transfer of energy and matter), food chains follow just one path. 4. Provide an example of a food chain. Answers will vary. (Example: grass→ frog → snake → hawk c. Have students complete their individual assignment using their group's food web. d. Answer Key for Results/Conclusion: 1. Explain what would happen if all of the primary consumers became extinct. The population of secondary and tertiary consumers would decrease since they would not have a food source, and the population of the producers would increase since they would not have a predator. 2. Predict what would happen if a non-native species is introduced into the food web. Introduction of a non-native species could affect the population of the native species. If they could survive in their new environment, they would have no natural predators therefore giving them an advantage. For example the pythons introduced in the Everglades are eating the Everglades endangered and threatened species. Reference the video shown prior to beginning lab. 3. Explain why food webs with many species (biodiverse) are more resilient than those with few species. If the food web only has a few species, the loss of one species would have a greater impact on the other parts of the food web. 4. Review your trophic pyramid, do you think there are more organisms at the base and less organisms as you travel up the pyramid. Yes there are more organisms in the base, since they must provide the food and energy needed for the levels above. 5. In theory, the earth could support many more people if we ate at a lower trophic level. List 2 benefits of doing this.

	Answers may vary. Examples: fewer acres are needed to support a single human, do not consume as many toxins as organisms that eat higher up in the food chain, could support a larger population of humans. List 2 drawbacks of eating lower on the food chain. Answers may vary. Examples: supporting a larger human population leads to greater pollution, more areas being used for agriculture can lead to loss of biodiversity 6. Large predatory fish usually are found at the 3rd or 4th trophic level of an energy pyramid. What does this mean in terms of energy loss? Due to the general rule that 10% of the energy in one trophic level transfers to the next trophic level. The further along the food chain you go, the less food (and hence energy) remains available. 7. Large predatory animals can also be problematic to eat because of bioaccumulation and biomagnifications of toxins such as lead or mercury in their habitats. What do those two big words mean and why should this be considered when discussing food chains and trophic levels. Bioaccumulation: Chemicals such as mercury are not excreted by animals or plants. When a plant takes up the mercury, all of that mercury is taken into the next trophic level (likely the zooplankton, such as krill). Krill need to consume quite a lot of phytoplankton to sustain themselves, and therefore eat a lot of mercury. In turn, the salmon eat the krill, and therefore accumulate more mercury. Finally, we eat the fish, so the mercury becomes a part of us which is an example of biomagnification.

Extension:

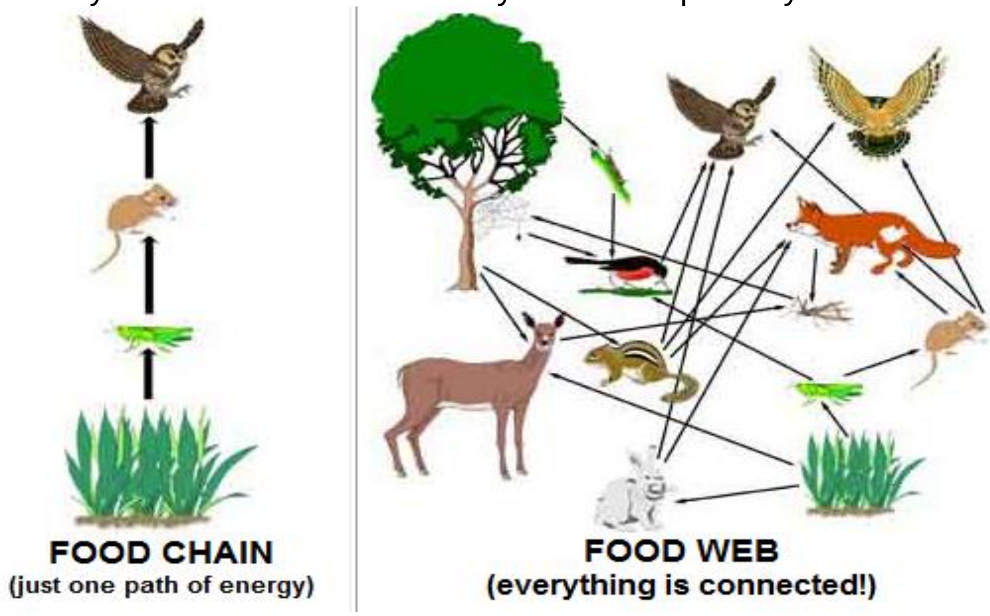
- Gizmo: Food Chain

Student

Designing Food Chains and Food Webs

NGSSS:
SC.912.L.17.9 Use a food web to identify and distinguish producers, consumers, and decomposers. Explain the pathway of energy transfer through trophic levels and the reduction of available energy at successive trophic levels. (**AA**)

Background: (Source: www.epa.gov)
All organisms in an ecosystem need energy to survive. This energy is obtained through food. Producers obtain energy by making their own food whereas consumers must feed on other organisms for energy. This dependence on other organisms for food leads to feeding relationships that interconnect all living things in an ecosystem. A food chain illustrates the simplest kind of feeding relationship. For example, in a forest ecosystem, a grasshopper feeds on plants. The grasshopper is consumed by a spider and the spider is eaten by a bird. Finally, that bird is hunted by a hawk. A food chain clearly shows this pathway of food consumption.



You could probably think of another food chain for a forest ecosystem. In fact, many different food chains exist in ecosystems. Although there are many different kinds of food chains, each food chain follows the same general pattern. A link in a food chain is called a trophic, or feeding level. The trophic levels are numbered as the first, second, third, and fourth levels, starting with the producers.

Each of the trophic levels is occupied by a certain kind of organism. Producers are always in the first trophic level since they do not feed on another organism. Consumers occupy the rest of the trophic levels. The second trophic level is the first consumer in the food chain and is called a primary consumer. Primary consumers eat plants and are therefore herbivores or omnivores. The next consumer in the food chain is the secondary consumer. The secondary consumer is in the third trophic level. Since the secondary consumer feeds on another animal, it is a carnivore or an omnivore. Similarly, the tertiary consumer occupies the fourth trophic level, and is a carnivore. The last link in a food chain is also referred to as the top carnivore since it is at the top of the food chain and is not hunted by other animals.

Student

Problem Statement: Are food chains and food webs the same? How do organisms transfer energy?

Vocabulary: food chain, food web, producer, consumer, decomposer, energy transfer, trophic level

Materials (per group):
- butcher paper or poster paper
- markers

Procedures:

Group Assignment

Work in small groups of 3 – 4 to draw each of the connections in a food web of a shoreline coastal ecosystem of the Everglades (mangrove).

1. On a piece of butcher-block paper, construction paper, or poster board, write the names of each shoreline organism randomly over the entire piece of paper. (See accompanying list.)
2. Identify the role of each organism in the ecosystem by writing one of the following letters beneath the name of the organism: (P) Producer, (C) Consumer, (D) Decomposer, (S) Scavenger, and (Dt) Detritivore.
3. Circle the name and letter of each organism. Color code their role and include a key.
4. Draw an arrow between each food source and the organism that eats that food. Remember that the arrow represents the flow of energy.

Observation/Data Analysis:

Individual Assignment

1. Find and write as many food chains as you can from your team's food web (minimum of 6). Two of the food chains must include a producer and three levels of consumers (primary, secondary, tertiary). Label them.
2. Sketch a trophic pyramid using the food chains you created and place the names of your organism at the proper level.

Results/Conclusion:

1. Explain what would happen if all of the primary consumers became extinct.
2. Predict what would happen if a non-native species is introduced into the food web.
3. Explain why food webs with many species (biodiverse) are more resilient than those with few species.
4. Review your trophic pyramid, do you think there are more organisms at the base and less organisms as you travel up the pyramid.
5. In theory, the earth could support many more people if we ate at a lower trophic level.
   a. List 2 benefits of doing this.
   b. List 2 drawbacks of eating lower on the food chain.
6. Large predatory fish usually are found at the 3^{rd} or 4^{th} trophic level of an energy pyramid. What does this mean in terms of energy loss?
7. Large predatory animals can also be problematic to eat because of bioaccumulation and biomagnifications of toxins such as lead or mercury in their habitats. What do those two big words mean and why should this be considered when discussing food chains and trophic levels.

Student

Shoreline Organisms

Plants

- ☐ Red mangrove
- ☐ White mangrove
- ☐ Black mangrove
- ☐ Buttonwood
- ☐ Seaside Daisy
- ☐ Seagrass
- ☐ Glasswort

Animals

- ☐ Shrimp (arthropods)
- ☐ Lobster (arthropods)
- ☐ American Crocodile (reptile)
- ☐ Garfish (fish)
- ☐ Raccoon (mammal)
- ☐ Opossum (mammal)
- ☐ Amphipods (zooplankton)
- ☐ Mysids (zooplankton)
- ☐ Copepods (zooplankton)
- ☐ Snook (fish)
- ☐ Mullet (fish)
- ☐ Snapper (fish)
- ☐ Crested Goby (fish)
- ☐ Barracuda (fish)
- ☐ Bull Shark (fish)
- ☐ Tarpon (fish)
- ☐ Hermit Crab (arthropods)
- ☐ Osprey (bird)
- ☐ Great Blue Heron (bird)
- ☐ Egret (bird)
- ☐ Ibis (bird
- ☐ Bald Eagle (bird)
- ☐ Lady Fish (fish)
- ☐ Seatrout (fish)
- ☐ Queen Conch (mollusk)
- ☐ Otter (mammal)
- ☐ Fiddler Crab (arthropods)
- ☐ Water Moccasin (reptile)
- ☐ Bottlenose Dolphin (mammal)
- ☐ Mosquito Larvae (insect)

Other

- ☐ Algae (phytoplankton)
- ☐ Protozoa
- ☐ Bacteria
- ☐ Fungi

Teacher

Human Impact – Effects of Acid Rain

NGSSS:
SC.912.L.17.20 Predict the impact of individuals on environmental systems and examine how human lifestyles affect sustainability. (**AA**)

Purpose of the Lab/Activity:
- To determine the effects of acid rain on seed germination.
- To simulate the human impact on the environment.

Prerequisites:
- Students should be familiar with the pH scale.
- Students should be able to differentiate between an acid and a base.
- Students should be familiar with seed germination.

Materials (per group):
- graduated cylinder
- filter paper
- medicine droppers
- pH meter
- 5 Petri dishes
- water
- vinegar (acetic acid)
- 25 radish seeds

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Gather materials and make sure that pH meters are calibrated. Instead of a pH meter teacher can substitute with pH paper. b. You can modify this lesson by using mung beans instead of radish seeds; but the concentration of vinegar must be changed. c. It is important for students to complete an experimental design diagram prior to the investigation in order for them to understand all parts of the activity. 1. What is the problem statement? How does the concentration of vinegar affect the germination of radish seeds? 2. State the hypothesis. Answer will vary but should include both independent and dependent variable. (Example: If 100% vinegar is applied to the radish seeds, they will not germinate. 3. Identify the independent and dependent variable. Independent: concentration of vinegar (%) Dependent: seed germination 4. Identify the variables held constant. # seeds in each Petri dish, amount of each solution, filter paper 5. Explain the tests conducted, identify both the experimental and control test. Experimental Test: 100%, 75%, 50%, 25% Control Test: 0% vinegar solution 6. List the number of trials per test. 1 trial (Remind students that multiple

	trials are necessary in order to validate your conclusion. You could gather group data and compile a classroom data table; each student group would be a trial. d. Student misconceptions should be addressed. Some common misconceptions are: Acid rain is a result of global warming. Global warming and ozone layer depletion are one and the same.
During activity:	**What the teacher will do:** a. Monitor students to make sure they are remaining on task and are following proper lab protocol. b. Review the experimental design diagram by asking individual students in groups to explain the different parts of the experiment. c. Follow laboratory procedural plan; making sure to model proper laboratory safety and use of equipment. d. Emphasize importance of data collection by groups. e. Ask groups to brainstorm the effect of human activities on ecosystems. f. Ask the following questions: 1. Predict what would happen if I applied a basic solution instead of an acid solution to seed germination. 2. What effect does the varying concentration have on seed germination?
After activity:	**What the teacher will do:** a. Analyze class data; making sure to note the importance of multiple trials, and repeatability in scientific investigations. b. Remind students that they will need to leave Petri dishes in the classroom in order to observe their germination after 5 days. c. Have students graph the data of their experiment; (Mr. DRY MIX: the **D**ependent variable is the **R**esponding variable that in a graph is recorded on the **Y**-axis; the **M**anipulated variable is the **I**ndependent variable and is graphed on the **X**-axis. d. Give each student a post-it note. Ask students to list a human activity that impacts ecosystems. These post-its will be the used to make sure all students can engage in discussion. e. Answer Key for Results: 1. Identify the relationship between pH and vinegar concentration. The greater the concentration of vinegar the lower the pH. Vinegar's (acetic acid) has pH is roughly around 2.40 - 3.40. 2. Is vinegar an acid? Explain how that can be inferred from this activity. Vinegar is acidic in nature as it is a solution of acetic acid. In can be inferred since the higher the concentration of vinegar in the sample the lower the pH. 3. Compare your results with the class; were there any differences in the germination or pH by lab group? Is so, speculate on possible reasons for these differences. Answers will vary. Some possible reasons for error could be contamination of solutions; inaccurate dilution of vinegar. 4. Under which vinegar concentration did the seeds germinate best? Is this consistent with your expectations? 5. Predict how the results of this experiment can be used to explain the effects of acid rain on our environment. Acid rain; due to the low pH value can stunt the growth of plants; it can also affect soil nutrients.

	6. Explain how acidic water can harm aquatic plants and animals. Acid rain causes a cascade of effects that harm or kill individual fish, reduce fish population numbers, completely eliminate fish species from a waterbody, and decrease biodiversity. As acid rain flows through soils in a watershed, aluminum is released from soils into the lakes and streams located in that watershed. Some types of plants and animals are able to tolerate acidic waters. Others, however, are acid-sensitive and will be lost as the pH declines. Generally, the young of most species are more sensitive to environmental conditions than adults. At pH 5, most fish eggs cannot hatch. At lower pH levels, some adult fish die. Some acid lakes have no fish.

Extension:

- Acid Rain Tutorial (from Environmental Protection Agency): http://www.epa.gov/acidrain/education/site_students/acid_anim.html
- Gizmo: Water Pollution

Student

Human Impact – Effects of Acid Rain

NGSSS:
SC.912.L.17.20 Predict the impact of individuals on environmental systems and examine how human lifestyles affect sustainability. **AA**

Background: (Source: www.epa.gov)
The burning of fossil fuels during the industrialization of the world has caused many negative environmental impacts. Acid rain is a broad term used to describe several ways that acids fall out of the atmosphere. A more precise term is acid deposition; which has two part wet and dry. Wet deposition refers to acidic rain, fog, and snow. The strength of the effects depend on many factors, including how acidic the water is, the chemistry and buffering capacity (the ability to neutralize acidic compounds) of the soils involved, and the types of fish, trees, and other living things that rely on the water. Dry deposition refers to acidic gases and particles. The wind blows these acidic particles and gases onto buildings, cars, homes, and trees.

Scientists discovered, and have confirmed, that sulfur dioxide (SO_2) and nitrogen oxides (NO_x) are the primary causes of acid rain. In the U.S., about 2/3 of all SO_2 and 1/4 of all NO_x comes from electric power generation that relies on burning fossil fuels like coal. Acid rain occurs when these gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds. Sunlight increases the rate of most of these reactions. The result is a mild solution of sulfuric acid (H_2SO_4) and nitric acid (HNO_3).

Acid rain is measured using a scale called pH. The pH scale measures how acidic or basic a substance is. It ranges from 0 to 14. A pH of 7 is neutral. A pH less than 7 is acidic, and a pH greater than 7 is basic. Mixing acids and bases can cancel out their extreme effects; much like mixing hot and cold water can even out the water temperature. Normal rain is slightly acidic because carbon dioxide (CO_2) dissolves in it, so it has a pH of about 5.5. In recent years, the most acidic rain falling in the US has a pH of about 4.3.

Acid deposition has a variety of effects, including damage to forests and soils, fish and other living things, materials, and human health. Acid rain also reduces how far and how clearly we can see through the air, an effect called visibility reduction.

Problem Statement: How does the concentration of vinegar affect the germination of radish seeds?

Safety: Handle solutions carefully to avoid spills. The simulated “acid rain” solution may cause irritation and should be rinsed off promptly if it comes into contact with the sun. Wear goggles at all times. If any of the solutions get into your eye, flush the eye with water for 15 minutes and seek medical attention.

Vocabulary: pH, acid, base, germination, concentration, acid rain, fossil fuels, environment

Materials (per group):
- graduated cylinder
- filter paper
- medicine droppers

Student

- pH meter
- 5 Petri dishes
- water
- vinegar (acetic acid)
- 25 radish seeds

Procedures:

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:
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 front of the room.
7. Uses the pH meter to measure the acidity of each of the 5 solutions provided for the 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.

Observations/Data:

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

Data Analysis:
Create a line graph using the data from the table above; make sure to label your axis(s) and include the units of measurements.

Effects of pH on the Germination of Radish Seeds

Results:

1. Identify the relationship between pH and vinegar concentration.
2. Is vinegar an acid? Explain how that can be inferred from this activity.
3. Compare your results with the class; were there any differences in the germination or pH by lab group? Is so, speculate on possible reasons for these differences.
4. Under which vinegar concentration did the seeds germinate best? Is this consistent with your expectations?
5. Predict how the results of this experiment can be used to explain the effects of acid rain on our environment.
6. Explain how acidic water can harm aquatic plants and animals.

Conclusion:

Write a lab report using the “Power Writing Model 2009” answering the following questions:

- What was investigated?
- Was the hypothesis supported by the data?
- What were the major findings?
- How did your findings compare with other researchers?
- What possible explanations can you offer for your findings?
- What recommendations do you have for further study and for improving the experiment?
- What are some possible applications of the experiment?

Teacher

Evidence for the Theory of Evolution
(Adapted from: Prentice Hall Laboratory Manual)

NGSSS:
SC.912.L.15.1 Explain the scientific theory of evolution is supported by the fossil record, comparative anatomy, comparative embryology, biogeography, molecular biology, and observed evolutionary change. (**AA**)

Purpose of Lab/Activity:
- To examine and piece together part of skeleton from duplicate fossilized bones.
- To compare the partial skeleton to skeletons of modern day alligator and bird.
- To explore the evidence of evolution through comparative anatomy, embryology, and molecular biology.

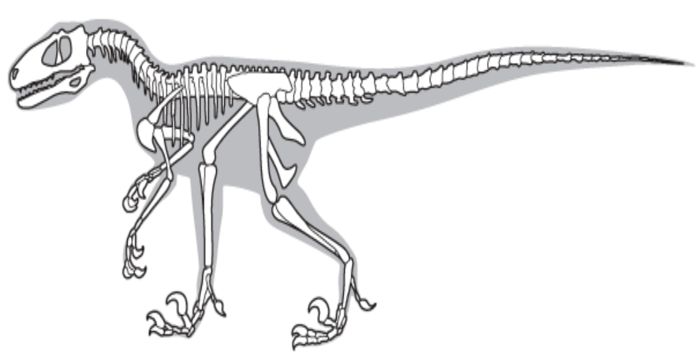
Prerequisites:
- Students should be familiar with Darwin's Theory of Evolution by natural selection. Students should be able to describe the process of adaptation and evolution using the tenets of Darwin.
- Students should be able to identify factors that could influence natural selection and give examples and explanations such as climate overpopulations, mutations, and pollution.
- Students understand the concepts of genetic drift, gene flow, mutation, and natural selection.
- Students should be familiar with the evidences that support the Theory of Evolution: through comparative anatomy: homologous structures, analogous structure, and vestigial structures; comparative embryology, and molecular biology.

Safety: Pointed-tip scissors can cut or puncture your skin. Always direct a sharp object or edge away from yourself and others. Use sharp instruments only as directed.

Materials (per group):
- Replica fossilized bone "casts"
- Scissors
- Paper
- Tape or glue

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Make copies of the paper fossils and homologous structure worksheet. b. Discuss the essential question: What are some evidences that support the theory of evolution? c. Have students read the background information about the fossil they are going to piece together and how fossils are obtained. d. Have students answer pre-lab questions or discuss with the class the pre-lab questions given. 1. Describe the process by which paleontologists and their team remove fossils from rock. Large earth-moving equipment is used to move rock. Then smaller hand equipment is used to remove bits of rock and dirt

	from the fossils. The fossils are covered in plastic wrap or foil to protect them. Then they are covered with plaster. A paleontologist works under the fossils to remove them from the rock. The fossil block is then removed from the earth, tipped over, and plaster is applied to the bottom side. The fossils are now ready to transport to a laboratory for study. 2. Fossil skeletons are rarely complete. How do you think casts and collaboration help paleontologists create more complex skeletal models? If a scientist at one lab or museum is missing a key piece of a skeleton, the scientist can request a cast of the missing bone from a colleague. 3. What role do you think inferences play in the work of a paleontologist? Answers may vary. When certain bones are not available for observation, the paleontologist will have to infer what the bone may have looked like based on other bone sample and the homologous bone in similar species.
During activity:	**What the teacher will do:** a. To make the activity more realistic and challenging, cut out the bone pieces and place them in envelopes. Randomly remove one bone from each envelope and place it in a different envelope. Lab groups will then have to collaborate to get all the pieces that they need. b. Use comparative anatomy to help guide them in the placement of other bones. Activity takes approximately 20 minutes for Part A. c. Have students check off which features you observe in each skeleton. Activity should take approximately 15 minutes. d. Activity C: color the homologous structures the same color according to each species. Approximately 15 minutes. e. Activities D-G can be continued the next day. Covers analogous structures, vestigial structures, and comparative embryology. f. Expected results of piecing together *Deinonychus* bones with only one limb of each. 
After activity:	**What the teacher will do:** a. Discuss with the class how they think each contributes to the evidence to the theory of evolution. Student answers should include that each branch provides proof of each evolution of the species. b. Discuss the molecular evidence that contributes also to the theory of

	evolution. With the advancement of DNA technology, scientists now rely more upon comparisons of protein structure, amino acid sequences, and DNA sequences to determine evolutionary relationships. The more closely related the species, the more similar their genetic material will be. c. Discuss how biogeography also contributes to the theory of evolution. Biogeography is the study of the distribution of life forms over geographical areas. Biogeography not only provides significant inferential evidence for evolution and common descent, but it also provides what creationists like to deny is possible in evolution: testable predictions. Biogeography is split into two areas: ecological biogeography which is concerned with current distribution patterns and historical biogeography which is concerned with long-term and large-scale distributions.

Extension:

- Gizmo: Evolution – Natural Selection and Artificial Selection, Mutation and Selection

Student

Evidence for the Theory of Evolution

(Adapted from: Prentice Hall Laboratory Manual)

NGSSS:
SC.912.L.15.1 Explain the scientific theory of evolution is supported by the fossil record, comparative anatomy, comparative embryology, biogeography, molecular biology, and observed evolutionary change. (**AA**)

Background Information:
Evolution is not just a historical process; it is occurring at this moment. Populations constantly adapt in response to changes in their environment and thereby accumulate changes in the genes that are available to the species through its gene pool. In today's lab you will explore some of the evidence for evolution and will examine a few of the mechanisms through which evolution acts. In this laboratory you will review some of the classical examples used as evidence for evolution. Keep in mind that the support goes far beyond these simplistic examples and this selection is only intended as an introduction to the subject.

In 1964 scientist John Ostrom discovered the fossil skeleton that you will study in an area called the Cloverly Formation in Bridger, Montana. The area that Ostrom and his team prospected that field season had not yielded as many fossils as they had hoped. However, on the last day of the season, Ostrom discovered some bones he could not identify. The next year he returned to search for more of the skeleton. Eventually this newly discovered, extinct animal was named *Deinonychus*.

Deinonychus lived during the early Cretaceous period, approximately 100 million years ago. It belonged to a group of dinosaur species called theropods, relatively small meat-eating dinosaurs that walked on 2 legs. The animal received its name, which means “terrible claw”, because the second toe on each of its hind feet had a large, sharp claw that probably was used to tear the flesh from prey. The claws were held up off the ground as the animal moved about, possibly preventing the claws from wearing down. You will observe that the *Deinonychus’s* skeleton shares many features of the skeletons of both modern alligators and birds. Many researchers hypothesize that the ancestor of birds was a feathered theropod. However, other researchers hypothesize that theropods and birds share common features because they had a common ancestor from which both lineages evolved separately. Much further research is needed to evaluate these 2 hypotheses. In this lab, you will model the work performed by paleontologists as you examine *Deinonychus* and identify the reptilian characteristics its skeleton retains as well as the bird like features it displays.

Problem Statement: What are some evidences that support the theory of evolution?

Safety: Pointed-tip scissors can cut or puncture your skin. Always direct a sharp object or edge away from yourself and others. Use sharp instruments only as directed.

Vocabulary: evolution, fossil, homologous structures, molecular biology, vestigial organ, comparative biology

Student

Preparing Fossils

Removing fossils from rock is a long process that requires both skill and a lot of patience. First, the rock surrounding the top and bottom of the fossils is removed with large earth-moving equipment. Scientists use smaller equipment such as shovels, picks, and brushes when working close to a fossil. Before removing a fossil from the ground, workers must encase it in a plaster "jacket" to prevent it from crumbling during transport to the lab. After treating a fossil with glue to harden it, paleontologists cover the top of the fossil with tissue paper or foil to protect it from the plaster. The plaster is allowed to harden on the top and sides of the fossil. Then the paleontologist climbs under the fossil and frees it from the ground. The fossil is removed from the rock and flipped over so that plaster can be applied to the bottom side.

In the lab, a person called a "preparatory" begins that long process of removing the plaster jacket and the small bits of rock still surrounding the fossil. The preparatory may use a microscope and tools as fine as needles to clean the fossils literally one grain of sand at a time. Once the bones are free from the rock, paleontologists may make casts of the bones to send to other paleontologists so they can collaborate in studying them.

Pre-Lab Questions:

1. Describe the process by which paleontologists and their team remove fossils from rock.
2. Fossil skeletons are rarely complete. How do you think casts and collaboration help paleontologists create more complex skeletal models?
3. What role do you think inferences play in the work of a paleontologist?

Materials (per group):

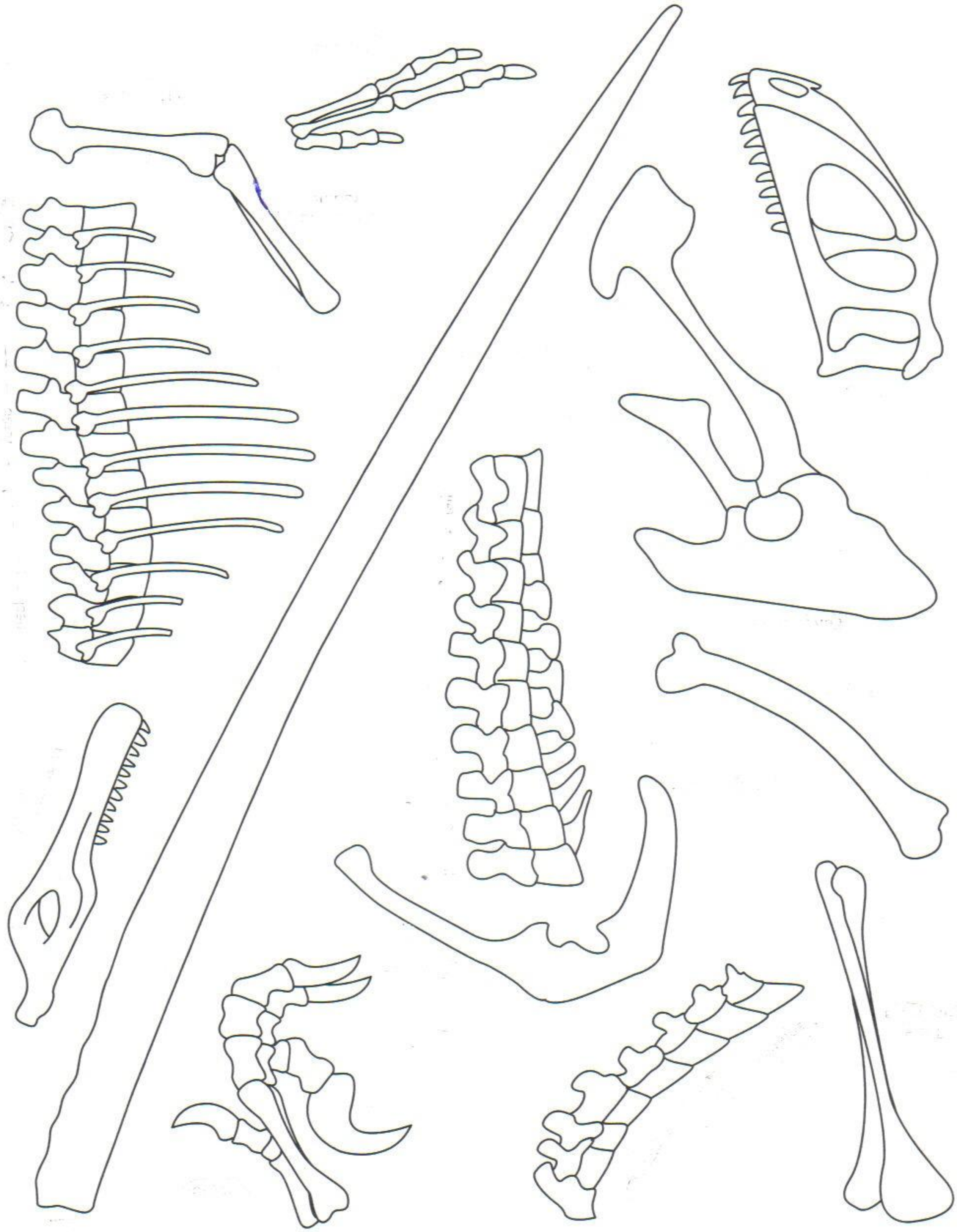
- Replica fossilized bone "casts"
- Scissors
- Paper
- Tape or glue
- Color pencils

Procedures:

Part A: *Deinonychus* Fossil Evidence

1. Cut out the *Deinonychus'* "casts" and spread them out on a flat surface. Note that this is only a partial skeleton. Very seldom does a fossil dig produce a complete skeleton. In this fossil dig, for example, paleontologists were only able to obtain the limbs from the left side of the animal's body. Try to fit the bones together. First, locate recognizable bones such as the skull and backbone.
2. Use the reference skeletons in Part B below to guide you in the placement of the other bones. Collaborate with other groups if you cannot decide where to place a bone.
3. Once you have decided how the bones should be connected, tape or glue them in place on a piece of paper.

Deinonychus Fossil Evidence Casts



Student

Part B: Comparative Anatomy

1. Look closely at the scapula, sternum, tail, and feet of all 3 skeletons (Figure 1 and the Deinonychus' casts). Note that both the *Deinonychus* and the bird have an extra toe that points backward.
2. Fill in data in Table 1 by checking off which features you observe in each skeleton.

Part C: Homologous Structures

1. Carefully examine the drawings of the bones shown in Figure 2. Look for similarities among the various animals.
2. Color each part of the human arm a different color. (Note: All bones of the wrist should be a single color; all the bones of the hand should be a different single color, etc.). Then color the corresponding bone in each of the other animals the same color as the human bone.
3. Complete the Data Analysis/Results section of laboratory.

Part D: Analogous Structures

1. Examine the butterfly wing and the bird wing shown in Figure 3.
2. Complete Data Analysis/Results section of laboratory.

Part E: Vestigial Structures

1. Gradual changes have occurred through time that have in some cases reduced or removed the function of some of the body structures and organs. The penguin's wings and the leg bones of snakes are examples of this phenomenon.
2. Examine the cavefish and minnow shown in Figure 4. They are related, but the cavefish is blind.
3. Complete the Data Analysis/Results section of laboratory.

Part F: Human Vestigial Structures

1. Read the list of human vestigial structures shown in Table 3. Suggest a possible function for each structure and explain why it became vestigial. Record your answers in the table.
2. Complete the Data Analysis/Results section of laboratory.

Part G: Comparative Embryology

1. Examine the embryos in Figure 5 and list the similarities of each embryo in Table 4.
2. Complete the Data Analysis/Results section of laboratory.

Data Analysis/Results:

Part B: Comparative Anatomy

Student

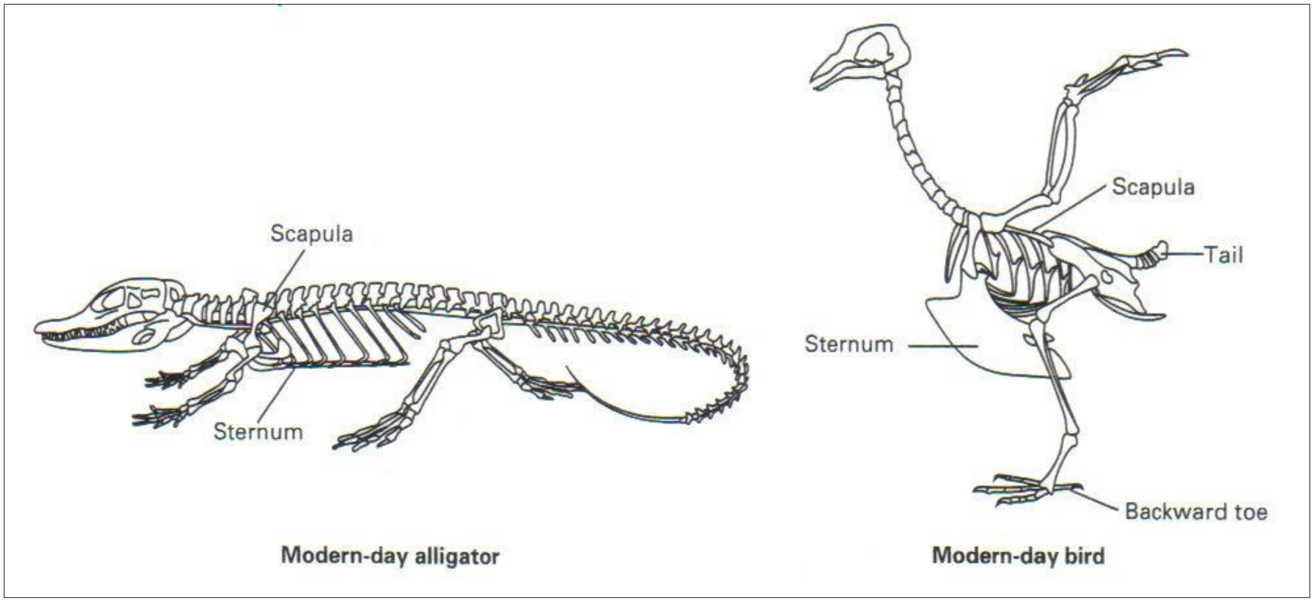


Figure 1

Table 1

Characteristic	**Alligator**	**Bird**	***Deinonychus***
Narrow scapula (shoulder blade)			
Wide scapula (shoulder blade)			
Prominent sternum (breastbone)			
3 primary toes on hind feet			
4 primary toes on hind feet			
Extra toe that points backward			
Hind legs underneath the body rather than to the sides			
Long tail			
Short tail			
Claws on front feet			
Claws only on hind feet			
Bipedal (walks on 2 legs)			
Quadrupedal (walks on 4 legs)			
Teeth			

Student

Part C: Homologous Structures

These structures are formed in similar ways during embryonic development and share like arrangements; however they have somewhat different forms and functions. They are called homologous structures.

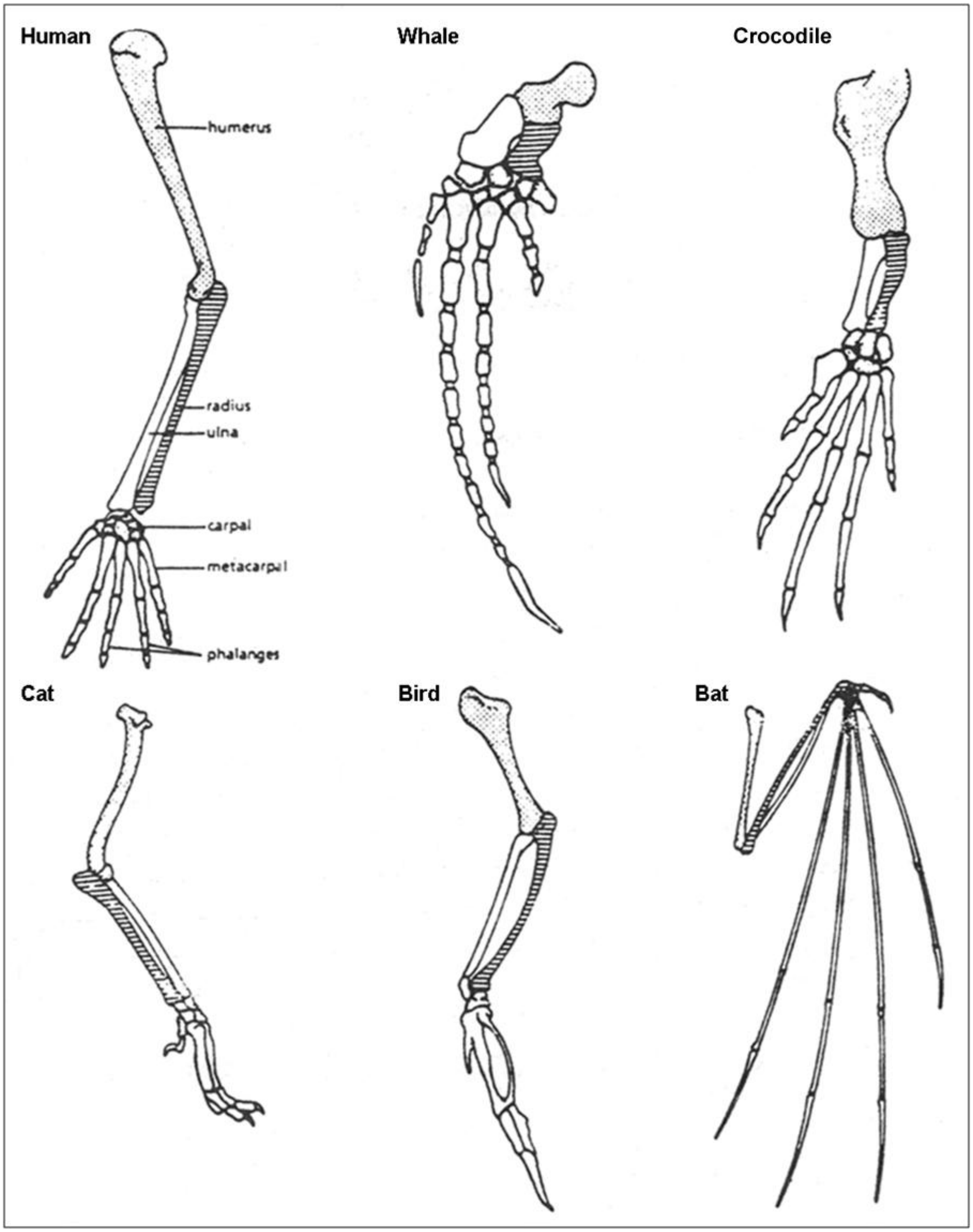


Figure 2

1. Describe the function of each structure from Figure 4 in Table 2.

Table 2

Animal	Function of Structure
Human	
Whale	
Cat	
Bat	
Bird	
Crocodile	

2. Are the bones arranged in a similar way in each animal?

Part D: Analogous Structures

Some apparently unrelated animals have organs with similar functions, yet are very different in structure and form. These structures are called analogous structures.

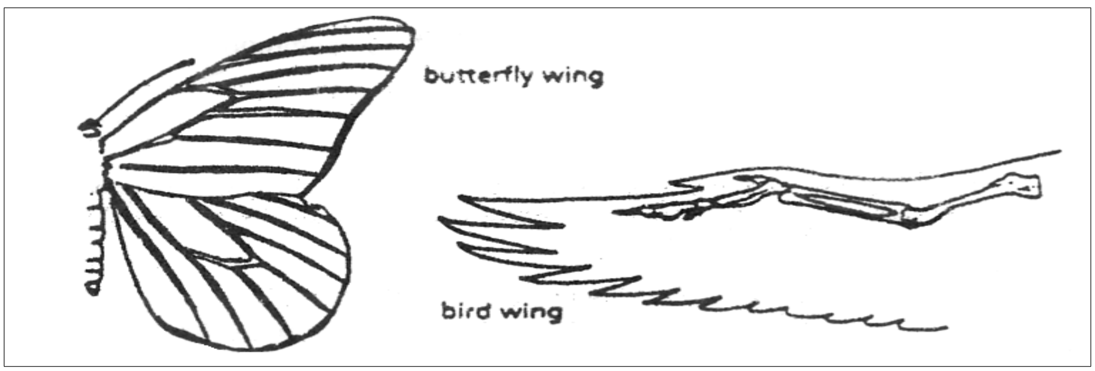


Figure 3

1. What function do these structures share?
2. How are these structures different?
3. Do birds and insects share any structural (elements inside the wing) similarities that would suggest they are closely related taxonomically?

Part E: Vestigial Structures

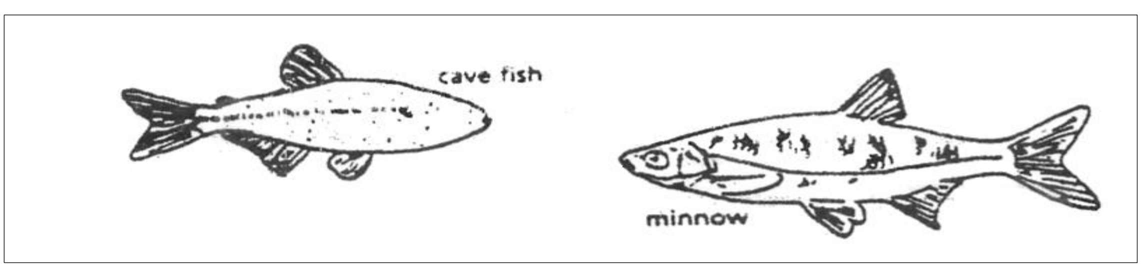


Figure 4

Student

1. Explain why eyesight is not an important adaptation to life in a cave.
2. What do you think has become the most important adaptation of the cave fish (think about senses)? (Explain your answer)
3. What about the internal structure of the cavefish and minnow suggest common ancestry?

Part F: Human Vestigial Structures

Table 3

Structure	Possible Function	Why vestigial?
appendix (digests leaves in koala bears)		
coccyx (tail bones)		
muscles that move ears		
muscles that make hair stand up		

Part G: Comparative Embryology

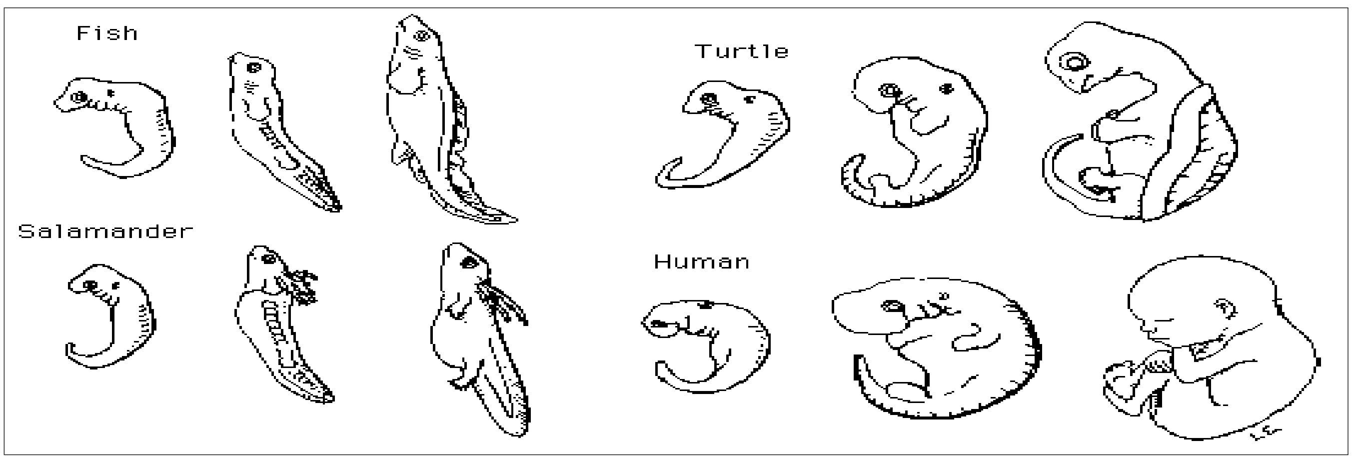


Figure 5

Table 4

Species	List similarities of each embryo to others
Fish	
Turtle	
Salamander	
Human	

Student

Conclusions: Explain in paragraph form, how each of the following provides evidence for evolution:

- fossil evidence,
- comparative anatomy (homologous structures, analogous structures, and vestigial structures), comparative embryology.

Teacher

Examining the Fossil Record

NGSSS:
SC.912.L.15.1 Explain the scientific theory of evolution is supported by the fossil record, comparative anatomy, comparative embryology, biogeography, molecular biology, and observed evolutionary change. (**AA**)

Purpose of the Lab/Activity:
- analyze characteristics of fossils
- compare placement of fossils and determine relative ages
- develop a model evolutionary tree based on the morphology and age of fossils

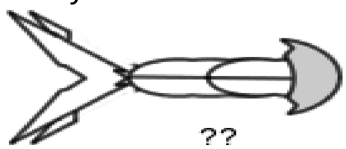
Prerequisites:
- Students should be familiar with the evidences that support the Theory of Evolution: through comparative anatomy: homologous structures, analogous structure, and vestigial structures; comparative embryology, and molecular biology.

Materials (per group):
- Chart paper
- Scissors
- Markers
- Glue or tape

Procedures: Day of Activity:

Before activity:	a. **What the teacher will do:** Set up different stations that would allow space for each of the parts of the activity. b. Make sure there is a copy of the lab for each group. Provide chart paper or newsprint to record the information collected from their investigation. Students will need space to cut out the "fossils" and arrange them in their logical order. c. It is important for students to complete an experimental design diagram prior to the investigation in order for them to understand all parts of the activity. 1. What is the problem statement? Allow the students to discuss with their group and decide on a question they choose to answer. For example: How did the "fossil" of this species change over time? What did the fossils suggest in terms of how this species evolved? 2. State the hypothesis. Answer will vary but should include both independent and dependent variable or reasoning from the students and what they might be looking for. In this type of investigation QUALITATIVE DATA will be collected. Therefore, students will provide analysis and discussion 3. Identify the possible independent and dependent variable. Independent: progression of changes in the species Dependent: analysis and conclusion of the way the species may have evolved. 4. Examples: how often the fossils branched, the number of differences, possible age of the fossils found.

	d. Student misconceptions should be addressed: The concept of punctuated equilibrium versus gradualism as mechanisms for evolution, geologic age where fossils are found, dating methods of rocks surrounding fossils, index fossils and their use.
During activity:	**What the teacher will do:** a. Monitor students to make sure they are remaining on task and are following proper lab protocol. b. Review the experimental design diagram by asking individual students in groups to explain the different parts of the experiment. c. Follow laboratory procedural plan; making sure to model proper laboratory safety and use of equipment. d. Emphasize importance of data collection by groups, including observations and analysis about the different "fossil samples" observed. . e. Ask groups to brainstorm the different mechanisms for evolution and what that may look like. f. Ask the following questions: 1. Predict what kind of fossils you might expect in any of the gaps. Explain your reasoning. 2. What kind of environmental or other selective pressures could have caused the different changes in body plans in the species as evidenced by the fossils?
After activity:	**What the teacher will do:** a. Analyze class data; making sure to note the importance of differing opinions and allowing for class discussion for each of the points of views. b. Remind students to pay close attention to the jumps in variations and the different geologic time periods the fossils match. Have the groups report their analysis and investigations to the rest of the class and defend their statements. c. Facilitate a group discussion for the students on the findings for the group and the possible reasons for the adaptations and body plan changes in the species. d. Answer Key for Results: 1. Give a brief description of the evolutionary changes that occurred in the organism. (Answers will vary among the groups, but must be directly from observations from the pictures observed) 2. During which time period did the fossils differentiate into two branches? (Coloradian) 3. Explain how the chart illustrates both punctuated equilibrium and gradualism. Use specific fossils from the chart to support your answer.(student answers should include a description of the change in body plan during the Coloradian period for punctuated equilibrium and any of the others for gradualism.) 4. Making the assumption that each fossil represents a separate species. Explain how the chart illustrates divergent and phyletic speciation. Use specific fossils from the chart to support your answer. (Student answers will vary, but should include the change in body plans in the Coloradian period as divergent speciation and the other less drastic

	changes as phyletic speciation.) e. Define the following terms: 1. morphology (the form and structure of an organism considered as a whole.) 2. fossil (A remnant or trace of an organism of a past geologic age, such as a skeleton or leaf imprint, embedded and preserved in the earth's crust) 3. phylogenetic tree (diagram that depicts the lines of evolutionary descent of different species, organisms, or genes from a common ancestor) f. Examine the fossil that was unearthed in a museum, apparently the labels and other information were lost. Using your fossil record, determine the time period this fossil is likely from.  (Middle Montanian) g. Of the two major species that arose from the parent species, which was more successful? How do you know? (The species with more body segments because there were more occurrences of this body plan in the fossil record) h. For each of the "blanks" on your fossil record make a sketch of what the animal would look like. Draw these on your fossil record. (Answers will vary)

Student

Examining the Fossil Record

NGSSS:

SC.912.L.15.1 Explain the scientific theory of evolution is supported by the fossil record, comparative anatomy, comparative embryology, biogeography, molecular biology, and observed evolutionary change. (**AA**)

Objectives:

- analyze characteristics of fossils
- compare placement of fossils and determine relative ages
- develop a model evolutionary tree based on the morphology and age of fossils

Background

Fossils are traces of organisms that lived in the past. When fossils are found, they are analyzed to determine the age of the fossil. The absolute age of the fossil can be determined though radiometric dating and determining the layer of rock in which the fossil was found. Older layers are found deeper within the earth than newer layers.

The age and morphologies (appearances) of fossils can be used to place fossils in sequences that often show patterns of changes that have occurred over time. This relationship can be depicted in an evolutionary tree, also known as a phylogenetic tree.

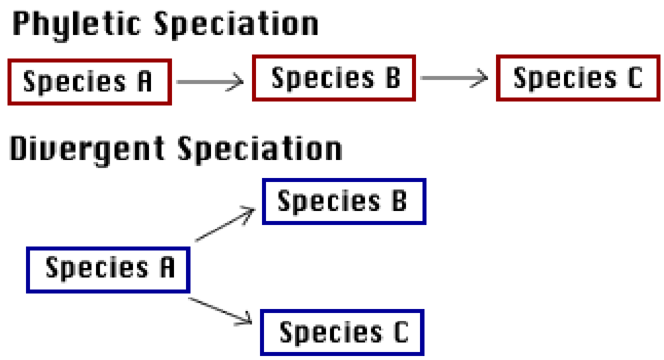
There are two major hypotheses on how evolution takes place: **gradualism** and **punctuated equilibrium**. Gradualism suggests that organisms evolve through a process of slow and constant change. For instance, an organism that shows a fossil record of gradually increased size in small steps, or an organism that shows a gradual loss of a structure. Punctuated equilibrium suggests that species evolve very rapidly and then stay the same for a large period of time. This rapid change is attributed to a mutation in a few essential genes. The sudden appearance of new structures could be explained by punctuated equilibrium.

Gradualism: creature became larger, segments fused

Punctuated equilibrium: head changed shape, loss of segment

<u>Speciation</u>

The fossil record cannot accurately determine when one species becomes another species. However, two hypotheses regarding speciation also exist. Phyletic speciation suggests that abrupt mutations in a few regulatory genes occur after a species has existed for a long period of time. This mutation results in the entire species shifting to a new species. Phyletic speciation would also relate to the Punctuated Equilibrium hypothesis regarding evolution. Divergent speciation suggests that a gradual accumulation of small genetic changes results in subpopulation of a species that eventually accumulate so many changes that the subpopulations become different species. This hypothesis would coincide with the gradualism model of evolution. Most evolutionary biologists accept that a combination of the two models has affected the evolution of species over time.



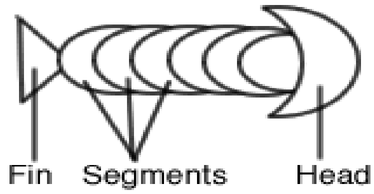
Procedure:

1. The diagram you are creating requires a large space. To create your workspace, tape together 8 sheets of standard sized paper and use a ruler to draw the following chart on your workspace

Time Period (2 1/2 inches wide)	Began (years ago) (2 1/2 inches wide)	Fossils (8 inches wide)
Wyomington (oldest)	995,000	5 inches (Each row here must be 5 inches tall)
Ohioian	745, 000	5 inches
Nevadian	545,000	5 inches
Texian	445,000	5 inches
Oregonian	395,000	5 inches
Coloradian	320,000	5 inches
Montanian	170,000	5 inches
Californian	80,000	5 inches
Idahoan (the present)	30,000	5 inches

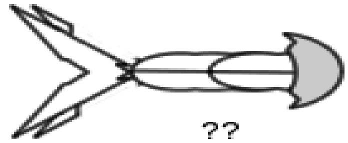
2. The group of "fossils" you will work with are fictitious animals. Each fossil on your sheet is marked with a time period. Cut out each fossil and make sure you include the time period marked below it.
3. Arrange the fossils by age. On your data chart, place each fossil next to the period from which the fossil came from. Some fossil names are preceded by “lower” and “upper” descriptions. The term "**upper**" means more recent, these fossils should be placed lower on the chart. The term "**lower**" means an earlier time period, fossils from a "lower" time

period should be place toward the older time periods. In each fossil column, you may have 3 specimens, one from the main time period, one from the upper, and one from the lower. Not all fossils are represented, illustrating the incompleteness of any fossil record.



4. While keeping the fossils in the proper age order, arrange them by morphology (appearance). To help you understand the morphology of the specimen, view the diagram. Arrange the fossils using the following steps.
   a. Center the oldest fossil at the top of the fossil column (toward the oldest layer)
   b. Throughout the chart, those fossils that appear to be the same (or close to the same) as the fossils preceding them should be placed in a vertical line
   c. During a certain period, the fossils will split into two branches. In other words, one fossil from that period will show one type of change, and another fossil will show a different change. When this happens, place the fossils side by side in the appropriate time period. From this point on you will have two lineages.
5. Once all the fossils have been placed correctly according to time and morphology, tape or glue the fossils in place.

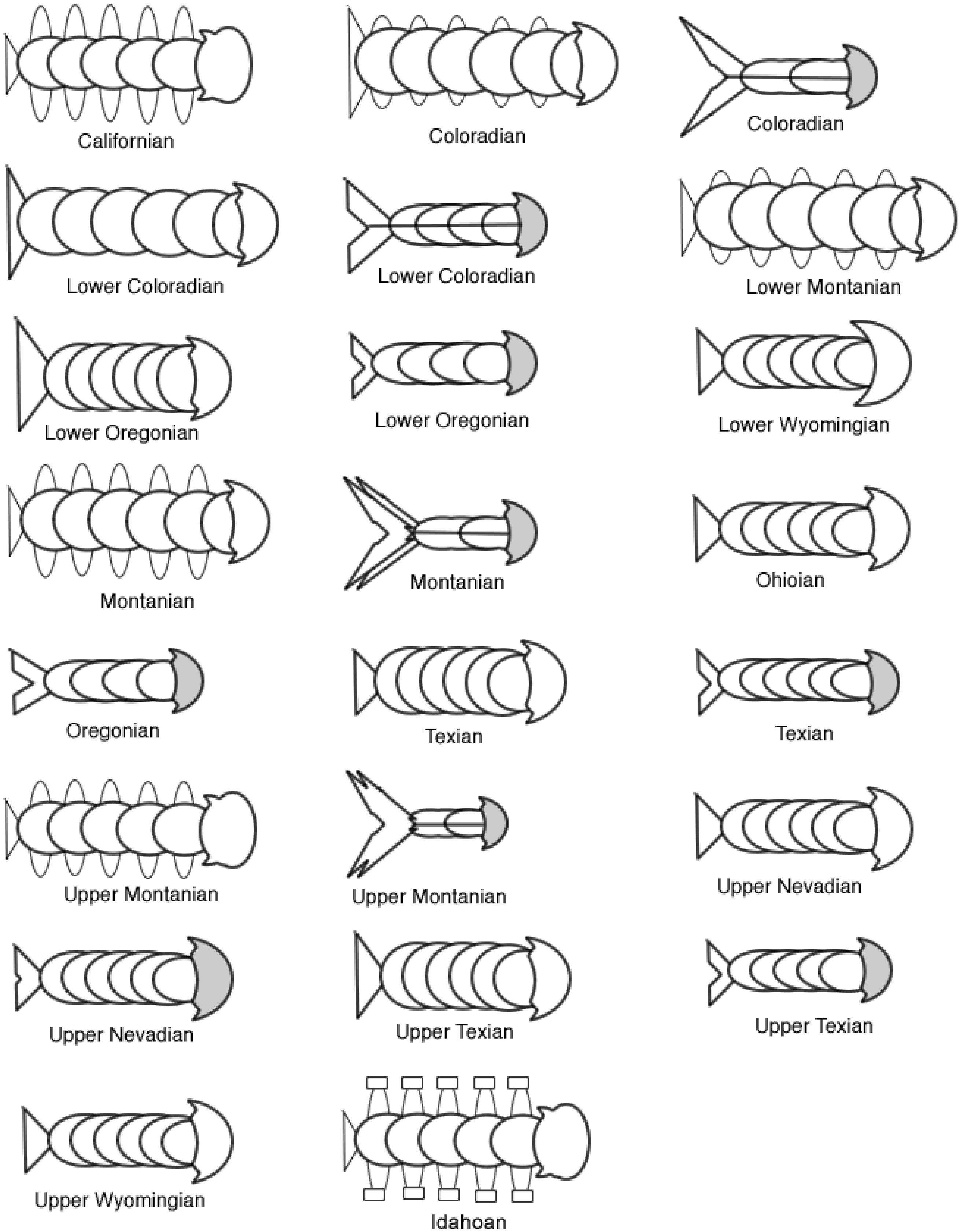
Analysis:
1. Give a brief description of the evolutionary changes that occurred in the organism.
2. During which time period did the fossils differentiate into two branches?
3. Explain how the chart illustrates both punctuated equilibrium and gradualism. Use specific fossils from the chart to support your answer.
4. Making the assumption that each fossil represents a separate species. Explain how the chart illustrates divergent and phyletic speciation. Use specific fossils from the chart to support your answer.
5. Define the following terms:
   a. morphology
   b. fossil
   c. phylogenetic tree
6. Examine the fossil that was unearthed in a museum, apparently the labels and other information were lost. Using your fossil record, determine the time period this fossil is likely from.



7. Of the two major species that arose from the parent species, which was more successful? How do you know?
8. For each of the "blanks" on your fossil record make a sketch of what the animal would look like. Draw these on your fossil record.

Student

Fossils



Teacher

Natural Selection

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

NGSSS:
SC.912.L.15.13 Describe the conditions required for natural selection, including: overproduction of offspring, inherited variation, and the struggle to survive, which result in differential reproductive success. (**AA**)

Purpose of Lab/Activity:
- To explore how the frequencies of three beak phenotypes change over several generations in a population of birds on an island.
- To explore how environmental changes can affect animal populations.

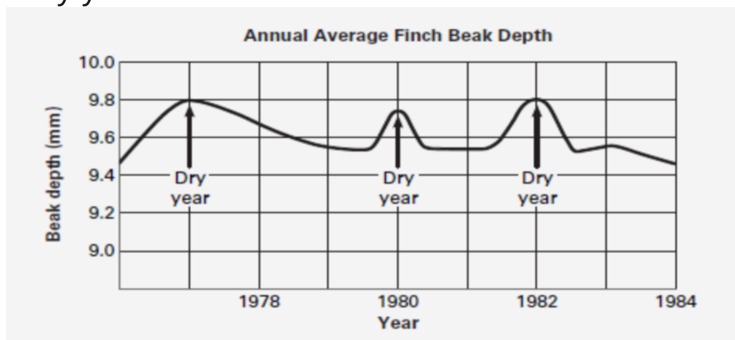
Prerequisites:
- Students should be familiar with Darwin's Theory of Evolution by natural selection.
- Students should be able to describe the process of adaptation and evolution using the tenets of Darwin.
- Students should be able to identify factors that could influence natural selection and give examples and explanations such as climate overpopulations, mutations, and pollution.
- Students understand the concepts of genetic drift, gene flow, mutation, and natural selection.

Safety:
- Be sure students inform you of allergies to nuts or other foods if you will be using that particular food item.
- Take care that students do not injure themselves or others while moving around or using their utensil "beaks".
- Do not consume any food items being used in activity.

Materials (per group):
- Plastic spoon, knife, or fork
- Self-sealing plastic sandwich bag
- Food pieces (candies, unshelled nuts, beans, etc.)
- Plastic container for nest (optional)

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Review the rules of the island and survival criteria table or print it out. b. Discuss the essential question: Can natural selection change the frequency of traits in a population in only a few generations? c. Set up a particular area for the "food" items and another area for "nest" area. d. Have students complete the pre-lab activity and answer the following questions. e. Study the graph below showing the average beak depth found in the medium ground finch population over a period of 8 years. In which years did the medium ground finch population have the largest average beak

<table>
<tr><td></td><td>depth? Were these wet years or dry years? 1977, 1980, 1982. All three years were dry years.


1. Depending the types of tools and “food” items being used, have students form a hypothesis to identify the tools they think would be the best in picking up the “food” items.</td></tr>
<tr><td>During activity:</td><td>What the teacher will do:
a. Not every student will participate in the simulation for each round. If the student is not participating in the simulation for a round, they must still collect the data and share it with those who did participate.
b. Do a trial run of 1 minute for the first round to get an idea of how long the class takes to get their food to the nest. Adjust according depending on class times. Start round 1 with one student per beak type.
c. If using soft food items, the students are allowed to stab the food items with their utensil “beaks”.
d. Have students who are not participating keep records of survival and reproduction.
e. Round 2-3 should include the students who “survived” in round 1 and add more students depending on how much food they got from the first round. For example, 6 = 1 offspring; 12 = 3 offspring; 18 = 4 offspring.
f. To calculate frequency of variation, use formula provided.
$$\frac{\text{variation population size}}{\text{total population size}} \times 100\% = \text{frequency of variation in total bird population}$$
g. Before you begin rounds 4-6, switch the food items to correlate with hard dry season foods. Perform the procedures the same way for the first 3 rounds.
h. Have students record and calculate data from the tables given.</td></tr>
<tr><td>After activity:</td><td>What the teacher will do:
a. Discuss student results. Expected results were as follows: In the wet season when softer foods are used, the students using forks and knives will “survive.” However, in the dry season, when they cannot stab the foods, they do not fare as well.
b. Review the following questions:
1. Was there one beak phenotype that was more successful than another in round 1-3? If so, which one? Answers vary depending what kind of food items was being used. However, they will mostly like answer that the knife or fork variations were the most successful since they were able to stab the several food items with the tools “beaks”.
2. On the same x- and y-axes, plot three line graphs representing the</td></tr>
</table>

	success of each beak variation throughout the six rounds. Plot rounds 1–6 on the *x*-axis. Plot the percent frequency of each variation on the *y*-axis. Be sure to title your graph and label the axes and the three graph lines. Check graphs for correct labeling of axes and title. Graphs should represent their data. 3. Describe the pattern of change for each beak type as displayed in your graph. Identify the most successful beak type or types and suggest reasons for success. Discuss how the beak shapes enabled them to efficiently capture the different types of food. 4. Did the frequency of the different beak variations change when the food supply changed? Relate this to what you learned about the finches on Daphne Major. Yes, when the food supply changed, the knife variation was especially affected. While the forks and spoons could scoop up the food, the knives could barely carry back one piece at a time. On Daphne Major during dry years, many of the finches with small beaks did not survive because they were unable to crack open harder seeds and expand their food supply. 5. How do you think the results of the Grants' research might have been different if the beak-depth variations were not genetically based traits (were not passed on from the generation to generation)? If beak depth were not a genetic trait, then the percent frequencies of the variations in depth would not change after a dry year. 6. Competition and variation are two factors that play key roles in the natural selection in the population of ground finches on Daphne Major during the drought years. There are variations in the depth of beaks among medium ground finches. During drought years, finches with deeper beaks have more access to food. These finches are more apt to survive and reproduce than finches with less deep beaks.

Additional instructions/Handouts:

Rules of the Island

1. You may not use your hands except to hold the plastic utensil (your "beak") and open the plastic bag (the "nest").
2. You may not push other "birds," deliberately knock the food out of the other "birds' beaks," or steal food from the other "birds' nests."
3. You must put your nest in the same general area as the other birds' nests.
4. When your teacher says that time is up, stop where you are. If you have food held securely in your beak, you may bring it to your nest.
5. Do not eat any of the food.

Teacher

Survival Criteria

Food Pieces Collected	Outcome
Fewer than 6	Does not survive
6 – 11	Survive but does not reproduce
12 – 17	Survives and produces 1 offspring
18 – 23	Survives and produces 2 offspring
24 – 29	Survives and produces 3 offspring

Extension:

- Gizmo: [Natural Selection]
- Have students work in pairs to make a list of ways that the model in this activity simulated natural conditions and ways that the model differed from natural conditions. Suggest one change to the model that could control for an additional variable or more closely simulate the natural world.

Student

Natural Selection

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

NGSSS:
SC.912.L.15.13 Describe the conditions required for natural selection, including: overproduction of offspring, inherited variation, and the struggle to survive, which result in differential reproductive success. (**AA**)

Background Information:
To start your investigation you will learn about a population of birds called medium ground finches on Daphne Major, one of the Galápagos Islands. Then you and your classmates will simulate the fitness of birds of a fictional species called *Saccharae utensilus*. This bird species has three possible variations in beak phenotype. Each "bird's" ability to acquire food will determine whether it dies, or whether it survives and reproduces. The number of offspring produced depends on the amount of food each bird acquires, which can vary greatly under changing environmental conditions. After simulating changes in the bird population for six generations, you will analyze data to discover how the frequency of each beak phenotype in the population changed over the generations.

Medium ground finches typically feed on small, soft fruit and seeds. The birds prefer soft seeds because they are easier to crack. However, during periods of drought, food becomes scarce. The birds are forced to eat more hard seeds that are difficult to break open. Scientists Peter and Rosemary Grant and their team studied the island's population of medium ground finches and discovered that there are significant variations in the beak depths of individual birds. Birds with deeper beaks are better able to crack open hard seeds than birds with shallower beaks. These variations in beak depth made it possible for some of the medium ground finches to get enough food to survive and reproduce during long droughts.

Problem Statement:
Can natural selection change the frequency of traits in a population in only a few generations?

Safety:

- Be sure to inform your teacher of allergies to nuts or other foods if they are going be using that particular food item.
- Take care that you do not injure yourselves or others while moving around or using their utensil "beaks".
- Do not consume any food items being used in activity.

Vocabulary:
Evolution, natural selection, adaptation, decent with modification, phenotype

Materials (per group):

- Plastic spoon, knife, or fork
- Self-sealing plastic sandwich bag
- Food pieces (candies, unshelled nuts, beans, etc.)
- Plastic container for nest (optional)

Student

Procedures:

1. Holding your “beak” in your hand, gather food and return to your nest to deposit it. Go to the food source to get more food as many times as possible until time is up.
2. When your teacher tells you the round is over, follow the table below to determine if you collected enough food to survive to the next round and reproduce.

Food Pieces Collected	Outcome
Fewer than 6	Does not survive
6 – 11	Survive but does not reproduce
12 – 17	Survives and produces 1 offspring
18 – 23	Survives and produces 2 offspring
24 – 29	Survives and produces 3 offspring

3. In Data Table 1, record the initial population size for each beak variation in Round 1 as well as the total population size. (You will need to collect data from your classmates to record these numbers.)
4. Next, use the following formula to calculate the frequency of each variation as a percentage. Enter your results in Data Table 1. Total population size.

$$\frac{\text{variation population size}}{\text{total population size}} \times 100\% = \text{frequency of variation in total bird population}$$

5. After rounds 2 and 3 are complete, fill in the rest of Data Table 1
6. Fill in Data Table 2 to calculate the change in frequency of each beak variation over rounds 1-3.
7. Now suppose that your island is experiencing a drought. The type of food available for the island’s birds to eat has changed. Perform rounds 4-6 in the same way you performed rounds 1-3. Record the results in Data Table 3.
8. Fill in Data Table 4 to calculate the change in frequency of each beak variation over rounds 4-6.

Observations/Data:
Data Table 1

	Round 1		Round 2		Round 3	
Beak variation	**Pop. Size**	**% Frequency**	**Pop. Size**	**% Frequency**	**Pop. Size**	**% Frequency**
Spoon						
Fork						
Knife						
Total						

Student

Data Table 2

Beak Variation	% Frequency in Round 3 (A)	% Frequency in Round 1 (A)	Change in % Frequency (A – B)
Spoon			
Fork			
Knife			

Data Table 3

	Round 4		Round 5		Round 6	
Beak variation	**Pop. Size**	**% Frequency**	**Pop. Size**	**% Frequency**	**Pop. Size**	**% Frequency**
Spoon						
Fork						
Knife						
Total						

Data Table 4

Beak Variation	% Frequency in Round 6 (A)	% Frequency in Round 4 (A)	Change in % Frequency (A – B)
Spoon			
Fork			
Knife			

Data Analysis/Results:

1. Was there one beak phenotype that was more successful than another in rounds 1-3? If so, which one?
2. One the same *x*- and *y*-axes, plot three line graphs representing the success of each beak variation throughout the six rounds. Plot rounds 1 - 6 on the *x*-axis. Plot the percent frequency of each variation on the *y*-axis. Be sure to title your graph and label the axes and the three graph lines.

Conclusions:

1. Describe the pattern of change for each beak type as displayed in your graph. Identify the most successful beak type or types and suggest reasons for the success.
2. Did the frequency of the different beak variations change when the food supply changed? Relate this to what you learned about the finches on Daphne major.
3. How do you think the results of the Grants' research might have been different if the beak-depth variations were not genetically-based traits (were not passed on from generation to generation)?

Teacher

Using a Dichotomous Key for Invertebrate Phyla

(Adapted from http://www.msc.ucla.edu/oceanglobe/pdf/Invertebrates/Inverts_Entire.pdf)

NGSSS:
SC.912.L.15.6 Discuss distinguishing characteristics of the domains and kingdoms of living organisms. (**AA**)

Purpose of Lab/Activity: The purpose of the lab is to use morphological features from pictures or specimens with a dichotomous key and to identify and name different invertebrate phyla.

Prerequisite: Prior to this activity, the student should be able to know the names of anatomical structures from the vocabulary of the student section of this laboratory. The student should be familiar with the classification system of organisms.

Materials (per group):

- Invertebrate handouts (pictures)
- Invertebrate specimen samples
- Dichotomous key

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. The teacher will cut out pictures of different invertebrates from different phyla or the teacher will find invertebrate animal samples that students can handle for keying out. b. Discuss the following essential questions: 1. Can different phyla of invertebrates be identified via the use of a dichotomous key and the identification of different morphological traits for different invertebrates? 2. Can we identify different invertebrates based on morphological differences using a dichotomous key? c. Activate students' prior knowledge of invertebrates by having them work in teams to classify organisms. 1. Write the following organisms name on the board: anemone, butterfly, clam, coral, crab, earthworm, grasshopper, hydra, jellyfish, lobster, mussel, nematode, octopus, oyster, planarian, sand dollar, scorpion, sea urchin, shrimp, slug, snail, spider, sponges, squid, starfish, tapeworm, tick 2. Write the following categories: porifera, cnidarians, flatworm, roundworm, annelid, gastropod, bivalve, cephalopod, crustacean, arachnid, insect, echinoderm 3. Ask the students to place each organism in a category.
During activity:	**What the teacher will do:** a. Reinforce the expectations of the lab and review the directions. 1. Remind students to write down all of the steps followed when using the dichotomous key as they identify each invertebrate. b. Review the following questions with the students. 1. What is the definition of an animal? 2. What specific features distinguishes animals?

Teacher

After activity:	**What the teacher will do:** a. Engage in class discussion use the following questions as a guide: 1. Was the key helpful in identifying the invertebrates? Why? 2. Write the characteristics of each animal pictured, its phylum and common name. 3. Would you change the identification key? How? 4. Why has it it been so hard for scientists to classify some invertebrates as animals? 5. How do animals who are sessile, able to find new locations in which to live? 6. How can animals who are sessile, meet others of the same species to reproduce? b. Have students complete a conclusion for this activity in which they: 1. Contrast from the simplest invertebrates to the very complicated vertebrates. 2. Discuss the differences that can be seen by noting the external morphological differences?

Extension:

Student

Using a Dichotomous Key for Invertebrate Phyla

(Adapted from http://www.msc.ucla.edu/oceanglobe/pdf/Invertebrates/Inverts_Entire.pdf)

NGSSS:
SC.912.L.15.6 Discuss distinguishing characteristics of the domains and kingdoms of living organisms. (**AA**)

Background: An invertebrate is any animal without a backbone. Invertebrates make up 95% of all species of animals on the earth, and the variety of invertebrates is enormous. Scientists group or "classify" all of these different types of animals into broad categories called phyla, on the basis of their patterns of symmetry and on the basis of their overall body plan. There are 5 particularly important invertebrate phyla (and about another 23 less important phyla). The major invertebrate groups are classified as: Phylum Cnidaria, Phylum Annelida, Phylum Mollusca, Phylum Arthropoda, Phylum Echinodermata.

Various guidelines are used by taxonomists (zoologists who initially describe new species and classify animals) to establish the Classification System for the Animal Kingdom, just as librarians use a guideline, the Dewey Decimal System, for arranging books in a library. Pattern of symmetry is an important consideration for determining relationships at the phyletic level of classification, but symmetry alone does not provide sufficient information to determine phyletic status. For example, lobsters are bilaterally symmetrical, with a left side and a right side, with a front end and a rear end, and with a top side (called the "dorsal" side) and a bottom side (designated "ventral").

Since we ourselves exhibit this same set of relationships, bilateral symmetry does not seem to be particularly unusual, except that humans walk upright and we call our dorsal side our "back" and we call our ventral side the "front". All vertebrates, including people, are bilaterally symmetrical, and, indeed, so are most invertebrates. Lobsters and all of their millions of relatives, from butterflies to crabs and all other members of the Phylum Arthropoda, are also bilaterally symmetrical. But arthropods are not related to vertebrates, even though both groups exhibit similar patterns of bilateral symmetry. This is because arthropods and vertebrates have extremely different body plans, with different types of skeletons and muscles, and different patterns of plumbing.

Vertebrates have internal skeletons of bone, whereas arthropods have external skeletons made of an animal plastic called chitin. The muscles that move our fingers lie outside of and around the bones of the hand, whereas the muscles that move the pincers of the claws of a lobster are inside the claw, beneath the chitinous shell, its external skeleton. The basic architecture of these two groups of animals is so different that they cannot have had a common ancestor, and so we classify arthropods and vertebrates as belonging to separate phyla.

Problem Statement: Using a dichotomous key, can you identify and name different invertebrate phyla?

Vocabulary: appendages, asymmetry, bilateral symmetry, colonial, dorsoventrally, exoskeleton, gelatinous, nematocyst, pentaramous symmetry, porous, radial symmetry, radula, segmented, sessile, siphon, solitary, tentacles

Student

Materials (per group):
- Invertebrate handouts (pictures) or Invertebrate specimen samples
- Dichotomous key

Procedures:
1. In your assigned group observe and discuss the specimens that you were given.
2. As a group, arrange them into piles according to similarities and differences.
3. Use the dichotomous key provided to determine which phyla the animals belong to. (Hint: Definitions from the assigned vocabulary will help).
4. Once you have identified a phyla for all the specimens provided, verify with the teacher if you were correct.

Observations/Data:
1. Match the letter of the animal to the phyla.
2. Write down the step by step sequence of events that led your team towards finding the name of the phyla to which each animal belongs to.
3. List several observations that helps us "see" this animal's behavior when it is alive:

Data Analysis/Results:
1. Was the key helpful in identifying the invertebrates? Why?
2. Write the characteristics of each animal pictured, its phylum and common name.
3. Would you change the identification key? How?

Conclusion:
- Why has it been so hard for scientists to classify some invertebrates as animals?
- How do animals that are sessile, able to find new locations in which to live?
- How can animals who are sessile, meet others of the same species to reproduce?
- Contrast the simplest invertebrates to very complicated vertebrates.
- What are some of the differences that can be seen by noting the external morphological differences?
- Write conclusions to your observations following the guidelines on the **Parts of a Lab Report: A Step-by-Step Checklist.**

Invertebrate Handout

Taxonomic Key to the Major Invertebrate Phyla

Most taxonomic keys are "dichotomous," (two branches), which is to say they are written with a series of two choices to be made about the anatomy of an animal (or photograph of an animal) you are looking at. Keys are not made to be read from start to finish like a book or a poem. In each numbered series you should read both choices, determine which choice best applies to the specimen you are looking at, then go where the key tells you to go, often skipping other steps in between that don't apply.

1. Radial symmetry or asymmetry 2
   Bilateral symmetry 4

2. Highly porous surface, not true tissues………………………………… .... **Phylum Porifera**
   Surface is not highly porous, true tissues present 3

3. Exhibits pentaramous symmetry and tube feet ....**Phylum Echinodermata**
   Lacks pentamerous symmetry and tube feet, possesses tentacles
   (with nematocysts) ……….. **Phylum Cnidaria**

4. Macroscopic colony of sessile, microscopic individuals,
   individuals ‹ 0.5 mm in size ....**Phylum Ectoprocta (Bryozoa)**
   Solitary or colonial in form, individuals of colony › 0.5 mm in size 5

5. Gelatinous 6
   Not gelatinous 7

6. Solitary individuals with 8 rows of comb plates ....**Phylum Ctenophora**
   Solitary and/or colonial with incurrent and excurrent siphons,
   and a gelatinous exterior called a tunic ....**Phylum Chordata**

7. Possesses segmentation 8
   Lacks segmentation 9

8. Exoskeleton with jointed appendages .... **Phylum Arthropoda**
   No exoskeleton, appendages, if present, not jointed, segmented worm-like body, possibly in a tube (if in a tube, may have tentacles) ....**Phylum Annelida**

9. Possesses a foot, radula, arms and/or shell .... **Phylum Mollusca**
   Lacking all of above, dorso-ventrally flattened to a thickness of
   less than 1 mm .... **Phylum Platyhelminthes**

Teacher

Classification of Fruits

NGSSS:
SC.912.L.15.6 Discuss distinguishing characteristics of the domains and kingdoms of living organisms. **(AA)**

Purpose of Lab/Activity:
- Students will review the concept of classification
- Students will be able to relate their observations to different ways of classifying organisms

Prerequisite: Prior to this activity, the student should be able to
- Make accurate and detailed observations
- Have a basic understanding of classifying organisms based on their characteristics

Materials (individual or per group):
- Fruit pictures (may be substituted for real fruit)

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Prepare cards of fruits to hand out to each group b. Pre-assess student understanding of classification. c. Review with students what each fruit is and answer any questions about color or texture. You may also allow opportunities to research the types of fruits online to determine any characteristics that are not easily seen.
During activity:	**What the teacher will do:** a. As students perform the lab activity, allow students to observe the different pictures of fruit and help guide them in terms of classifying them based on their similarities. Also allow the use additional resources such as the textbook and the Internet to answer questions:. 1. Example: What are the different textures of the fruit? Which fruits have big seeds or small seeds? 2. Which fruit comes from a tree? Which one comes from a vine or herbaceous plant? b. When students prepare to tape or glue the pictures of the fruit to the chart paper, make sure they wait until all discussion is final before sticking the pictures to the chart paper. c. Ensure discussions from students stay productive when disagreements arise on how to classify the fruits.
After activity:	**What the teacher will do:** a. Assess student understanding of how to classify different organisms based on observations by having them present their charts to the rest of the class. b. Engage students into a discussion on the importance of making many observations about an organism before deciding on its classification and the importance of having a classification system in place. Some questions to use: 1. Can classification help show possible evolutionary relationships? 2. Do common characteristics always imply shared ancestors?

Teacher

	3. Is there more than one way to classify the fruit? What does this mean for the study of science?

Extension:

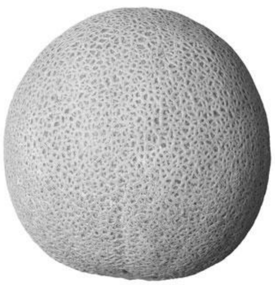
- Ask students to redo the activity using different items, such as different leaves, different types of buttons, etc.
    - Advanced students can create their own groups of living organisms that could possibly exist in the future and classify them into groups.

Teacher

Part 1: List of Fruits

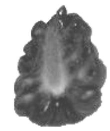
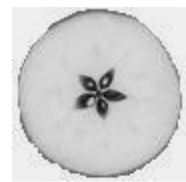
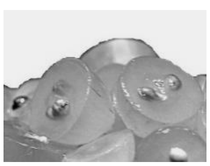
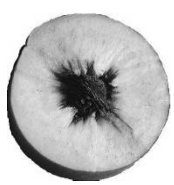
 Almond Fruit	 Nectarine	 Avocado	 Blackberry
 Cherries	 Mulberry	 Raspberry	 Apple
 Grapes	 Tomato	 Lime	 Orange
 Plum	 Peach	 Pear	 Pepper

Teacher

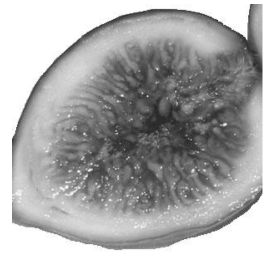
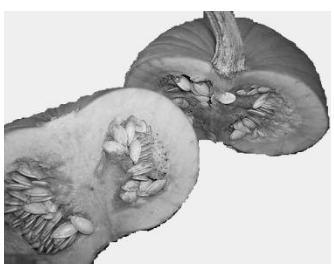
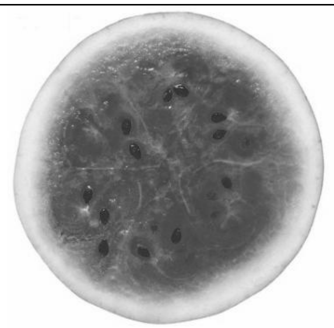
 Strawberry	 Cucumber	 Banana	 Fig
 Cantaloupe	 Coconut	 Osage Orange	 Eggplant
 Pumpkin	 Watermelon	 Pineapple	 Squash

Teacher

Part 2: List of Fruits

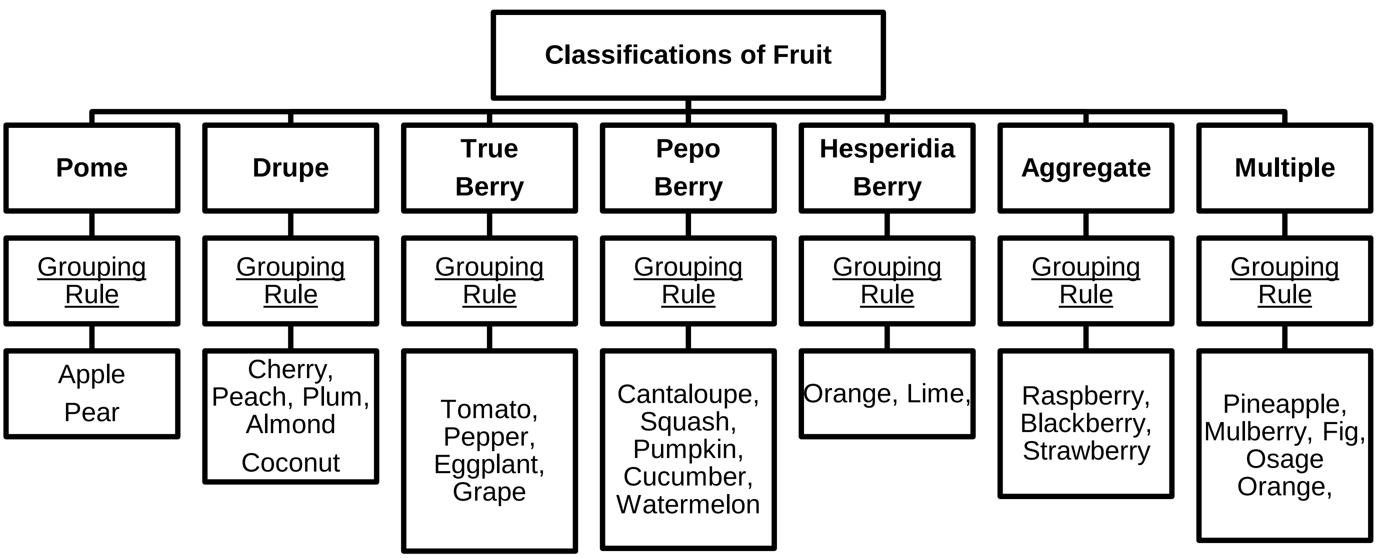
 Almond Fruit	 Nectarine	 Avocado	 Blackberry
 Cherries		 Raspberry	 Apple
 Grapes	 Tomato	 Lime	 Orange
 Plum	 Peach	 Pear	 Pepper

Teacher

 Strawberry	 Cucumber	 Banana	 Fig
 Cantaloupe	 Coconut	 Osage Orange	 Eggplant
 Pumpkin	 Watermelon	 Pineapple	 Squash

Teacher

Group	Subgroup	Grouping Rules
Pomes		A fleshy fruit composed of the mature ovary along with other flower parts. Edible exocarp and mesocarp. Seeds are located within the endocarp.
Drupes		Develops from an ovary with a single compartment. Edible exocarp and mesocarp with an inedible, hard endocarp (pit).
Berries	**True**	Develop from ovaries with multiple compartments. When cut open these fruits show separate seed containing compartments.
	Pepo	Same as a true berry except these have a comparatively thick exocarp.
	Hesperidia	A berry with a leathery skin containing oils, such as citrus.
Aggregates		Fruits that develop from multiple adjacent ovaries that each develop tiny fruits.
Multiples		Are the result of several flowers clustered on one stem. Ovaries develop individually, but the individual fruits combine into a single larger fruit.



Student

Classification of Fruits

NGSSS:
SC.912.L.15.6 Discuss distinguishing characteristics of the domains and kingdoms of living organisms. **(AA)**

Background: Fruits are developed from flowering plants. Fruits are the ovaries of flowers. After fertilization, the ovary expands as the seed ripens. Some fruits are the result of ovaries with a single compartment while other fruits may have ovaries with multiple compartments. Most fruits are composed of three basic layers; an exocarp (outer), mesocarp (middle) and endocarp (inner).

The botanical way of classifying a fruit is done by observing various characteristics of the flower and the fruit. One of these characteristics requires counting the number of ovaries in the flower; another, deals with the number of chambers in each ovary; and a third, describes the number of flower ovaries that grow together into one fruit.

Purpose or Problem Statement:

- Relate observations to different ways of classifying organisms
- Develop rules for categorizing the fruits used in the activity

Safety:
If using real fruit:

- Handle fruit with care, it may stain your clothes and some fruit juices may be irritating to the eye.
- Tell your teacher if you are allergic to any of the fruits used in the experiment.

Vocabulary: flower, fruit, characteristic, seed, ovary, fertilization, classification

Materials (individual or per group):

- Fruit pictures (may be substituted for real fruit)

<u>Part 1</u>
Procedures:

1. As a team discuss ways to group fruit into different categories.
2. Create rules for categorizing each fruit
3. Make sure each fruit meets the required rule for the category it is placed.
4. Name each group

Observations/Data:

Note: Additional tables may be needed to accommodate more groups

Student

	Group 1:	Group 2:	Group 3:
Rule:			
Types of fruit			

Data Analysis/Results

1. How many different groups did your team make to organize the given fruits?

2. What steps did your team make in order to group the given fruits?

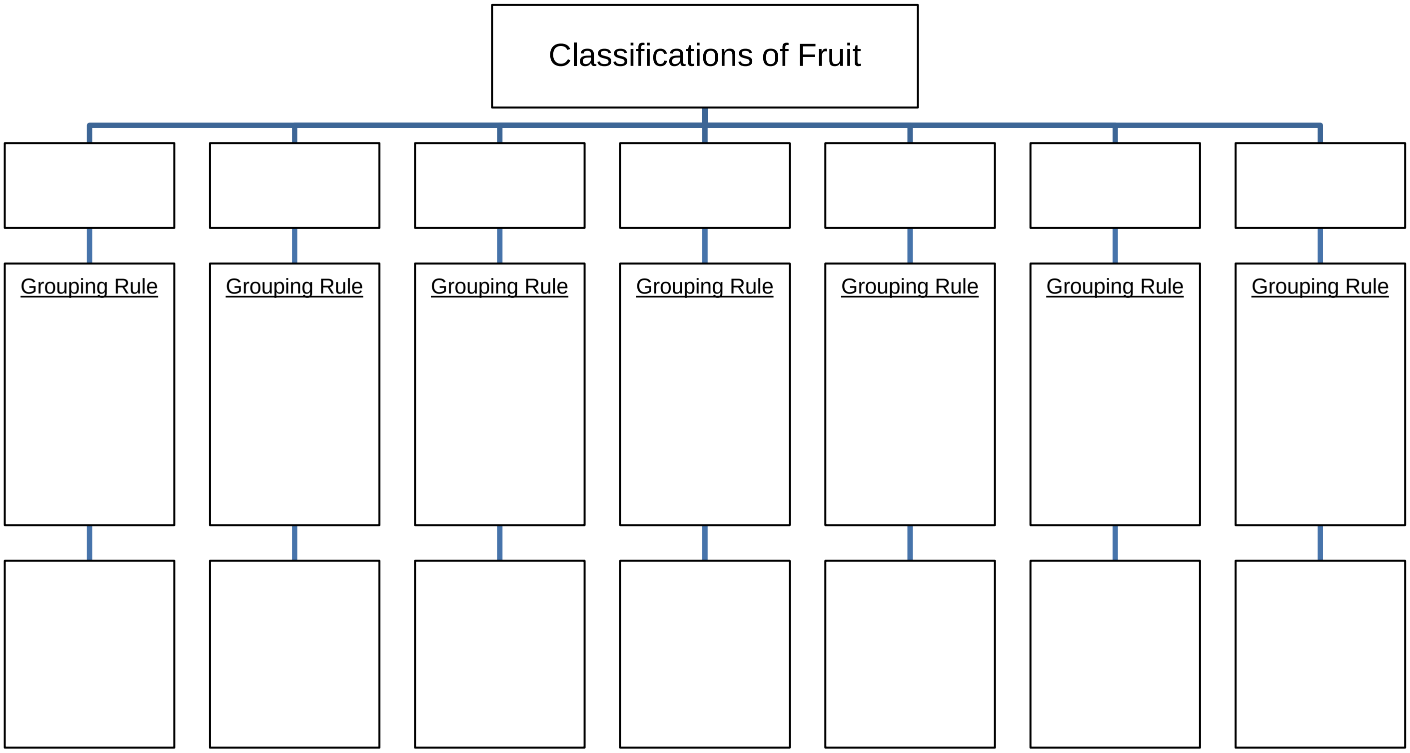
3. How many different ways did your team group the fruits before deciding on your final grouping rules?

4. Describe the rules your team created and briefly explain what brought about the decision to make these rules.

<u>Part 2</u>
Procedures:

1. Organize the fruit cards into seven (7) groups.
2. As a team discuss possible rules for each category and write them in the table below.

Student



Observations and Conclusion

1. How did you go about grouping your fruits?

2. How many different ways did your team group the fruits before deciding on your final grouping rules?

3. How did your final groupings compare to **Part 1** of this activity?

Teacher

Cladistics

NGSSS:
SC.912.L.15.6 Discuss distinguishing characteristics of the domains and kingdoms of living organisms. **(AA)**

Purpose of Lab/Activity:
- Construct a cladogram.
- Properly interpret and analyze cladogram in terms of recognizing the concepts of common ancestry and degrees of evolutionary relationship.

Prerequisite: Prior to this activity, the student should be able to
- Identify characteristics of organisms

Materials (individual or per group):
- Organism Cards and Linnaean Table (in student packet)
- Clear (see-through) plastic bags – 7 per group
- 3 x 5 cards or sticky notes
- Scissors
- Printer paper
- Color pencils or markers

Procedures: Day of Activity:

Before activity:	**What the teacher will do:**
	a. Gather together a set of 7 plastic bags for each group.
	b. Provide each student with a handout of the reading passage "The De-riving Force of Cladogenesis"
	   1. Have students read the passage (incorporate jump-in reading, one sentence summaries or any other favorite reading strategy to engage and discover student prior knowledge).
	   2. Review vocabulary words during the reading.
	c. Discuss the concept of Cladogenesis.
	d. Handout the Organisms Cards to each group.

During activity:	**What the teacher will do:** a. As students perform the lab activity, allow students to observe the different pictures of animals and help guide them in terms of following the steps in creating a cladogram from the cards. b. Ensure discussions from students stay productive when disagreements arise on how to place the organism into the bags and the bags into each other. As students perform the lab activity, allow students to use additional resources to answer the introductory questions, such as the textbook and the Internet.

After activity:	**What the teacher will do:**
	c. Assess student understanding of cladograms by discussing the group work.
	   1. Review Observation/Conclusion questions:
	      i. Why do organisms resemble one another? They are related to each other.

	ii. What does it mean when two organisms are very similar? The more similar, the closer related they are and the more recent the common ancestor is. iii. List and describe at least two ways that similarity between organisms can be determined. Comparing anatomy, Comparing DNA, Comparing embryology (development before birth). iv. Compare and contrast a cladogram (branching tree diagram) with a pedigree (family tree). Both show relatives & ancestors. Cladograms include more distant relatives over a longer period of time and can thus be used to predict the characteristics of common ancestors.

Extension:

- Introduction to classification, phylogenetic trees, and cladistics by UCMP: "What did *T. rex* taste like?" - http://www.ucmp.berkeley.edu/education/explorations/tours/Trex/index.html
- Cladistics is a Zip—Indiana EDU: http://www.indiana.edu/~ensiweb/lessons/clad.bag.html
- Go to the following website http://www.pbs.org/wgbh/evolution/change/family/index.html and do the activity from PBS called, All in the Family. Questions on this activity are found in the activity itself. When tree is completed check for correctness.
    - Click on each organism that you think are the two closest relatives. The pictures will appear on an evolutionary tree.
    - The remaining species will move into position on the remaining branch and you will find out if your first guess was correct.
    - Use the tools to compare anatomical, developmental, and molecular traits.
    - Figure out which traits are primitive (they are the ones held by the out-groups).
    - Assume that traits that aren't primitive must be derived.
    - Find the two organisms that share the most derived traits.
    - Drag organisms to put this pair in the top two branches of the tree.
    - When you think the tree is correct check the answers.

Additional Resources:

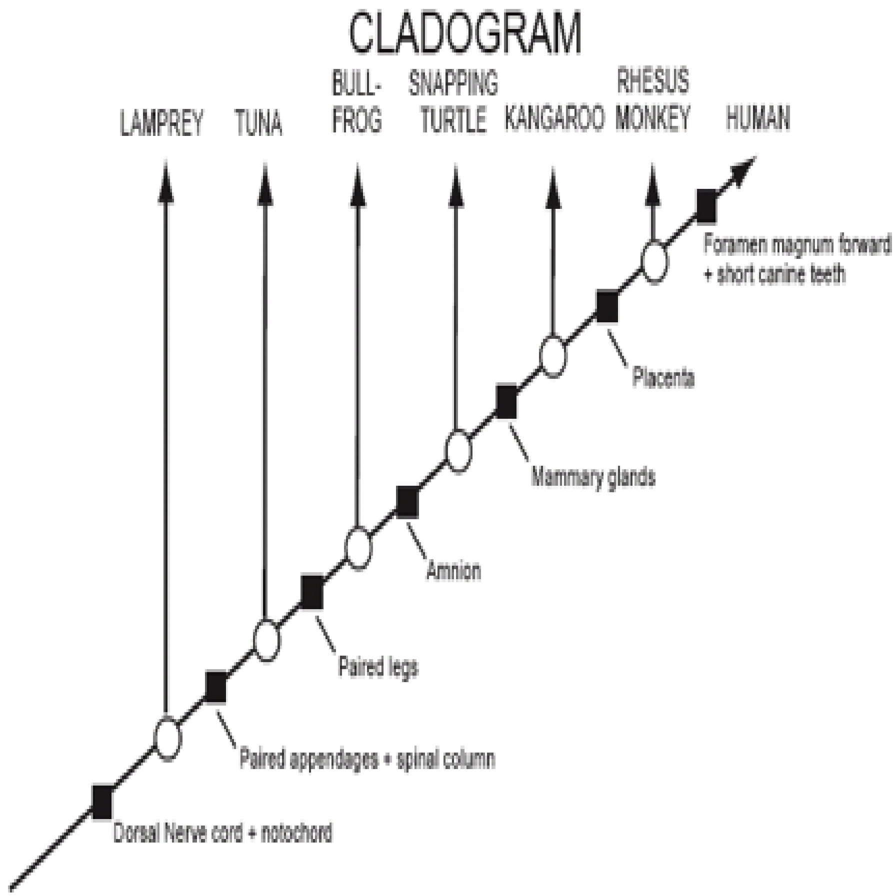
In this lesson, classification can (and should) be used to illustrate more than a mere hierarchical grouping of organisms. This lesson introduces students to the building of cladograms as evolutionary trees, showing how "shared derived characters" can be used to reveal degrees of relations. Students are introduced to the process of illustrating evolutionary relationships with branching diagrams called **cladograms**. Students learn that once a cladogram has been constructed for a group of organisms, it can be used to answer all kinds of interesting questions based on the shared inherited features of those organisms.

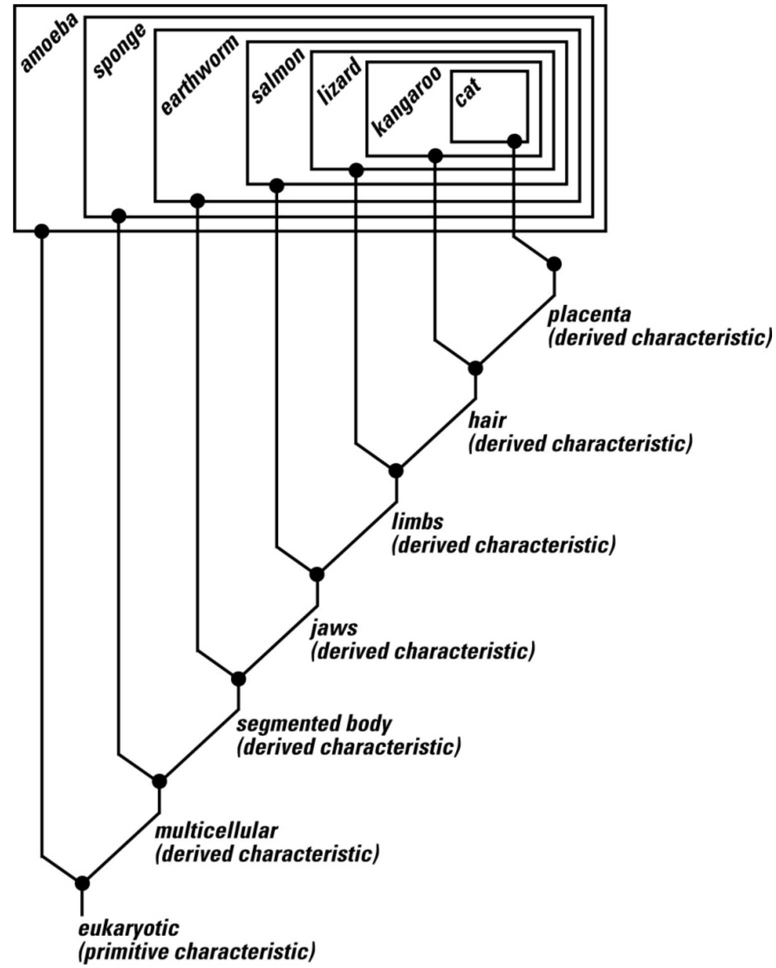
The concepts are as follows:

- All living things are related by common ancestry.
- Branching diagrams, called cladograms, are used to illustrate evolutionary relationships.
- Cladograms are based on shared, inherited features.
- Cladograms refine our ability to understand and interpret evolutionary history.

Teacher

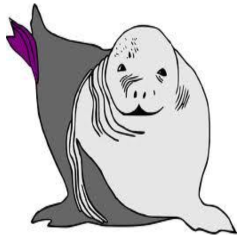
Example Cladograms:





Teacher

Organism Cards

Name: **Date Palm** *Phoenix dactylifera*  Energy Source: Autotroph Vertebrae (backbones): n/a Body Temperature: n/a Limbs: n/a Eyes: n/a Retractable Claws: n/a Other: Does not move.	Name: **Sea Lion**  Energy Source: Heterotroph Vertebrae (backbones): yes Body Temperature: constantly warm Limbs: 4 flippers with claws Teeth: Pointed teeth Eyes: eyeballs on side of head: Retractable Claws: no	Name: **Leopard Frog** Rana pipiens  Energy Source: Heterotroph Vertebrae (backbones): yes Body Temperature: varies with environment Limbs: 4 legs Eyes: eyeballs on top/side of head Retractable Claws: n/a Other: Tongue attached to front of jaw.	Name: **African Lion** Panthera leo  Energy Source: Heterotroph Vertebrae (backbones): yes Body Temperature: constantly warm Limbs: 4 legs with clawed feet Teeth: Pointed teeth Eyes: front of head Retractable Claws: no Other: Roars, social animal, males have manes.
Name: **Honey Bee** *Apis mellifera*  Energy Source: Heterotroph Vertebrae (backbones): no Body Temperature: varies with environment Limbs: 6 legs Eyes: on side of head Retractable Claws: n/a Other: Compound eyes.	Name: **House Cat** *Felis silvestris*  Energy Source: Heterotroph Vertebrae (backbones): yes Body Temperature: constantly warm Limbs: 4 legs with clawed feet Teeth: Pointed teeth Eyes: front of head Retractable Claws: yes Other: Purrs,but cannot roar.	Name: **Bactrian Camel** *Camelus bactrianus*  Energy Source: Heterotroph Vertebrae (backbones): yes Body Temperature: constantly warm Limbs: 4 legs with hooves Teeth: Square, flat teeth Eyes: eyeballs on side of head Retractable Claws: n/a	Name: **Siberian Tiger** *Panthera tigris*  Energy Source: Heterotroph Vertebrae (backbones): yes Body Temperature: constantly warm Limbs: 4 legs with clawed feet Teeth: Pointed teeth Eyes: front of head Retractable Claws: no Other: Roars, stripes, solitary animal.

Teacher

Linnaean table

Common Name	Date Palm	Honey Bee	Leopard Frog	Bactrian Camel	House Cat	African Lion	Siberian Tiger	California Sea lion
Kingdom	Plantae	Animalia	Animalia	Animalia	Animalia	Animalia	Animalia	Animalia
Phylum	Magnoliophyta	Artropoda	Chordata	Chordata	Chordata	Chordata	Chordata	Chordata
Class	Liliopsida	Insecta	Amphibia	Mammalia	Mammalia	Mammalia	Mammalia	Mammalia
Order	Arecales	Hymenoptera	Anura	Artiodactyla	Carnivora	Carnivora	Carnivora	Carnivora
Family	Arecaceae	Apidea	Ranidae	Camelidae	Felidae	Felidae	Felidae	Otariidae
Genus	*Pheonix*	*Apis*	*Rana*	*Camelus*	*Felis*	*Panthera*	*Panthera*	*Zalophus*
Species	*dactylifera*	*mellifera*	*pipiens*	*bactrianus*	*silvestris*	*leo*	*tigris*	*Californianus*

The De-riving Force of Cladogenesis

Andrew J Petto University of Wisconsin, Milwaukee, and Editor, National Center for Science Education

Cladogenesis is the term used to describe the branching off of new taxa. These branches - or *clades* - are based on several criteria that make the descendants along a particular branch different from their ancestors and from related taxa on other branches. Each new branch exhibits a combination of novel characteristics that are unique to that branch mixed with some "familial" characteristics, which this branch shares with its evolutionary ancestors. Although certain novel traits may be diagnostic for members of an evolving lineage, it is often the *combination* of unique and shared characteristics that defines new branches.

The basis of constructing a valid cladogram is the ability to identify the characteristics of the ancestral population and those of the descendants. Characteristics found among the ancestors and shared by most or all members of related taxa are referred to as *primitive*. In cladistic studies this word is understood as "original" or "primal" and not as "crude" or "simple".

A cladogram is constructed on these combinations of ancestral and derived characteristics in related taxa by organizing and diagramming the pattern and sequence in which they could have arisen. Ideally, we want a cladogram based on branches defined by uniquely derived characters that emerge once in an evolving lineage and are shared by all subsequent descendants. This helps us to test our hypotheses about common descent in evolving lineages. A branch that includes all the organisms descended from the same ancestral population is said to be *monophyletic.*

Two fundamental principles used in evaluating cladograms are parsimony and robusticity. First, when there is more than one way to draw a cladogram, *and* when there are no *other* data that suggest one of these is more likely than the others, we tend to choose the one in which derived traits are re-invented in different branches the fewest number of times. Second, we prefer trees that maintain their basic form; even when different options are applied to the sequence of changes in one or more of their branches. However, when more data are available about the history or the origin of a particular feature, these data are more important tools in determining which of the alternative trees is better. In contrast to exercises in mere *classification, we* want to base our *taxonomy* on the cladogram. The guiding principle is that our taxa should be monophyletic. Each evolutionary branch must contain all descendants of a common ancestor.

Fossil data help to refine cladistic analysis by providing information about the sequence or order in which certain derived traits emerged. Cladistic analysis helps to resolve the "problem" of the so-called "missing links" or the intermediate specimens, because it does not require that fossil species *evolve into* any related species, which emerge later. Instead, it represents the evolutionary history of an evolving lineage in terms of a collection of characteristics that can be passed along to descendant populations - or not!

Student

Cladistics

NGSSS:
SC.912.L.15.6 Discuss distinguishing characteristics of the domains and kingdoms of living organisms. **(AA)**

Background: When scientist do studies in comparative anatomy, and find different numbers of shared derived characteristics between different groups, they can draw a diagram of branching lines which connect those groups, showing their different degrees of relationship. These diagrams look like trees and are called "phylogenetic trees" or "cladograms" (CLAY-doe-grams). The organisms are at the tips of the stems. The shared derived features of the homologous structures are shown on the cladogram by solid square boxes along the branches, and common ancestors are shown by open circles. The more derived structures two organisms share, the closer is their evolutionary relationship -- that is, the more recently their common ancestor lived. On the cladogram, close relationships are shown by a recent fork from the supporting branch. The closer the fork in the branch between two organisms, the closer is their relationship.

In this activity a series of plastic bags will be used to create a three dimensional Venn Diagram to illustrate the hierarchical grouping of organisms based on their shared derived features, thus forming the basis of a cladogram.

Purpose or Problem Statement:
- Construct a cladogram.
- Properly interpret and analyze cladogram in terms of recognizing the concepts of common ancestry and degrees of evolutionary relationship.

Safety: Be careful with scissors, do not point, swing, or play with scissors.

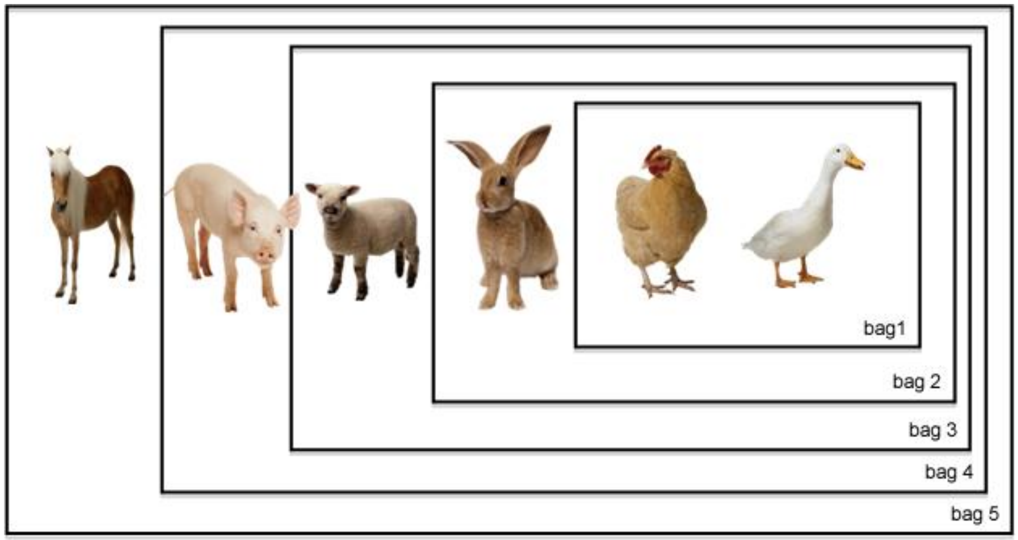
Vocabulary: Phylogeny, Cladogram, Taxonomy, Classification, Binomial Nomenclature

Materials (individual or per group):
- Organism Cards and Linnaean Table (in student packet)
- Clear (see-through) plastic bags – 7 per group
- 3 x 5 cards or sticky notes
- Scissors
- Printer paper
- Color pencils or markers

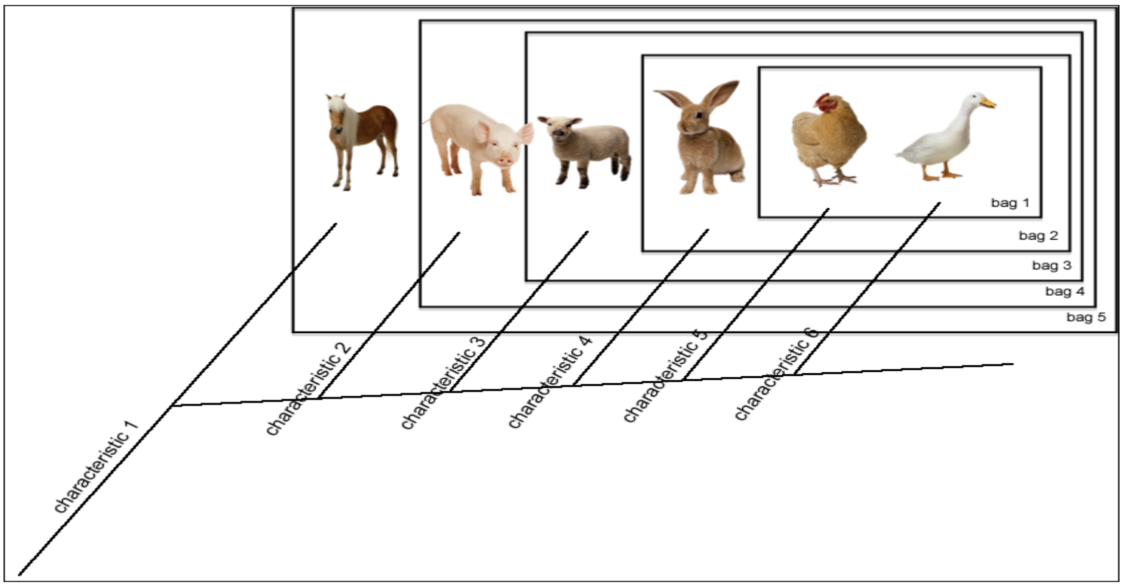
Procedures:
1. Create a set of Name Cards by cutting 3x5 cards into 3 pieces until you have 8 pieces (sticky notes may be used instead).
2. Name each cut piece using the names on the Organism Cards provided
3. Examine the descriptions on the Organism Cards and the Linnaean table in order to select the two most similar organisms.
4. Put their name cards together in plastic bag 1.
5. Select the organism which is most like the ones you chose in step #3 and place this name card in bag 2.
6. Place bag 1, with its two name cards into bag 2.

Student

7. Select the next most similar organism to the organisms in bag 2 and place its name card in bag 3.
8. Then add bag 2 (containing all the previous cards) into bag 3.
9. Repeat step 7 and 8 until all the name cards have been bagged.
10. Final "nested" bags should look like this:

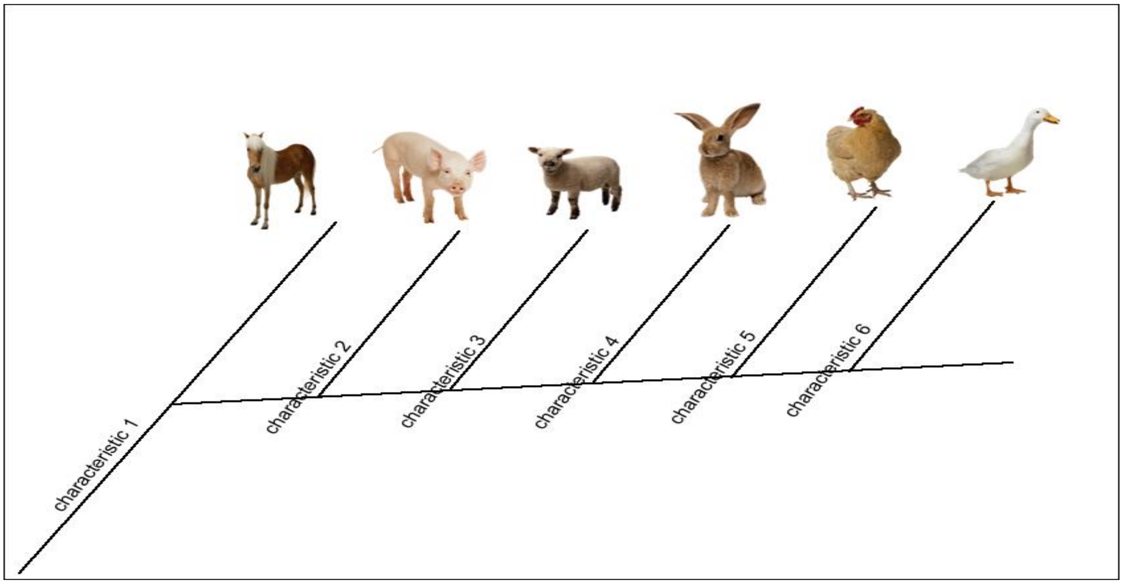


11. Place the 3-D Venn diagram on top of a piece of paper.
12. Record your data: Consider what characteristic is common to all the organisms in the bags. Write this characteristic at the end of a line connecting to the outermost organism. (Characteristic 1 in picture)
13. Consider the remaining bags of organism cards. What do all these organisms have in common? Write down that characteristic on another line connecting to the second largest Venn region.
14. Continue to examine the organisms in your bags and describe a common characteristic of the remaining organisms.



Student

15. When you are done, you will have a branching tree diagram that looks a bit like a bonsai tree.
16. Remove the Name Cards from the bags and place in the appropriate line.



Observations/Conclusions:

1. Why do organisms resemble one another?
2. What does it mean when two organisms are very similar?
3. List and describe at least two ways that similarity between organisms can be determined.
4. Compare and contrast a cladogram (branching tree diagram) with a pedigree (family tree).

Teacher

Plant Structure and Function

NGSSS:
SC.912.L.14.7 Relate the structure of each of the major plant organs and tissues to physiological processes. (**AA**)

Purpose of Lab/Activity:
- Students will identify the parts of a plant
- Students will be able to relate the structure of plant parts to their function

Prerequisite: Prior to this activity, the student should be able to
- Identify parts of a plant and their functions

Materials (individual or per group):
- Tea leaves or tea bag (Leaf
- One fruit (any kind) (Flower)
- Celery plant (Stem and Leaf)
- Carrot or onion (Root)
- Live green plant (in a pot)
- If possible, a leaf sample from an "Oyster" plant (***Tradescantia discolor)***

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Prepare materials and display them to the whole class. b. Engage student prior knowledge and understanding by asking the following questions: 1. What do all these items have in common? 2. What are the basic parts of a plant? 3. Where do plants come from?
During activity:	**What the teacher will do:** a. Display the green plant 1. Ask students to identify parts of the plant. 2. After identifying the parts of the plant ask students to describe the order in which the plant will grow starting with the seeds. 3. As students describe the growth of a plant, draw or show pictures of each part. b. Engage students in a discussion on the function of each of the following parts of the plant: Roots, Stems, Leaves, and Flowers. c. Have students make a table on the structure and function of each part discussed, providing sufficient examples and descriptions.
After activity:	**What the teacher will do:** a. Assess student understanding of plant structure and function by reviewing its different parts. b. For additional reinforcement on the concept of plant structure and function provide students with the handouts on Major Plant Organs and Functions.

Extension:

Teacher

- Plant Structure and Function Extension (Student handout)

	Structure	Function
Leaves	• Thin with a large surface area. • Cells contain chlorophyll in chloroplasts.	• Short distances for gases to diffuse. Large area for absorption of light. • Leaves are a plant's food factory. They are the main site of photosynthesis, where sugars are made from water and carbon dioxide, using sunlight energy that has been absorbed by chlorophyll.
Stems	• Long and cylindrical. Woody tissues - xylem and fibres (sclerenchyma) - add strength. • Contain xylem and phloem (in 'veins').	• Support the leaves, flowers and fruit. Can bend or resist the wind. • Transport water, minerals to leaves and sugars to roots, flowers, fruit and roots.
Roots	• Branch extensively through the soil. • Root hairs - provide huge surface area. • Contain xylem and phloem (in 'veins'). • Root tip - area of cell division. • Root cap - covers the root tip.	• Provide anchorage in the soil. • Enable absorption of water and nutrients. • Enable transport of water and nutrients. • Grow into the soil. • Protects and lubricates the growing root.

Student

Plant Structure and Function Extension

NGSSS:
SC.912.L.14.7 Relate the structure of each of the major plant organs and tissues to physiological processes. (**AA**)

Part 1A: Leaves

The leaf of a plant serves two basic functions: photosynthesis and cellular respiration.

Photosynthesis is a chemical reaction in which plants convert radiant energy (light energy) into chemical energy (food energy or more specifically, glucose). Cellular respiration is the chemical reaction in which chemical energy (glucose) is converted into usable energy for the plant.

Can you list the reactants and products for the processes of photosynthesis and cell respiration?

Photosynthesis Equation: ____

Cell Respiration Equation: ____

Leaf Cross-Section
The leaf is the primary photosynthetic organ of the plant. It consists of a flattened portion, called the blade that is attached to the plant by a structure called the petiole. Sometimes leaves are divided into two or more sections called leaflets. Leaves with a single undivided blade are called simple, those with two or more leaflets are called compound.

The outer surface of the leaf has a thin waxy covering called the cuticle (A), this layer's primary function is to prevent water loss within the leaf. (Plants that leave entirely within water do not have a cuticle). Directly underneath the cuticle is a layer of cells called the epidermis (B). The vascular tissue, xylem and phloem are found within the veins of the leaf. Veins are actually extensions that run from to tips of the roots all the way up to the edges of the leaves. The outer layer of the vein is made of cells called bundle sheath cells (E), and they create a circle around the xylem and the phloem. On the picture, xylem is the upper layer of cells (G) and is shaded a little lighter than the lower layer of cells - phloem (H). Recall that xylem transports water and phloem transports sugar (food).

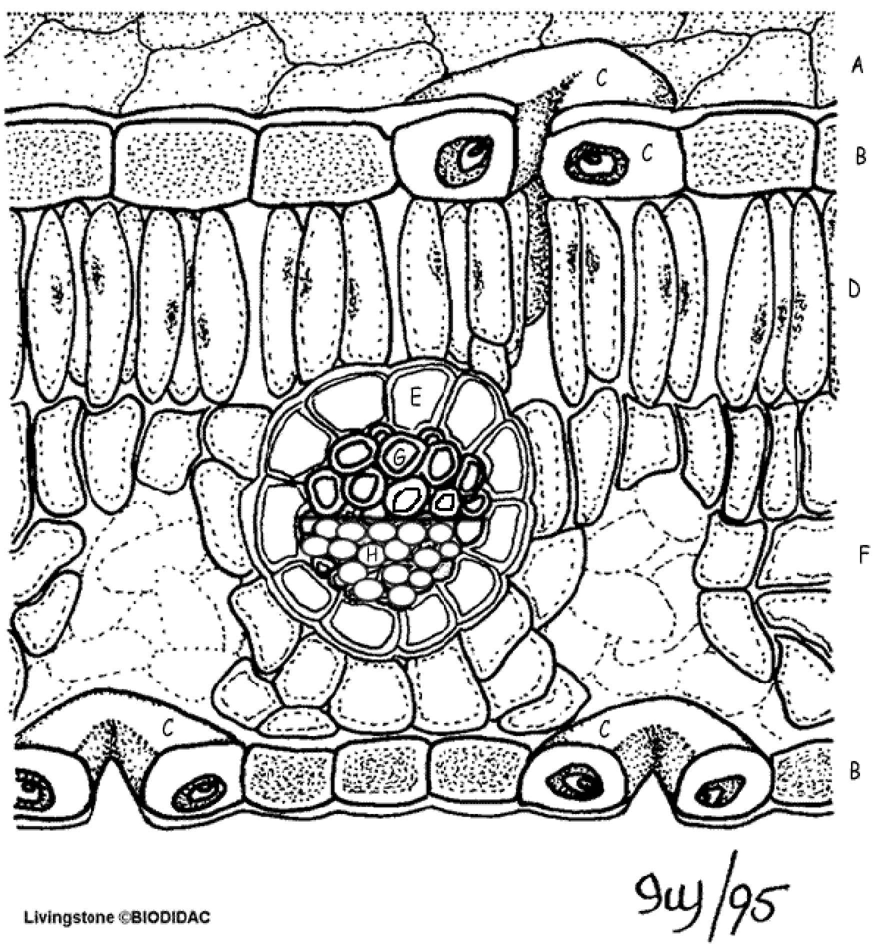
Within the leaf, there is a layer of cells called the mesophyll. The word mesophyll is greek and means "middle" (meso) "leaf" (phyllon). Mesophyll can then be divided into two layers, the palisade layer (D) and the spongy layer (F). Palisade cells are more column-like, and lie just under the epidermis, the spongy cells are more loosely packed and lie between the palisade layer and the lower epidermis. The air spaces between the spongy cells allow for gas exchange. Mesophyll cells (both palisade and spongy) are packed with chloroplasts, and this is where photosynthesis actually occurs.

Epidermis also lines the lower area of the leaf (as does the cuticle). The leaf also has tiny holes within the epidermis called stomata. Specialized cells, called guard cells (C) surround the stomata and are shaped like two cupped hands. Changes within water pressure cause the stoma (singular of stomata) to open or close. If the guard cells are full of water, they swell up and bend away from each other which opens the stoma. During dry times, the guard cells close.

Identify the structures:

Color the structures underlined above. Make sure that the entire picture is colored and that the color matches the words. For simplicity only part of the picture is labeled.

- Cuticle (light blue)
- Epidermis (yellow)
- Guard cells (pink)
- Palisade Mesophyll (dark green)
- Phloem (purple)
- Xylem (orange)
- Spongy Mesophyll (light green)
- Bundle Sheath(dark blue)



Student

Answer the following questions:

1. What two tissues are found within a vein?
2. What does the word "mesophyll" mean?
3. What two layers of the plant contain chloroplasts?
4. The outermost layer of cells: ___________________________
5. The waxy covering of the leaf.: _________________________
6. These cells function to open and close stomata. ______________________
7. Outer layer of the vein: __________________________
8. Column like cells that lie just under the epidermis. ____________________
9. Openings that allow for gas exchange. ___________________________
10. The stalk that connects the leaf to the stem. ________________________

Extension:

1. Write a paragraph discussing how leaf structure contributes to the efficiency of the process of photosynthesis.

2. Predict adaptations that would be found in leaves located in the following environments.
   a. Desert
   b. Tropical rain forest
   c. Aquatic environment

Part 2A: Stomata and Guard Cells:

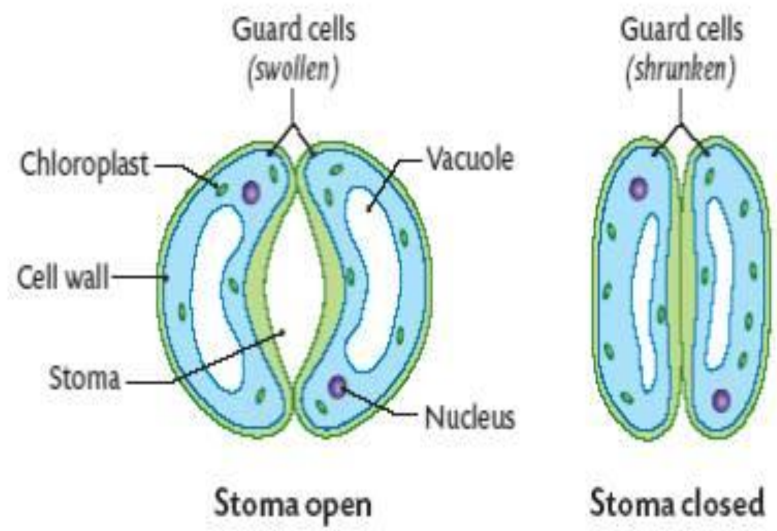
Materials:

- Plant leaves
- Clear fingernail polish
- Clear cellophane tape (clear package sealing tape)
- Microscope
- Microscope slides
- Oyster plant leaf

Procedure:

1. Obtain a leaf from a plant; generally any plant will work for this procedure.
2. Paint a thick patch of clear nail polish on the leaf surface being studied. Make a patch at least one square centimeter.
3. Allow the nail polish to dry completely.
4. Tape a piece of clear cellophane tape to the dried nail polish patch. (The tape must be clear. Do not use Scotch tape or any other opaque tape. Clear carton-sealing tape works well.)
5. Gently peel the nail polish patch from the leaf by pulling on a corner of the tape and peeling the fingernail polish off the leaf. This is the leaf impression you will examine. (Only make one leaf impression on each side of the leaf, especially if the leaf is going to be left on a live plant.)
6. Tape your peeled impression to a very clean microscope slide. Use scissors to trim away any excess tape.

7. Scan the slide until you find a good area where you can see the stomata. Each stoma is bordered by two sausage-shaped cells that are usually smaller than surrounding epidermal cells. These small cells are called guard cells and, unlike other cells in the epidermis, contain chloroplasts.



8. Cut a small piece of the Oyster plant leaf. Observe directly under the microscope. A cross section or slide is not needed. Observe the stomata and guard cells and compare them to the ones previously observed.

Analysis:

1. Sketch and label the Stoma, Guard Cells, Epidermal Cells, and Chloroplasts
2. Estimate the number of stomata in both of your samples.
3. Where were most of the stomata found? Why do you think this is? Explain your answer in evolutionary terms.

Extension:

1. Question: Will plants have more stoma open during the day than during the night?
2. Develop a hypothesis about the number of open stomata found in a plant kept in the dark compared to a plant in the light.
3. Repeat the procedure above for preparing your slide. You will make two impressions, one from a "Dark Plant" and one from a "Light Plant" You will compare the two impressions.
4. Write a short paragraph that answers the question; use your data to support your conclusions.
5. Discuss the factors that cause the stomata to be open during the day and closed at night. Under what circumstances the stomata might be closed during the day?

Student

Part B: Roots

Materials:

- Plant roots (monocot and dicot)
- Microscope
- Microscope slides

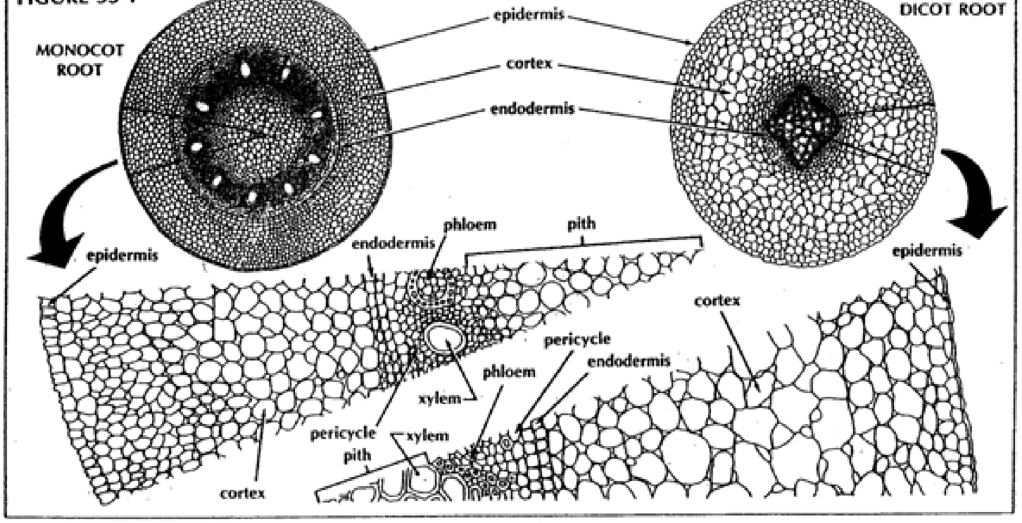
Cells in plants cells are organized into four main tissues—protective, vascular, meristematic, and fundamental. Protective tissue surrounds the outside of a root and the rest of the plant. This tissue is composed of epidermis and/or cork cells. Vascular tissue contains cells which conduct materials such as water, minerals, and food to the organs of the plant. It also provides support. Two of the major vascular tissues are xylem and phloem. Fundamental tissue includes storage areas and cells where food is manufactured. This tissue also provides support. Meristematic tissue is growth tissue. It produces new cells which develop into the other three types of tissues.

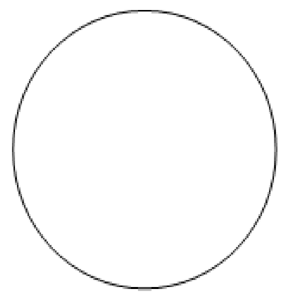
In this investigation, you are to observe and identify the various tissues in herbaceous monocot and dicot roots, the area of lateral root origin, and onion root. You are to compare the relative sizes of each cell type observed. You are also to observe and identify primary and secondary roots from different types of root systems.

Herbaceous Monocot and Dicot Roots:

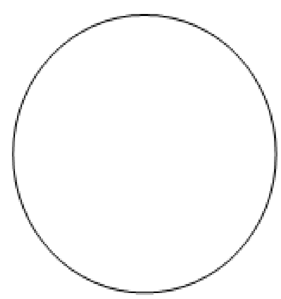
1. Observe the monocot and dicot root slides on low power, then on high power of your microscope.
2. For each root, locate and identify the epidermis, cortex, endodermis, pith, xylem, pericycle, and phloem (Figure 53-1). Determine whether each cell type is protective, vascular, fundamental, or meristematic tissue.
3. Compare the relative size of each type of cell.
4. Make a sketch of each type of cell.

FIGURE 53-1



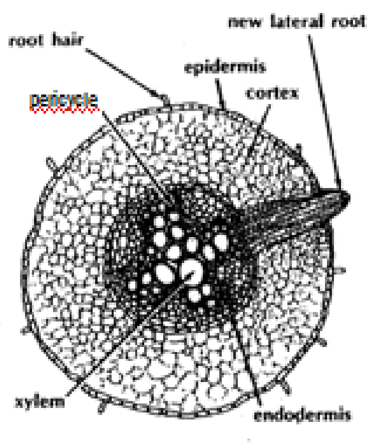


Monocot _____X



Dicot _____X

Lateral Root Origin



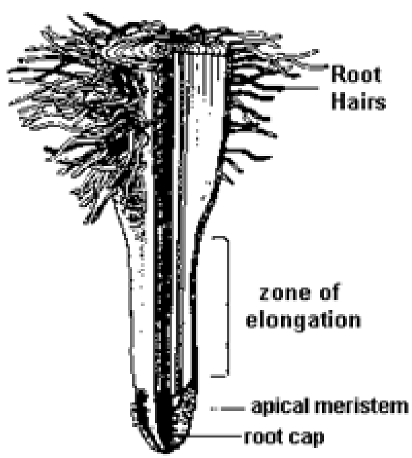
Lateral Root Origin

FIGURE 53-2

______X

1. Observe the slide of the area of lateral root origin on low power, then on high power.
2. Determine the tissue from which the lateral root is growing. (See Figure 53-2).
3. Make a sketch of your observations.

Onion Root Tip (Longitudinal Section)



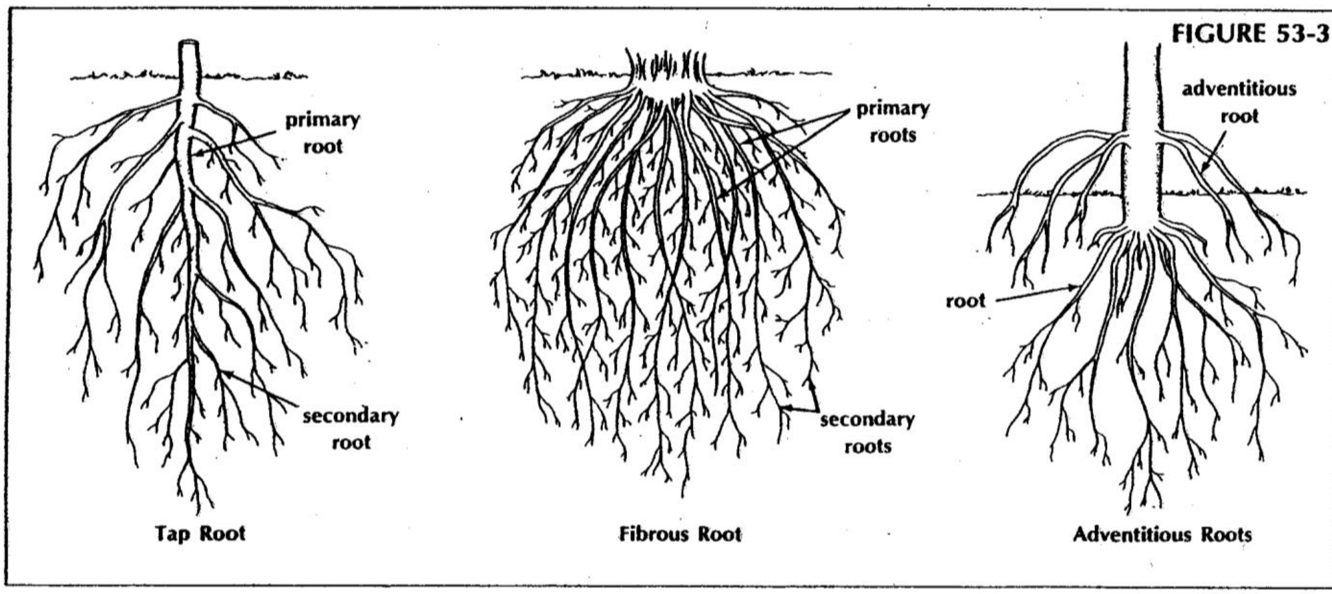
______X

1. Observe the onion root tip slide on low then medium power.
2. Label the apical meristem (the area where the cells are dividing). Note that the cells are smaller and less developed closer to the meristem and that they elongate and mature as they get older (farther up the root).
3. What is the function of the root cap at the very tip of the root? Sketch what you see.

Student

Root Systems

Using Figure 53-3, observe the different types of root systems.



1. The blue-stained material in the cortex of the dicot root is starch. Why is it found in the root and how did it get there?
2. From what specific tissue does a lateral root originate? Is it meristematic? Why?
3. How do xylem patterns differ in monocot and dicot roots?
4. How do tap root systems differ from fibrous root systems?
5. Which root system, tap or fibrous, is more similar to an adventitious root system? Explain?
6. What are four basic functions of roots?

Student

Part C: Stems

Materials:

- Plant stems (monocot and dicot)
- Microscope
- Microscope slides

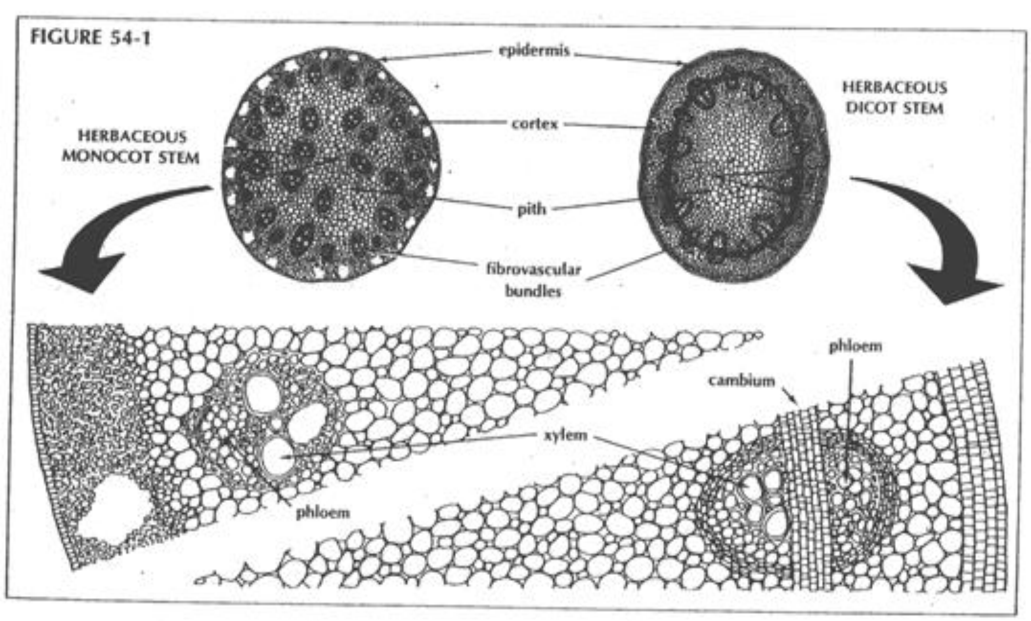
As in roots, protective, vascular, fundamental, and meristematic tissues are found in stems. The difference between roots and stems may be slight or significant.

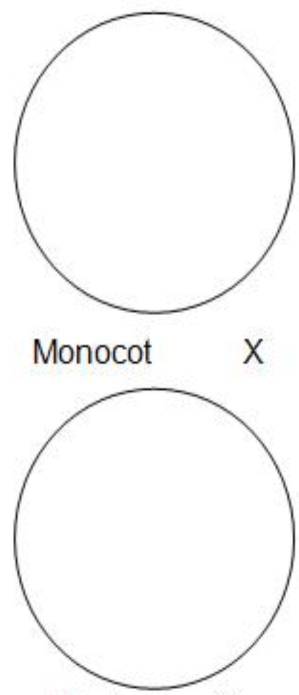
In this investigation, you are to observe and identify the tissues in an herbaceous monocot stem, and herbaceous dicot stem, and a woody stem. You are to compare the relative size of each cell to the other cells and make sketches of each. You are to observe and identify the external parts of a woody twig and determine the pattern of leaf arrangement.

Herbaceous Monocot and Dicot Stems:

1. Observe the monocot and dicot slides on low power, then on high power of your microscope.
2. Make a sketch of each stem and label the *epidermis, cortex, vascular bundles, xylem, phloem, cambium, and pith* (Figure 54-1).
3. List the functions of each cell type.
4. Determine whether each cell type is protective, vascular, fundamental, or meristematic tissue.
5. Compare the relative size of each cell to the other cells.

FIGURE 54-1





Monocot X

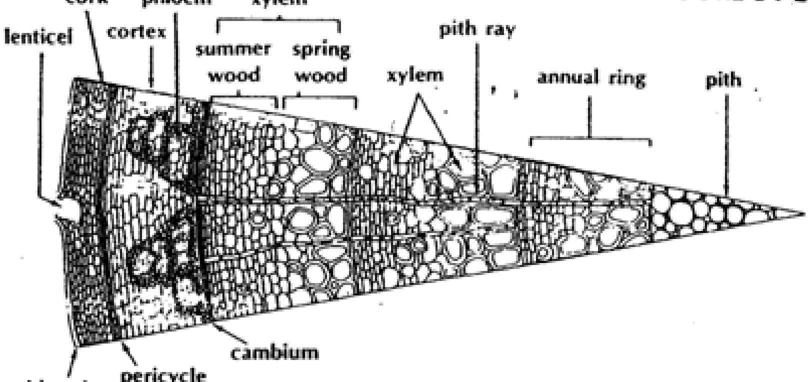
Dicot X

Student

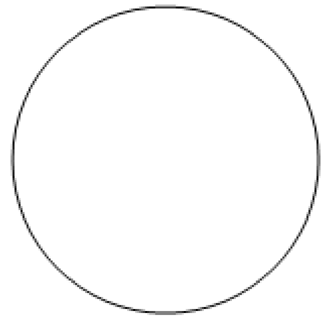
***Tilia* Stem (Woody growth):**

1. Observe the *Tilia* stem slide on low power, then on high power of your microscope.
2. Sketch and label the *epidermis, cork, cortex, phloem, cambium, spring wood, summer wood, xylem, pith rays, and pith* (Figure 54-2).
3. List the functions of each cell type.
4. Determine whether each cell type is that of protective, vascular, fundamental, or meristematic tissue.
5. Compare the relative cell sizes.

FIGURE 54-2



Woody Stem Section



X

Woody Twig:

1. Observe the woody twig.
2. Locate and identify the terminal bud, lateral bud, lenticels (small pores in the bark), bud scale, bud scale scar, node, internode, and leaf scar (Figure 54-3).

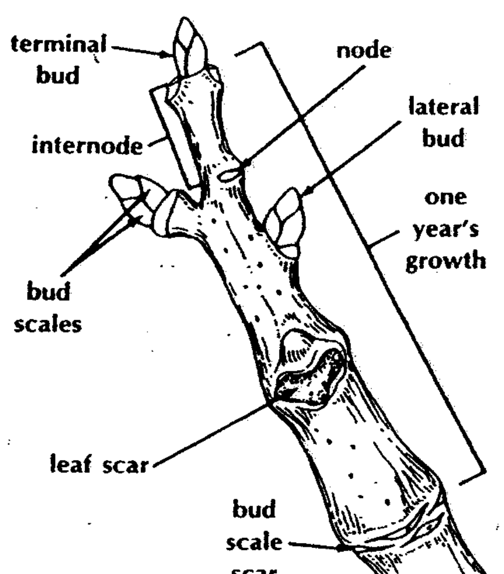


FIGURE 54-3

3. List the functions of each part of a woody twig.
4. Determine whether the stem has an alternate or opposite leaf arrangement.

5. The area between two bud scale scars is one year's growth. Count the years of growth on the twig.

Analysis Questions:

1. State the various functions of a stem.
2. How is woody xylem in *Tilia* different from xylem in herbaceous monocots and dicots?
3. What other major differences exist between woody stems and herbaceous stems?
4. How do monocot and dicot stems differ in location of cambium, xylem, and phloem?
5. Explain how you would tell if one growing season was more favorable for growth than others.
6. What function do lenticels serve? What would happen to a woody twig with no lenticels?
7. How can you determine the past arrangement of leaves on a bare twig?

Teacher

Exploring Flower Structure

NGSSS:
SC.912.L.14.7 Relate the structure of each of the major plant organs and tissues to physiological processes. (**AA**)

Purpose of Lab/Activity:
- Students will be able to list the parts of a flower
- Students will be able to relate the structure of the flower parts to their function
- The students will see the macroscopic and microscopic structures of a flower using both a compound and stereo microscope

Prerequisite: Prior to this activity, the student should be able to
- Identify parts of a plant and their function within the plant

Materials (individual or per group):
- Stereo and compound microscopes
- Brassica rapa or similar type of flowers
- Forceps
- Scissors
- index cards
- pencil
- tape
- microscope slides
- cover slips
- water
- disposable pipettes
- rubber stopper

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** c. Begin with a brief introduction of terms associated with a flower. d. Have students read through the first part of the lesson and answer introductory questions. e. Ask students to describe the function of each part of the flower. 1. Why are some flowers colorful? 2. Why do some flowers produce scent? 3. What is the purpose of flowers?
During activity:	**What the teacher will do:** d. As students perform the lab activity, allow students to use additional resources to answer the introductory questions, such as the textbook and the Internet. 1. Example: What are the five main parts of a flower? Most flowers have the same basic parts, though they are often arranged in different ways. The five main parts of a flower are the sepals, petals, stamens, pistil, and nectaries. (The sepals are the green leaf like structures at the base of the petals that protect the developing flower. The petals are the colored leaf-like structures within the sepals). 2. What are the functions of the basic parts of a flower? 3. Why are some parts of the flower sticky? e. When students prepare to dissect the flower, make sure to show them how to use the rubber stopper to secure and stabilize the flower.

	f. Make sure students complete their index cards with the required flower parts and their labels.
After activity:	**What the teacher will do:** c. Assess student understanding of flower functions by reviewing its different parts. d. Engage students into a discussion on the importance of pollination and its relation to flower structure and function. Example topics: 1. Evolution of plant adaptations to attract pollinators. 2. How is our food supply impacted by pollination? 3. How do structures of flowers help with pollination and the spreading of seeds?

Extension:

- Activities and flower images at *www.fastplants.org*
- Gizmo: Flower Pollination, Pollination: Flower to Fruit

Student

Exploring Flower Structure
(Adapted from Flower Dissection – http://www.swiftoptical.com/EducationalResources.aspx)

NGSSS:
SC.912.L.14.7 Relate the structure of each of the major plant organs and tissues to physiological processes. (**AA**)

Background: Although the basic principles of sexual reproduction are the same in a plant, an insect, an animal, and a human; observing the structure of flowers is necessary to create a full picture and completely understand the reproductive process of pollination for a flower. Dissecting a variety of flowers and identifying their parts will help visualize and relate the structure of flowers to their function.

Major parts of a flower can be identified in the diagram below:

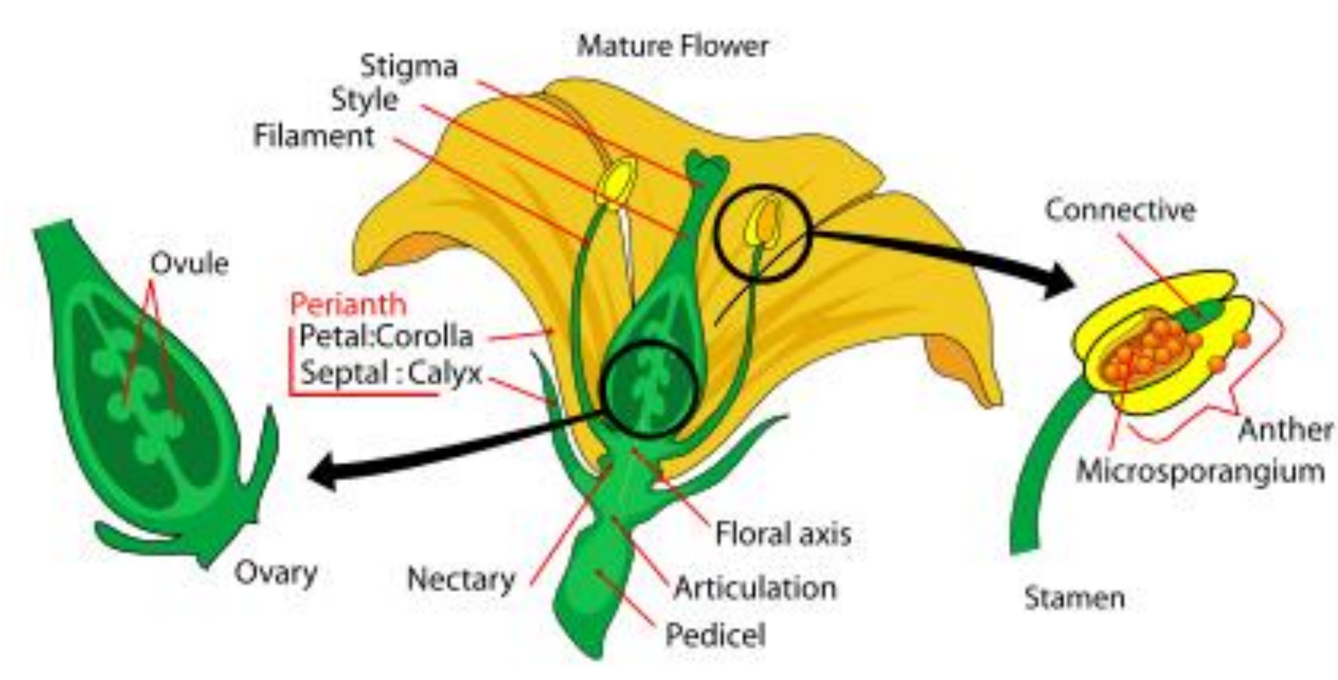


Figure 1 - *Drawing by Mariana Ruiz*

Purpose or Problem Statement:

- To list the parts of a flower
- To relate the structure of the flower parts to their function
- To identify the macro and microscopic structures of a flower using both a dissecting and compound microscope

Safety: Students should take extreme care when handling dissecting equipment such as scissors and forceps

Vocabulary: petals, stamen, pistil, pollen grains, stereo microscope, compound microscope, sepal, nectarines, anther, filament, seed pod, nectar, ovary, ovules, pedicel

Student

Materials (individual or per group):

- Stereo and compound microscopes
- Brassica rapa or similar type of flowers
- Forceps
- Scissors
- index cards (4” x 6” or bigger)
- pencil
- tape
- microscope slides
- cover slips
- water
- disposable pipettes
- rubber stopper

Procedures:

1. Begin with a brief introduction of terms associated with a flower.
2. Read the information provided (including additional information from the textbook, Internet, or other source) and answer the introductory questions
3. Perform a flower dissection:
   a. While dissecting the flower, identify each structure of the flower using the stereo microscope
   b. Place all flower parts onto an index card and label each part.
   c. Save one stamen to examine pollen grains.
4. Using the collected stamen, create a wet mound of pollen grains and observe them under a compound microscope.
5. Clean up: properly store the microscope and lab materials.

Observations/Data:

<u>Introduction</u>

What is a flower? In human eyes it is something to enjoy, with color and fragrance. For many plants, flowers are vital organs of reproduction containing both male and female gametes. For bees and other nectar-feeding animals, flowers are a source of food.

1. What is the purpose of a flower for a plant?
2. Do flowers help any other organisms? How do they help those organisms?
3. Why do you think flowers are brightly colored?
4. What are the five main parts of a flower?
5. What are the two leaf-like structures of a flower called?

The stamen has two parts, the anther and the filament. The anther contains the pollen grains, which contain the male gametes. The pistil usually has three parts, the stigma (which receives the pollen), the style (the neck below the stigma) and the carpel (or ovary).

Brassica flowers have two fused carpels, separated by a thin membrane. The carpels house the ovules, which contain the female gametes. Sugar-rich nectar is secreted by the specialized nectary tissues. These are strategically located in the flower to ensure that nectar-gathering animals will receive pollen from anthers and transmit it to stigmas.

6. What is the male structure of the flower called? What are the two parts of this structure?
7. What is the female structure of the flower called? What are the three parts of this structure?
8. Which part of the flower do you think become the seeds of a plant? (see Figure 1)
9. What part of the flower do you think becomes the seedpod? (see Figure 1)

10. On which part of the flower are pollen grains found?

<u>Flower Dissection</u>

1. Let's start with stabilizing the flower. You all have a black rubber stopper that has an incision in it. If you squeeze the stopper, the incision will widen. When the incision widens, you can place your flower into the slot. Release the stopper, and the flower will remain in place; watch your teacher for further instruction.
2. Before you begin to dissect the flower, look at the flower from above. Do this with your stereo microscope. Adjust your stereo microscope so that you are examining the flower under 10X.
   a. If you look closely between the petals, near the receptacle, you will see the nectaries. They look like droplets of water. **Note**: Feel free to adjust the microscope power to 20X, 30X or 40X for a closer look; the powers you use depend on the options on your stereo microscope. How many nectaries do you see? Number of nectaries: _______
   b. Examine the flower under 10X, 20X, 30X and/or 40X. Look closely at the petals, stamen and pistil. The petals glisten in the light. Why might have plants evolved to have brightly colored flowers?
   c. Examine the pistil under 10X, 20X, 30X and/or 40X. The pistil looks slightly sticky. Why do you suppose this structure is sticky? Is there anything stuck to the pistil?
   d. Look closely at the stamen under 10X, 20X, 30X and/or 40X. Do you see the clumps of yellow fuzz? That is the pollen. We will be looking at the pollen later in this lesson.
3. It is now time for the dissection. Dissection may be easier if it is done under the magnification of your microscope. Start by removing the sepals of the flower.
   a. It may be easiest to do this if you hold the flower with your finger from below the pedicel and begin to remove the sepals with a pair of tweezers.
   b. Place the sepals on the index card, tape them in place, and label them.
4. Repeat the same procedure for the following flower parts in the following order: petals and pistil. See Figure 2

Figure 2

5. You still have stamens remaining on your flower. Remove all but one of the stamens, tape them onto your index card, and label them.
   a. Place the last stamen to the side to be used to observe pollen grains.
6. On your finished index card, you should have sepals, petals, stamens and one pistil. All structures should be labeled.
7. Please put your tape and tweezers back in their proper locations.
8. Write your name on your index card and hand it in to your teacher.

<u>Compound Microscope Applications: Observation of Pollen Grains</u>

1. Obtain your one remaining stamen from your *Brassica rapa* flower.
2. Place the stamen onto your microscope slide and tap the stamen a few times with your tweezers. Pollen grains should fall from the stamen.
3. Remove the stamen, leaving pollen grains behind, add one drop of water, and cover it with a cover slide.
4. Adjust your microscope. Start with the 10X objective. Locate small, yellowish, oval shaped objects. Change your objective to 40X. These small, yellowish, oval shaped objects are the pollen grains of the *Brassica rapa* flower. Draw the pollen grains in the box below. Be sure you label the magnification correctly.
5. Clean up your materials and hand this packet into your teacher or have all your observations and conclusions in your journal.

<u>Digital Microscopy Applications</u>

Create a "virtual index card": Using your Swift Cam and Swift Imaging Software you can capture images during the dissection process. Capture the image that you see when using the 10X objective (label the image with the correct magnification - 100X). Capture the image that you see when using the 40X objective (label the image with the correct magnification - 400X). Be sure to save your images. Create annotated images with each part appropriately labeled. Be sure to include measurements of each structure for each part you identify. Can you think of any other annotations you may do using the software? Hint: You can measure and use the filter options.

Teacher

Investigating the Effect of Light Intensity on Photosynthesis
(Adapted from: State Adopted – Prentice Hall (Laboratory Manual B))

NGSSS:
SC.912.L18.9 Explain the interrelated nature of photosynthesis and cellular respiration. (**AA**)
SC. 912.L.14.7 Relate the structure of each of the major plant organs and tissues to physiological processes. (**AA**)

Purpose of Lab/Activity:
- To observe how light affects photosynthesis.
- To understand how photosynthesis in important to life.
- To understand the consequences of what can happen when plants and trees are destroyed.

Prerequisites: Students should be familiar with the generalized equation for photosynthesis and be able to identify the reactants and products of photosynthesis. They should also be aware of the current debates and discussions about global warming and how the destruction of plants and trees contributes to such a problem.

Materials (per group):
- Test tube
- Source of bright light
- Sodium bicarbonate solution (Baking Soda)
- Watch or clock with second indicator
- 400-mL beaker
- Plastic gloves
- Sprig of evergreen (Example; Florida Slash Pine) or Elodea/*Anacharis* (Fresh Water Aquarium Plant)
- Hand lens
- Forceps

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Prep Work: Prepare a saturated solution of 7 g sodium bicarbonate per 100 mL water. Pour off the solution, leaving any undissolved solid behind. Provide sprigs that are as freshly cut as possible. If possible, cut stems underwater and keep the cut ends in water until use. The time required for this lab is 30 minutes. b. Essential Question/Problem Statement: 1. "How does the destruction of forests affect the rate of photosynthesis?" 2. "How does this change our living environment and what consequences can a low level of photosynthesis cause to our atmosphere?" c. Inform the students to read the entire investigation. Have them work with a partner to answer the pre-lab questions. These questions should be in the student's hand-out. Once the students have completed the pre-lab discussion questions, initiate a class discussion asking different students to share their answers.

Teacher

During activity:	**What the teacher will do:** a. Use the following questions to engage student thinking during the activity: 1. What is the name of the gas inside the bubbles released by the sprig? How do you know? 2. Why are these bubbles produced by the plant? 3. From what part of the plant do you observe the bubbles being emitted? 4. Which light intensity do you think most bubbles will be released? Why? b. Ensure that students are recording their observations in the Data Table.
After activity:	**What the teacher will do:** a. Conduct a whole-class discussion to assess student understanding of the activity. The following questions can be used to engage student thinking and connect the concepts of this activity to the NGSSS. 1. How does the intensity of light affect the rate of photosynthesis? 2. Was your hypothesis correct or not? Explain what occurred. 3. 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? b. Have the students develop a 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:
- Repeat this activity using different colors of light.
- Gizmo: Photosynthesis

Student

Investigating the Effect of Light Intensity on Photosynthesis

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

NGSSS:
SC.912.L18.9 Explain the interrelated nature of photosynthesis and cellular respiration. (**AA**)
SC.912.L.14.7 Relate the structure of each of the major plant organs and tissues to physiological processes. (**AA**)

Background Information:
In order to carry out photosynthesis, a plant must have light. 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.

Purpose of Lab/Activity:
- To observe how light affects photosynthesis.
- To understand how photosynthesis is important to life.
- To understand the consequences when plants and trees are destroyed.

Problem Statement(s):
- Does the intensity of light affect the rate of photosynthesis?
- 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?

Pre-Lab 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.

Safety: Safety goggles required

Vocabulary: photosynthesis, carbon cycle, greenhouse effect, chlorophyll, chloroplast, stroma, thylakoid.

Materials (per group):
- Test tube
- Source of bright light
- Sodium bicarbonate solution (Baking Soda)
- Watch or clock with second indicator
- 400-mL beaker
- Plastic gloves
- Freshly cut sprig of evergreen or Elodea/*Anacharis* (Fresh Water Aquarium Plant)
- Hand lens
- Forceps

Procedures:

Student

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.

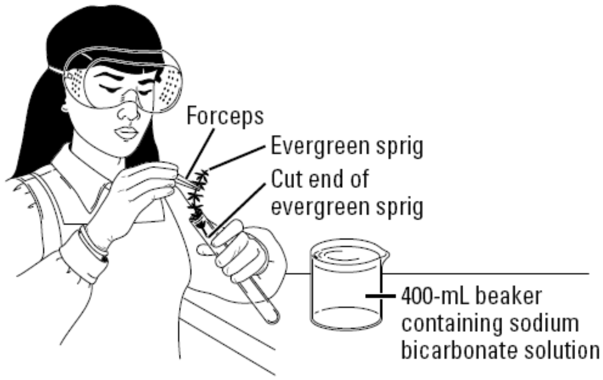


Figure 1

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 (See 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 (See Figure 2).

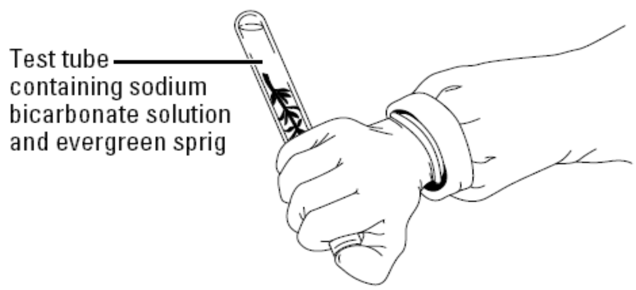


Figure 2

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 3

5. Gently lower the test tube inside the beaker so that the test tube leans against the side of the beaker (See Figure 4 and 5).

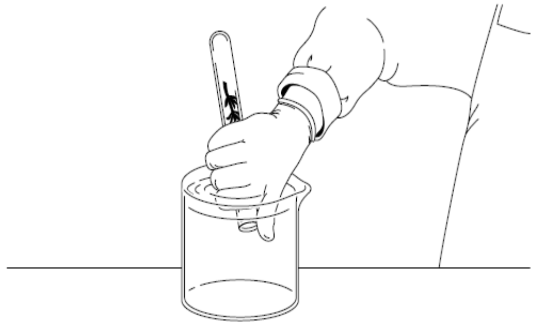


Figure 4

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.

Observations/Data:

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

Data Analysis/Results:
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/Conclusions:
1. How does the intensity of light affect the rate of photosynthesis? Was your hypothesis correct or not? Explain what occurred.
2. How do your results compare with those of your classmates? How are they similar? How are they 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?

Teacher

Cellular Respiration

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

NGSSS:
SC.912.L.18.9 Explain the interrelated nature of photosynthesis and cellular respiration. (**AA**)
SC.912.L.14.7 Relate the structure of the major plant organs and tissues to physiological processes. (**AA**)

Purpose of Lab/Activity:

- To understand how photosynthesis and cellular respiration work hand-in-hand.
- To observe how cellular respiration occurs under aerobic conditions.

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

Materials (per group):

- Distilled water
- Straw
- Heat-resistant gloves
- Hot Plate
- Cotton ball
- Beakers 500-mL (two)
- Test tubes (4)
- Purple cabbage leaves or Bromothymol blue
- Test tube rack
- Slotted spoon (large)
- Stoppers
- Radish seedlings (10)
- Forceps
- Aluminum foil

Procedure: Day of Activity:

<table>
<tr><td>Before activity:</td><td>What the teacher will do:
a. Prep work: Germinate radish seedlings at least one week before lab. Use 1 part Bromothymol blue to 10 parts of water as a substitution of the cabbage indicator.
b. Essential question (or problem statement): “How do organisms release energy from food?”
c. Procedures: Students should read the entire investigation. Then, work with a partner to answer the “engagement” questions. These questions should be in the student’s hand-out.
d. Once the students have completed the questions, initiate a class discussion asking different students to share their answers. Continue the discussion by asking the following questions.
1. What is cellular respiration?
2. How are the processes of photosynthesis and cellular respiration related?
3. What are the reactants and products of cellular respiration?
4. In this investigation, how are we going to find out if plants carry on cellular respiration?</td></tr>
</table>

Student

During activity:	**What the teacher will do:** a. Questions to engage student thinking during activity: 1. What do you think is the reason for the color change when you used a straw to blow into the uncovered test tube? 2. What is the purpose for covering one of the test tubes with aluminum foil? 3. What do you think will happen to the test tube that contains the radish seeds? Why? b. Make sure that students are recording their results in the Data Table.
After activity:	**What the teacher will do:** a. Use the following questions to engage student thinking after the activity and to connect concepts of this activity to the NGSSS. 1. Did the color of the cabbage indicator change when you exhaled into the test tube? Explain why. 2. Did the color of the cabbage indicator change in the test tube that contained the radish seedlings? Explain the reason 3. Compare the reaction that occurred in the test tube that contained the radish seedlings with one that occurred in the test tube into which you exhaled. How are they similar? 4. Did cellular respiration occur in this experiment? Explain. 5. Was your hypothesis correct or incorrect? Explain your answer in detail. 6. Why is the process of cellular respiration common to all forms of life? 7. Why do most living things take in oxygen? 8. Where in the cell does cellular respiration take place? 9. What is the interrelated nature of photosynthesis and cellular respiration? b. The students should complete a formal laboratory report.

Extension:

- Gizmo: Cell Energy Cycle

Cellular Respiration

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

NGSSS:
SC.912.L.18.9 Explain the interrelated nature of photosynthesis and cellular respiration. (**AA**)
SC.912.L.14.7 Relate the structure of the major plant organs and tissues to physiological processes. (**AA**)

Background:
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 cellular respiration.

Problem Statement: How do organisms release energy from food?

Safety: Wear goggles at all times in the science laboratory. To avoid burns, exercise caution when working with the hot plate and heated materials. Be careful not to inhale any of the cabbage indicator.

Vocabulary: aerobic respiration, alcoholic fermentation, anaerobic respiration, cellular respiration, electron transport chain, glycolysis, Krebs Cycle, lactic acid fermentation

Materials (per group):
- Distilled water
- Straw
- Heat-resistant gloves
- Hot Plate
- Cotton ball
- Beakers 500-mL (two)
- Test tubes (4)
- Purple cabbage leaves or Bromothymol blue
- Test tube rack
- Slotted spoon (large)
- Stoppers
- Radish seedlings (10)
- Forceps
- Aluminum foil

Pre-Lab Questions:
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.

Student

Procedures:

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.

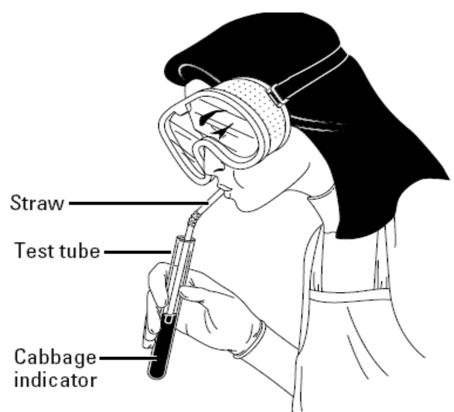


Figure 1

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.

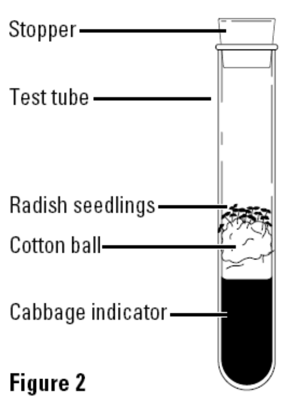


Figure 2

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

Observations/Data:

Test Tube	Description	Color of Cabbage Indicator

Data Analysis:

1. Observing: Did the color of the cabbage indicator (or bromothymol blue) change when you exhaled into the test tube? Explain why.
2. Observing: Did the color of the cabbage indicator (or bromothymol blue) 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/Conclusions:

1. Was your hypothesis correct or incorrect? Explain your answer in detail.
2. Why is the process of cellular respiration common to all forms of life?
3. Why do most living things take in oxygen?
4. Each student will complete a formal lab report following the guidelines on the **Parts of a Lab Report: A Step-by-Step Checklist**

Teacher

Animal-Vertebrate Fish "Perch" Dissection
(Adapted from: Prentice Hall Biology and various internet sites)

NGSSS:
SC.912.L.15.6 Discuss distinguishing characteristics of the domains and kingdoms of living organisms. (**AA**)

Purpose of Lab/Activity: The purpose of the lab is to:
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.

Prerequisites: Prior to this activity, the student should be able to know the names of anatomical structures from the vocabulary of the student section of this laboratory. The student should be familiar with the classification system of organisms.

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

Procedure: Day of Activity:

Before activity:	**What the teacher will do:** a. Acquire necessary materials and have stations ready for each group to survey or enough of each species in order for each group to survey all the species. b. Review the important parts or vocabulary with the students. c. Review safety procedures and guidelines, making sure that goggles, gloves, and aprons are being used. d. Group the students in productive teams. You can assign roles based on guidelines provided by the District. This would assist in classroom management and accountability.
During activity:	**What the teacher will do:** a. Provide guidance and support for questions on how to make initial incisions and dissection cuts. Move about the room and be available.
After activity:	**What the teacher will do:** a. Have a class discussion about the data collected and whether the hypotheses were proven or not. Discuss and review new questions that may have arisen about the evolutionary features of vertebrate fish.

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

Student

Animal-Vertebrate Fish "Perch" Dissection

(Adapted from: Prentice Hall Biology and various internet sites)

NGSSS:
SC.912.L.15.6 Discuss distinguishing characteristics of the domains and kingdoms of living organisms. (**AA**)

Objective/Purpose: The purpose of the lab/activity is to:

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:

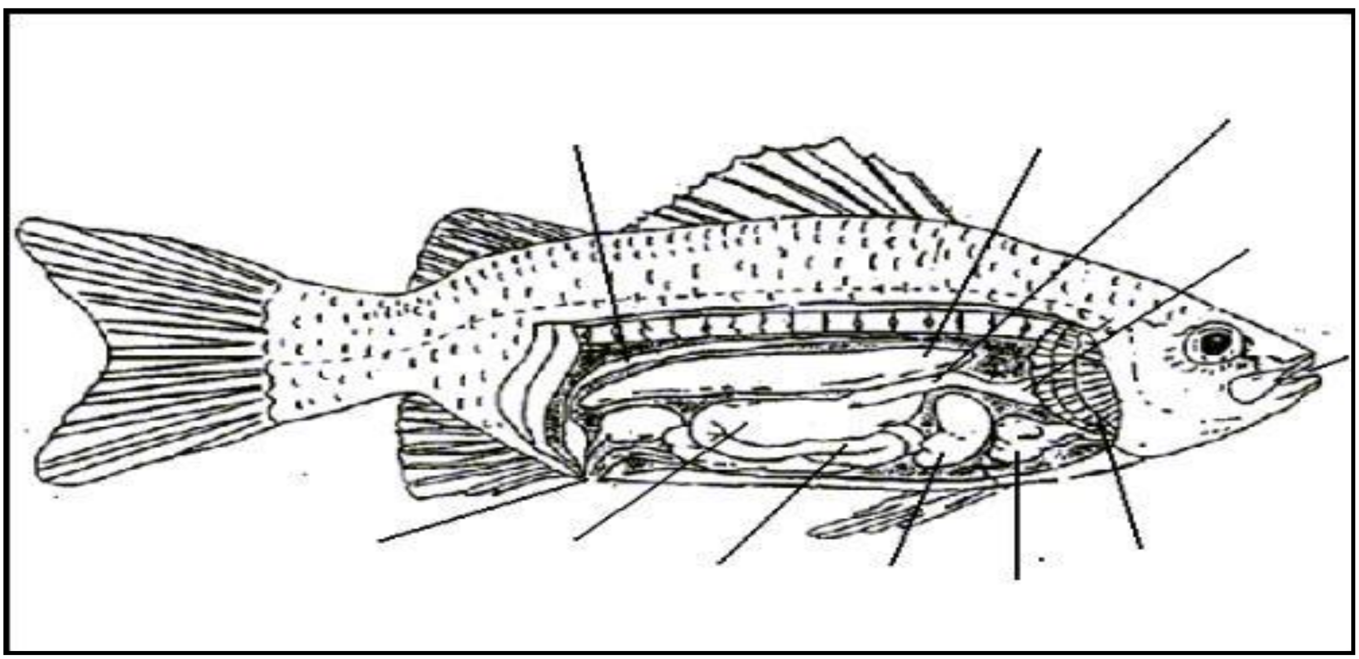
- Preserved perch (fish)
- Dissecting tray
- Dissecting kit
- Dissecting microscope
- Paper towel
- Plastic bags
- Live goldfish
- Beaker
- Water from aquarium
- Fish net
- Stopwatch

Procedures:

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.

Student

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.
11. 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.
12. The fish contains a 2-chambered heart. Locate this organ found just behind and below the gills.
13. 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.
14. Locate the rather large liver located just in front of the stomach.
15. Follow the intestine to the anus.
16. Locate the kidneys, found just below the spinal column. Their main function is to rid the body of nitrogenous waste.
17. The swim bladder is the last remaining organ to be identified. It is located between the kidneys and gonads.
18. Label the perch figure.
19. Draw or record the different internal and external features and organs in your journal or handout.



Student

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?
4. What does the body structure imply about its evolutionary origins?

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.
4. Write a conclusion of your observations following the guidelines on the **Parts of a Lab Report: A Step-by-Step Checklist**.

Teacher

Circulation Lab

(Adapted from: Prentice Hall. Biology Exploring Life)

NGSSS:
SC.912.L.14.36 Describe the factors affecting blood flow through the cardiovascular system. (**AA**)

Purpose of Lab/Activity: The purpose of this activity is to:

1. Describe how the sounds of a heart through a stethoscope relate to the stages of a heartbeat.
2. Observe the relationship between heart rate and exercise.

Prerequisite: Prior to this activity, the student should be able to:

- Label the parts of the heart
- Identify and describe the general flow of blood through the circulatory system

Materials (per station or per group):

- Stethoscope
- Rubbing alcohol
- Cotton balls
- Stopwatch

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. The teacher will have to gather all materials and should trouble shoot the different heart rate monitors to determine if a constant and realistic heart rate reading is observed. b. The teacher will prepare 4 sets of stations, each set focusing on different stimuli: 1. Exercise, and 2. Baroreceptor stimuli. c. Engage students by eliciting prior knowledge and asking questions pertinent for each station: 1. What effect does exercising have on the heart rate? 2. How does the heart rate change as a person stands up starting from a squatting position? (This motion produces a sudden increase in the amount of blood circulation, how does this change affect the heart rate?) d. Review general procedures for using the respiration and heart rate monitors. It is expected that all students be involved and participate during the lab. This means that all students must take turns in running the heart rate monitor or in being the patient who is being monitored. Students need to know what parts of the body are affected by stimulation of the sympathetic nervous versus stimulation from the parasympathetic nervous system. e. As you start the lab, students need to be sure to have consistent and realistic heart rates at the beginning of each experiment. Make sure that students correctly gather and record their data.

Teacher

During activity:	**What the teacher will do:** a. Once the base line reading has been established, the student can be directed to undergo the treatment phase. Treatment consists of performing specific exercise as determined by the procedures. After the exercise phase, the student can be directed to stand quietly next to the lab station to begin the recovery phase. b. As you walk around the room, question students on general concepts and ideas. Examples: 1. What is the resting heart rate? 2. How a person's vital sign can be an indicator about their health? 3. What are realistic base line values for vital signs? 4. What are some vital sign values that indicate if the person is in good physical shape? 5. What are some vital sign values that indicate that the person's vital signs are showing a person in poor health? c. As you walk around the room, question students on station specific concepts and ideas. Examples: <u>Exercise Stimuli:</u> 1. What are some of the reasons that the heart rate changes with increase exercise? 2. Does the level of physical fitness have an effect on how quickly a person's heart rate recovers after exercise? 3. Describe what is changing within the muscles as you exercise. 4. What organs, besides the heart have increased use during exercise? 5. Do you expect to have an upper limit on increasing heart rate as you exercise? Why/why not? <u>Baroreceptor Stimuli:</u> 1. How much and in which direction (increase or decrease) did the heart rate change as a result of standing? Squatting?
After activity:	**What the teacher will do:** Have the students share results with other students and have a class discussion about data, graphs, and conclusions.

Extension:

- Gizmo: Circulation System

Student

Circulation Lab

(Adapted from: Prentice Hall. Biology Exploring Life)

NGSSS:
SC.912.L.14.36 Describe the factors affecting blood flow through the cardiovascular system. (**AA**)

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?"

Safety:

Vocabulary: heart rate, blood, pulse

Materials:
- Stethoscope
- Rubbing alcohol
- Cotton balls
- Stopwatch

Procedures:
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):
1. 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

2. 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

3. 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?

Extension:
Repeat lab activity with people of different age groups.

Teacher

Take a Heart Hike

(Adapted from: PowertoLearn.com; http://www.powertolearn.com/lesson_activities/index.shtml)

NGSSS:
SC.912.L.14.36 Describe the factors affecting blood flow through the cardiovascular system. (**AA**)

Purpose of Lab/Activity: The purpose of this activity is to:

- Students will walk and talk through the heart and pulmonary blood pathways in order to understand how the heart and lungs work together to transport oxygen and carbon dioxide via the blood.

Prerequisite: Prior to this activity, the student should be able to:

- Students should be familiar with each circulatory organ (heart, blood vessels, and blood) and its role in the movement of oxygen and carbon dioxide. A resource that is available to help demonstrate blood flow through the heart can be found at: http://www.sumanasinc.com/webcontent/animations/content/human_heart.html
- Students need to understand how the lungs work and how gases can diffuse into and out of cells.

Materials (per station or per group):

- 3-inch-wide masking tape, blue and red
- Large magic marker to write on tape
- Two small bowls or pans
- 20 quarter-sized red circles and 20 quarter-sized blue circles

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. This activity requires you to construct (on the floor) a two-dimensional diagram of a three-dimensional system. 1. Draw the diagram (Teacher Download, figure 1) with tape on the floor of your classroom. 2. Label the chambers of the heart, the lungs, the body cells, and all blood vessels according to the diagram (see the Cardiovascular Model). 3. Place a bowl of blue circle cut outs in the body cells and a bowl of red circle cut outs in the lungs. b. Engage students by eliciting prior knowledge and asking questions: 1. What are factors that affect the healthy blood flow in a heart? 2. Does the rate at which we breathe affect our heart rate? 3. Which way does blood flow in your body?
During activity:	**What the teacher will do:** a. To begin the activity, position a student (or several) in a standing position at a station along the route taped to the floor. 1. Give a student the appropriate color circle for where they are standing. For example, a student standing in the right atrium of the heart would be holding a blue circle. b. Have students move along the route and describe to the group what they

	are doing at each stop — explaining to the group what route (blood vessel) they must take to reach the next stop. 1. Example: have students exchange red blood cells for blue blood cells at the body cells station and exchange blue blood cells for red blood cells at the lung station. (you may want to have a box holding the different "cells" or use a double sided plate that has red on one side and blue on the other so the students can show oxygenation and deoxygenation) 2. The color change illustrates the diffusion of oxygen into or out of the blood (blood cells carrying oxygen appear red and blood cells carrying carbon dioxide appear blue). 3. Point out that blood vessels carrying blood away from the heart (arteries) usually carry red blood and blood vessels carrying blood towards the heart (veins) usually carry blue blood. The only exceptions to this color-coding are the pulmonary arteries and veins (see the Cardiovascular Model). 4. Point out that the right side of the heart handles blue blood and the left side of the heart handles red blood.
After activity:	**What the teacher will do:** After all students have had a chance to do the activity, assess their knowledge of blood flow structures and patterns with a written exercise (see Assessment Criteria).

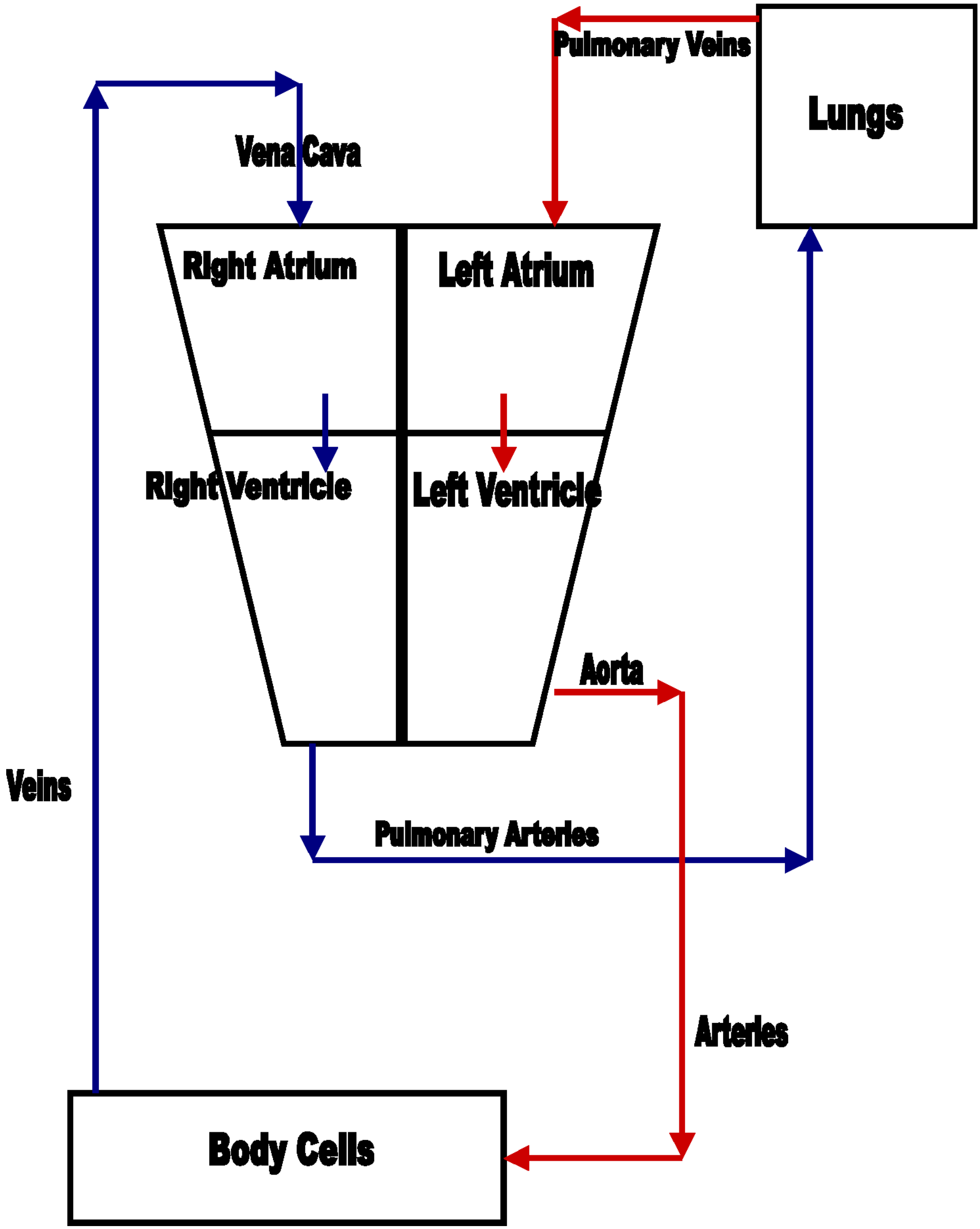
Extension:

- **Brain Pop**: (http://www.brainpop.com); (great general health, science, and technology resource for high school students. Have students pick the movie on the heart for a good (and funny) overview.)

- **<u>This Extension is necessary to fulfill the annually assessed benchmark associated with this unit:</u>**
  Repeat and modify the activity, but assign different groups the following factors affecting blood flow:
  - blood pressure
  - blood volume
  - resistance
  - disease
  - exercise

Teacher

Cardiovascular Model



Student

Take a Heart Hike

(Adapted from: PowertoLearn.com; http://www.powertolearn.com/lesson_activities/index.shtml)

NGSSS:

SC.912.L.14.36 Describe the factors affecting blood flow through the cardiovascular system. (**AA**)

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.

Objectives:

- Students will be able to describe the sequence of blood flow from heart to lungs and back and from heart to body and back.
- Students will be able to label the parts of the cardiovascular system and describe their respective functions.
- Students will be able to describe the different factors that affect heart rate and analyze how to prevent them.

Safety: classroom management

Vocabulary: heart, circulatory system, cardiovascular system, blood, lungs, blood flow, blood vessels, anatomy, physiology

Materials:

- 3-inch-wide masking tape, blue and red
- Large magic marker to write on tape
- Two small bowls or pans
- 20 quarter-sized red circles and 20 quarter-sized blue circles

Procedures:

1. Follow teacher directions.
2. Begin the activity in a standing position at a station along the route taped to the floor.
3. Using the color circle representing the type of blood for your position, walk along your route and describe to the class what is happening at each stop.
4. Explain what route (blood vessel) must be followed to reach the next stop.

Results and Conclusions:

1. Write the steps of blood flow on the board and have students write them down in the proper order after the activity is complete.
2. Give students a list of parts of the cardiovascular system and have them describe the respective functions (or match structures and functions).

Extension:

As a group, repeat and modify the activity using one of the following factors that affect blood flow:

- blood pressure
- blood volume
- resistance
- disease
- exercise

The Deadly Fuchsia Disease

(Adapted from Epidemic – The Deadly Fuchsia Disease – www.vcu.edu/lifesci)

NGSSS:
SC.912.L.14.52 Explain the basic functions of the human immune system, including specific and nonspecific immune response, vaccines, and antibiotics. (**AA**)

Purpose of Lab/Activity: To demonstrate that one infected person in a population can, over a period of time, infect a large number of individuals

Prerequisite: Prior to this activity, the student should be able to:
- define a specific and non-specific immune disease response
- understand the purpose and function of a vaccine

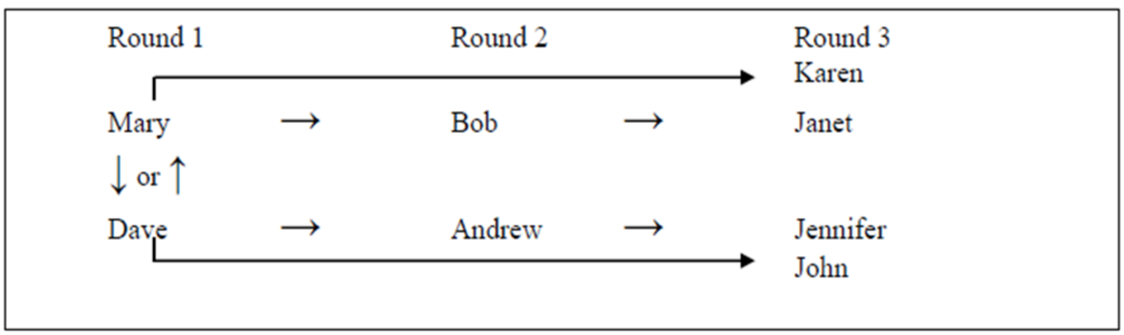
Materials (per station or per group):
- test tube racks
- test tube
- distilled water
- NaOH (0.1 M)
- phenolphthalein

Procedures: Day of Activity:

<table>
<tr><td>Before activity:</td><td>a. Prepare NaOH solution
b. Prepare test tubes with distilled water and select one test tube with NaOH solution (this will be the infected student).
c. Evaluate student prior knowledge by discussing their understanding of an “Epidemic” and how diseases can be transmitted.</td></tr>
<tr><td>During activity:</td><td>a. Monitor the students that they only exchange “fluids” for the amount of times specified in the lab.
b. Ensure that when you put drops of phenolphthalein, that you do not contaminate the pipette.
c. Discuss the reasons for a false positive, if it occurs.</td></tr>
<tr><td>After activity:</td><td>What the teacher will do:
a. Share results with other students and have a class discussion about data, graphs, and conclusions.
<table>
<tr><th></th><th colspan="3">Contacts of Infected People</th></tr>
<tr><th>Infected persons</th><th>Round 1</th><th>Round 2</th><th>Round 3</th></tr>
<tr><td>Bob*</td><td>Beth</td><td>Mary*</td><td>Janet*</td></tr>
<tr><td>Jennifer*</td><td>Wendy</td><td>John*</td><td>Andrew*</td></tr>
<tr><td>Karen*</td><td>Steve</td><td>Tim</td><td>Mary*</td></tr>
<tr><td>Dave*</td><td>Mary*</td><td>Andrew*</td><td>John*</td></tr>
<tr><td>Janet*</td><td>Ralph</td><td>Sheila</td><td>Bob*</td></tr>
<tr><td>John*</td><td>Mike</td><td>Karen*</td><td>Dave*</td></tr>
<tr><td>Andrew*</td><td>Kim</td><td>Dave*</td><td>Jennifer*</td></tr>
<tr><td>Mary</td><td>Dave*</td><td>Bob*</td><td>Karen*</td></tr>
</table>
(*) = Infected person</td></tr>
</table>

b. An asterisk (*) is placed next to each name in the Class Data Table who was found positive for the simulated disease. The Data Table above shows that Bob exchanged with Beth, Mary, and Janet. This shows that in round 1, Bob did not have the disease when he exchanged fluids with Beth (because she tested negative), but received it in Round 2.
c. The Class Data Table is then used to devise a flow chart and to trace the route of transmission. In Round 1, Dave and Mary, have tested positive for the disease. This indicates that these two people were involved in the original exchange.
d. In Round 2, Mary and Dave exchanged “Simulated Bodily Fluids” with Bob and Andrew. The flow chart now shows two rounds of exchanges and a total of four infected people.
e. For Round 3, the names of the individuals that exchanged with Bob, Andrew, Mary, and Dave are filled in. They were janet, Jennifer, Karen, and john, respectively. This completed flow chart shows that in Round 2, four people had the disease, but in Round 3, the number of infected people has doubled to a total of eight people. Thus, the disease has passed from an original exchange of two people, to a total of eight people.

Example Route of Transmission Flow Chart



The chart above shows that in Round 1, Mary and Dave exchanged fluids. Since they are both positive in Round 1, they pass on the disease to Bob and Andrew in Round 2, and to Karen and Jennifer in Round 3. Then Bob and Andrew pass it onto Janet and John, respectively. In an actual epidemic situation, one cannot trace a disease as easily as in this simulation. In an open system, it is almost impossible to trace a disease back to an original carrier. Because the class is a closed system, we can trace back to an original exchange. If you had completed another round of “Simulated Bodily Fluid” exchange, then 16 people would be infected; with each round of transmission the number of infected people doubles.

Extension:

- Gizmo: Disease Spread

Student

The Deadly Fuchsia Disease

(Adapted from Epidemic – The Deadly Fuchsia Disease – www.vcu.edu/lifesci)

NGSSS:
SC.912.L.14.52 Explain the basic functions of the human immune system, including specific and nonspecific immune response, vaccines, and antibiotics. (**AA**)

Background:
A disease can be caused by a virus, or microorganisms such as bacteria, fungi, and parasites. The human body becomes 'sick" when it is unable to fend off a disease-causing organism or a pathogen. A pathogen is an invader such as a virus or bacteria that resists internal defenses and begins to grow and harms the host. Most diseases will eventually be eradicated from the body by the body's immune system. Some diseases are resistant to the immune system and are able to thrive in the body and cause harm including death to the host. Certain viruses, such as "Colds", can be easily detected by symptoms such as a fever or a runny nose, but some viruses do not cause any symptoms till a later date. An example of this is HIV which causes AIDS. An HIV positive person can walk around for years transmitting it to others without knowing he/she has the virus.

In this lab, you will be given an unknown "Simulated Bodily Fluid". This fluid is clear, and can represent the aerosol droplets from a cough or sneeze, the bodily fluids exchanged in the transmission of HIV, or in any other disease. You will simulate the exchange of bodily fluid with three other students. After three exchanges have taken place, you will then test your sample for the disease. Once the testing is complete, you will find out which student's samples, in your entire class, turn out to be positive. Using this information you will then trace the route of transmission by using a flow chart to find the original carrier.

Purpose or Problem Statement:
To demonstrate that one infected person in a population can, over a period of time, infect a large number of individuals

Safety:
- Wear safety goggles
- NaOH is a skin irritant. In case of skin contact flush with large amounts of water. In case of ingestion do not induce vomiting and give large amounts of water followed by fruit juice.

Vocabulary:
Disease, endemic, epidemic, immunization, infection, quarantine, vaccine

Materials:
- test tube racks
- test tube
- distilled water
- NaOH (0.1 M)
- phenolphthalein

Student

Procedures:

Before testing

1. You need to obtain your body fluids. In order to do this, I will come around and give you one test tube filled with distilled water. This will represent your bodily fluids. However, ONE of you will be give a test tube that contains a few drop of Sodium Hydroxide. This represents the virus and so you will already be infected with the disease and have the potential to infect those people you swap bodily fluids with. **You will not know if you already have the disease or not!**
2. Next, you will need to swap bodily fluids with **three** people in your community.
   a. Choose a partner (male or female does not matter)
   b. One of you needs to pour your liquid into the other's test tube.
   c. Now your fluids have mixed.
   d. Pour half of the liquid back into the empty cup. You should both now have an equal amount of bodily fluids.
   e. Record your partner's name in the data table below.
   f. You need to do this **THREE** times **ONLY**!

Student Data:

Trial #	Name of Partner
1	
2	
3	

Make a Hypothesis:

1. (Problem Statement)How many people do you think will become infected by the end of the lab? ___________
   (Remember only one person will be infected with the virus in the beginning)
   Or
   Create your own problem statement (research question) and hypothesis. Example: Does disease transmission depend on human patterns?
   ____
   ____

Time to Get Tested:

2. Now that you have swapped bodily fluids with others, you are at-risk for an infection. You have now decided to go to the doctor.
3. One at a time, make a doctor's visit. I can be found in my white lab coat in the area labeled "Doctor Aycart"
4. I will place a few drops of phenolphthalein indicator into your cup. If pink, you tested positive (+) for the virus. You must then report to Quarantine area in the back of the classroom. If clear, you tested negative (-) for the virus. You may return to your seat. Write your test results below:
   Test results: ______________
5. Now, record your name and results on the class data sheet.

Student

Class Results:

6. Fill in the names of infected people in your class as well as their contacts. Place an asterisk (*) next to each name who is found to be positive for the disease.

Class Data Table:

Contacts of Infected Persons			
Infected Persons	**Round 1**	**Round 2**	**Round 3**

Route of Transmission Flow Chart:

Round 1	Round 2	Round 3

Original Carrier:

7. Looking at the class data, who was originally infected with the virus?
8. Was there a pattern in the pathway that the virus was transmitted?

NOTE: Because your class is a closed system, you can only trace the disease back to an original exchange (Round 1), but cannot determine which one of the two individuals involved in the original exchange had the disease. The only way that this can be accomplished is to test the two individuals involved in the original exchange, prior to beginning the exchange.

Analysis/Conclusion:

1. How is disease caused?
2. In the end, how many people were infected with the virus?
3. What percentage of the population does this represent?
4. Were you surprised by the number of people who acquired the disease? Explain your answer.
5. Why would it be important to find out where/who the virus came from?
6. What preventative measures could have been taken to avoid exposure to the virus?
7. Draw a bar chart that represents the percentage of people that were exposed/unexposed in the beginning and by the end of the lab (so you should have three bars total). Label your axes.

Teacher

Cell Model Project

NGSSS:
SC.912.L.14.3 Compare and contrast the general structures of plant and animal cells. Compare and contrast the general structures of prokaryotic and eukaryotic cells. (**AA**)

Purpose of the Lab/Activity:
- Construct a model of an animal or plant cell.
- Compare and contrast the general structures of plants and animals cells.
- Relate the structure to function for the components of plants and animal cells.

Prerequisites:
- An understanding of the cellular roles of biomolecules, including carbohydrates, lipids, proteins, and nucleic acids.

Materials (per group):
- open space

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Activate student's prior knowledge: 1. What are some of the structures inside a cell that help it to live and perform its role in an organism? Answers will vary. Students may be aware of the nucleus and plasma membrane. 2. How do you think plant cells differ from animal cells? (Hint: What can plants do that animals cannot?) Answers will vary. Students may note that plants can produce energy from sunlight, so they must need some kind of structure for doing this. b. Prior to this activity, Students' misconceptions should be addressed. Some common misconceptions are: 1. Cells are the same in all living things.
During activity:	**What the teacher will do:** a. It is suggested that the cell model project be completed as a home learning activity, however if completed during class period have students review the cell to city analogy. Website: http://biology.unm.edu/ccouncil/Biology_124/Summaries/Cell.html b. Creating an analogy of a cell to a city can help students understand the basic functions of the organelles. You may use the analogy provided or come up with your own. In many ways, cells can be compared to the structures and institutions that keep a city running. c. As students are working or just after they are done, discuss the following questions: 1. Which organelle functions like a city government? nucleus 2. Which organelle can be compared to the post office? golgi apparatus 3. Which organelle is the power plant for the cell? mitochondria 4. Which organelles are like factories? ribosomes 5. Which organelle is like a solar panel? chloroplast

<table>
<tr><td></td><td>6. Which organelle is like a road system? endoplasmic reticulum</td></tr>
<tr><td>After activity:</td><td>
What the teacher will do:
a. Have the student groups present their cell models and explain how they created their model. Randomly ask individual students to identify 5 parts and explain their function.
b. Answer Key for Results/Conclusion:
1. Complete the following chart:
<table>
<tr><th>ORGANELLE</th><th>LOCATION</th><th>DESCRIPTION</th><th>FUNCTION</th></tr>
<tr><td>cell wall</td><td>plant, not animal</td><td>*outer layer
*rigid, strong, stiff
*made of cellulose</td><td>*support (grow tall)
*protection
*allows H2O, O2, CO2 to pass into and out of cell</td></tr>
<tr><td>cell membrane</td><td>both plant/animal</td><td>*plant - inside cell wall
*animal - outer layer; cholesterol
*selectively permeable</td><td>*support
*protection
*controls movement of materials in/out of cell
*barrier between cell and its environment
*maintains homeostasis</td></tr>
<tr><td>nucleus</td><td>both plant/animal</td><td>*large, oval</td><td>*controls cell activities</td></tr>
<tr><td>nuclear membrane</td><td>both plant/animal</td><td>*surrounds nucleus
*selectively permeable</td><td>*Controls movement of materials in/out of nucleus</td></tr>
<tr><td>cytoplasm</td><td>both plant/animal</td><td>*clear, thick, jellylike material and organelles found inside cell membrane</td><td>*supports /protects cell organelles</td></tr>
<tr><td>endoplasmic reticulum (E.R.)</td><td>both plant/animal</td><td>*network of tubes or membranes</td><td>*carries materials through cell</td></tr>
<tr><td>ribosome</td><td>both plant/animal</td><td>*small bodies free or attached to E.R.</td><td>*produces proteins</td></tr>
<tr><td>mitochondrion</td><td>both plant/animal</td><td>*bean-shaped with inner membranes</td><td>*breaks down sugar molecules into energy</td></tr>
<tr><td>vacuole</td><td>plant - few/large
animal - small</td><td>*fluid-filled sacs</td><td>*store food, water, waste (plants need to store large amounts of food)</td></tr>
<tr><td>lysosome</td><td>plant – uncommon
animal - common</td><td>*small, round, with a membrane</td><td>*breaks down larger food molecules into smaller molecules
*digests old cell parts</td></tr>
<tr><td>chloroplast</td><td>plant, not animal</td><td>*green, oval usually containing chlorophyll (green pigment)</td><td>*uses energy from sun to make food for the plant (photosynthesis)</td></tr>
</table>
2. Complete a Venn Diagram to compare plant and animal cells. Use table above to check student's diagram.
3. Identify two similarities and two differences between plant and animal cells. Similar: nucleus, plasma membrane, mitochondria Different: plant cells have cell walls and chloroplasts; animal cells have neither
</td></tr>
</table>

Teacher

Extension:

- Gizmo: Cell Structure
- The Biology Place Lab Bench: Cell Structure and Function
- Cells Alive! Website: http://www.cellsalive.com/cells/3dcell.htm

Student

Cell Model Project

NGSSS:
SC.912.L.14.3 Compare and contrast the general structures of plant and animal cells. Compare and contrast the general structures of prokaryotic and eukaryotic cells. (**AA**)

Background: (Source: www.explorelearning.com)
All living cells can be divided into two general groups, the *prokaryotes* and *eukaryotes*. All bacteria are prokaryotes, while all other organisms (protists, fungi, plants and animals) are eukaryotes. Prokaryote cells are more simple and primitive than eukaryote cells. Prokaryotes have no nucleus, lack most organelles (they do have ribosomes), and lack internal membranes. Eukaryotes, by contrast, have a nucleus and a variety of membrane-bound organelles.

Many of the differences between plants and animals are explained by differences between plant cells and animal cells. Plant cells have three structures that animal cells lack: a cell wall, chloroplasts, and a large vacuole. Chloroplasts allow the plant to produce its own food from sunlight, carbon dioxide, and water. The cell wall provides support and structure to the plant cell, but does not facilitate mobility. The vacuole stores water for the plant and also helps support the cell.

Because they cannot produce their own food, animals must consume other organisms for energy. Animal cells are descended from mobile protists that used flagella, cilia, or pseudopods to move around and hunt for food. Some of these protists could engulf other organisms by surrounding them with their cell membrane. (Our white blood cells use this method to engulf harmful bacteria.) The only organelle that is unique to animal cells is the lysosome, a sac of digestive chemicals that animals use to break down food. Animal cells generally have greater energy requirements than plant cells, and usually contain more mitochondria than plant cells.

Problem Statement: Do plant and animal cells have the same structures?

Vocabulary: Cell membranes, cell wall, rough endoplasmic reticulum, smooth endoplasmic reticulum, chloroplast, nucleus, nucleolus, lysosome, vacuole, centriole, cytoplasm, mitochondria, ribosomes, Golgi apparatus.

Materials (per group):
- You will be providing your own materials, use recyclable household items.

Requirements:
- Your cell must be 3-dimensional, as was shown in class. This means it needs to have a front, back, and sides. It cannot be a piece of paper with things glued on it. Your plant cell must be rectangular and/or your animal cell must be circular.
- Materials used should be recyclable household items that are not edible. Be unique and creative.
- All parts of your cell must be labeled clearly in order to receive credit; I suggest using toothpicks and pieces of paper to make little flags, as was shown in class.
- Your representations of the organelles must be similar to the ones seen in class: for example, your nucleus can not be square. Review the chapter on cells in your textbook, and also diagrams for plant and animals cells that we have gone over in class.

Student

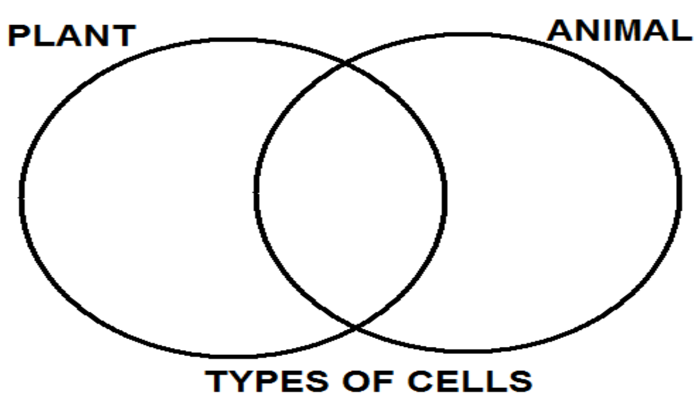
- You must be able to locate parts on your model and explain their functions. You will be asked to identify 5 parts (at random) and explain their function.
- You will use the attached rubric to see which organelles need to be present, accurate, and labeled. You will turn your copy of the rubric when you turn in your 3-D model.

Results/Conclusion:

1. Complete the following chart.

Organelle	Location (plant and/or animal)	Description	Function
cell wall			
cell membrane			
nucleus			
nuclear membrane			
cytoplasm			
endoplasmic reticulum (E.R.)			
ribosome			
mitochondrion			
vacuole			
lysosome			
chloroplast			

2. Complete a Venn diagram in your journal to compare plant and animal cells.



3. Identify two similarities and two differences between plant and animal cells.

Student

Name: ____ Group: _________________

3-D Plant Cell Model Project Rubric

Grading:
You will initially start with a 100 for your project grade. You will lose points for the following items:

- Missing an organelle (deduct 4 points for each organelle)
- Missing a label on an organelle (deduct 4 points for each label)
- Organelle is mislabeled (deduct 4 points for each mistake)
- No name on project (deduct 4 points)
- Plant cell is not square (deduct 20 points)
- Project is sloppy (deduct up to 8 points)
- Project is late (deducted: 10 points per day: after 5 days project grade is a 0)
- Project is not three-dimensional (deduct 30 points)

Remember: Your project grade is worth 100 points total. It is intended to help you better understand the cell and improve your grade. Please take this seriously and turn it in on time.

Organelle	Present	Label	Total
Cell Wall			
Cell Membrane			
Cytoplasm			
Nucleus			
Nucleolus			
Smooth ER			
Rough ER			
Ribosomes			
Golgi Complex			
Vacuoles			
Mitochondria			
Chloroplasts			

General Project Guidelines	Total
No name on project	
Plant cell is not square	
Sloppiness	
Not 3-dimensional	
Late: Date turned in: ___________ # of days late:______________	

Final Grade: __________/100__

Comments:

Student

Name: ____ Group: _________________

3-D Animal Cell Model Project Rubric

Grading:
You will initially start with a 100 for your project grade. You will lose points for the following items:

- Missing an organelle (deduct 4 points for each organelle)
- Missing a label on an organelle (deduct 4 points for each label)
- Organelle is mislabeled (deduct 4 points for each mistake)
- No name on project (deduct 4 points)
- Animal cell is not circular (deduct 20 points)
- Project is sloppy (deduct up to 8 points)
- Project is late (deducted: 10 points per day: after 5 days project grade is a 0)
- Project is not three-dimensional (deduct 30 points)

Remember: Your project grade is worth 100 points total. It is intended to help you better understand the cell and improve your grade. Please take this seriously and turn it in on time.

Organelle	Present	Label	Total
Cell Membrane			
Cytoplasm			
Nucleus			
Nucleolus			
Smooth ER			
Rough ER			
Ribosomes			
Golgi complex			
Vacuoles			
Mitochondria			
Lysosomes			

General Project Guidelines	Total
No name on project	
Animal cell is not circular	
Sloppiness	
Not 3-dimensional	
Late: Date turned in: ___________ # of days late:______________	

Final Grade: ___________/100__

Comments:

Teacher

Diffusion and Osmosis

NGSSS:
SC.912.L.14.3 Compare and contrast the general structures of plant and animal cells. Compare and contrast the general structures of prokaryotic and eukaryotic cells. (**AA**)

Purpose of the Lab/Activity:
- Address the movement of material through a semi-permeable membrane.
- To observe the process of osmosis and how it occurs in cells.
- Examine and describe the different environmental conditions that can affect a cell and its processes.

Prerequisites:
- The movement of ions and molecules across membranes is discussed.
- Iodine indicator is used to test for the presence of starch. It turns blue-black when starch is present.
- Basic understanding of the structure and function of cells.

Materials (per group):
- open space

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Activate student's prior knowledge by the following demonstration. b. Drop several drops of food coloring into a glass beaker of water. Ask students to observe what happens over the next couple of minutes and have them note changes to water and food coloring in their journals. Have students predict what will happen after 5, 10 and 20 minutes. Introduce the concept of "diffusion". c. Define and tell students that we will be exploring how diffusion occurs in different d. For activity #2, it is suggested that the teacher prepare the potato core samples using a cork borer prior to the activity. e. Ask the following questions: 1. Describe the function of the cell membrane. 2. Discuss how cell membranes are like a filter or gatekeeper. 3. Why is such a function necessary for a cell to function? 4. Define "selectively permeable." Hint: dissect the word parts and then explain its meaning)
During activity:	**What the teacher will do:** a. Monitor students to make sure they are remaining on task and are following proper lab protocol. b. Review the experimental design diagram by asking individual students in groups to explain the different parts of the experiment. 1. Follow laboratory procedural plan; making sure to model proper laboratory safety and use of equipment. 2. Emphasize importance of data collection by groups.

	3. Fill a test tube with Iodine in order for student's to see it's original color. Iodine acts as an indicator. Chemical indicators change color when the substance you are testing for is present. Iodine (starch indicator) turns blue-black when starch is mixed with iodine and remains amber (orange-brown) when starch is not present.
After activity:	**What the teacher will do:** a. Have each group share their observations. b. Lead discussion that focuses on questions in the investigations. c. Record each group's data for each investigation on the board or transparency, discussing each set of results as you record them. d. Identify the meaning of diffusion, permeable, semi-permeable, and impermeable as they apply to cell membranes. e. Identify impermeable as a membrane that will not allow any diffusion across a membrane. f. Show a visualization such as the following and discuss why materials have to pass into and out of the cell: 1. *Diffusion animation*: http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter2/animation__how_diffusion_works.html 2. *Osmosis animation*: http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter2/animation__how_osmosis_works.html g. Answer Key for Results/Conclusion: Activity 1: Diffusion of Starch 1. Sketch the experiment, use arrows to show the way the diffusion was occurring. Answers will vary. Students should illustrate that the starch inside the Ziploc bag is moving through the semi-permeable membrane (bag) 2. Observing the diffusion process in real cells is difficult because they are too small to be seen easily. In this activity you created a giant model of a cell so that you can observe the effects of diffusion through a membrane. In your cell model describe the role of each of the following parts: a. Ziploc bag: cell's membrane b. contents of the bag: cell's cytoplasm c. area outside the bag: cell's environment Activity 2: Potato Osmosis 1. In this experiment, why was it important that the potato cores were the same length? In order for this to be a controlled experiment the core samples must be the same size. If not, any change in the core sample after placing them in the different solutions could be attributed to the different size not the concentration of salt. 2. Why was it important to cover each beaker with a piece of aluminum foil? To minimize the rate of evaporation. 3. Into which of the potato cores did water flow? From which of the potato cores did water flow? How can you tell? Surrounding the potato cell with a HYPOTONIC solution, such as 100% water, will result in the net movement of water INTO the potato cells.

	They will gorge up. Surrounding the potato cell with a HYPERTONIC solution, such as 80% water, 20% sucrose, will result in the net movement of water OUT of the potato cells. They will shrivel. Surrounding the cell with an ISOTONIC solution, will result in no net movement of water. They will stay the same. 4. Which solutions (if any) were hypertonic, isotonic, or hypotonic? Explain how you know. The data from the experiment will assist the students with identifying the tonicity of the solutions.

Extension:

- Gizmo: Osmosis, Diffusion

Student

Diffusion and Osmosis

NGSSS:
SC.912.L.14.3 Compare and contrast the general structures of plant and animal cells. Compare and contrast the general structures of prokaryotic and eukaryotic cells. (**AA**)

Background: (Source: www.explorelearning.com)
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.

Problem Statement(s): What is the movement of material through a semi-permeable membrane? (Activity 1) What is the osmotic effect of varying sodium chloride (NaCl) solutions on the physical characteristics of a potato core? (Activity 2)

Vocabulary: cell, cell membrane, permeable, diffusion, semi-permeable membrane, osmosis, hypertonic, hypotonic, isotonic

Materials (per group):

Activity 1

- Ziploc bag
- liquid starch
- forceps
- beaker (500 ml)
- water
- Iodine (Lugol's solution)

Activity 2

- razor
- potato
- ruler
- balance
- graduated cylinder
- distilled water
- sucrose solution
- dissecting needle
- beaker
- aluminum foil

Student

Procedures:

Activity 1: Diffusion through a semi-permeable membrane.

1. Get a small plastic zip-top bag, a cup of liquid starch, a forceps and a large container of water to which a few drops of iodine solution has been added. Be careful with container and do not get the iodine solution on your skin. It will stain.
2. Place liquid starch in plastic bag and securely zip the top closed. Record observations of the color of the starch and the water in the container.
3. Place bag with starch into the iodine/water solution. Let it sit while you go on to Activity 2.
4. Observe and record the changes over time to both the iodine/water solution and the starch in the bag. You will need to carefully lift the bag part way out of the water with a forceps to observe. Then lower the bag back into the water and return the container as directed by the teacher.

Activity 2: Potato Osmosis

1. Using the razor carefully cut each potato core into a cylinder of about three to five centimeters in length. Make sure that all of the potato cores are the same length and note this length for later use. Also measure and record the diameter of each potato core.
2. Using the balance, measure and record the mass of each potato core.
3. Fill the graduated cylinder with tap water two-thirds of the way up. Measure and record the volume of water in the graduated cylinder. Attach each potato core, one at a time, to the end of the dissecting needle and hold it so that the potato core is completely submerged in the water. Measure and record the water level in the cylinder. The difference in your two measurements is the volume of the potato core.
4. Place one potato core in the beaker with distilled water and label this beaker "100". Place the second core in the beaker of 90% water/10% sucrose and label the beaker "90/10". Place the third core in the beaker with 80% water/20% sucrose and label this beaker "80/20".
5. Cover the top of each beaker with a piece of aluminum foil. Fold the aluminum foil down along the sides of the beaker so that it cannot fall off easily.
6. Allow the beakers to sit for a day.
7. Remove the cores from each beaker using the dissecting needle and gently blot them. Measure and record the length, diameter, mass, and volume of each potato core as you did earlier.
8. Dispose of the cores in the trash, not the sink.

Observations/Data:

Table 1 - Diffusion of Starch

	Initial Observations	**Final Observations**
Ziploc Bag with Starch		
Iodine/Water Solution		

Student

Table 2 - Physical Changes in Potato Cores

	100% water			**90% water 10% sucrose**			**80% water 20% sucrose**		
	Day 1	Day 2	Change	Day 1	Day 2	Change	Day 1	Day 2	Change
Length (mm)									
Diameter (mm)									
Mass (g)									
Volume (ml)									

Record any qualitative changes (in color, texture, etc.) you noticed in the potato cores.

Observations/Data Analysis:

Activity 2: Potato Osmosis

1. Calculate the "Change" by subtracting "Day 1" from "Day
2. Calculate the "% Change" by dividing the "Change" by "Day 1" (NOTE: Keep any calculations which are negative do not use the absolute value).
3. Graph the % change in mass on one graph and the % change in the volume on a separate graph.
4. Correctly label the Y (vertical) axis and the X (horizontal) axis of each graph.

Activity 1: Diffusion of Starch

1. Sketch the experiment, use arrows to show the way the diffusion was occurring.

Student

Results/Conclusion:

Activity 1: Diffusion of Starch

Observing the diffusion process in real cells is difficult because they are too small to be seen easily. In this activity you created a giant model of a cell so that you can observe the effects of diffusion through a membrane. In your cell model describe the role of each of the following parts:

a. Ziploc bag:
b. contents of the bag:
c. area outside the bag:

Activity 2: Potato Osmosis

1. In this experiment, why was it important that the potato cores were the same length?
2. Why was it important to cover each beaker with a piece of aluminum foil?
3. Into which of the potato cores did water flow? From which of the potato cores did water flow? How can you tell?
4. Which solutions (if any) were hypertonic, isotonic, or hypotonic? Explain how you know.

Investigating Inherited Traits

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

NGSSS:

SC.912.L.16.1 Use Mendel's laws of segregation and independent assortment to analyze patterns of inheritance. (**AA**)

Purpose of Lab/Activity:

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

Prerequisites:

- Students should understand the concepts of Punnett squares, probability, genotype, dominant traits, recessive traits, alleles, genes, and phenotype.
- Review Mendels's laws of segregation and independent assortment.
- Students should understand how these processes occur in the cell during the process of Meiosis.
- Students should also be familiar with the following modes of inheritance: dominant, recessive, co-dominant, sex-linked, polygenic, and multiple alleles.

Materials (per pair):

- 3 textbooks
- 2 coins

Procedure: Day of Activity:

Before activity:	**What the teacher will do:** a. Prep work: To reduce the noise produced by the flipping of coins, use plastic disks used for bingo or tiddlywinks (available at toy or hobby shops). 1. 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). 2. 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 mass. (Optional) b. Essential question (or problem statement): "If you have both parent phenotypes for a trait, then can you accurately predict the phenotype of an offspring?" 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. c. Some common misconceptions associated with inherited traits and how they can be resolved are provided below: 1. Students incorrectly believe that if no one else in the family is affected, the condition is not inherited. Students often believe that if they do not see a characteristic such as in their family, then it must not be inherited. For example, if a student had a hitchhikers thumb, but their parents and possibly grandparents did not, then the student may believe something happened to their thumb to make it bend back. This is especially

	common with genetic disorders, like colorblindness, which often skip generations. Drawing Punnett Squares and pedigrees can help students visualize that some traits or genetic disorders tend to skip generations. 2. Students inaccurately believe that traits are inherited from only one of their parents. Some students believe girls inherit most of their characteristics from their mothers and boys inherit most of their characteristics from their fathers. Some students may also believe their mothers give them more genetic material because they were carried in their mothers as fetuses. Students may tend to believe they look more like one parent and therefore they received most of their genetic material from that parent. In reality, each parent contributes half of their genetic material to their offspring. One parent may pass more dominant traits to their offspring, which would result in that offspring looking more like that parent. This misconception can be overcome by discussing the processes of meiosis and fertilization. 3. Students have difficulty with the relationship between genetics, DNA, genes, and chromosomes. Students may realize that physical appearances are inherited, but they may not make the connection that these characteristics have underlying biochemical processes, such as Meiosis. They do not understand the position of the traits on the structure of a chromosome. This misconception can be overcome through review and use of chromosomes in the discussion of Punnett squares. Students need to understand that calculating probability in a Punnett square is truly calculating the probability of which chromosome will be present in a sex cell. 4. Students have difficulty distinguishing the difference between acquired and inherited characteristics. While many of our characteristics come directly from our genetics, that is not the case for all of our characteristics. Genetics plays a role in some behaviors and diseases, but the majority of these are the result of one's environment. Talent is something that can be inherited, but skills must be practiced in order for talent to develop. This misconception can be overcome by looking at several examples of inherited characteristics and several examples of acquired characteristics. 5. Students inaccurately believe that one gene controls one trait and all genetics show Mendelian patterns of inheritance. When teaching genetics, it is important to emphasize that there are non-Mendelian patterns of inheritance. Most traits in humans are not monogenic (controlled by one gene). Monogenic traits are the first examples that we teach, so students assume that all traits are governed by one gene. Examples should be given for other patterns of inheritance, such as polygenic inheritance or linked genes, which will not show Mendelian patterns. d. Have students read through the laboratory procedures. e. Make sure that they know what to look for in each phenotype. You may want to point out each phenotype (particularly the earlobes and the widow's peak) to the class and answer any questions students may have about their identification.

	f. Explain to the students that the actual combination of some genes is more complicated than is indicated here. Some traits shown in Figure 1 actually result from multiple genes. In order to simplify the investigation, assume that all of the traits used are the result of a single allele pair.
During activity:	**What the teacher will do:** a. Circulate throughout the room to make sure that students are properly identifying each phenotype. 1. Emphasize to students that no phenotype listed is more or less desirable than another. 2. Discourage any kind of comparisons or observations that might make a student feel self-conscious about a particular trait, such as the shape of his or her earlobes or the amount of freckles he or she has. b. Use the following questions to engage student thinking during the activity. 1. What does a single side of the coin or disk represent? Each side represents one of two possible alleles. 2. What are the chances that any coin or disk tossed will land heads up? The chance of a coin or disk landing heads up is ½, or one out of two. 3. How is a coin toss like the selection of a particular allele? They are alike because the results of both occur only by chance. 4. For the traits in this investigation, do all heterozygous pairs of alleles produce an intermediate phenotype? No, some phenotypes are the result of either homozygous combination of alleles. 5. Can you accurately determine a person's genotype by observing his or her phenotype? Explain. No, some phenotypes are the result of either homozygous or heterozygous combinations of alleles. c. Have the students repeat this investigation with their partner to "produce" a second offspring. Afterwards, they can make a drawing of their offspring. What similarities exist between your first and second offspring? What are the differences? Would you expect a third offspring to resemble either the first or the second offspring? Explain your reason.
After activity:	**What the teacher will do:** a. 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. b. The following questions may be used to engage student thinking after the activity and to connect the concepts of this activity to the NGSSS. 1. What percent chance did you and your partner have of "producing" a male offspring? There is a 50% chance of producing either a male or a female offspring because there is a 50% chance that the coins will land with the same side up. 2. Would you expect the other pairs of students in your class to have an off spring completely similar to yours? Explain your answer? No. Because there are so many traits being modeled, and chance plays an important role in this investigation, it would be highly unlikely to have two completely similar offspring. 3. What are the possible genotypes of the parents of a child who has wavy hair (Hh)? HH and Hh; Hh and Hh; Hh and hh. 4. Which traits in this investigation showed incomplete dominance? Size of mouth, nose, ears, and eyes; shape of lips; texture of hair; spacing of

	eyes. 5. Do you think that anyone in the class has all the same genetic traits that you have? Explain your answer. No. With the exception of identical twins, each person has a unique combination of many genetic traits passed on by parents. 6. How might it be possible for you to show a trait when none of your relatives shows it? Relatives might be heterozygous; one or more masked recessive genes could be passed to you. As a homozygous recessive for that trait, you would display the recessive trait.

Extension:

- Gizmo: Mouse Genetics (1 trait), Mouse Genetics (2 traits)

Investigating Inherited Traits

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

NGSSS:
SC.912.L.16.1 Use Mendel's laws of segregation and independent assortment to analyze patterns of inheritance. (**AA**)

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

Vocabulary: allele, dominant, genotype, heterozygous (hybrid), homozygous (pure), intermediate inheritance, phenotype, recessive

Materials (per group):
- 3 textbooks
- 2 pennies

Procedures:
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 “Data Analysis” page.
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.
8. Note: *Some information in Figure 1 has been simplified. Some listed traits are actually produced by two or more genes.*
9. Using the recorded traits, draw the facial features for your offspring in the space provided on the “Data Analysis” page.

Student

Observations/Data:

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*

Student

Data Analysis:

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/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?

Teacher

Differences in Similar Phenotypes

NGSSS:
SC.912.L.16.1 Use Mendel's Laws of Segregation and Independent Assortment to analyze patterns of inheritance. (**AA**)

Purpose of Lab/Activity:
- To observe differences in phenotypes for a particular trait among individuals in a population.
- To determine the reason for the differences in phenotypes for a particular trait among individuals in a population.

Prerequisites:
Before conducting this activity, the teacher should have covered Mendel's Laws of Inheritance. Students should know the meanings of terms such as alleles, dominant, recessive, phenotype, genotype, homozygous, and heterozygous. They should also be familiar with inheritance patterns caused by various modes of inheritance, including dominant, recessive, co-dominant, sex-linked, polygenic, and multiple alleles.

Materials (per group):
- Metric ruler
- Meter Stick

Procedure: Day of Activity:

Before activity:	**What the teacher will do:** a. The day before this activity, you may want to place "*Table 2 - Class Data on Right-hand Width and Length*" on the board in front of the room. b. In order to access prior knowledge and detect any misconceptions, review Mendel's Laws of Segregation and Independent Assortment. Also, review the meaning of the vocabulary words which are located in the student's hand-out. c. Have students read the entire lab, and ensure they understand the procedures. d. Assign each student a partner. e. Demonstrate to students how to measure the length and width of their right hand in centimeters. Some students may need assistance making measurements in metric.
During activity:	**What the teacher will do:** a. Circulate around the room and monitor students to ensure they are accurately measuring the length and width of their right-hand. b. In order to minimize "traffic flow" in the classroom, select a student to record class data to minimize any errors in recording data. c. Have all students involved in tabulating the results of the class measurements by totaling the number of males and females with each hand length and width and recording in Table 3 and Table 4. d. The teacher has the option to include the data from all the classes running this experiment. Table 5 and Table 6 is provided that will allow the tabulation of several classes of data.

	e. Make sure the students understand that they will be developing two bar graphs; one for hand length and one for hand width. f. As students are developing their bar graph, ask the following: "What is the independent variable and dependent variable?" The measurements of the width and length are the independent variables and the number of times that measurement appeared is the dependent variable. Remind students to make sure that the graph has a title and that both axes are labeled clearly.
After activity:	**What the teacher will do:** a. Use the questions, found in the Observations/Data Analysis, to assess student understanding of the activity. b. Have students develop a written report in which they summarize the results of this investigation. In this report, they should give possible explanations for their findings by making connections to the NGSSS and mention any recommendations for further study in this investigation.

Extension:

- Gizmo: Chicken Genetics

Student

Differences in Similar Phenotypes

NGSSS
SC.912.L.16.1 Use Mendel's Laws of Segregation and Independent Assortment to analyze patterns of inheritance. (**AA**)

Background:
Humans are classified as a separate species because of all the special characteristics that they possess. These characteristics are controlled by strands of DNA located deep inside their cells. This DNA contains the code for every protein that an organism has the ability to produce. These proteins combine with other chemicals within the body to produce the cells, tissues, organs, organ systems, and finally the organism itself. The appearance of these organs, such as the shape of one's nose, length of the fingers, or the color of the eyes is called the phenotype. Even though humans contain hands with five fingers, two ears, or one nose, there are subtle differences that separate these organs from one another. There are subtle differences in a person's genes that allows for these different phenotypes. In this lab, we are going to observe some of these differences in phenotype and try to determine why they happened.

Problem Statement: Do all human hands measure the same?

Vocabulary: alleles, dominant, genotype, homozygous, heterozygous (hybrid), phenotype, recessive

Materials (per group):
- Metric ruler
- Meter stick

Procedures:
<u>Hand Measurement</u>:
All human hands look pretty much alike. There are genes on your chromosomes that code for the characteristics making up your hand. We are going to examine two of these characteristics: hand width and hand length.

1. Choose a partner and, with a metric ruler, measure the length of their right hand in centimeters, rounding off to the nearest whole centimeter. Measure from the tip of the middle finger to the beginning of the wrist. Now have your partner do the same to you. Record your measurements in **Table 1**.
2. Have your partner measure the width of your hand, straight across the palm, and record the data in **Table 1**. Have your partner do the same to you.

Student

Table 1 - Group Data on Right Hand Width and Length

Name: ______________________________	Name: ______________________________
Length of Hand ____________________cm.	Length of Hand _____________________cm.
Width of Hand _____________________cm.	Width of hand ______________________cm.

Class Data: After the entire class has completed **Table 1**, have the students record their data on the board in the front of the room. Use **Table 2** below to record the data for your use. Extend the table on another sheet of paper if needed.

Table 2 - Class Data on Right- Hand Width and Length

Student	Gender M/F	Hand Length (cm)	Hand Width (cm)
	M / F		
	M / F		
	M / F		
	M / F		
	M / F		
	M / F		
	M / F		
	M / F		
	M / F		
	M / F		
	M / F		

Tabulate the results of your class measurements by totaling the number of males and females with each hand length and width and entering these totals in the tables below.

Student

Table 3 - Class Hand Length

Measurement of Hand Length in cm.	# of Males	# of Females	Total No. of Males and Females

Table 4 - Class Hand Width

Measurement of Hand Length in cm.	# of Males	# of Females	Total No. of Males and Females

In order to form a more accurate conclusion, the collection of additional data is necessary. The teacher has the option to include the data from all the classes running this experiment. Below find tables that will allow the tabulation of several classes of data.

Student

Table 5 - All Classes Hand Length

Measurement of Hand Length in cm.	**# of Males**	**# of Females**	**Total No. of Males and Females**

Table 6 - All Classes Hand Width

Measurement of Hand Length in cm.	**# of Males**	**# of Females**	**Total No. of Males and Females**

Bar Graph the data from **Tables 5 and 6**, and then answer the questions that follow. Use the measurements of the width and length as your independent variable and the number of times that measurement appeared as your dependent variable.

Student

Graph Title: ____

Student

Observations/Analysis:

1. Examine the graphs. What is the shape of the graph for hand length? What is the most abundant measurement for hand length?
2. What is (are) the least abundant measurement(s)?
3. If we are to assign letters to represent the various lengths, what value(s) would we assign to the dominant genotype (HH)? The recessive genotype (hh)? The heterozygous genotype (Hh)?
4. What would be the phenotypic name for the (HH) genotype?
5. What would be the phenotypic name for the (Hh) genotype?
6. What would be the phenotypic name for the (hh) genotype?
7. What is the shape of the graph for hand width?
8. What is the most abundant measurement for hand width?
9. What is (are) the least abundant measurement(s)?
10. If we assign letters to represent the various widths, what value(s) would we assign to the dominant genotype (WW)? The recessive genotype (ww)? The heterozygous genotype (Ww)?
11. What would be the phenotypic name for the (WW) genotype?
12. What would be the phenotypic name for the (Ww) genotype?
13. What would be the phenotypic name for the (ww) genotype?
14. Are there any similarities in the graphs of the two characteristics? If so, what are they?
15. Are there any differences in the graphs of the two characteristics? If so, what are they?
16. Is there a difference in the length and width of the male and female hand? Does the gender of a person have an effect on the phenotype of a trait? Explain:

Conclusion:

Develop a written report that summarizes the results of this investigation. Use the analysis questions as a guide in developing your report. Make sure to give possible explanations for your findings by making connections to the NGSSS found at the beginning of this lab hand-out. Also, mention any recommendations for further study in this investigation.

Teacher

Making Karyotypes

(Adapted from: Prentice Hall, Lab Manual A)

NGSSS:

SC.912.L.16.10 Evaluate the impact of biotechnology on the individual, society and the environment, including medical and ethical issues. (**AA**)

Purpose of Lab/Activity:

- To construct a karyotype.
- To understand the importance of karyotypes in determining genetic disorders or syndromes.

Prerequisites:

- Students should already be familiar with the topics of mitosis and meiosis. They should be able to distinguish among DNA, genes, and chromosomes.
- Students should also understand the meanings of autosomes and homologous pairs before doing this lab.
- Students should also understand that this activity is modeling a genetic engineering lab procedure in which a picture is taken of the nucleus of a cell during mitosis; it is enlarged, and then analyzed for abnormalities.

Materials (per individual):

- Scissors
- Glue or transparent tape

Procedure: Day of Activity:

Before activity:	**What the teacher will do:** a. Review the topics of mitosis and meiosis. b. Essential question (or problem statement): "Can chromosomal abnormalities be observed?" c. Inform the students to read the entire investigation. d. Use the following questions to initiate a class discussion on karyotypes. 1. What is a karyotype? 2. What information can we obtain from a karyotype? 3. Can chromosomal abnormalities be detected from analyzing a karyotype? Give examples.
During activity:	**What the teacher will do:** a. Ensure that students are matching the chromosomes by taking into consideration their overall size, the position of the centromere, and the pattern of the light and dark bands. b. Engage student thinking during the lab activity by asking the following questions. 1. What clues to the presence of certain genetic disorders can be seen in a karyotype? Karyotypes can reveal missing, damaged, or extra chromosomes. 2. Why might a laboratory worker attempting to diagnose a genetic disorder prefer to work with photographs of chromosomes rather than

	the chromosomes themselves? Chromosomes are very small and fragile, and photographs of them can provide a great deal of information about the presence and structure of specific chromosomes in an individual's cells. 3. Why would it be much more difficult to construct a karyotype of unstained chromosomes? Stained bands on the chromosomes help workers distinguish one from the other 4. Which pair of chromosomes can contain two very different chromosomes and still be considered normal? Explain your answer. Members of chromosome pair 23, the sex chromosomes, are very different in a normal male, including an X chromosome and a Y chromosome. 5. How do autosomes differ from sex chromosomes? Autosomes do not carry information about the individual, while sex chromosomes determine the individual's sex. c. Ensure students have developed a data table in which they have recorded their observations of the karyotypes shown in Figures 1, 3, 4, & 5.
After activity:	**What the teacher will do:** a. The following questions may be used to connect concepts of the activity to the NGSSS. 1. Of the four karyotypes that you observed, which was normal? Which showed evidence of an extra chromosome? Which showed evidence of an absent chromosome? The karyotype in Figure 1 is normal. The karyotypes in Figures 3 and 4 show evidence of an extra chromosome, while the karyotype in Figure 5 shows that a chromosome is missing. 2. What chromosomal abnormality appears in the karyotype in Figure 4? Can you tell from which parent this abnormality originated? Explain your answer. Chromosome 23 has an extra chromosome. Of these three chromosomes, the Y originated from the father, and one of the X chromosomes originated from the mother. The second X chromosome, however, could have come from either parent. 3. Are chromosomal abnormalities such as the ones shown confined only to certain parts of the body? Explain your answer. No; because all chromosomes occur in every cell in the body, these abnormalities would pervade the body. 4. Are genetic defects associated with abnormalities of autosomes or of sex chromosomes? Explain your answer. Genetic defects can be associated with abnormalities of either autosomes or sex chromosomes, for example, the extra autosome at 21 in Figure 3, and the missing sex chromosome in Figure 5. 5. Formulate a question that could be answered by observing chromosomes of different species of animals. Students' questions might center on comparisons of the number and appearance of chromosomes of different animal species. b. Closure Activity: Have the students present their karyotypes to the class and explain the importance about karyotyping in determining genetic disorders.

Extension:

- Gizmo: Human Karyotyping
- Using library materials or the Internet, the students will 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.

Making Karyotypes

(Adapted from: Prentice Hall, Lab Manual A)

NGSSS:
SC.912.L.16.10 Evaluate the impact of biotechnology on the individual, society and the environment, including medical and ethical issues. (**AA**)

Background:
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.

Problem Statement: Can chromosomal abnormalities be observed?

Safety: Be careful when handling scissors.

Vocabulary: centromere, chromosomes, chromatids, genes, homologous pairs, karyotype, mutations, Trisomy 21- Down syndrome, Klinefelter syndrome, Turner syndrome

Materials (per individual):
- Scissors
- Glue or transparent tape

Procedures:
<u>Part A. Analyzing a Karyotype</u>
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.

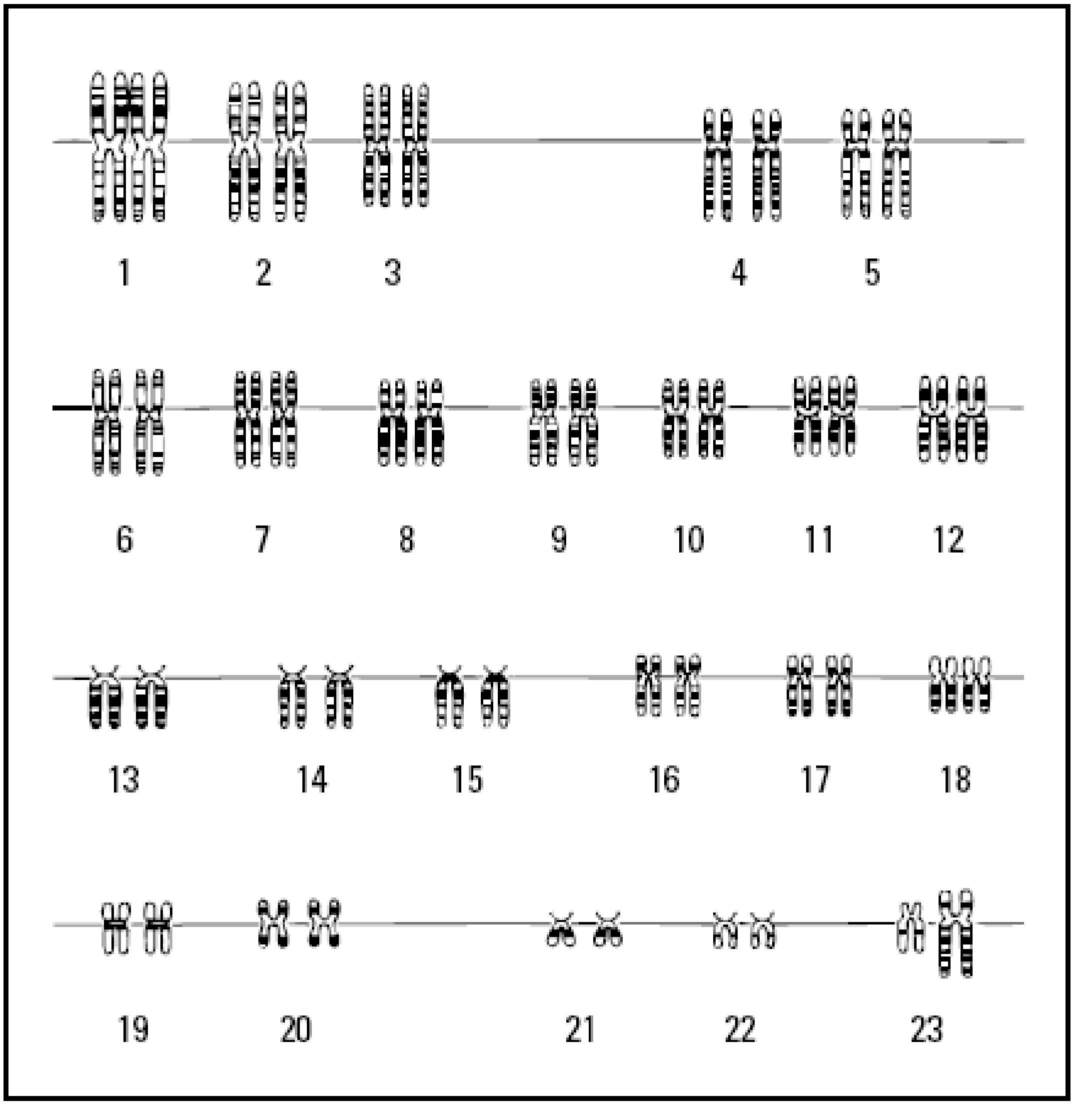


Figure 1

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.

Student

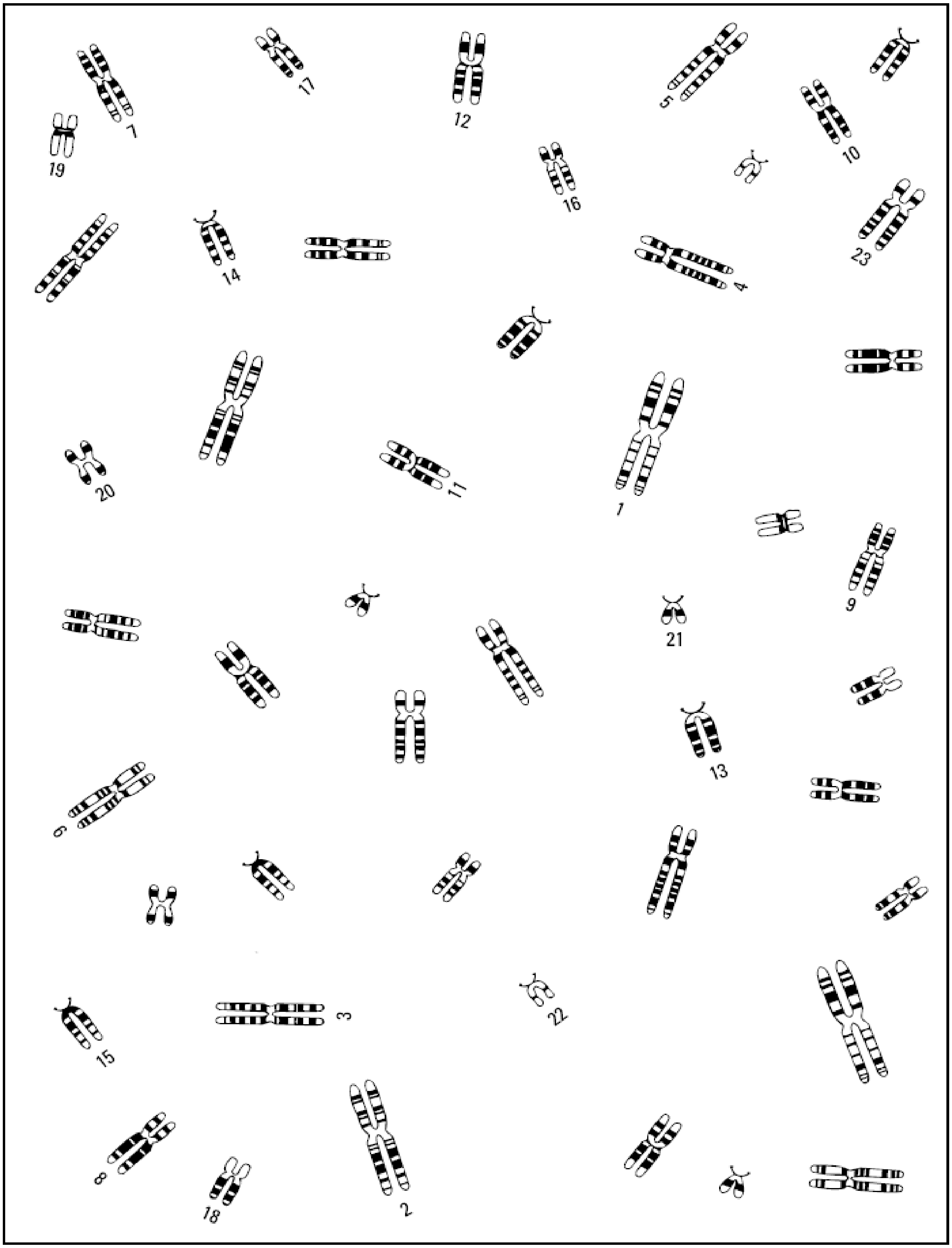


Figure 2

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.

Observations/Data Analysis:

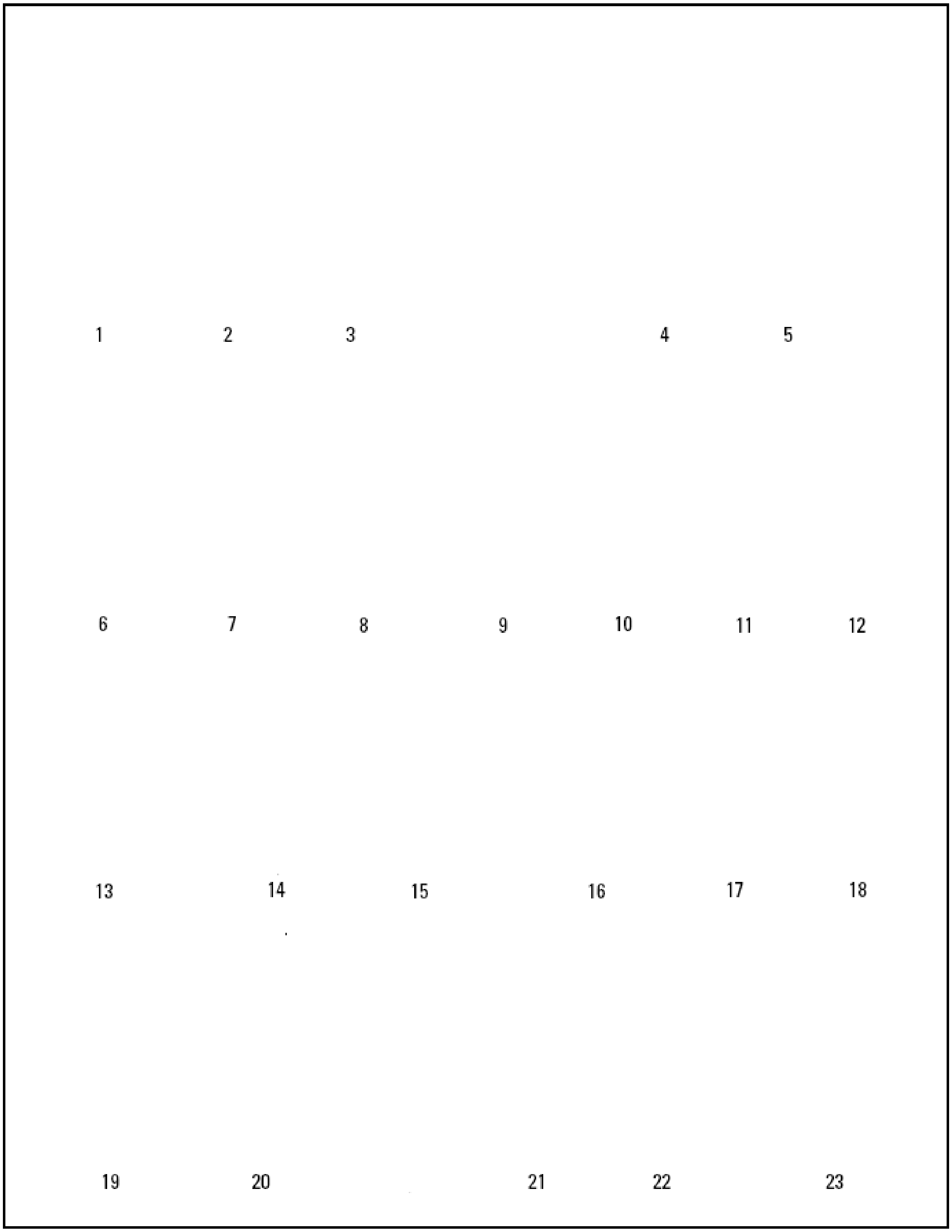


Figure 3

Student

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

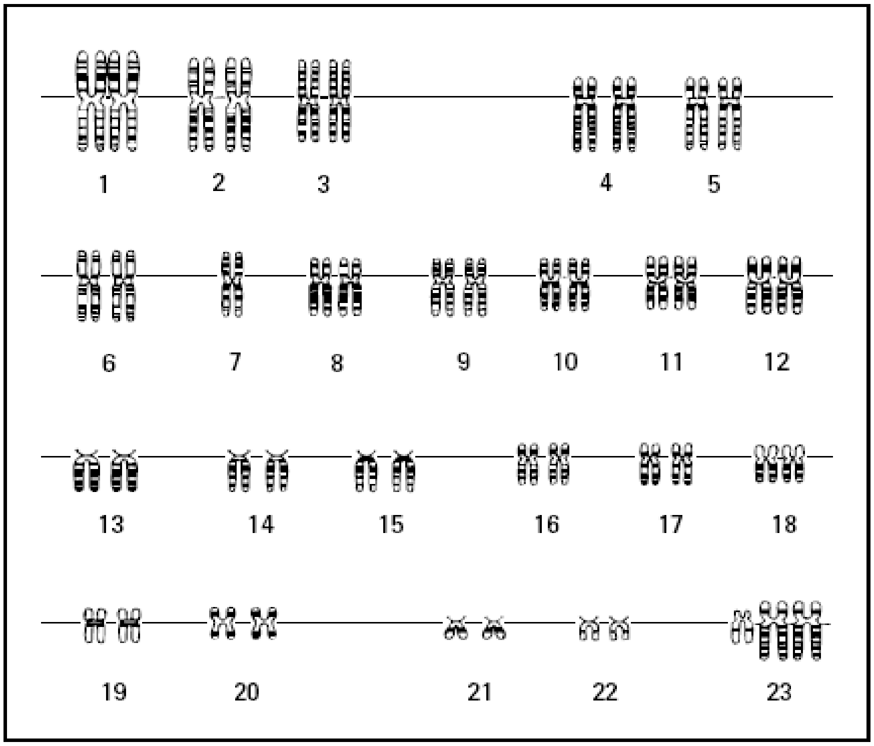


Figure 4

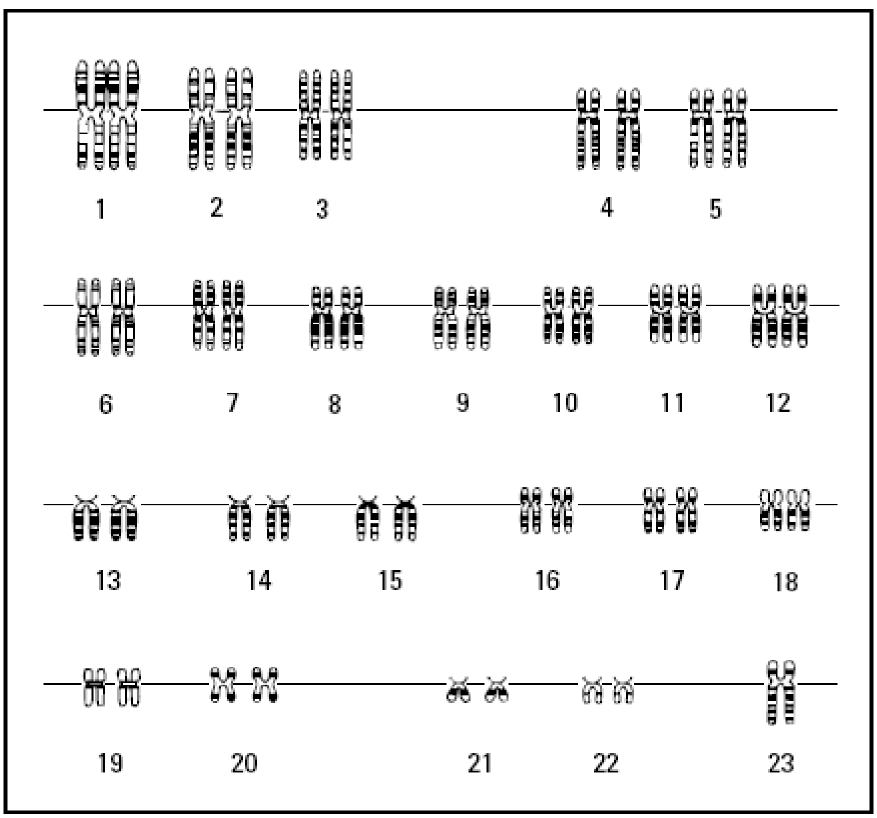


Figure 5

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/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.

Teacher

Building a DNA Model Project

(Adapted from: Prentice Hall - Laboratory Manual A)

NGSSS:
SC.912.L.16.3 Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information. (**AA**)

Purpose of the Lab/Activity:

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

Prerequisites:

- 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.
- Genetic and chromosomal mutations should also have been covered with the students including substitution, inversion, deletion, duplication, non-disjunction, frame-shift 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.

Materials (per group):

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

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Address the essential question: 1. If during replication a base pair gets substituted, then what effect might it have on the DNA molecule? b. Start the lesson by asking the students to answer the pre-lab questions. 1. Which two molecules make up the "sides" of a DNA molecule? Deoxyribose and phosphate group 2. When you construct your model of DNA, which materials will you use to represent the sides of a DNA molecule? Strips of cardboard 3. Which molecules make up the "rungs" of a DNA molecule? Adenine, guanine, cystosine, and thymine 4. When you construct your model of DNA, which materials will you use to represent the rungs of a DNA molecule? Different color gumdrops 5. Which bases usually pair together to form the rungs of a DNA molecule? A-G; C-T c. Introduce the structure of the DNA including the phosphate and

	deoxyribose backbone; nitrogen bases found within as Adenine(A), Cystosine(C), Guanine (G), and Thymine (T) d. Review the steps of DNA replication and what happens in a chromosomal mutation including substitution, inversion, deletion, duplication, non-disjunction, and frame shift mutation. e. Be sure students understand the concept of what occurs in each mutation and how it can affect the DNA of an offspring.
During activity:	**What the teacher will do:** a. Ask students to make a hypothesis based on the problem statement. If during replication a base pair gets substituted, then the DNA molecule will be mutated. b. Have students construct a rough draft of what the DNA model is going to look like, include the keys prior to constructing the final model. c. Make sure students understand that adenine and thymine; cytosine and guanine pairs with each other exclusively. A-T;C-G d. Ask students what makes up a nucleotide: phosphate group, sugar (deoxyribose), and a nitrogen base. e. Given the following bases, predict to which base each would be bonded: 1. A _T__ T _A__ G _C__C __G__ 2. G _C__ A _T__ T_A_ C__G_ 3. T _A__ C _G__ G_C__ A _T__ f. 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. If you changed the base on one side of the DNA molecule, you should change the base on the other side of the molecule to the complementary base.
After activity:	**What the teacher will do:** a. Have the student groups present their DNA models and explain their illustrations. Also have the students explain the importance of DNA replication. b. 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. c. Apply their understanding of a DNA model by asking the following questions: 1. Consider the following base sequence in one DNA 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 would you fill in the corresponding portion of the other chain? C C G T A C T G C T T G A A T AG CC G T A A T C G G T T A A 2. How could a very high fever affect DNA replication, if temperature affects enzymes in the body? Temperature affects enzymes' function, DNA replication involves enzymes and with high temperature, those enzymes cannot function properly. d. Answers for Results and Conclusions: • How does the model you constructed differ from an actual DNA molecule? Answers may vary.

Teacher

	• 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? Both strands are used as a template for replication therefore creating two identical molecules of DNA.

Extension:

- Gizmo: Building DNA

Student

Building a DNA Model Project

(Adapted from: Prentice Hall - Laboratory Manual A)

NGSSS:
SC.912.L.16.3 Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information. (**AA**)

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.

The DNA molecule is the shape of a double helix (spiral). The molecules making up DNA are deoxyribose, phosphate, and four nitrogenous bases: adenine, thymine, cytosine, and guanine. These are called nucleotides. Adenine and guanine are purines and cytosine and thymine are pyrimidine. They are also known by their code letters of A, G, T, and C. There is a specific manner in which they bond A only to T and C only to G.

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

Safety: Do not eat any of the edible food items used in this lab.

Pre-Lab 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?
   When you construct your model of DNA, which materials will you use to represent the rungs of a DNA molecule?
4. Which bases usually pair together to form the rungs of a DNA molecule?

Vocabulary: double helix, nucleotide, purines, pyrimidines, DNA replication, DNA polymerase, mutation

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

Student

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.

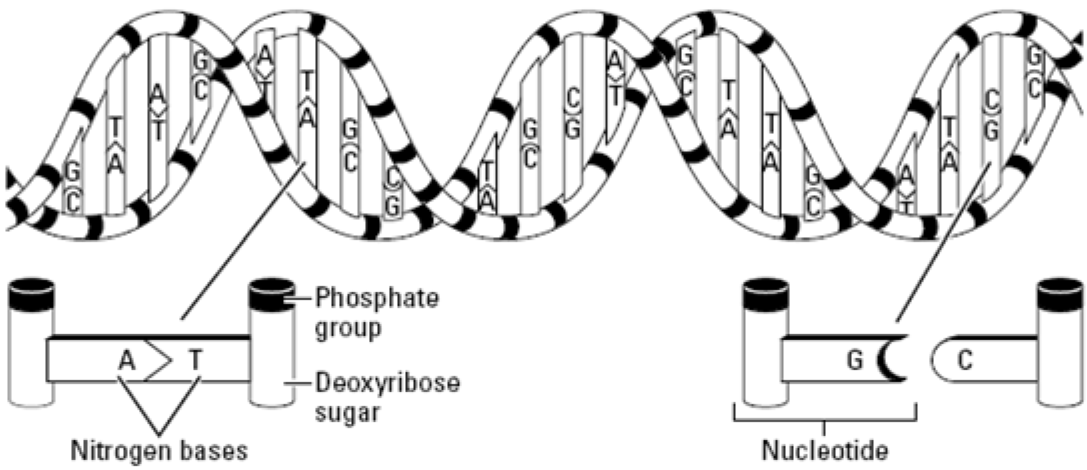


Figure 1

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.
6. 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.
7. Attach the nitrogen base rungs to the ladder by taping the free toothpick ends to the sugar bases.
8. Continue to add correctly paired nitrogen-base gumdrop rungs to the sugar units of the ladder. When your ladder is completed, you might want to stand it up by inserting the two strips into mounds of modeling clay.

Student

Observations/Data:
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:

1. Given the following bases, predict to which base each would be bonded:
   a. A ____ T ____ G ____C _____

   b. G ____ A ____ T____ C_____

   c. T ____ C ____ G____ A _____
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.

Results/Conclusions:

1. How does the model you constructed differ from an actual DNA molecule?
2. 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?

Student

DNA Model Project

(Adapted from: www.africangreyparrot.com)

Student Name: ____________________________________ **Due Date:** __________________

Requirements:

Make a model of DNA. Your model may be out of any materials that you choose as long as they are not perishable and are sturdy. Please make sure that your model includes at least 8 nucleotides. Each structure should look different from the others, and should clearly show which 2 other structures they are connected to. Please attach a key to your model, which labels each structure and shows what it is. Your model should be in a double helix form, as is DNA.

Please use this checklist to make sure you have completed your project, and check the parts as you do them.

Rubric: The following need to be included for full credit. (Total possible points is 50)

	Structure	**Check**		**Connections**	**Check**		**Labels on Key**	**Check**
2pts	Sugar	□	4pts	Sugar	□	1 pt	Sugar	□
2pts	Phosphate	□	2pts	Phosphate	□	1 pt	Phosphate	□
2pts	Adenine	□	2pts	Adenine	□	1 pt	Adenine	□
2pts	Thymine	□	2pts	Thymine	□	1 pt	Thymine	□
2pts	Cytosine	□	2pts	Cytosine	□	1 pt	Cytosine	□
2pts	Guanine	□	2pts	Guanine	□	1 pt	Guanine	□
2pts	Helix	□	---	---	---	2 pts	Nucleotide	□
2pts	H – bonds	□	6pts	Overall neatness	□	1 pt	Hydrogen bonds	□
2pts	8 nucleotides	□	2pts	Sturdy	□	1 pt	checklist	□

Extra Credit: DNA that unzips at the hydrogen bonds (2 pts)

Teacher

DNA Extraction Lab

NGSSS:
SC.912.L.16.3 Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information. (**AA**)

Purpose of Lab/Activity:
- To observe DNA in an organism.
- To compare and contrast the amount of DNA found in different individuals of a species.

Prerequisites:
- 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 know that all living organism contain DNA and DNA is contained within the nucleus of the living organism.
- Students should have been introduced to chromosome number of different organism i.e. haploid, diploid, and etc.

Materials (per group):
- 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)

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Prepare the DNA extraction buffer. In a container add 900mL water, then 50mL dishwashing detergent (or 100mL shampoo), and finally 2 teaspoons salt. Slowly invert the bottle to mix the extraction buffer. b. Be sure to provide different size strawberries and to have enough strawberries. c. Keep ethanol in refrigerator or ice bath the night before experiment. d. Discuss where in the cell the DNA is contained. e. Pre-Lab questions: 1. What do you think the DNA will look like? Answers may vary. 2. Where is DNA found? DNA is found in the nucleus of a cell of an organism.
During activity:	**What the teacher will do:** a. Ask students why an extraction buffer is needed. We will use an extraction buffer containing salt, to break up protein chains that bind around the nucleic acids, and dish soap to dissolve the lipid (fat) part of the strawberry cell wall and nuclear membrane. This extraction buffer will help provide us access to the DNA inside the cells.

	b. Ask students what components of the cells are being filtered out with the cheesecloth. Cheesecloth will filter out the larger cell parts like the cell wall and nuclear membrane. c. Be sure to make the ethanol VERY cold. If it is not, the amount of DNA extracted will be less. d. When the ethanol is poured SLOWLY into the solution, white thread-like DNA strands should be observed.
After activity:	**What the teacher will do:** a. Have the students complete the following "Data Analysis (Calculations)": 1. How is the appearance of your DNA similar or dissimilar to what you have learned about DNA structure? Answers may vary. 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? DNA strands are very small and similar to a single strand of thread. When DNA material is clumped together, it is more visible than a single strand. 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. Because DNA is not soluble in ethanol, the DNA strands will form a precipitate (clump together). b. It is important that the students understand the steps in the extraction procedure and why each step is necessary. 1. Filter strawberry slurry through cheesecloth: To separate components of the cell 2. Mush strawberry with salty/soapy solution: To break up proteins and dissolve cell membranes 3. Initial smashing and grinding of strawberry: To break open the cells 4. Addition of ethanol to filtered extract: To precipitate DNA from solution c. Have the students summarize the significance of this experiment, use the following questions as a guide: 1. What did the DNA look like? Relate what you know about the chemical structure of DNA to what you observed today. Answers may vary. DNA looks like thin white threads. 2. Why is it important for scientists to be able to remove DNA from an organism? List two reasons. DNA can be used for study of genetic diseases and in forensic science. DNA can be used in biotechnological research. 3. Is there DNA in your food? How do you know? Yes, foods are either plant or animal. Plants and animals are made up of cells, therefore contains DNA.

Extension:

- Gizmo: DNA Fingerprinting Analysis
- Discuss results and analysis questions with the class. 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.

Student

DNA Extraction Lab

NGSSS:
SC.912.L.16.3 Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information. (**AA**)

Background Information:
DNA is too small to see under a regular microscope, so how can it be studied? DNA is a large molecule found in all living things; therefore it is possible to extract it from cells or tissues. 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. DNA extractions from onion, bananas, liver, or wheat germ are commonly used in laboratory investigations.

Plants used in agriculture and horticulture are often artificially selected for their large flowers and fruits. Strawberries are no exception; wild strawberries are not as large as the ones you get in the grocery store. Strawberries are octoploid, meaning that they have eight copies of each type of chromosome. With eight sets of chromosomes, they have plenty of DNA for classroom extraction.

Problem Statement: Do you think you have ever eaten DNA?

Safety:
- Handle breakable materials with care. Do not touch broken glassware.
- If you are allergic to certain plants, tell your teacher before doing activity in which plants are involved. Wash your hands when you are finished with the activity.
- Flammable materials may be present. Make sure no flames, sparks, or exposed heat sources are present.

Vocabulary: extraction, buffer, octaploid, chromosome, artificial selection

Materials (per group):
- 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)

Procedures:
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 (4-6 mL) with *ice cold* ethanol.
7. Stir gently with inoculation loop and spool DNA as it clumps at the EtOH (ethanol)/filtrate interface.

8. Compare the amount of your extracted DNA with other groups' DNA.

Observations/Data: Draw and describe the DNA removed from the strawberries.

Data Analysis/Results:

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.

Conclusions:

1. It is important that you understand the steps in the extraction procedure and why each step was necessary. Each step in the procedure aided in isolating the DNA from other cellular materials. Match the procedure with its function:
2. Match the procedure with the appropriate function

PROCEDURE	FUNCTION
A. Filter strawberry slurry through cheesecloth	___ To precipitate DNA from solution
B. Mush strawberry with salty/soapy solution	___ Separate components of the cell
C. Initial smashing and grinding of strawberry	___ Break open the cells
D. Addition of ethanol to filtered extract	___ Break up proteins and dissolve cell membranes

3. What did the DNA look like? Relate what you know about the chemical structure of DNA to what you observed today.
4. Why is it important for scientists to be able to remove DNA from an organism? List two reasons.
5. Is there DNA in your food? ________ How do you know?
6. 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.

Teacher

Candy DNA Replication

(Adapted from Flagler Schools: http://flaglerschools.com/media/documents/68684242-948b-4ed9-a06d-152a70ed5aa8.pdf)

NGSSS:

SC.912.L.16.3 Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information. (**AA**)

Purpose of Lab/Activity:

- To describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information.

Prerequisites:

- How to describe the process of DNA replication and/or its role in the transmission and conservation of genetic information.
- How to describe gene and chromosomal mutations in the DNA sequence.
- How gene and chromosomal mutations may or may not result in a phenotypic change.

Materials:

- Red licorice chunks (red and black) - 24 piece each color
- Gum drops or colored marshmallows (4 different colors) - 6 of each color
- Wooden toothpick halves – about 70

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Obtain different candy pieces from a wholesale or dollar store. Make sure the outside pieces for the DNA are two different colors and the “bases” are four different colors. b. Provide wax paper in order to cover tables and protect the models. You may also want to provide a base such as a paper plate or box top in order to store the models. c. Break the toothpick pieces in half so joints are seamless and materials are not wasted.
During activity:	**What the teacher will do:** a. Ask questions of the students in relation to the importance of the structure of DNA to hold genetic information. b. As you move around the class, check the models as the students are working on them to ensure correct placement and sequence in building the model. Six complete nucleotides are to constructed first before the building of the full DNA model. The idea is that this activity is modeling what is occurring in the nucleus of a eukaryotic cell during mitosis. Student misconceptions include a misunderstanding of where replication occurs and hence, where DNA is located in an organism. c. If necessary explain to the students that the paper or base they are using is meant to represent the nucleus and they are modeling nucleotide synthesis as well as DNA replication during Interphase of Mitosis or Meiosis in the cell.

	d. Students may also not be paying attention to the direction in which the complementary strand is going. Even though it is not assessed, an understanding of how a complementary strand in DNA is oriented (5', 3' direction) should be reviewed. e. Another student misconception and important factor in DNA replication is the importance of enzymes in a DNA model in order to allow for its unzipping in the replication process. Without these restriction enzymes, replication would not occur. Have the students model the "cutting" of the hydrogen bonds in their DNA model, using their restriction "enzymes" (scissors). f. Students also need to understand that these enzymes are actually proteins in the body. When macromolecules are taught, restriction enzymes can be applied to the content as an example of a protein. g. Students should be drawing every stage of their modeling process into their journals and label what is occurring at every point. Use these observations for your assessments.
After activity:	**What the teacher will do:** a. Ensure the students clean up their models. You may choose to have them store it with plastic wrap in order to use them on assessments or during discussions. b. Have the students complete the following "Data Analysis": 1. What is the function of DNA? (to preserve genetic information in the cell) 2. Why is it so important that the order of base pairs stays the same? (to ensure that the sequence of the genetic code stays the same and to prevent mistakes from occurring in cell division) 3. What would happen if there was a change in the base pair sequence? (Changes in the DNA sequence can cause a mutation in the individual proteins of an organism causing problems such as cancer or uncontrolled cell growth. These mutations can also become new variations in a species if they are carried on.) 4. What special proteins make replication of DNA possible? (Enzymes allow the unzipping of a DNA strand in order to allow it to be replicated.) 5. What is the difference between replication and duplication? (Replication is a complimentary copy of the strand of DNA, filling one side to its matching pairs. Duplication would mean exact copy of the original bases) 6. At which stage of cell division (mitosis) does replication take place? (During the Synthesis phase before Mitosis) c. 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:

- Gizmo: DNA Fingerprinting Analysis

Candy DNA Replication

(Adapted from Flagler Schools: http://flaglerschools.com/media/documents/68684242-948b-4ed9-a06d-152a70ed5aa8.pdf)

NGSSS:
SC.912.L.16.3 Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information. (**AA**)

Background Information: DNA or deoxyribonucleic acid is an organic compound called a nucleic acid. The building blocks of nucleic acids are nucleotides. Nucleotides are made up of 3 parts: phosphate group, deoxyribose sugar, and a nitrogen base. The differences in DNA lie in the different sequence of nitrogen bases. DNA is replicated during the Synthesis phase of Interphase of Mitosis. It is a simple process involving the unwinding of the helix by an enzyme called DNA helicase and adding complementary nitrogen bases by an enzyme called DNA polymerase.

Objective:

- To describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information.

Safety:
Be sure that working surfaces and hands have been cleaned before starting this activity, if you intend to consume your models after finishing.

Vocabulary: Nitrogen base, replication, nucleotides, deoxyribonucleic acid, phosphate group, deoxyribose sugar, polymerase, complimentary strand

Materials:

- Red licorice chunks (red and black) - 24 piece each color
- Gum drops or colored marshmallows (4 different colors) - 6 of each color
- Wooden toothpick halves – about 70

Procedures:

1. Gather the supplies you need. The red licorice represent the phosphate backbone with the part of the gummy representing the deoxyribose sugar. The gumdrops will represent the different nitrogen bases. Choose any order you want, but remember to follow the base- pairing rule

2. Assign one nitrogen base to each of the four colors of gum drops or marshmallows.
   Adenine (A) =_________________
   Thymine (T) =_________________
   Cytosine (C) =_________________
   Guanine (G) =_________________

3. What do the black Licorice represent?______________________________
4. What do the red Licorice represent?______________________________
5. What structure is formed from a red Licorice, a black Licorice and a gum drop (or marshmallow)? ____

Student

6. Prepare six individual nucleotides: use toothpicks to connect one black to one red Licorice piece. Then add one color candy piece perpendicularly to the black candy. Is this a full DNA strand? Explain why or why not. ________________________________
7. Assemble nucleotides into a polynucleotide strand by connecting the red piece of one nucleotide to the black of another. Continue until a strand of six nucleotides has been constructed. DRAW THIS IN YOUR JOURNAL.
8. Which combinations of two bases form the complimentary base pair “rungs” of DNA? ____
9. Assemble a strand that is complementary to the strand that you have already built. Place the second strand next to the first so that the complimentary "bases" touch. DRAW THIS STRUCTURE IN YOUR JOURNAL.
10. Have your teacher check your model and initial your journal.
11. You are now ready to REPLICATE!!!!
12. To demonstrate replication, first make 12 more nucleotides with the same nitrogen bases as the first two strands.
13. "Unzip" the DNA double strand, one “rung” at a time.
14. Assemble the proper nucleotides, one by one. DRAW THIS NEW STRUCTURE ALONG WITH THE “OLD” ONE
15. Once you have finished replicating, have your teacher check your model and initial your journal ________________________.
16. After you demonstrate this to the teacher you may dispose of your models. This is one case where you may eat your science project, if you have kept everything clean. Be sure to remove toothpicks before you eat!!!
17. Clean up, being sure that no toothpicks or sticky residue is left behind. Wash your hands!

Observations/Data: Draw and describe the Nucleotides (step 7), the DNA strand (step 9), and the unzipped DNA strand (steps 12-14).

Data Analysis/Conclusions:
1. What is the function of DNA?
2. Why is it so important that the order of base pairs stays the same?
3. What would happen if there was a change in the base pair sequence?
4. What special proteins make replication of DNA possible?
5. What is the difference between replication and duplication?
6. At which stage of cell division (mitosis) does replication take place?

Teacher

Protein Synthesis: Transcription and Translation

(Adapted from: Protein Synthesis Lab, www.Accessexcellence.org)

NGSSS:
SC.912.L.16.3 Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information. (**AA**)

Purpose of Lab/Activity:
- The student will learn the process of RNA transcription.
- The student will understand the implication of a mistake in RNA translation.

Prerequisites:
- 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 have learned about the importance of the base-pairing rule in DNA structure and DNA replication.
- Students should understand process of transcription and compare of transcription vs. replication.
  - similarities: base-pairing rule crucial for both; monomers added one at a time and joined by covalent bonds; carried out by a polymerase enzyme
  - differences (see table on page 4 of student protocol)
- Students should understand the process of translation, including roles of mRNA, tRNA and ribosomes
  - understand function of mRNA and tRNA
  - mRNA carries genetic message from nucleus to ribosomes; each mRNA codes for the sequence of amino acids in a protein and each triplet codon in the mRNA codes for a specific amino acid in the protein
  - tRNA needed for translation -- different types of tRNA bring the right amino acid for each position in the polypeptide; tRNA anti-codon has three nucleotides which are complementary to the three nucleotides in an mRNA codon; the other end of each tRNA molecule binds to the amino acid specified by that mRNA codon
  - explain how proteins are synthesized using genetic information from DNA

Materials (per group):
- Pencils
- DNA strands worksheet

Procedures: Day of Activity:

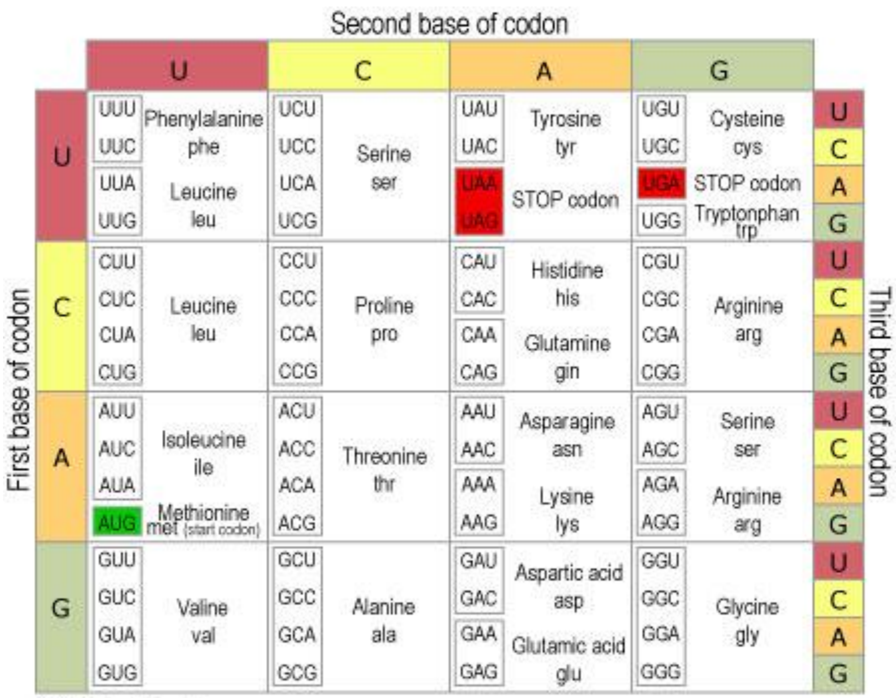
Before activity:	**What the teacher will do:** a. Make copies of the strands of DNA and table worksheet. b. Essential Question: “What effect would occur from the change in the exact chemical makeup of a protein?” c. Review the vocabulary words and the importance of the DNA “language” d. Each codon (three nitrogenous base) codes for a specific amino acid; discuss what will happen if one or two nitrogenous base is missing or deleted.

	e. Review the procedures on how to encode the mRNA with the table given. f. Misconceptions: DNA replication is similar to transcription but is not the same. Students usually confuse them to have the same purpose. DNA replication is for mitosis and meiosis. Transcription is for used to make a copy of the DNA for the purpose to making a particular protein/enzyme.
During activity:	**What the teacher will do:** a. While students are decoding the DNA strand to mRNA, be sure the students understand that RNA does not contain Thymine and contains Uracil (U) instead. b. Discuss the similarities of transcription and translation; and how the activity closely related the process itself i.e. review and checking mechanisms. c. Also, ask what happens in misread base in transcription and translation. chromosomal mutation will occur including substitution, inversion, deletion, duplication, non-disjunction d. Review the “Data Analysis (Calculations)”, Have the students record the entire list of amino acids and write it in on the board. Start with the beginning segment, followed by the middle, and ending with tail. Refer to worksheet.
After activity:	**What the teacher will do:** a. Review the results of the experiments in order to assess student’s understanding of the protein transcription and translation. b. Engage in class discuss using the following questions as a guide: 1. How many amino acids does this complete protein contain? 80 amino acids 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? 51 amino acids 3. Explain the importance of having the exact genetic code for this protein and why mutations can cause a problem. Answers should include that insulin plays an important role in glucose regulation and with mutations other methods have to be used to monitor blood glucose. 4. If the sixth letter in the entire strand is changed to a “G,” does it change the protein? Explain your answer.No it does not change the protein. The change will code for the same amino acid. 5. If the sixth letter in the entire strand is changed to “T,” does it change the protein? Explain your answer. Yes it also changes the protein; change will code for Leu instead of Phe. 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? The last letter being deleted would cause a mutation in the cell and individual. 7. Discuss as a class the answers to #4, #5, and #6. Compare the different responses and write a consensus for each on the board.

Teacher

Extension:

- Gizmo: [RNA and Protein Synthesis]
- Provide the students with the opportunity to research another protein and compare its structure to the one shown below. What are the similarities in the function/structure of the additional protein?



Second base of codon

First base of codon	U	C	A	G	Third base of codon
U	UUU, UUC Phenylalanine phe UUA, UUG Leucine leu	UCU, UCC, UCA, UCG Serine ser	UAU, UAC Tyrosine tyr UAA, UAG STOP codon	UGU, UGC Cysteine cys UGA STOP codon UGG Tryptophan trp	U C A G
C	CUU, CUC, CUA, CUG Leucine leu	CCU, CCC, CCA, CCG Proline pro	CAU, CAC Histidine his CAA, CAG Glutamine gln	CGU, CGC, CGA, CGG Arginine arg	U C A G
A	AUU, AUC, AUA Isoleucine ile AUG Methionine met (start codon)	ACU, ACC, ACA, ACG Threonine thr	AAU, AAC Asparagine asn AAA, AAG Lysine lys	AGU, AGC Serine ser AGA, AGG Arginine arg	U C A G
G	GUU, GUC, GUA, GUG Valine val	GCU, GCC, GCA, GCG Alanine ala	GAU, GAC Aspartic acid asp GAA, GAG Glutamic acid glu	GGU, GGC, GGA, GGG Glycine gly	U C A G

Teacher

Answer Key - Protein Synthesis: Transcription and Translation

Strand A

T A C A A A C A T T T A G T T G T A A A C A C A C C C T C A G T G G A C C A A C T C C G C A A C A T A A A C C A A A C

A UG/U U U/G UA/A A U/C A A/C A U/UU G/U G U/G G G/A G U/C A C/C U G/GU U/G A G/G CG/U UG/U A U/U UG/G U U/UG

A C C G C T C G C G C C G A A A A A G A T A T G G G G T T T T G G---

U/G G C/G AG/C G C/G G C/U UU/UU C/U A U/ A C C/C C C/A A A/A C C

Strand B

T C T T C C C T C G C G C T C C T A A A C G T T C A A C C G G T T C A A C T T A A T C C G C C G C C A G G G C C C C G

A G A/A G G/G A G/C G C/G AG/G AU/U UG/C A A/GU U/G G C/C AA/G U U/G AA/U U A/GG C/G G C/G G U/CC C/G G G/G C

C C C C T C A G A A G T T G G T G A T G C G---

G/G G G/AG U/C UU/C A A/C C A/C U A/C G C

Strand C

A A T C T C C C A T C A G A C G T T T T T G C C C C G T A A C A A C T T G T T A C A A C A T G G T C A T A A A C G T C A

UU A/G A G/G GU/A G U/C U G/C AA/A A A/C G G/GG C/A UU/G U U/G AA/C A A/U G U/UG U/A C C/A G U/A UU/UG C/A G U

G A G A T G G T C A A T C T C T T A A T G A C G T T A A C T--

C U C/U A C/C A G/UU A/G A G/AA U/U A C/U G C/A AU/U G A

Data (Tables and Observations):

DNA strand	mRNA	Protein (amino acid or polypepetide chain)	Which End?
A	Refer to key above.	Met(start)-Phe-Val-Asn-Gln-Leu-Cys-Gly-Ser-His-Leu-Val-Glu-Ala-Leu-Val-Cys-Gly-Glu-Arg-Gly-Phe-Phe-Tyr-Thr-Pro-Lys-Thr	Start strand
B	Refer to key above.	Arg-Arg-Glu-Arg-Glu-Asp-Leu-Gln-Val-Gly-Gln-Gln-Pro-Gly-Ala-Gly-Ser-Leu-Gln-Pro-Gln-Pro-Leu-Arg	Middle strand
C	Refer to key above.	Leu-Glu-Gly-Ser-Leu-Gln-Lys-Arg-Gly-Ile-Val-Glu-Gln-Cys-Cys-Thr-Ser-Ile-Cys-Leu-Tyr-Gln-Leu-Glu-Asn-Tyr-Cys-Asn-Stop	Last strand

Student

Protein Synthesis: Transcription and Translation

(Adapted from: Protein Synthesis Lab, www.Accessexcellence.org)

NGSSS:

SC.912.L.16.3 Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information. (**AA**)

Background Information:

Protein synthesis involves a two-step process. One strand of the DNA double helix is used as a template by the RNA polymerase to synthesize a messenger RNA (mRNA). This mRNA migrates from the nucleus to the cytoplasm. Then, in the cytoplasm, the ribosomes bind to the mRNA at the start codon (AUG). The ribosome moves from codon to codon along the mRNA as amino acids are added one by one to form a polypeptide (amino acid chain). At one of three stop codons, the amino acid chain or polypeptide chain will stop forming. The instructions on the mRNA 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 either harmful, or beneficial.

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 is the beginning, middle, or end of the insulin molecule. Once they have determined their segment, they will group up with the missing two segments and complete the exercise.

Problem Statement: What effect would occur from the change in the exact chemical makeup of a protein?

Vocabulary: transcription, translation, codon, anti-codon, messenger RNA (mRNA), mutations, substitution, inversion , deletion, duplication, non-disjunction, transfer RNA (tRNA), ribosomes, polypeptide, amino acid

Materials (per group):

- Pencils
- DNA strands worksheet

Procedures:

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

Student

Second base of codon

First base of codon	U		C		A		G		Third base of codon
U	UUU	Phenylalanine phe	UCU	Serine ser	UAU	Tyrosine tyr	UGU	Cysteine cys	U
	UUC		UCC		UAC		UGC		C
	UUA	Leucine leu	UCA		UAA	STOP codon	UGA	STOP codon	A
	UUG		UCG		UAG		UGG	Tryptonphan trp	G
C	CUU	Leucine leu	CCU	Proline pro	CAU	Histidine his	CGU	Arginine arg	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	Glutamine gln	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	Isoleucine ile	ACU	Threonine thr	AAU	Asparagine asn	AGU	Serine ser	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	Lysine lys	AGA	Arginine arg	A
	AUG	Methionine met (start codon)	ACG		AAG		AGG		G
G	GUU	Valine val	GCU	Alanine ala	GAU	Aspartic acid asp	GGU	Glycine gly	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	Glutamic acid glu	GGA		A
	GUG		GCG		GAG		GGG		G

Student

Protein Synthesis: Transcription and Translation
Strand A

T A C A A A C A T T T A G T T G T A A A C A C A C C C T C A G T G G A C C A A C T C C G C A A C A T A A A C C A A A C

A C C G C T C G C G C C G A A A A A G A T A T G G G G G T T T T G G

Strand B

T C T T C C C T C G C G C T C C T A A A C G T T C A A C C G G T T C A A C T T A A T C C G C C G C C A G G G C C C C G

C C C C T C A G A A G T T G G T G A T G C G

Strand C

A A T C T C C C A T C A G A C G T T T T T G C C C C G T A A C A A C T T G T T A C A A C A T G G T C A T A A A C G T C A

G A G A T G G T C A A T C T C T T A A T G A C G T T A A C T

Data (Tables and Observations):

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

Student

Data Analysis:

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/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?

Teacher

Building Macromolecules

NGSSS:
SC.A.912.L.18.1 Describe the basic molecular structures and primary functions of the four major categories of biological macromolecules. (**AA**)

Purpose of Lab:
- Students will construct the basic components of organic molecular structure.
- Describe and illustrate different ways in which molecules are represented.
- Synthesize what occurs in a chemical reaction.

Prerequisites:
- Students should have a basic understanding of the four basic categories of macromolecules and their roles and function in the body of an organism.

Materials (per group):
- Use different household or food items to represent the different elements
  - Blueberries= Hydrogen
  - Red Grapes= Oxygen
  - Green grapes= Carbon
  - Radish= Nitrogen
  - Bonds= wooden toothpicks or dry spaghetti pieces

Procedure: Day of Activity:

Before activity:	**What the teacher will do:** a. Prep work**:** Obtain all materials before beginning this lab activity. b. Before passing out the fruit, have the students think about what macromolecules are necessary for growth and energy in the body. . c. Use the following questions to engage student thinking during a pre-lab discussion: 1. Do all macromolecules look the same? 2. Does their structure relate directly to their function in an organism? d. What factors may affect the structure of these macromolecules? Assign four students per group. For student reference, make copies of the "Lab Roles and Their Descriptions." e. Review the types of molecules in the handout with the students. f. Pass out the fruit and provide wax paper or paper plates to hold the "molecules."
During activity:	**What the teacher will do:** a. Circulate throughout the room and help any group that is having trouble with any aspect of the procedure. b. Monitor students for safety procedures, and keep students focused on their hypothesis. c. The following questions may be used to engage student thinking during the lab activity: 1. What is the process that allows molecules to bond? Why does this occur? 2. What is the function of the macromolecules in the body of an organism?

	3. Does the size of the different molecules affect its purpose or the amount of energy needed to make it? 4. What do all the molecules have in common? What makes them different from each other?
After activity:	**What the teacher will do:** a. Ask the following questions. 1. How many valence electrons does each carbon atom have? (4 electrons or bonding sites) 2. What gives carbon the ability to form chains that are almost unlimited in length? (The amount of bonding sites on each atom.) 3. Many of the molecules in living cells are so large they are called ____________________. (Macromolecules) 4. ________________________________ is the process that forms large organic molecules. (Dehydration Synthesis) 5. When two or more __________________ join together, a polymer forms.(Molecules) 6. Create a table in which you compare the components and functions of the following macromolecules: carbohydrates, lipids, nucleic acids, and proteins. (Answers will vary.)

Extension:

- Use this link to show the students the conceptual drawings of each of the different types of macromolecules and review how the structure of each is different. (There is extra information in the Powerpoint so focus on the four categories the students will be responsible for.
  http://teacher.cgs.k12.va.us/bwebster/Biology/Chapter%20PowerPoints/5%20Macromolecules.pdf

Student

Building Macromolecules

NGSSS:
SC.A.912.L.18.1 Describe the basic molecular structures and primary functions of the four major categories of biological macromolecules. (**AA**)

Background:
Biological macromolecules are defined as large molecules made up of smaller organic molecules. There are four classes of macromolecules: **carbohydrates**, **lipids**, **proteins**, and **nucleic acids**. The base elements of carbohydrates and lipids are Carbon (C), Hydrogen (H) and Oxygen (O). Protein is also made up of these base elements but it also contains Nitrogen (N). When viewing the chemical structures of carbohydrates, lipids and proteins you can distinguish proteins from the other two by the presence of N in its chemical structure.

Each macromolecule is made up of smaller organic molecules. For carbohydrates and proteins these smaller molecules are known as monomers. These similar or identical monomers are covalently bonded together to create a large polymer molecule. The monomer unit for carbohydrates is a **monosaccharide** or a simple sugar. When two of these monosaccharides are linked by covalent bonds a disaccharide is created. When several monosaccharides are bonded together a **polysaccharide** or complex sugar, is created. Polysaccharides are the polymers of carbohydrates. Proteins are made up of monomers called **amino acids**. There are twenty amino acids and they can be strung together in unique combinations known as polypeptide chains, the polymer unit for proteins.

The exception to the **monomer/polymer** rule is lipids. Lipid base units are not considered monomers. One type of lipid or fat is made up of fatty acids and glycerol molecules in a 3:1 ratio. The bonding of three fatty acids to one glycerol molecule creates a triglyceride.
Monomers, or base units are bonded together to create larger molecules via dehydration. This involves the removal of a water molecule at the bonding site. The larger molecule can be broken down by the reverse process, hydrolysis. This occurs when water is added to break the covalent bonds created during dehydration.

Carbohydrates have the general molecular formula CH_2O, and thus were once thought to represent "hydrated carbon". However, the arrangement of atoms in carbohydrates has little to do with water molecules.

Starch and cellulose are two common carbohydrates. Both are macromolecules with molecular weights in the hundreds of thousands. Both are polymers (hence "polysaccharides"); that is, each is built from repeating units, monomers, much as a chain is built from its links. The monomers of both starch and cellulose are the same: units of the sugar **glucose**.

Objective:
- Students will construct the basic components of organic molecular structure.
- Students will recognize the way macromolecules are put together and discover how smaller molecules are repeated to form polymers.

Vocabulary: Macromolecule, Monomer, Polymer, Carbohydrate, Monosaccharide, Disaccharide, Proteins, Amino acids, Lipids, Nucleic acids

Student

Materials (per group):

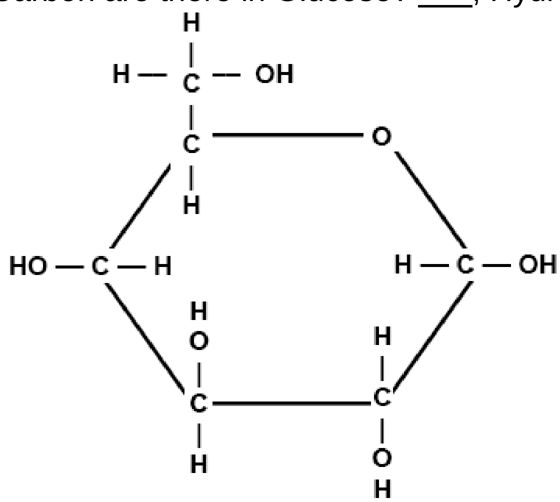
- Use different household or food items to represent the different elements
  - Blueberries= Hydrogen
  - Red Grapes= Oxygen
  - Green grapes= Carbon
  - Radish= Nitrogen
  - Bonds= wooden toothpicks or dry spaghetti pieces

Procedures:

1. Construct each of the following monomers and answer the questions using the information in the explain portion. Each group will submit completed models as a group. Include diagram of molecules as shown on this document.
2. Molecules are 3-dimensional so models cannot be flat! When constructing a functional group (-OH, -COOH, -NH2) put bonds between all the elements!!
3. Create a key in your journal identifying which food represents which element. Refer to this in building your models.
4. Draw all the molecules you create into your journal and answer the corresponding questions for each completely.

Construct glucose

A. How many atoms of Carbon are there in Glucose? ___; Hydrogen? ____; Oxygen? ___



B. What is the chemical formula for glucose?

C. Glucose is a monomer for what macromolecule?

D. What other simple sugar(s) has the same chemical formula as glucose?

E. Simple sugars like glucose are called.

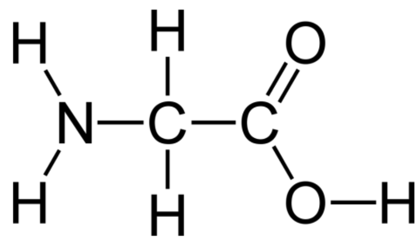
F. What is the function of carbohydrates for the body?

Student

Construct Glycine

A. Draw a BOX around the amino group on this picture.

B. Circle the carboxyl group on this picture.



C. Glycine is what type of monomer? (Two words)

D. Name the 4 things attached to the center carbon in ALL amino acids.
   i.
   ii.
   iii.
   iv.

E. How many amino acids exist?

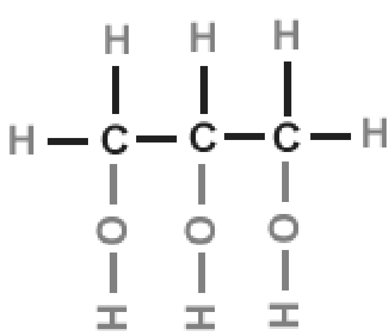
F. What element is found in amino acid that isn’t found in simple sugars like glucose or fructose?

G. Amino acids join together to make what type of macromolecule?

H. What are some of the functions of proteins in the body? (List several)

Construct Glycerol

A. Place a CIRCLE around a hydroxyl group.



Glycerol

Student

B. Glycerol is one of two molecules that make up a monomer known as

C. Besides glycerol, what 3 other molecules make up a triglyceride?

D. Glycerol and other organic compounds with an –ol ending are called

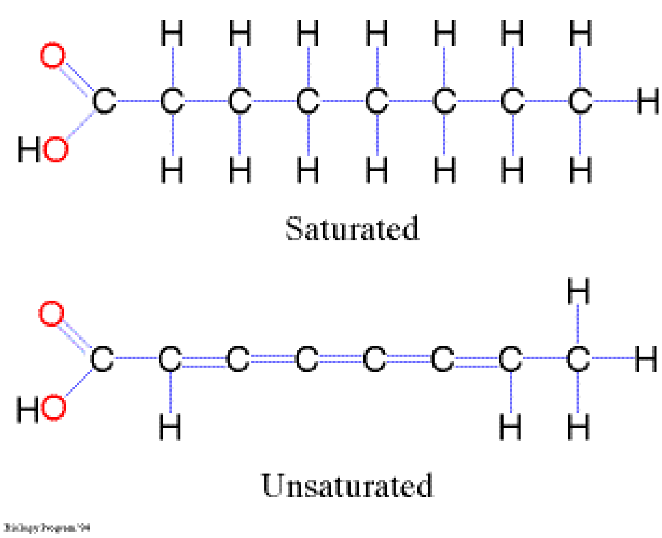
E. Triglycerides are the monomers for what type of macromolecule?

F. Give 3 types of lipids and give their function.
   i.
   ii.
   iii.

Construct a Fatty acid

A. Draw a BOX around the hydrocarbon chain in these pictures.

B. Circle the carboxyl group in both pictures.



C. Fatty acids are made of long chains of _______ atoms with attached ________ atoms.

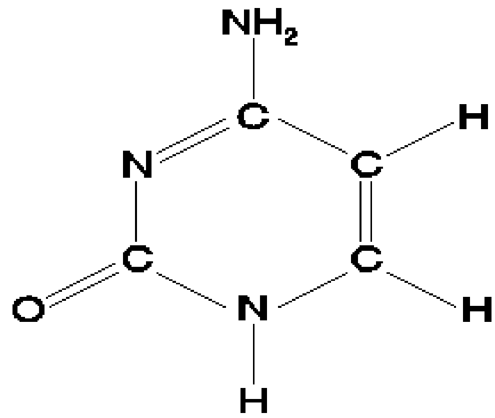
D. How many bond(s) does each carbon atom have?

E. How many bond(s) does each hydrogen have?

F. What 3 elements make up fatty acids?
- ______________________________
- ______________________________
- ______________________________

Student

Construct Cytosine



A. Cytosine is an example of a nitrogen base found on ____________ acids.

B. Name the 2 nucleic acids found in organisms.

C. List the name for the elements making up cytosine.

D. Name the other 3 nitrogen bases found on DNA.

E. What nitrogen base is found on RNA but not DNA?

Observations/Conclusions:

1. How many valence electrons does each carbon atom have?
2. What gives carbon the ability to form chains that are almost unlimited in length?
3. Many of the molecules in living cells are so large they are called ___________________
4. ______________________________ is the process that forms large organic molecules.
5. When two or more _________________ join together, a polymer forms.
6. Create a table in which you compare the components and functions of the following macromolecules: carbohydrates, lipids, nucleic acids, and proteins.

Student

Macromolecule	Components	Functions	Basic Structure and Formula
Carbohydrates			
Lipids			
Nucleic acids			
Proteins			

7. What role does water play in the process of building macromolecules? Why is it such an important component of life?

Extension:

- The Monomers of Macromolecules

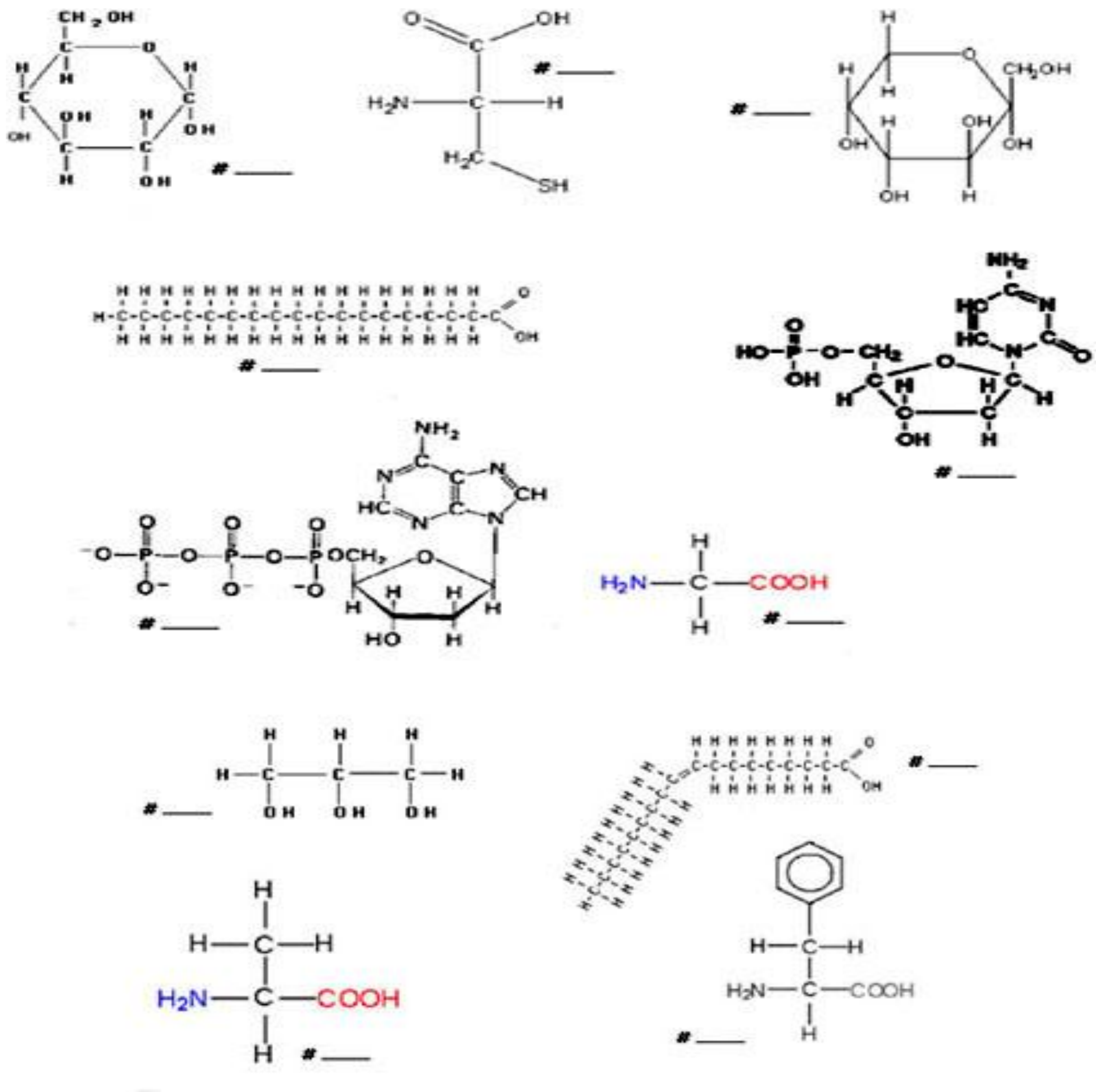
All key components of every living cell are made of macromolecules. The four kinds of macromolecules are lipids, carbohydrates, nucleic acids, and proteins. Most macromolecules are polymers constructed of many organic molecules called monomers.

These molecules represent one level of basic building blocks of life. These monomers, or single molecules, can be joined with other monomers to form larger units (polymers). They can be divided into four groups:

1. carbohydrates (sugars for energy and structure)
2. lipids (fats for membranes and energy storage)
3. nucleic acids (information bearers)
4. proteins (the molecular machines of the cells).

Student

Try to determine some ways of classifying these molecules below into four groups. There may be more than one right answer. Number each molecule 1, 2, 3 or 4.



Finally, what different kinds of atoms are present in these molecules? Write the initials of each kind of atom here ____.

Teacher

Enzyme Catalyst Lab

NGSSS:
SC.A.912.L.18.1 Describe the basic molecular structures and primary functions of the four major categories of biological macromolecules. (**AA**)

Purpose of Lab:
- Investigate the effect of variations in enzyme concentration on rate of reaction.
- Investigate the effect of variations in substrate concentration on rate of reaction.

Prerequisites: Review with students how enzymes affect activation energy. Describe how an enzyme's shape is important to its function. Ensure that students know the difference between the meaning of the word catalase and the word catalyst. Some students may confuse these terms. It is important that students are familiar with all of the vocabulary terms listed in the student section.

Materials (per group):
- Yeast solution
- Eight 50 ml beakers
- Hydrogen peroxide
- Distilled water
- Filter paper disks
- Marking pencil
- Forceps
- Paper towels
- Graph paper

Procedure: Day of Activity:

Before activity:	**What the teacher will do:** g. Prep work**:** Obtain all materials and prepare yeast solution well before beginning this lab activity. h. Before passing out the lab, 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. i. Use the following questions to engage student thinking during a pre-lab discussion: 1. What does catalyzed mean? 2. How does the induced-fit model apply to this lab activity? 3. What other factors can affect the rate of reaction? 4. What is meant by "denaturation of the protein?" j. Assign four students per group. For student reference, make copies of the "Lab Roles and Their Descriptions." k. Review the background information with the students. 1. Write the formula for hydrogen peroxide, H_2O_2, on the white board. Then write the following equation for its decomposition: $2H_2O_2 \rightarrow 2H_2O + O_2$ 2. Ask the following question. If hydrogen peroxide is a liquid, what might you expect to see when it decomposes? (Accept all reasonable answers.) Bubbles of gas will be visible as oxygen is released and water remains. 3. Explain to students that the function of the enzyme, catalase, is to speed up the decomposition of hydrogen peroxide. l. Read aloud or have a student read aloud the problem statement at the

	beginning of the investigation. Based upon the problem statement, have students decide on an individual hypothesis for their lab group, focusing on lower concentration effects and higher concentration effects on the rate of reaction. m. Remind students that they will complete a minimum of three trials for each peroxide solution.
During activity:	**What the teacher will do:** d. Circulate throughout the room and help any group that is having trouble with any aspect of the procedure. e. Monitor students for safety procedures, and keep students focused on their hypothesis. f. The following questions may be used to engage student thinking during the lab activity: 1. What is the substrate in this investigation? What is the enzyme? 2. What is the function of the enzyme in this investigation? 3. What are the reactants and products in the following equation? $2\ H_2O_2 \rightarrow 2\ H_2O + O_2$
After activity:	**What the teacher will do:** a. Ask the following questions. 1. Was your hypothesis confirmed or refuted? 2. How do your results compare to your preconceptions of what would happen? 3. What experimental conclusions can you now draw from your data? b. Ask the following questions to connect the concepts of this activity to the NGSSS. 1. Explain the role of activation energy in a reaction. How does an enzyme affect activation energy? 2. Describe how a substrate interacts with an enzyme. c. In a five-minute oral presentation, the students should share with the class the results of their investigation. Here, they should state their hypothesis and discuss whether their results confirm or refute their hypothesis. (Allow for time to debate and discussion between groups.) d. Have students complete a formal lab report.

Extension:

- Gizmo: Collision Theory
- **This Extension is necessary to fulfill the annually assessed benchmark associated with this unit:**
  1. Choose another factor to test. Develop a new problem statement and design a new experiment to test for this factor. Record all parts of the lab (from the parts of a lab) in your journal. Present your findings to the class.
  2. Make sure to identify the test (independent) variable, responding (dependent) variable, controls, and constants.

Student

Enzyme Catalyst Lab

NGSSS:
SC.A.912.L.18.1 Describe the basic molecular structures and primary functions of the four major categories of biological macromolecules. (**AA**)

Background:
This lab focuses on one particular enzyme – catalase. Catalase plays an indispensable role in a living cell by preventing the accumulation of toxic levels of hydrogen peroxide formed as a byproduct of metabolism. 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: How will different concentrations of hydrogen peroxide affect the reaction of an enzyme? Or develop your own problem statement and experiment based on the factors that can affect the reaction rate of a catalyst. (pH, temperature, or concentration)

Safety:
- Hydrogen peroxide is an oxidizer and could bleach clothing.
- Protect clothing by wearing a lab apron.
- Wear safety goggles

Vocabulary: activation energy, active site, enzyme, catalase, catalyst, denaturation, enzyme, induced-fit model, rate of reaction, substrate

Materials (per group):
- Yeast solution
- Hydrogen peroxide
- Filter paper disks
- Forceps
- Eight 50 ml beakers
- Distilled water
- Marking pencil
- Paper towels
- Hot plate
- Vinegar
- Graph paper

Procedures:
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).

Observations/Data:

Table: Rising Time

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

Data Analysis:
Construct and analyze a graph from your table.

Results/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.
4. Complete a formal laboratory report.

Extension:
1. Choose another factor to test. Develop a new problem statement and design a new experiment to test for this factor. Record all parts of the lab (from the parts of a lab) in your journal. Present your findings to the class.
2. Make sure to identify the test (independent) variable, responding (dependent) variable, controls, and constants.

Teacher

Properties of Water

NGSSS:
SC.912.L.18.12 Discuss the special properties of water that contribute to Earth's suitability as an environment for life: cohesive behavior, ability to moderate temperature, expansion upon freezing, and versatility as a solvent. (**AA**)

Purpose of the Lab/Activity:
- Determine the effect of the different substances on the properties of water.
- Investigate water's properties and behaviors.
- Explain why water is a polar molecule and investigate the effects of that polarity.

Prerequisites:
- Students should understand chemical bonding.
- Students should be able to explain polarity.
- Students should understand the importance of water in living things.
- Students should be able to explain the states of matter.

Materials (per group):
- glass of water
- paperclip
- penny
- soda straw
- Hot plate (optional for new questions)
- Salt (optional for new questions)
- glass slide
- glass test tube
- a strip of jeans
- paper strip with a marker dot
- wax paper

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. You can modify this lesson by providing the materials to the students and allowing them to develop their own controlled experiment. Procedural plan would have to be approved prior to experimentation. b. Demonstration: Water Molecule Model and Physical States 1. On the front desk set up a large beaker on a hot plate. 2. Obtain ice cubes for the demo. 3. Construct a 3-D model of a water molecule. Use something round and large for the oxygen atom (like an orange) and two smaller round objects (grapes) for the two hydrogen atoms. Use a toothpick to connect the objects. Remember the hydrogen atoms make a 105^0 angle with the center of the oxygen atom. 4. At the start of the period, put some water and ice cubes in the beaker on the hot plate at the front desk and turn the heat on high. Advise students to keep an eye on what is happening as you continue. c. Activate student's prior knowledge by asking the following questions: 1. What is water? How would you best describe what water is in chemical terms? Water is a molecule composed of two atoms of hydrogen bonded to an oxygen atom. 2. Explain the physical phases of water. Water molecules exists as a

	solid, liquid or gas. As a solid (ice), water molecules are bonded to each other in a solid, crystalline structure. As a liquid, some of the molecules bond to each other with hydrogen bonds (bonds break and reform continuously). As a gas, water vapor, the water molecules are not bonded to each other (they float as single molecules). 3. Water is a polar molecule. What does that mean? It means that there is an uneven distribution of electron density. Water has a partial negative charge near the oxygen atom due to the unshared electrons, and partial positive charges near the hydrogen atoms. d. Have students write a hypothesis for each of the following water concepts: To do this you need to pick a specific substance from the materials list to test for each hypothesis. e. Students should have eight hypotheses. For example, one hypothesis might be: If the substance used is the penny then the water will group together and show surface tension. f. The group's hypotheses must be approved prior to experimentation.
During activity:	**What the teacher will do:** a. Monitor students to make sure they are remaining on task and are following their procedural plan. b. Review the experimental design diagram by asking individual students in groups to explain the different parts of the experiment. c. Follow laboratory procedural plan; making sure to model proper laboratory safety and use of equipment. d. Emphasize importance of data collection by groups. e. Ask the following questions: 1. How many drops of water can you place on a penny? Why do you think this? 2. Predict what would happen if you added soap to the water, would the penny be able to hold more water. Explain why. 3. What will the drop of water look like on the wax paper? Why do you think this? 4. Predict what will happen to the drop on the paper when it is placed in the beaker? Why do you think this? 5. What will happen when the straw is placed in a beaker of water? 6. Describe the properties of water do you think are responsible for water's unique behaviors?
After activity:	**What the teacher will do:** a. Analyze class data; making sure to note the importance of multiple trials, and repeatability in scientific investigations. b. Answer Key for Results: 1. How did this investigation demonstrate cohesion, adhesion surface tension and capillary action? Commercial bubble solution should create the biggest bubble. 2. What implications do these concepts have for living things? Answers will vary. Students show include data that explains the difference in bubble size between the 4 solutions tested. 3. Have you ever done a belly flop? If so explain how it felt and what property of water caused you to feel pain. If not, guess what property of

	water causes the pain felt from doing a belly flop. Answers will vary. Doing a belly flop stings because of water's surface tension. 4. Why is water important for keeping animals cool? How does sweating cool us down? Water is the medium in which all chemical reactions in the body take place. Water regulates animal's body temperature. By sweating, animals attempt to lose extra body heat via evaporative cooling. 5. Why does ice float? Why is this important to the fish in a lake? Ice floats because it is less dense than liquid water. If water did not act like this any fish or other organisms that live in the lake would not be able to survive during the winter. 6. What are the terms used to describe waters attraction to itself and other things? What bonding allow for this? What does the charge of the molecule have to do with its properties? Water is attracted to other water. This is called cohesion. This is due to the polarity of the water molecule and the hydrogen bonding involved. The hydrogen of one molecule (positive charge) is attracted to the oxygen (negative charge) of another molecule. Water can also be attracted to other molecules. This is called adhesion. 7. What attraction is important to water striders? Surface tension

Extension:

- Web Tutorial: Properties of Water
- Gizmo: Element Builder
- **This Extension is necessary to fulfill the annually assessed benchmark associated with this unit:**
  1. Choose another factor to test. Develop a new problem statement and design a new experiment to test for this factor. Record all parts of the lab (from the parts of a lab) in your journal. Present your findings to the class.
  2. Make sure to identify the test (independent) variable, responding (dependent) variable, controls, and constants.

Student

Properties of Water

NGSSS:
SC.912.L.18.12 Discuss the special properties of water that contribute to Earth's suitability as an environment for life: cohesive behavior, ability to moderate temperature, expansion upon freezing, and versatility as a solvent. (**AA**)

Background:
Water is the most common substance on Earth. Nearly three-quarters (about 70 percent) of the Earth's surface is covered with water. Water is unique because it is the only substance that occurs naturally on Earth in all three states—solid, liquid, and gas. About 2 percent of the world's water is solid, including snow, frost, glaciers, and the polar ice sheet. Less than one-thousandth of a percent of the world's water is gaseous, as water vapor. The rest of the world's water is liquid, and can be found in oceans, seas, lakes, rivers, streams, and groundwater.

Sometimes we call water H_2O. That's because water molecules have two hydrogen atoms and one oxygen atom. While water molecules are neutral as a whole, one end of the water molecule tends to have a positive charge while the other has a negative charge (polarity). Each end of a water molecule is attracted to the opposite charged end of another water molecule.
This is called "hydrogen bonding."

Cohesion is the attraction of water molecules to other molecules. It is the result of hydrogen bonding – the attraction of the hydrogen atoms in water to the oxygen atoms in water. It is the property that allows water droplets to form. Cohesion is responsible for surface tension. This property allows some insects to walk across water.

Adhesion is the ability of water to stick to other surfaces. For example, water forms on mirrors in a steamy bathroom. Adhesion is a property that causes water to be drawn up through soil and into paper towel. When water is drawn up through small spaces, it is called capillary action.

Water is an amazing substance that is critical to life. It serves a purpose in various processes such as cellular metabolism, heat transfer, and structural support. For these reasons and more, the presence of water is a good indicator that life may be sustainable in certain environments, such as the Jovian moon of Europa.

Problem Statement: What are the properties of water that contribute to living things? Or develop your own problem statement and experiment based on the different properties of water and its importance to sustaining life on earth (ability to moderate temperature, cohesion, etc.)

Safety: Make sure that the bubble solution is poured on top of trash bags on the tables, report any spills immediately to the teacher. Use napkins routinely to clean up your lab area.

Vocabulary: polar, nonpolar, adhesion, cohesion, surface tension, capillary action, solvent

Student

Materials (per group):

- glass of water
- paperclip
- penny
- soda straw
- glass slide
- glass test tube
- hot plate (optional)
- salt (optional)
- a strip of jeans
- paper strip with a marker dot
- wax paper

Procedures:

- Write a hypothesis for each of the following water concepts:
- To do this you need to pick a specific substance from the materials list to test for each hypothesis. You should have eight hypotheses. For example, one hypothesis might be: If the substance used is the penny then the water will group together and show surface tension.
- After getting approval for all of your hypotheses you will need to write your procedures. It may help you to look at the data table.

Observations/Data:

Check the appropriate box if the listed property occurred in your experiment. Polar or Non-Polar must be selected for each investigation.

Properties of Water

Substance	Polar	Non-Polar	Adhesion	Cohesion	Surface Tension	Capillary Action
Putting paper clip in water						
Pouring water on penny						
Putting regular straw in water						
Putting jean strip in water						
Putting paper strip with dot in water						
Pouring water on glass slide						
Pouring water on wax paper						
Putting water in test tube						

You should also collect qualitative data such as observations about each substance.

Student

Results:

1. From the data collected, what happened in each of the 8 procedural plans.
2. How do you know those substances possess the qualities of the ones you checked?

Conclusion:

1. How did this investigation demonstrate cohesion, adhesion surface tension and capillary action?
2. What implications do these concepts have for living things?
3. Have you ever done a belly flop? If so explain how it felt and what property of water caused you to feel pain. If not, guess what property of water causes the pain felt from doing a belly flop.
4. Why is water important for keeping animals cool? How does sweating cool us down?
5. Why does ice float? Why is this important to the fish in a lake?
6. What are the terms used to describe waters attraction to itself and other things? What bonding allow for this? What does the charge of the molecule have to do with its properties?
7. What attraction is important to water striders?

Extension:

- **<u>This Extension is necessary to fulfill the annually assessed benchmark associated with this unit:</u>**
    1. Choose another property of water to test. Develop a new problem statement and design a new experiment to test for this property. Record all parts of the lab (from the parts of a lab) in your journal. Present your findings to the class.
    2. Make sure to identify the test (independent) variable, responding (dependent) variable, controls, and constants.

Teacher

Classification – Fishing for Protists

(Adapted from: Biology Exploring Life. Prentice Hall)

NGSSS:
SC.912.L.15.6 Discuss distinguishing characteristics of the domains and kingdoms of living organisms. (**AA**)

Purpose of Lab/Activity:

- 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.
- The student will be able to construct a dichotomous key using the protists studied.

Prerequisite:

- Students should be able to know the names of anatomical structures of protists.
- Students should be familiar with the classification system of organisms.

Materials (per group):

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

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Collect pond or canal water from your area and check for protists for use in the lab. Make sure to include algae or other type of producer in the water in order to keep the protists alive for a longer period of time. b. Discuss the following essential questions: 1. What kind of organisms do you think you will find in the water samples? 2. Predict features in protists that can be used to classify them. 3. Activate students' prior knowledge of protists and engage their interest. 4. Show the students pictures of protists and prompt them to see if they know: "How they are classified?", "Where do we find them in our environment?"
During activity:	**What the teacher will do:** a. Reinforce the expectations of the lab and review the directions. 1. Remind students to draw all other protists they see and write down their observations on their structure and movement. b. Review the following questions with the students. 1. What is the definition of a protist? 2. What specific features distinguishes them from each other? 3. What distinguishing characteristics allow them to be classified into their own kingdom?
After activity:	**What the teacher will do:** a. Engage in class discussion use the following questions as a guide: 1. Compare the anatomy of the protists in both habitats. What are the

	differences? 2. Did the data support your hypothesis? Explain your response. 3. Did the protists share any characteristics? 4. How did habitat affect the type and characteristics of the protists that live in the area? 5. Why is it necessary to construct dichotomous keys? b. Construct a dichotomous key using four protists studied in the lab. What is your reasoning for putting them in this order? c. 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.

Student

Classification – Fishing for Protists

(Adapted from: Biology Exploring Life - Prentice Hall)

NGSSS:
SC.912.L.15.6 Discuss distinguishing characteristics of the domains and kingdoms of living organisms. (**AA**)

Background:
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.

Purpose or Problem Statement: (Choose one or make up your own)

- Does environment determine the type of protist found?
- How does the presence of light affect the type of protists that inhabit an area?
- What protist characteristic affects its classification?

Safety: Wash hands after handling protists, microscope procedures

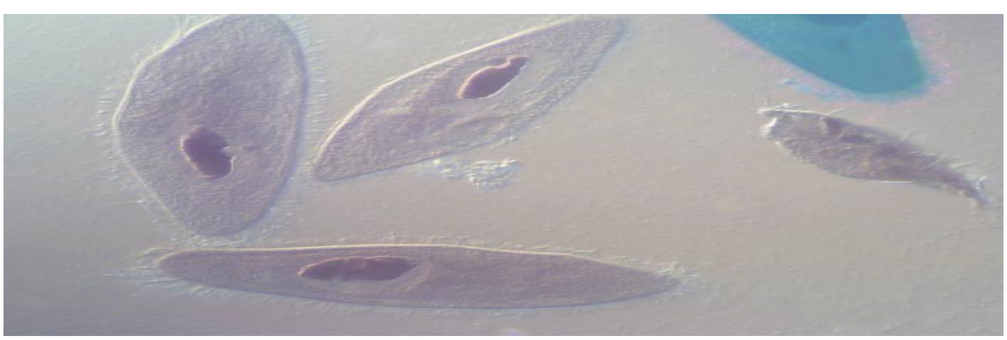
Vocabulary:
Protist, Euglena, Amoeba, Paramecium, Stentor, flagella, pseudopod, cilia, dichotomous key

Materials:

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

Procedures:

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.



Student

Observations/Data:

Surface Sample

Sketch	Description	Identification

Bottom Sample

Sketch	Description	Identification

Data Analysis/Results:

1. Compare the anatomy of the protists in both habitats
2. Construct a dichotomous key using four protists studied in the lab.
3. Did the data support your hypothesis? Explain your response.
4. Did the protists share any characteristics?
5. How did habitat affect the type and characteristics of the protists that live in the area?
6. Why is it necessary to construct dichotomous keys?

Teacher

Genetic Disorders: Informational Poster and Presentation

NGSSS:
SC.912.L.16.1 Use Mendel's Laws of Segregation and Independent Assortment to analyze patterns of inheritance. (**AA**)
SC.912.L.16.3 Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information. (**AA**)

Purpose of Activity:

- To research the symptoms, causes, treatments, social ramifications, and support groups of various genetic disorders.
- To provide students with a forum to discuss the significance of genetic factors, environmental factors, and pathogenic agents to health from the perspectives of both individual and public health.
- To provide an opportunity for students to analyze how heredity and family history can impact personal health.

Prerequisite: Students should be familiar with Mendelian inheritance patterns. They should know about chromosomes and the process of meiosis. Review meiosis before beginning this activity. Students should be familiar with how to read and construct a pedigree. They should also be familiar with such terms as single-gene defect, sex-linked disorders, and chromosomal disorders.

Materials (per group):

- Construction paper
- Diagrams
- Drawings
- Glue
- Markers
- Pictures
- Poster board
- Stapler

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Prep work: A week before the due date for the poster presentation, have students read the entire activity and clarify any misunderstandings they may have for the development of their Genetic Disorder Informational Poster and Presentation. Remind students that information must be typed and glued to a poster board. Emphasize that pictures, drawings and diagrams are desired. b. Some students may wish to use a "*Power Point*" presentation. If possible, the computer, LCD Projector, and/or overhead projector should be made available for student use. c. Review the causes of genetic disorders. The following questions can be used to elicit students' prior knowledge: 1. What is the relationship between trisomy 21 and Down syndrome. Describe how nondisjunction can result in trisomy 21. A person with trisomy 21 shows a set of symptoms called Down syndrome. If the pair of chromosomes in chromosome 21 fails to separate during meiosis, this could result in a gamete with an abnormal number of chromosome 21.

	2. List and define four types of damage to chromosome structure that can cause disorders. Duplication occurs when part of a chromosome is repeated; deletion occurs; deletion occurs when a fragment of a chromosome is lost; inversion occurs when a fragment of a chromosome reverses; translocation occurs when a fragment attaches to a nonhomologous chromosome. 3. How is a mother's age related to the probability of nonseparation of chromosomes in her gametes? With an increase in the mother's age, there is an increase in the probability of nonseparation of chromosomes (nondisjunction) during meiosis.
During activity:	**What the teacher will do:** a. After each poster presentation, the following questions should be asked in order to engage student thinking during the activity: 1. How do you recognize someone with this particular disease? 2. What is/are the cause(s) of this disease? 3. What are the complications of this disease? Is the disease fatal? 4. What are the social ramifications for those afflicted with this particular disease?
After activity:	**What the teacher will do:** a. Conduct a whole class discussion to assess student understanding and connect concepts of this activity to the NGSSS. Ask the following questions to guide your discussion: 1. What are examples of a recessive disorder, a dominant disorder, and a sex-linked recessive disorder, and describe how each is inherited? Recessive disorders such as albinism occur when a child inherits a recessive allele from each parent. Dominant disorders such as Huntington's disease occur when a child receives at least one dominant allele from a parent. A sex-linked recessive disorder such as colorblindness occurs when a male inherits the allele on an X chromosome from his mother or a female inherits the recessive allele on both X chromosomes. 2. What does a genetic counselor do? A genetic counselor examines a couple's family histories for any disorders with Mendelian characteristics; interprets genetic test results; helps couple determine risk of passing on disease to offspring.

Extension:

- Genetic Disorder Library: http://learn.genetics.utah.edu/content/disorders/whataregd/
- Gizmo: Human Karyotyping

Student

Genetic Disorders: Informational Poster and Presentation

NGSSS:
SC.912.L.16.1 Use Mendel's Laws of Segregation and Independent Assortment to analyze patterns of inheritance. (**AA**)
SC.912.L.16.3 Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information. (**AA**)

Background:
Genetic disorders are caused by abnormalities in genes or chromosomes. While some diseases, such as cancer, are due in part to genetic disorders, they can also be caused by environmental factors. Most disorders are quite rare and affect one person in every several thousands or millions. In this activity, you will select a genetic disorder from a list and develop a poster presentation.

Purpose of Activity:
- To research the symptoms, causes, treatments, social ramifications, and support groups of various genetic disorders.
- To provide students with a forum to discuss the significance of genetic factors, environmental factors, and pathogenic agents to health from the perspectives of both individual and public health.
- To provide an opportunity for students to analyze how heredity and family history can impact personal health.

Vocabulary: autosomal dominant, autosomal recessive, chromosomal defect, deletion, inversion, karyotype, multifactorial, mutation, pedigree, polygenic, sex-linked disorder, single-gene defect, translocation, X-linked dominant, X-linked recessive, Y-linked

Materials (per group)
- Construction paper
- Diagrams
- Drawings
- Glue
- Markers
- Pictures
- Poster board
- Stapler

Student

Genetic Disorder: ____________________________________ **Due Date**: ________________

Procedures:
Information on your poster must be written in your own words and include the following:

1. The name of your disease. (Choose a genetic disorder from the next page.)
2. Phenotypic characteristic: How do you recognize someone with your disease?
3. Describe the genetics of the disease. For example:
   a. What chromosome pair is affected?
   b. Is it a result of translocation?
   c. Is it sex-linked?
   d. Does it skip a generation?
4. What are the causes of your disease? How does it occur? Is it preventable? How?
5. What are the symptoms and complications of your disease?
6. Is the disease fatal? When? What is the life expectancy of an individual with the disorder?
7. What are current treatments for the disease? How effective are they?
8. What questions are researchers currently attempting to answer?
9. What are the social ramifications for those afflicted with the disease?
10. What are the support groups that exist for this disease? List at least one support organization.
11. Bibliography must contain a minimum of four references, two of which must be from the internet.

Information must be typed and glued to a poster board. Pictures, drawings and diagrams increase your grade.

GRADING: The final grade will have a value of three grades and will be calculated based on the following:

- Poster Content (60 points)
- Poster Presentation (40 points)

This form must be signed and turned in on the project due date.

I have read and understand the guidelines for the poster project assignment.
I understand that not turning in a poster will result in a zero grade. I also understand that if I do not present, the maximum number of points I can receive is 60, which will result in a D for the assignment. I also understand that the information on my poster board MUST be in my own words and not copied directly from the source!

STUDENT SIGNATURE: ____

PARENT/GUARDIAN SIGNATURE: _______________________________________

Genetic Disorders

Choose a disorder from this list for your group's project.
No two groups may choose the same topic.

Achondroplasia

Achromatopsia

Adrenoleukodystrophy

Cri Du Chat Syndrome

Cystic Fibrosis

Fragile X Syndrome

Hemochomatosis

Hemophilia

Huntington's Disease

Klinefelter Syndrome

Krabbes Disease

Leukodystrophy

Marfan Syndrome

Neurofibromatosis

Porphyria

Prader-Willi Syndrome

Progeria

Sickle Cell Disease

Tay - Sachs Disease

Trisomy X

Turner's Syndrome

Wilson's Disease

Modified
Hands-on Activities

Teacher

Marine Food Web Activity

(Modification to Designing Food Chains and Food Webs)

NGSSS:
SC.912.L.17.9 Use a food web to identify and distinguish producers, consumers, and decomposers. Explain the pathway of energy transfer through trophic levels and the reduction of available energy at successive trophic levels. (**AA**)

Objective: The student will understand the interrelatedness of food webs and see how populations affect other populations.

Materials: yarn, organism cards, hole-puncher, scissors

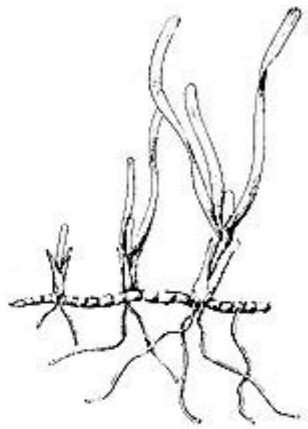
Procedures:

1. Review the concept of ecosystems by asking students what they think of when they hear the word "Florida marine ecosystem." List their responses as a flow chart. Ask students how the listed items (e.g. algae, plants shrimp, manatee etc.) interact. As students respond (e.g. the manatee lives in the oceans, the shrimp eats the algae, etc.), draw connecting lines between the listed items.
2. Ask students what they think the diagram looks like (a spider web). Introduce the concept of food chains and food webs. Introduce and show the Brain Pop free video. Following the video on food webs, ask for comments from students. What was most memorable about the film?
3. Move the students to an open area. Without in-depth explanation, have students stand in a large circle in an open area (preferable outdoors). The teacher should stand in the center of the circle. Explain that students will be transformed into a marine ecosystem.
4. Distribute organism cards to the students. (Punch holes in each card and give each participant a card and a piece of string to hang the card around his/her neck.
5. Have individuals identify energy (or food) sources. As each one is identified, pass a ball of yarn between the two people. For example: One student is a cow, and one is the grass. The cow will take the ball of yarn, hold onto one end of the string and pass the rest of the ball to the grass. The grass will hold onto the yarn and pass the rest of the ball to "what it eats," in this case, the sun. Be sure that the sun is connected to all the plants. Once the string gets to the sun, cut it off, and start again in another place.
6. Continue building the web, making the relationships as complex as time and numbers of participants allow.
7. Define terms such as herbivore, carnivore, insectivore, decomposer, etc and include them in your web. [Note that insectivores are specialized carnivores.]
8. Students can be in as many chains as you have time for; they do not have to be in all of the chains.
9. Discuss the nature and complexity of the food web that is formed. Note that it is not as complete or complex as most natural food webs, but that it illustrates how living things are dependent upon one another. Biologists feel that more complex food webs are more stable than simple ones.
10. After discussing the food web, the leader could ask what would happen if a species were removed from the web. Have a student pull on the strings they hold; anyone who feels a tug is directly affected by that organism. Those "organisms" affected directly could then pull on their strings and more organisms are affected.

11. Have different students pull on their strings. When the “sun” pulls on its string, everyone should be affected.
12. Have some organisms drop their string (become extinct) and see who is affected.
13. Have students tell you if certain populations will grow or decline. The teacher can represent nature and cause any type of problem to occur; for example, a wildfire could occur, but some birds were able to fly away and some types of trees reseed well after a fire. The teacher defines what happens and who is affected; the students then reveal what would happen.
14. New species could also move into the area at any time disrupting the web.
15. Discuss what would happen if all of the predators were removed. Some species might exhaust their food supply and starve, but others will continue to reproduce only until the food supply becomes limiting or their interactions limit population size.
16. If desired, discuss the simplified food webs that produce most foods used by people. Remind the participants that such food webs are inherently unstable and require large amounts of management (raising/slaughtering cows, chickens, etc) to avoid problems.
17. Upon returning to the classroom, have students complete a food chain and food web diagram based on the simulated classroom web. Remind them of the different interactions between plants and animals, shared food sources, etc. The images can be used for evaluation and posted throughout the classroom.

Teacher

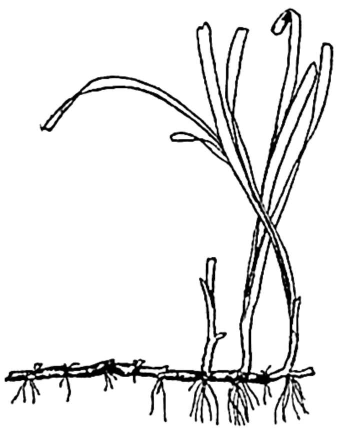
Trophic Level	Organism	Consumes	Consumed By
Producer	Turtle grass	Autotroph	Manatees
	Eel grass	Autotroph	Not eaten
	Shoal grass	Autotroph	Manatees
	Manatee grass	Autotroph	Manatees
	Wigeon grass	Autotroph	Manatees
	Diatoms	Autotroph	Scallops, crabs, shrimp
	Dinoflagellates	Autotroph	Zooplankton
	Green algae	Autotroph	Fish, crabs, zooplankton, sea urchins
	Brown algae	Autotroph	Sea stars, crabs, sea urchins
	Sargassum	Autotroph	Sea turtles
	Sea lettuce	Autotroph	Conch, fish larvae
Primary Consumer	Scallops	Plankton	Starfish
	Zooplankton	Algal cells (phytoplankton)	Oyster, scallops, sea stars
	Conch	Seagrasses	Lemon sharks, sea turtles, octopi, crabs
	Krill	Algal cells (phytoplankton)	Lanternfish
	Oysters	Plankton	Starfish
	Oithona	Algal cells (phytoplankton)	Fish larvae, squids
	Fish larvae	Seagrasses, algae	Crabs. Lanternfish, sea stars
	Crab	Seagrasses, algae, sea stars	Octopi, squids, emperor angelfish, lemon sharks
	Shrimp	Seagrasses, algal cells	Lanternfish
	Manatee	Seagrasses	None
Secondary Consumer	Emperor angelfish	Worms, sponges, coral animals, shrimp	Jellyfish, squids, octopi
	Squid	Fish, copepods, krill	Dolphins
	Octopus	Fish, copepods, krill	Moray eels, dolphin
	Jellyfish	Small fish	Crabs, sea turtle
	Moray eel	Fish, squid, octopus	Tiger sharks, lemon sharks
	Lanternfish	Shrimp, krill, copepods	Killer whales, dolphin, tiger sharks
	Dolphin	Squid, fish	Killer whales
	Tuna	Fish	Killer whales, dolphin, tiger sharks
	Sea star	Scallops, oysters, coral, fish	Fish, crabs
	Sea anemone	Small fish, zooplankton	Sea stars
Tertiary consumer	Tiger shark	Invertebrates, fish, marine mammals	Killer whales, tiger sharks
	Lemon shark	Fish, invertebrates, fish, marine mammals	Killer whales, tiger sharks
	Sea turtle	Fish, invertebrates	Lemon sharks, tiger sharks
	Killer whale	Fish, invertebrates, marine mammals	Top of food chain
Scavenger	Sea urchins	Decaying plant and animal matter	Fish
	Sea cucumbers	Decaying plant and animal matter	Sea star, fish
Decomposer	Marine fungi	Decaying plant and animal matter	Oysters
	Marine Bacteria	Decaying plant and animal matter	Oysters

<table>
<tr><td>TURTLE GRASS
</td><td>TURTLE GRASS

TROPHIC LEVEL: producer

FEEDING TYPE: autotrophic

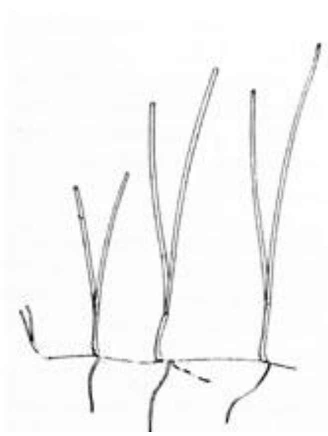
PREFERRED FOODS: make their own food

PREDATORS: manatees</td></tr>
<tr><td>EEL GRASS
</td><td>EEL GRASS

TROPHIC LEVEL: producer

FEEDING TYPE: autotrophic

PREFERRED FOODS: make their own food

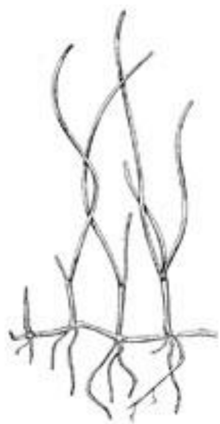
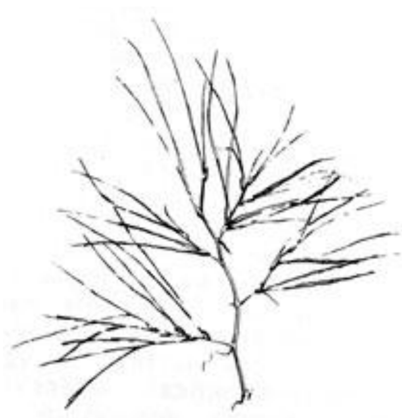
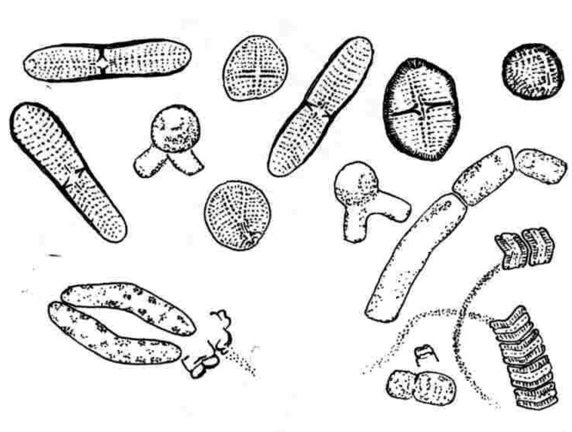
PREDATORS: not eaten</td></tr>
<tr><td>SHOAL GRASS
</td><td>SHOAL GRASS

TROPHIC LEVEL: producer

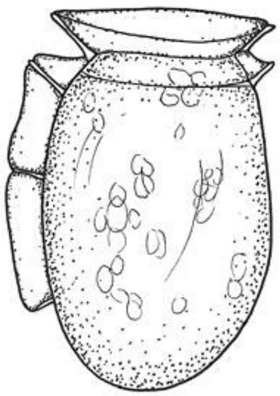
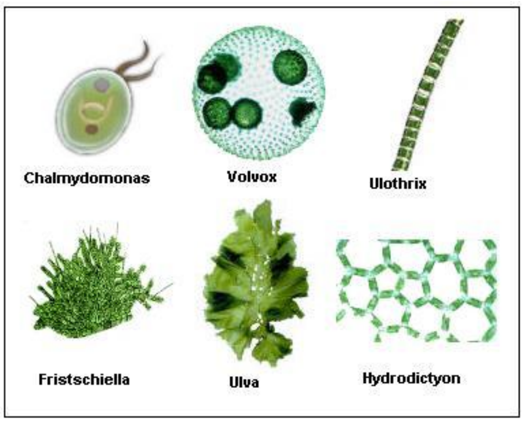
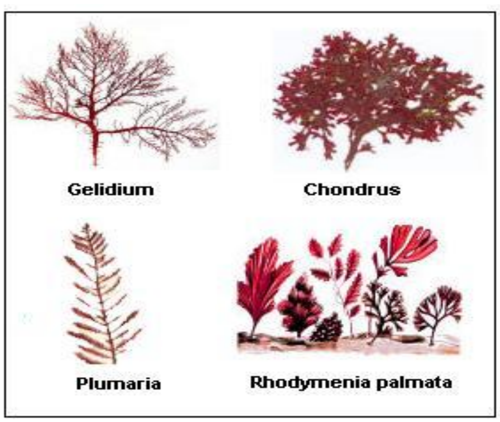
FEEDING TYPE: autotrophic

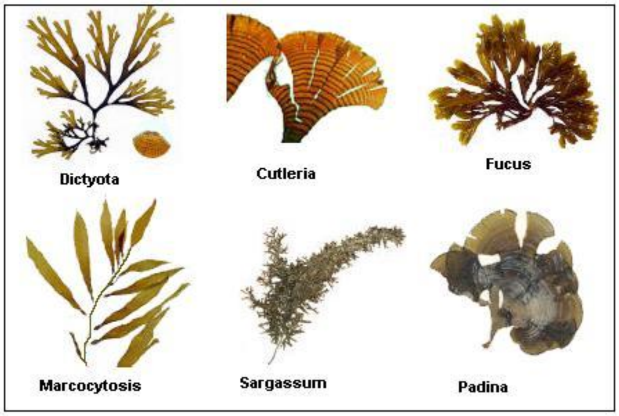
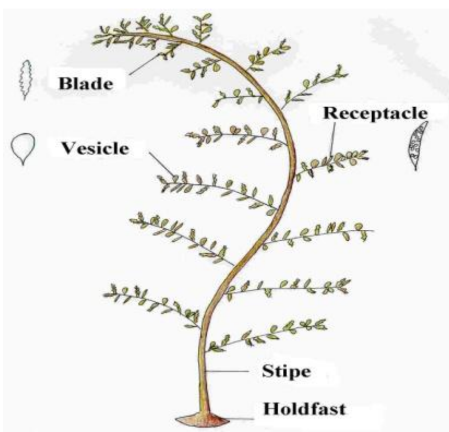
PREFERRED FOODS: make their own food

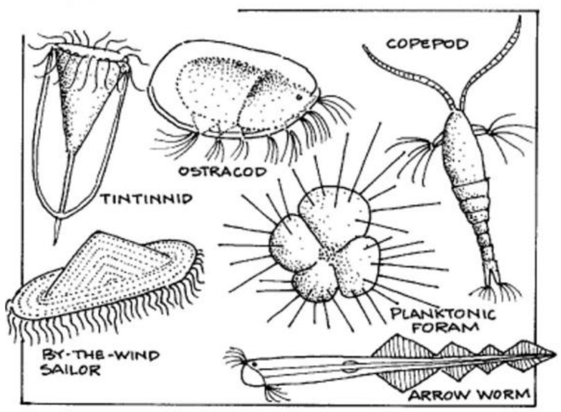
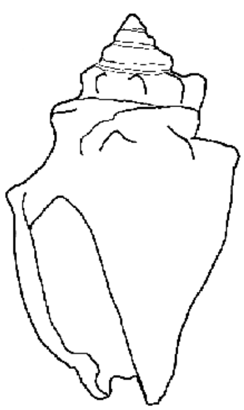
PREDATORS: manatees</td></tr>
</table>

MANATEE GRASS 	**MANATEE GRASS** **TROPHIC LEVEL: producer** **FEEDING TYPE: autotrophic** **PREFERRED FOODS: make their own food** **PREDATORS: manatees**
WIDGEON GRASS 	**WIDGEON GRASS** **TROPHIC LEVEL: producer** **FEEDING TYPE: autotrophic** **PREFERRED FOODS: make their own food** **PREDATORS: manatees**
DIATOMS 	**DIATOMS** **TROPHIC LEVEL: producer** **FEEDING TYPE: autotrophic** **PREFERRED FOODS: make their own food** **PREDATORS: Scallops, crabs, shrimp**

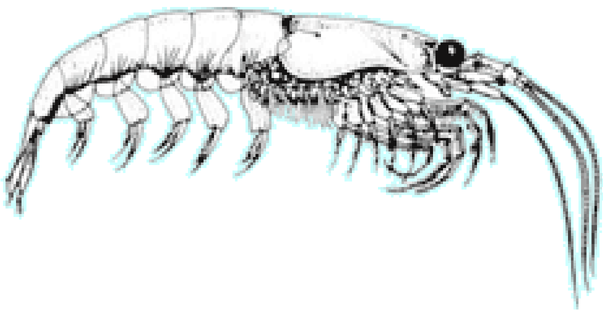
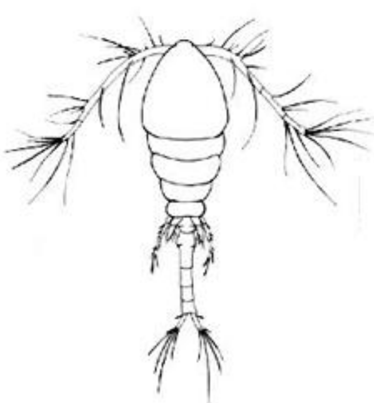
Teacher

DINOFLAGELLATES 	**DINOFLAGELLATES** **TROPHIC LEVEL: producer** **FEEDING TYPE: autotrophic** **PREFERRED FOODS: make their own food** **PREDATORS: zooplankton**
GREEN ALGAE 	**GREEN ALGAE** **TROPHIC LEVEL: producer** **FEEDING TYPE: autotrophic** **PREFERRED FOODS: make their own food** **PREDATORS: sea turtles, zooplankton**
RED ALGAE 	**RED ALGAE** **TROPHIC LEVEL: producer** **FEEDING TYPE: autotrophic** **PREFERRED FOODS: make their own food** **PREDATORS: fish, crabs, sea urchins, zooplankton**

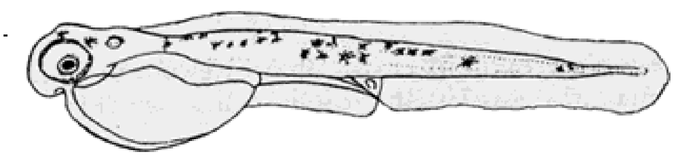
BROWN ALGAE  	**BROWN ALGAE** **TROPHIC LEVEL: producer** **FEEDING TYPE: autotrophic** **PREFERRED FOODS: make their own food** **PREDATORS: sea stars, crabs, sea urchins**
SARGASSUM  	**SARGASSUM** **TROPHIC LEVEL: producer** **FEEDING TYPE: autotrophic** **PREFERRED FOODS: make their own food** **PREDATORS: sea turtles**
SEA LETTUCE 	**SEA LETTUCE** **TROPHIC LEVEL: producer** **FEEDING TYPE: autotrophic** **PREFERRED FOODS: make their own food** **PREDATORS: conch, fish, larvae**

SCALLOP 	**SCALLOP** **TROPHIC LEVEL: primary consumer** **FEEDING TYPE: herbivore** **PREFERRED FOODS: algae, plant plankton** **PREDATORS: starfish**
ZOOPLANKTON  	**ZOOPLANKTON** **TROPHIC LEVEL: primary consumer** **FEEDING TYPE: herbivore** **PREFERRED FOODS: algal cells** **PREDATORS: oysters, sea stars, scallops**
CONCH 	**CONCH** **TROPHIC LEVEL: primary consumer** **FEEDING TYPE: herbivore** **PREFERRED FOODS: seagrasses** **PREDATORS: lemon sharks, sea turtles, octopi**

Teacher

KRILL 	**KRILL** **TROPHIC LEVEL: primary consumer** **FEEDING TYPE: herbivore** **PREFERRED FOODS: algal cells** **PREDATORS: lanternfish**
OYSTER 	**OYSTER** **TROPHIC LEVEL: primary consumer** **FEEDING TYPE: herbivore** **PREFERRED FOODS: algal cells** **PREDATORS: starfish**
OITHONA 	***OITHONA*** **TROPHIC LEVEL: primary consumer** **FEEDING TYPE: herbivore** **PREFERRED FOODs: algal cells** **PREDATORS: fish larvae, squids**

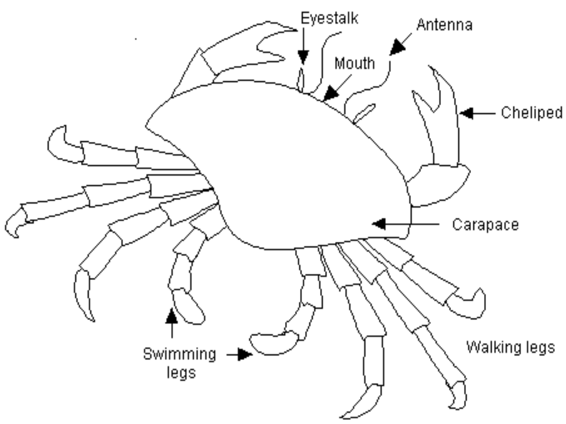
Teacher

<table>
<tr>
<td>FISH LARVA
</td>
<td>FISH LARVA

TROPHIC LEVEL: primary consumer

FEEDING TYPE: herbivore

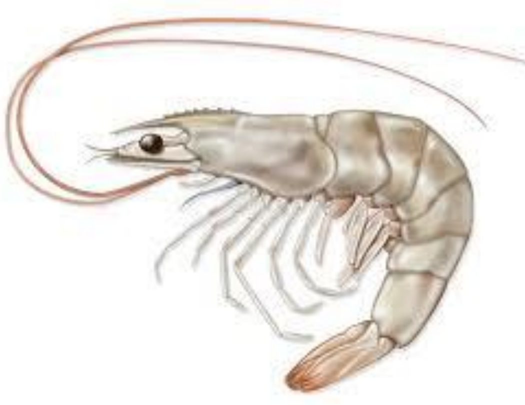
PREFERRED FOODs: algae, seagrasses

PREDATORS: crabs, sea stars, lanternfish</td>
</tr>
<tr>
<td>CRAB

</td>
<td>CRAB

TROPHIC LEVEL: primary consumer

FEEDING TYPE: omnivore

PREFERRED FOODs: algae, seagrasses, sea stars

PREDATORS: octopi, squid, lemon sharks</td>
</tr>
<tr>
<td>SHRIMP
</td>
<td>SHRIMP

TROPHIC LEVEL: primary consumer

FEEDING TYPE: herbivore

PREFERRED FOODS: algal cells, seagrasses

PREDATORS: lanternfish</td>
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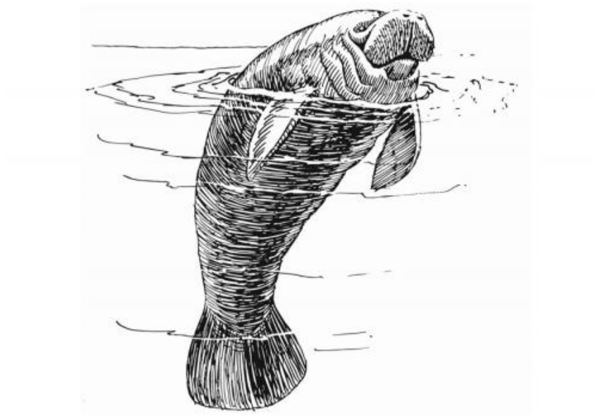
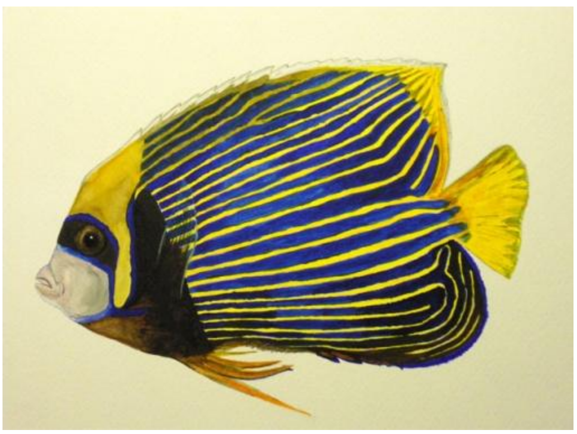
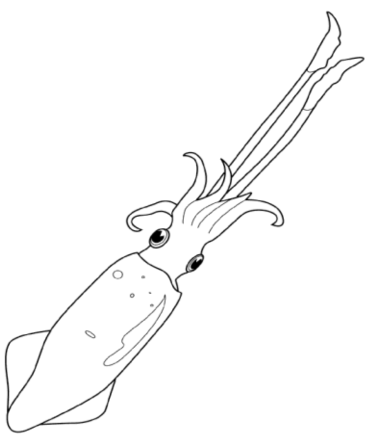
MANATEE 	**MANATEE** **TROPHIC LEVEL: primary consumer** **FEEDING TYPE: herbivore** **PREFERRED FOODs: seagrasses** **PREDATORS: none**
EMPEROR ANGELFISH 	**EMPEROR ANGELFISH** **TROPHIC LEVEL: secondary consumer** **FEEDING TYPE: carnivore** **PREFERRED FOODs: worms, sponges, shrimp** **PREDATORS: jellyfish, squid, octopi**
SQUID 	**SQUID** **TROPHIC LEVEL: secondary consumer** **FEEDING TYPE: carnivore** **PREFERRED FOODs: fish, copepods, krill** **PREDATORS: dolphins**

<table>
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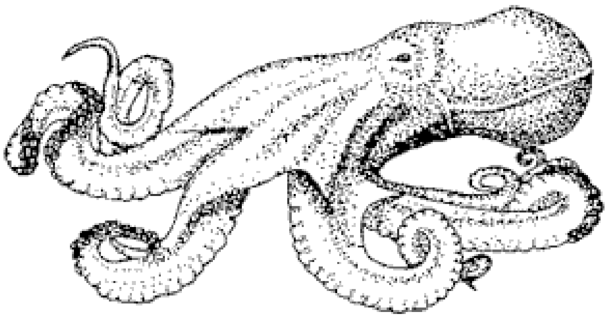
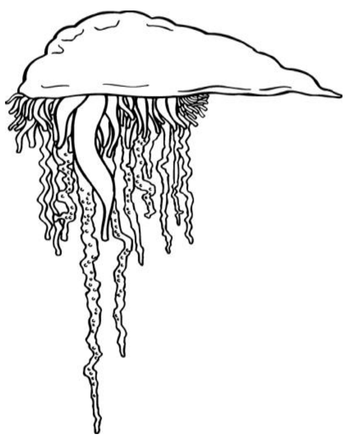
<td>OCTOPUS
</td>
<td>OCTOPUS

TROPHIC LEVEL: secondary consumer

FEEDING TYPE: carnivore

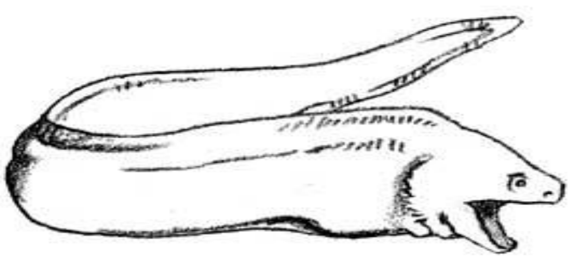
PREFERRED FOODS: fish, krill, copepods

PREDATORS: moray eels, dolphins</td>
</tr>
<tr>
<td>JELLYFISH
</td>
<td>JELLYFISH

TROPHIC LEVEL: secondary consumer

FEEDING TYPE: carnivore

PREFERRED FOODS: small fish

PREDATORS: crabs, sea turtles</td>
</tr>
<tr>
<td>MORAY EEL
</td>
<td>MORAY EEL

TROPHIC LEVEL: secondary consumer

FEEDING TYPE: carnivore

PREFERRED FOODS: fish, squid, octopi

PREDATORS: tiger sharks, lemon sharks</td>
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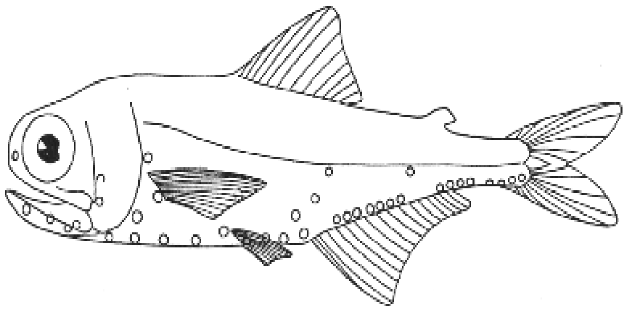
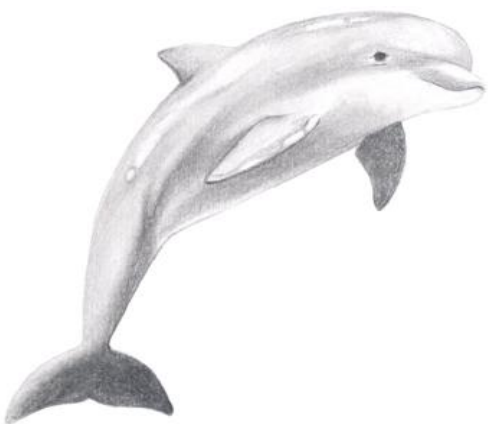
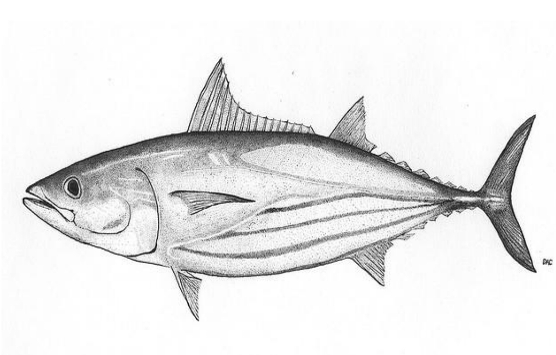
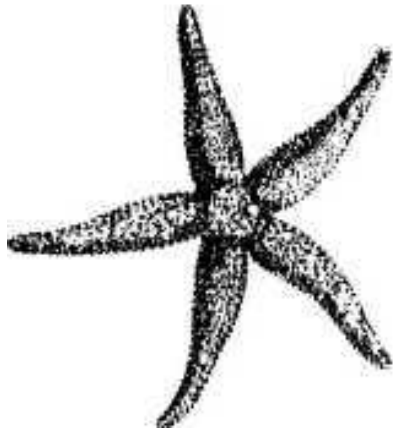
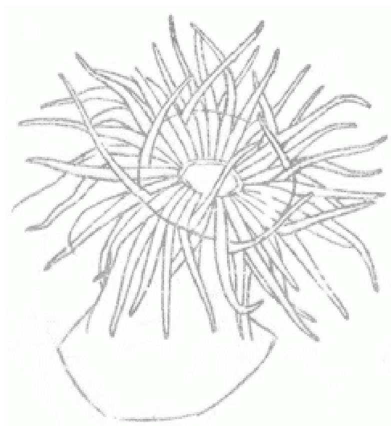
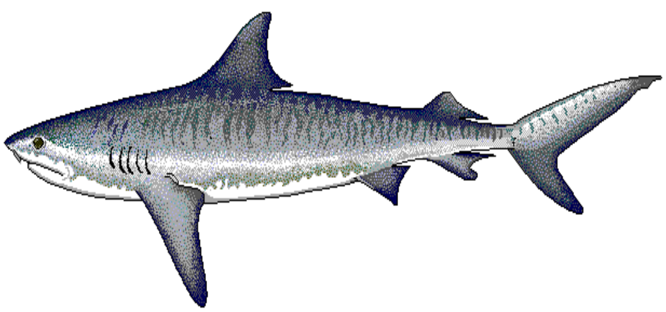
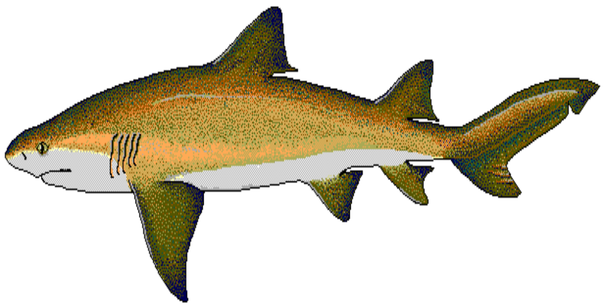
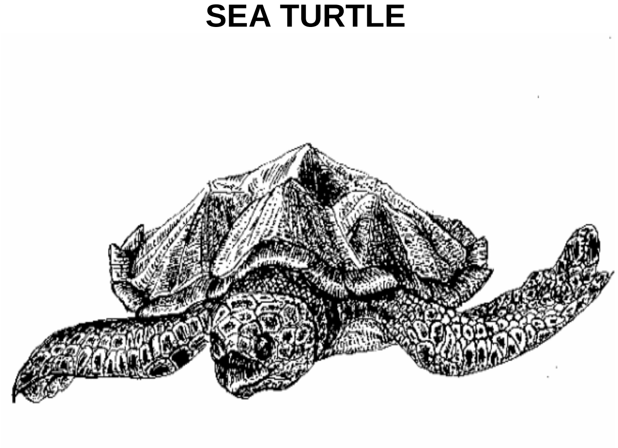
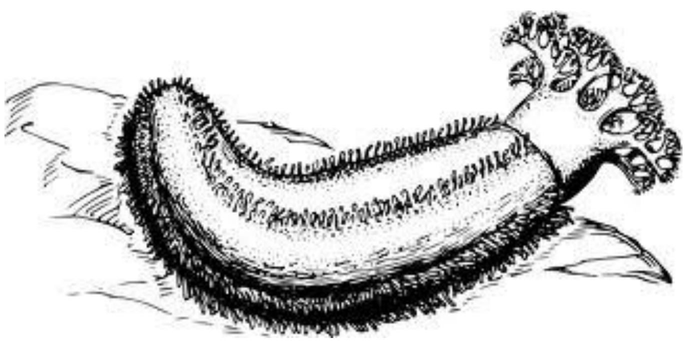
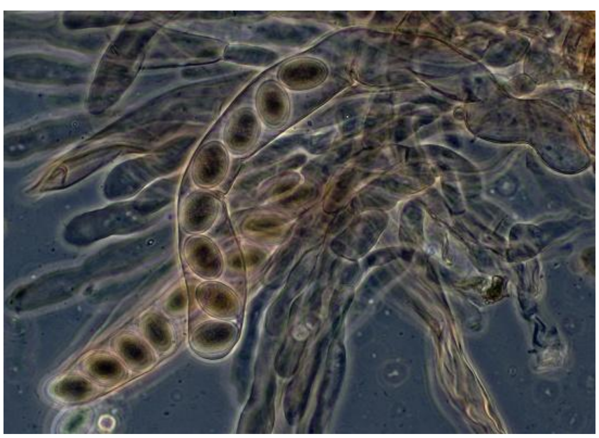
LANTERNFISH 	**LANTERNFISH** **TROPHIC LEVEL: secondary consumer** **FEEDING TYPE: carnivore** **PREFERRED FOODS: fish, copepods, krill** **PREDATORS: killer whales, dolphins, tiger sharks**
DOLPHIN 	**DOLPHIN** **TROPHIC LEVEL: secondary consumer** **FEEDING TYPE: carnivore** **PREFERRED FOODS: squid, fish** **PREDATORS: killer whales**
TUNA 	**TUNA** **TROPHIC LEVEL: secondary consumer** **FEEDING TYPE: carnivore** **PREFERRED FOODS: fish** **PREDATORS: killer whales, dolphins, tiger sharks**

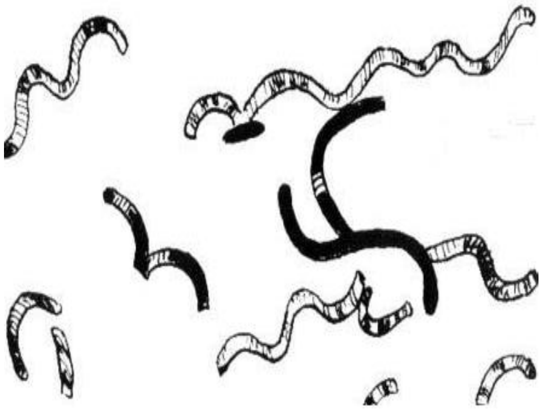
Teacher

SEA STAR 	**SEA STAR** **TROPHIC LEVEL: secondary consumer** **FEEDING TYPE: carnivore** **PREFERRED FOODS: coral, fish, scallops, oysters** **PREDATORS: fish, crabs**
SEA ANEMONE 	**SEA ANEMONE** **TROPHIC LEVEL: secondary consumer** **FEEDING TYPE: carnivore** **PREFERRED FOODS: small fish, zooplankton** **PREDATORS: sea stars**
TIGER SHARK 	**TIGER SHARK** **TROPHIC LEVEL: tertiary consumer** **FEEDING TYPE: carnivore** **PREFERRED FOODS: fish, invertebrates, marine mammals** **PREDATORS: killer whales, tiger sharks**

LEMON SHARK 	**LEMON SHARK** **TROPHIC LEVEL: tertiary consumer** **FEEDING TYPE: carnivore** **PREFERRED FOODS: fish, invertebrates, marine mammals** **PREDATORS: killer whales, tiger sharks**
SEA TURTLE 	**SEA TURTLE** **TROPHIC LEVEL: tertiary consumer** **FEEDING TYPE: carnivore** **PREFERRED FOODS: fish, invertebrates,** **PREDATORS: lemon sharks, tiger sharks**
KILLER WHALE 	**KILLER WHALE** **TROPHIC LEVEL: tertiary consumer** **FEEDING TYPE: carnivore** **PREFERRED FOODS: fish, invertebrates, marine mammals** **PREDATORS: top of food chain**

SEA URCHINS 	**SEA URCHINS** **TROPHIC LEVEL: scavenger** **FEEDING TYPE: omnivore** **PREFERRED FOODS: decaying plant and animal matter** **PREDATORS: fish**
SEA CUCUMBERS 	**SEA CUCUMBERS** **TROPHIC LEVEL: scavenger** **FEEDING TYPE: omnivore** **PREFERRED FOODS: decaying plant and animal matter** **PREDATORS: sea stars, fish**
MARINE FUNGI 	**MARINE FUNGI** **TROPHIC LEVEL: decomposer** **FEEDING TYPE: omnivore** **PREFERRED FOODS: decaying plant and animal matter** **PREDATORS: oysters**

MARINE BACTERIA



MARINE BACTERIA

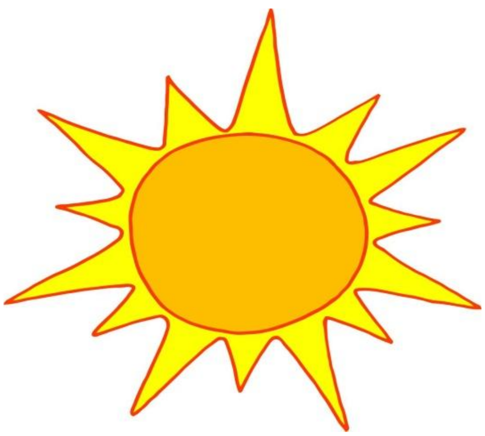
TROPHIC LEVEL: decomposer

FEEDING TYPE: omnivore

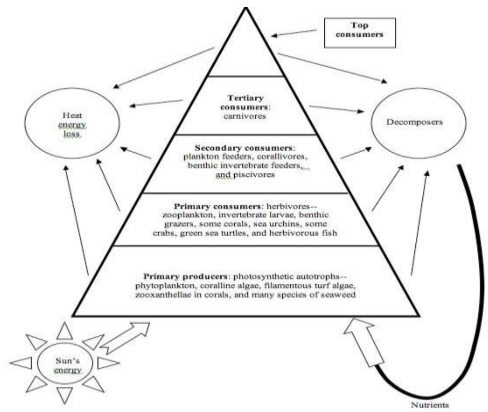
PREFERRED FOODS: decaying plant and animal matter

PREDATORS: oysters

THE SUN



The SUN



Additional Hands-on Activities

Teacher

Fun with Bubbles

NGSSS:
SC.912.N.1.1 Define a problem based on a specific body of knowledge, for example: biology, chemistry, physics, and earth/space science, and do the following: 1) pose questions about the natural world, 2) conduct systematic observations, 3) examine books and other sources of information to see what is already known, 4) review what is known in light of empirical evidence, 5) plan investigations, 6) use tools to gather, analyze, and interpret data (this includes the use of measurement in metric and other systems, and also the generation and interpretation of graphical representations of data, including data tables and graphs), 7) pose answers, explanations, or descriptions of events, 8) generate explanations that explicate or describe natural phenomena (inferences), 9) use appropriate evidence and reasoning to justify these explanations to others, 10) communicate results of scientific investigations and,11) evaluate the merits of the explanations produced by others. (**AA**)

Purpose of the Lab/Activity:
- To distinguish between qualitative and quantitative data.
- Utilize tools of measurements and emphasize importance of using the metric system.
- Practice making observations and inferences.
- Develop the steps of the scientific method by writing hypothesis and gathering data.
- Apply the scientific method to determine which bubble solution produces the largest bubble.

Prerequisites:
- Students should know laboratory safety rules and proper use of laboratory equipment.
- Students should be assigned their lab roles prior to the beginning of the activity.
- Students should know the steps of the scientific method.

Materials (per group):
- 3 different kinds of clear dishwashing liquids
- commercial bubble solution
- water
- glycerin
- rulers
- straws
- plastic trash bags to cover tables
- Four 50-ml beakers

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Gather materials and make sure to cover lab tables with plastic trash bags. (You may also want to complete this activity outdoors.) b. You can modify this lesson by providing the materials to the students and allowing them to develop their own controlled experiment. Procedural plan would have to be approved prior to experimentation. c. It is important for students to complete an experimental design diagram prior to the investigation in order for them to understand all parts of the activity. 1. What is the problem statement? Which solution makes the biggest bubbles?

	2. State the hypothesis. Answer will vary but should include both independent and dependent variable. (Example: If Bubble Solution # 1 is used, the bubble diameter will be the largest.) 3. Identify the independent and dependent variable. Independent: type of bubble solution (detergent), Dependent: bubble size (diameter) 4. Identify the variables held constant. amount of each solution, straw, bubble surface 5. Explain the tests conducted, identify both the experimental and control test. Experimental Test: Detergent Bubble Solutions 1 – 3 Control Test: Commercial Bubble Solution 6. List the number of trials per test. 3 trials d. Complete a **KWL** (what do you **K**now – what do you **W**ant to know – what did you **L**earn) in order to activate student's prior knowledge. e. Students' misconceptions should be addressed. Some common misconceptions are: There is no universal scientific method. If a hypothesis proven to be false the experiment has failed. Quantitative data and qualitative data are the same. If two events occur repeatedly, one event causes the other. Scientific-sounding studies in tabloid magazines are true.
During activity:	**What the teacher will do:** a. Monitor students to make sure they are remaining on task and are following proper lab protocol. b. Review the experimental design diagram by asking individual students in groups to explain the different parts of the experiment. c. Follow laboratory procedural plan; making sure to model proper laboratory safety and use of equipment. d. Create class data table on board. e. Emphasize importance of data collection by groups. f. Ask the following questions: 1. Do you think the size and thickness of the straw affects the size of the bubble? How and why? 2. Do you think that the size and gender of a person making the bubbles affect the size of the bubble? How and why? 3. What about if a tries to blow the bubbles? 4. Is the size dependent on the person or the solution? 5. Would being a smoker affect the size of the bubble blown? 6. What is the effect, if any, of the material on the surface of the table, on the size of the bubble?
After activity:	**What the teacher will do:** a. Have the students record their groups data (the average bubble diameter by solution) and hypothesis on class data table. b. Analyze class data; making sure to note the importance of multiple trials, and repeatability in scientific investigations. c. Have students graph the data of their experiment; have them use the average bubble size diameter. (Mr. DRY MIX: the **D**ependent variable is the **R**esponding variable that in a graph is recorded on the **Y**-axis; the **M**anipulated variable is the **I**ndependent variable and is graphed on the **X**-axis.

	d. Answer Key for Results: 1. From the data collected, which bubble solution makes the biggest bubbles? Commercial bubble solution should create the biggest bubble. 2. Compare the commercial bubble solution with the detergent solutions. Was there a difference? Answers will vary. Students show include data that explains the difference in bubble size between the 4 solutions tested. 3. Predict the importance of adding glycerin to bubble solutions. The Glycerin (or glycerol) improves the soap bubble mixture in two ways: It increases the lifetime of the bubbles, and it makes the bubbles bigger.

Extension:

- Interactive Scientific Method Investigation: http://sunshine.chpc.utah.edu/labs/scientific_method/sci_method_main.html
- GIZMO: Growing Plants

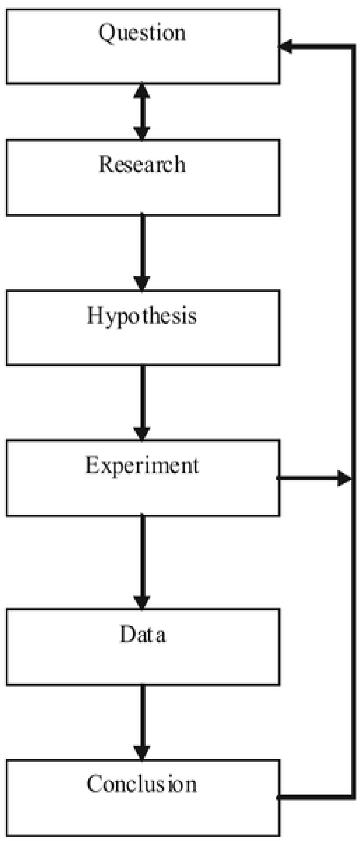
Student

Fun with Bubbles

NGSSS:

SC.912.N.1.1 Define a problem based on a specific body of knowledge, for example: biology, chemistry, physics, and earth/space science, and do the following: 1) pose questions about the natural world, 2) conduct systematic observations, 3) examine books and other sources of information to see what is already known, 4) review what is known in light of empirical evidence, 5) plan investigations, 6) use tools to gather, analyze, and interpret data (this includes the use of measurement in metric and other systems, and also the generation and interpretation of graphical representations of data, including data tables and graphs), 7) pose answers, explanations, or descriptions of events, 8) generate explanations that explicate or describe natural phenomena (inferences), 9) use appropriate evidence and reasoning to justify these explanations to others, 10) communicate results of scientific investigations and,11) evaluate the merits of the explanations produced by others. (**AA**)

Background:



The scientific method is a process for experimentation that is used to explore observations and answer questions. Scientists use the scientific method to search for cause and effect relationships in nature. In other words, they design an experiment so that changes to one item cause something else to vary in a predictable way.

Your own curiosity is the starting point for exploring through inquiry. The questions that drive inquiry are based on observations. Recorded observations are called data. Quantitative data is measured on a numerical scale. Data also may be qualitative, in the form of descriptions instead of measurements.

The basis of the scientific method is observing and gathering background information, asking a question, forming an hypothesis (or an educated guess about the answer to your question), and then trying to come up with the answers by collecting and analyzing data. Scientists use an experimental design diagram to identify the essential components of an experiment.

Student

Problem Statement: Which solution makes the biggest bubbles?

Safety: Make sure that the bubble solution is poured on top of trash bags on the tables, report any spills immediately to the teacher. Use napkins routinely to clean up your lab area.

Vocabulary: scientific method, hypothesis, independent variable, dependent variable, controlled experiment, quantitative, qualitative

Materials (per group):
- 3 different kinds of clear dishwashing liquids
- commercial bubble solution
- water
- glycerin
- rulers
- straws
- plastic trash bags to cover tables
- Four 50-ml beakers

Procedures:
1. Mix three bubble solutions in separate beakers using the following proportions of liquids: 5 ml dishwashing liquid, 30 ml water, and 5 ml plain glycerin. *Note:* If you want to make a lot of bubble solution, just use larger quantities of each ingredient, keeping them in the 1:6:1 proportion.
2. Put 40 ml of commercial bubble solution in a fourth beaker.
3. To test a solution, pour it <u>onto</u> the plastic trash bag on your table top, put your straw into one of the small bubbles and blow more air into the bubble. Continue blowing air into the bubble until it bursts.
4. Using centimeters, measure the diameter of each bubble print left behind on the trash bag.
5. Repeat this procedure three times for each of the different solutions.
6. While you are doing this activity, make some observations about the colors and other physical characteristics of the bubbles.
7. Record your group's results on the data sheet.
8. Complete the class data table and write a conclusion for the activity.

Student

Observations/Data:

	Diameter of Bubble Solution Detergent #1 (cm)	Diameter of Bubble Solution Detergent #2 (cm)	Diameter of Bubble Solution Detergent #3 (cm)	Diameter of Bubble Solution Commercial (cm)
Trial #1				
Trial #2				
Trial #3				
Average				

You should also collect qualitative data such as observations about the colors and other physical characteristics of the bubbles.

Data Analysis:
Create a bar graph using the data from the table above; make sure to label your axis(s) and include the units of measurements.

Average Bubble Size Diameter by Solution

Student

Results:

1. From the data collected, which bubble solution makes the biggest bubbles?
2. Compare the commercial bubble solution with the detergent solutions. Was there a difference?
3. Predict the importance of adding glycerin to bubble solutions.

Conclusion:

Write a lab report using the “Power Writing Model 2009”. Make sure to answer the following questions:

- What was investigated?
- Was the hypothesis supported by the data?
- What were the major findings?
- How did your findings compare with other researchers?
- What possible explanations can you offer for your findings?
- What recommendations do you have for further study and for improving the experiment?
- What are some possible applications of the experiment?

Stimuli Effects on Heart Rate: Sympathetic Stimuli and Coughing

NGSSS:
SC.912.L.14.36 Describe the factors affecting blood flow through the cardiovascular system. (**AA**)

Purpose of Lab/Activity: The purpose of this lab is to observe how the heart rate changes according to sympathetic (and parasympathetic) stimuli. The lab includes two separate stations, each focusing on a different stimulus.

Prerequisite: Prior to this activity, the student should be able to:

- Determine the constant breathing rate and constant heart rate
- Determine the resting breathing rate and resting heart rate
- Know how to get consistent and realistic readings for heart rate
- know the function of the sympathetic nervous system and the parasympathetic nervous system
- Relate the cough reflex to heart rate

Materials (per station or per group):

- *CBL2* with *TI 83* calculator
- ice water bath
- towel
- *DataMate App*
- *Vernier Respiration Rate Monitor*
- *Vernier Hand-Grip Heart Rate Monitor* or *Vernier Exercise Heart Rate Monitor*
- saline solution in dropper bottle for the exercise heart rate monitor

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. The teacher will have to gather all materials and should trouble shoot the different heart rate monitors to determine if a constant and realistic heart rate reading is observed. b. The teacher will prepare 4 sets of stations, each set focusing on different stimuli: (1) Sympathetic stimuli and (2) Coughing. c. Engage students by eliciting prior knowledge and asking questions pertinent for each station (e.g., How will the heart rate respond to different sympathetic stimuli? How does coughing (a sympathetic stimulation) affect the heart rate?) d. Review general procedures for using the respiration and heart rate monitors. It is expected that all students be involved and participate during the lab. This means that all students must take turns in running the heart rate monitor or in being the patient who is being monitored. Students need to know what parts of the body are affected by stimulation of the sympathetic nervous versus stimulation from the parasympathetic nervous system. e. Students need to be sure to have consistent and realistic heart rates at the beginning of each experiment.

Teacher

During activity:	**What the teacher will do:** a. Students should first be able to measure a base line reading for heart rate that is realistic and not excessively fluctuating. Once the base line reading has been established, the student can be directed to undergo the treatment phase. After the treatment phase, the student can be directed to stand quietly next to the lab station to begin the recovery phase. b. As you walk around the room, question students on general concepts and ideas. Examples: 1. What is the resting heart rate? 2. How a person's vital sign can be an indicator about their health? 3. What are realistic base line values for vital signs? 4. What are some vital sign values that indicate if the person is in good physical shape? 5. What are some vital sign values that indicate that the person's vital signs are showing a person in poor health? c. As you walk around the room, question students on station specific concepts and ideas. Examples: <u>Sympathetic Stimuli:</u> 1. What are examples of sympathetic stimuli? Parasympathetic stimuli? 2. How can you properly simulate sympathetic stimuli? Parasympathetic stimuli? <u>Coughing Stimuli:</u> 1. What effect will not coughing (a sympathetic inhibition) have on heart rate? 2. In what direction did your heart rate change in this experiment? Why? 3. According to the table in the Introduction, what are the possible explanations for this change? (Relate to stimulation and inhibition of sympathetic or parasympathetic nervous system).
After activity:	**What the teacher will do:** a. The teacher will propose the following questions: 1. In what direction did your heart rate change in this experiment during the sympathetic experiment? What about the parasympathetic? 2. According to the table in the Introduction, what are the possible explanations for this change? 3. There are medications that can selectively block the action of either sympathetic or parasympathetic influences on the heart. How can such medications be used to determine which of these systems is responsible for a change in heart rate such as was seen in this experiment? 4. Compare the response and recovery times recorded in Table 2. List possible survival advantages of the differences you see. 5. If the parasympathetic and sympathetic nerve supplies are severed during heart transplantation and are not surgically repaired, explain if the heart transplant recipient's heart rate would change with coughing (or with a severe fright)?

Extension:

- Gizmo: [Human Homeostasis]

Student

Stimuli Effects on Heart Rate: Sympathetic Stimuli and Coughing

(Adapted from Vernier Labs – www.Vernier.com)

NGSSS:
SC.912.L.14.36 Describe the factors affecting blood flow through the cardiovascular system. (**AA**)

Background: Since the earliest days of medicine, heart rate has been recognized as a *vital sign* (an indicator of health, disease, excitement, and stress). Medical personnel use heart rate to provide clues as to the presence of many medical conditions. Reflex changes in heart rate are one of the body's most basic mechanisms for maintaining proper perfusion to the brain and other tissues. Low blood volume caused by bleeding or dehydration results in the heart beating faster as it attempts to maintain adequate blood pressure. Excitement, stress, and anxiety activate the autonomic nervous system, which may also speed the heart rate and raise blood pressure.

The autonomic nervous system consists of **sympathetic** and **parasympathetic** branches, which have opposing effects on the circulatory and other organ systems. Sympathetic activation raises blood pressure in addition to pulse. After an initial activation of the sympathetic nervous system, the increase in blood pressure stretches nerve fibers in the baroreceptors (see Figure 1). This results in a reflex activation of the parasympathetic nervous system, which, through actions opposite to those of the sympathetic nervous system, helps to restore homeostasis.

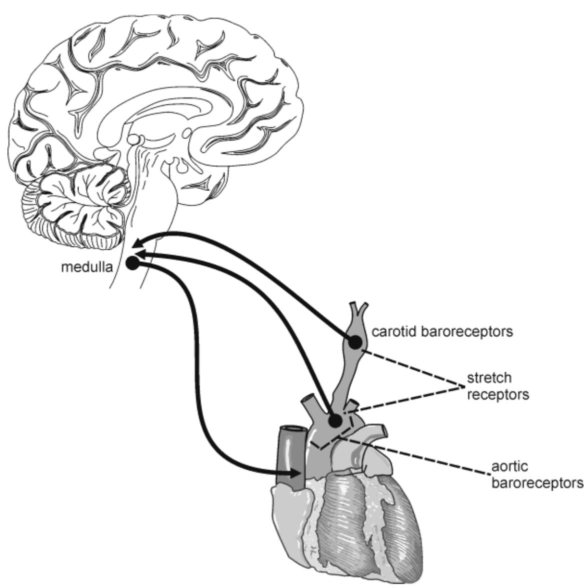


Figure 1

Involuntary coughing is the result of irritation of special sensory nerves in the respiratory tract. This helps to clear potentially damaging substances from the lungs (water, foreign bodies, dust, infection, mucous, etc.). Coughing can be more deleterious than helpful, causing discomfort, preventing sleep, or leading, in some cases, to dizziness or loss of consciousness (known as *cough syncope*).

The physiologic effects resulting from a cough are numerous. There is marked increase in intrathoracic pressure just prior to expulsion of air. When blood pressure is normal, this leads to a decrease in venous return to the right side of the heart and a decrease in cardiac output. On the other hand, a cough-induced increase in intrathoracic pressure may provide a form of “internal cardiopulmonary resuscitation” in a heart attack victim whose blood pressure is falling dangerously low. In this case, coughing can be as effective as the external chest compressions of CPR in raising blood pressure and providing better blood circulation to vital tissues.

Coughing, and the resulting wide fluctuations in intrathoracic pressure it produces, causes reflex stimulation of the autonomic nervous system. The sympathetic nervous system is an “activating system,” preparing the body for a “flight or fight response” by increasing heart rate and blood pressure. The parasympathetic nervous system acts through the vagus nerve to slow the heart and to lower blood pressure. Both the sympathetic and parasympathetic systems may be stimulated or inhibited by physiologic stimuli or medications.

The following table shows potential heart rate response to stimulation or inhibition of the sympathetic or parasympathetic nervous systems:

Branch of Autonomic Nervous System	**Heart Rate Response to Stimulation Inhibition**	
Sympathetic	↑	↓
Parasympathetic	↓	↑

Purpose or Problem Statement: In this experiment, you will observe how the heart responds to two different stimuli: cold stimulus applied peripherally and coughing. In both cases, cold and coughing will act as noxious stimuli, activating the “fight or flight” response through the sympathetic nervous system. The purpose of this lab is to evaluate how sympathetic stimuli alter the heart rate.

Safety: Do not attempt this experiment if physical exertion will aggravate a health problem. Inform your instructor of any possible health problems that might be exacerbated if you participate in this exercise. Do not attempt this experiment if you suffer from asthma or any condition that may be aggravated by repeated coughing.

Vocabulary: baroreceptors, sympathetic nervous system, parasympathetic nervous system, resting heart rate, maximum heart rate, homeostatic mechanisms, blood pressure, heart rate, stroke volume, intrathoracic pressure

Materials (individual or per group):

- *CBL2* with *TI 83* calculator
- ice water bath
- towel
- *DataMate App*
- *Vernier Respiration Rate Monitor*
- *Vernier Hand-Grip Heart Rate Monitor* or *Vernier Exercise Heart Rate Monitor*
- saline solution in dropper bottle for the exercise heart rate monitor

Student

Procedures:

1. Select a station to test the stimuli effects on the heart rate. Identify among the group members who will be the test subject(s) and who will collect data. Make sure to switch places when changing stations. Test subject(s) must prepare to submerge one foot in the ice water bath by removing the shoe and sock.
   a. Position the foot adjacent to the ice water bath and be ready to submerge it.
2. Connect the receiver module of the *Heart Rate Monitor* to CBL2, channel 1, and from the *Apps* menu choose *DataMate*.
3. Once you have entered the program, choose change time settings then press **enter**. Change the interval between samples to 5 seconds, and change the number of samples to 30. The duration of the experiment is 150 seconds. Then, select OK.
4. Set up the *Heart Rate Monitor*. Follow the directions for your type of *Heart Rate Monitor*.
   a. Depending upon your size, select a small or large size elastic strap. Secure one of the plastic ends of the elastic strap to the transmitter belt. It is important that the strap provide a snug fit of the transmitter belt.
   b. Wet each of the electrodes (the two textured oval areas on the underside of the transmitter belt) with 3 drops of saline solution.
   c. Secure the transmitter belt against the skin directly over the base of the rib cage (see Figure 2). The POLAR logo on the front of the belt should be centered. Adjust the elastic strap to ensure a tight fit.
   d. Take the receiver module of the Heart Rate Monitor in your right hand. Remember that the receiver must be within 80 cm of the transmitter in the *Heart Rate Monitor* belt.
   e. Stand quietly facing your table or work bench within the reception range of the receiver module.

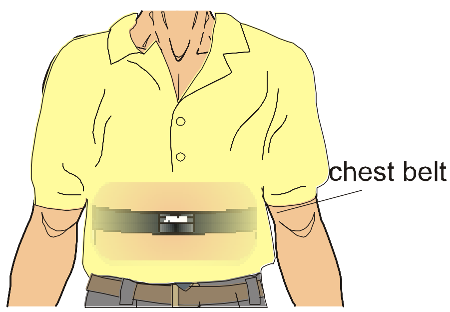


Figure 2

5. Set up the Hand-Grip Heart Rate Monitor: The receiver and one of the handles are marked with a white alignment arrow as shown in Figure 3. Locate these two arrows.
   a. Have the subject grasp the handles of the Hand-Grip Heart Rate Monitor so that their fingers are in the reference areas indicated in Figure 3. Hold the handles vertically.
   b. Have someone else hold the receiver near the handles so that the two alignment arrows are pointing in the same direction and are at approximately the same height as shown in Figure 3. Note: The receiver must stay within 60 cm of the handles during data collection.

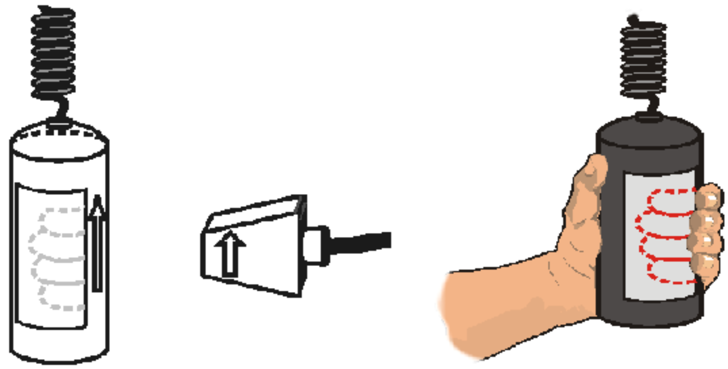


Figure 3

Sympathetic Stimuli (Cold water)

6. To determine that everything is set up correctly, click Collect to begin monitoring heart rate. **Note** that there may be up to a 30 second delay before data are seen. The readings should be within the normal range of the individual, usually between 55 and 80 beats per minute. Click Stop when you have determined that the equipment is operating properly, and proceed to the next step.
7. Collect data to observe the effect of submerging your foot in an ice water bath. **Note**: Read over this step prior to beginning data collection to familiarize yourself with the process.
   a. Click Collect. If the baseline is not stable, repeat Steps 6. If the baseline is stable, plunge your foot into the ice water bath at 40 s.
   b. Remove your foot from the ice water bath 30 s after immersion (when data have been collected for 70 s) and rest it on the towel.
   c. Remain seated and allow data collection to continue for the full 240 s data-collection period.
8. Click and drag over the area of the graph where the resting (“baseline”) heart rate is displayed. Click the Statistics button. The Statistics box will appear with the statistics calculated for the selected region. Record the mean resting heart rate, to the nearest whole number, in Table 1.
9. Move the Statistics brackets to highlight the total time of data collection. The values in the statistics box will be recalculated to reflect this change. Record the maximum and minimum heart rates, to the nearest whole numbers, and the corresponding times at which these rates are graphed, in Table 1.
10. Move the statistics brackets to highlight the region of the graph beginning at 40 s (when the foot was immersed in the ice water bath) and ending at the first peak (see Figure 4). Record the maximum heart rate value in Table 1. In the corresponding Time column record (to the nearest whole number) the Δx value displayed at the lower left corner of the graph.
11. Move the Statistics brackets to enclose the region of the graph beginning at the first peak and ending at the lowest point in the valley that follows (see Figure 5). Record the minimum heart rate value as the Rebound heart rate in Table 1. Record the Δx value in the corresponding Time column.

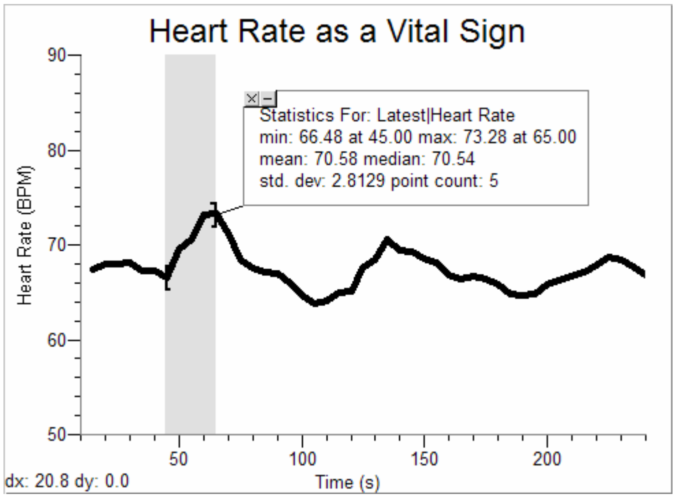


Figure 4

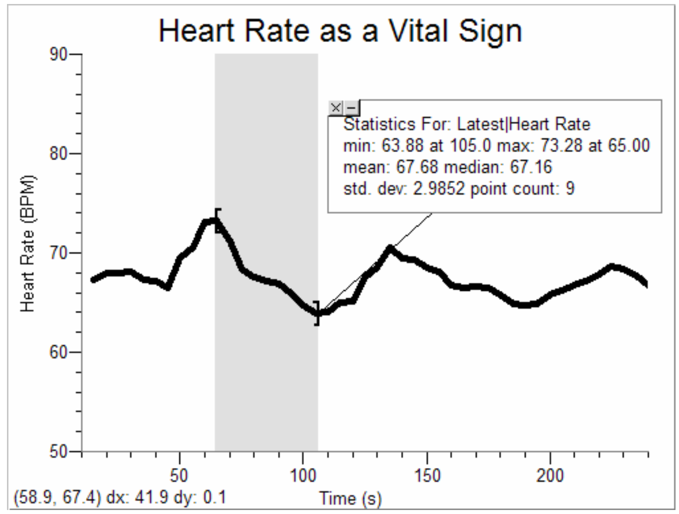


Figure 5

<u>Coughing:</u>

12. Click Collect to begin data collection. There will be a 15 s delay while data are collected before the first point is plotted on the upper graph. Thereafter, a point will be plotted every 5 s. Obtain approximately 45 s of graphed data as a baseline heart rate.
13. Begin data collection by pressing start.
    a. At approximately 60 s, begin to cough continuously (every 1–3 s). The heart rate will change in response to the coughing. When the heart rate levels off for at least 15 s (or reverses direction), stop coughing. Data will be collected for at least 200 s.
14. Determine the baseline heart rate.
    a. Tap and drag over the area of the graph where the baseline heart rate is displayed to select the data.
    b. Choose Statistics from the Analyze menu.
    c. Record the mean baseline heart rate, to the nearest whole number, in Table 2.
    d. Choose Statistics from the Analyze menu to turn off statistics.
15. Determine the maximum heart rate.
    a. Tap and drag over the region where the heart rate levels off.
    b. Choose Statistics from the Analyze menu.
    c. Record the mean heart rate to the nearest whole number as the Maximum heart rate in Table 2.
    d. Choose Statistics from the Analyze menu to turn off statistics.
16. Determine the difference between the Maximum heart rate and the Baseline heart rate and record this value in Table 2.
17. Determine the time between the onset of coughing and the beginning of the plateau.
    a. Tap the data point at approximately 60 s that represents the time at the onset of coughing and note the time component of this point.
    b. Tap the point at the beginning of the plateau and note the time component of this point.
18. Determine the difference between the two time values and record this value as the response time in Table 2.
19. Determine the recovery time.
    a. Tap the last data point on the plateau and note the time component of this point.

   b. Tap the point at which the heart rate returns to baseline and note the time component of this point. **Note:** If the baseline heart rate is not achieved before the end of the experiment, tap the last data point recorded.

20. Determine the difference between the two time values and record this value as the recovery time in Table 2.

Observations/Data:

Table 1 – Sympathetic Stimuli (Cold Water)

Condition	**Heart Rate (bpm)**	**Time (s)**
Resting heart rate		
Maximum heart rate		
Recovery time		

Table 2 – Coughing Data

Baseline heart rate (bpm)	**Maximum heart rate (bpm)**	**∆Heart rate (Max–baseline) (bpm)**	**Response time (s)**	**Recovery time (s)**

Data Analysis/Results:

<u>Sympathetic Stimuli (Cold Water)</u>:

1. How long after immersion did your heart rate reach its maximum value? Explain the physiologic mechanism that led to this change in heart rate.
2. Describe the changes in heart rate that occurred after the maximum value. How can you explain the minimum heart rate value? How would you explain the heart rate variations seen in the remainder of the experiment?
3. How long after the maximum heart rate did it take to arrive at your rebound heart rate? What can you say about the relative speed of physiologic response to a stimulus *vs.* the speed of mechanisms that are designed to maintain homeostasis?
4. If the heart rate is too slow there is inadequate blood pressure to maintain perfusion to the brain. This can lead to loss of consciousness (fainting). Keeping in mind the autonomic nervous system responses that you observed in this experiment, explain the sequence of events that results in a severely frightened person fainting.

<u>Coughing:</u>

1. In what direction did your heart rate change in this experiment? According to the table in the Introduction, what are the possible explanations for this change?
2. There are medications that can selectively block the action of either sympathetic or parasympathetic influences on the heart. How could such medications be used to determine which of these systems is responsible for a change in heart rate such as was seen in this experiment?
3. Compare the response and recovery times recorded in Table 2. List possible survival advantages of the differences you see.

4. The parasympathetic and sympathetic nerve supplies are severed during heart transplantation and are not surgically repaired. Would a heart transplant recipient's heart rate change with coughing (or with a severe fright)?
5. You are in a remote location and a member of your party complains of chest pain and dizziness. You find that his pulse is 35 bpm. You immediately call 911 and are told that it will take 15 minutes for the helicopter to arrive. You know that CPR should not be performed on conscious individuals. Drawing from the knowledge you have gained from this experiment, what might be done to improve your patient's pulse and blood pressure?

Conclusion: Write a report following the directions delineated by *"Parts of a Lab Report" or "Power Writing Model 2009"*.

Teacher

Stimuli Effects on Heart Rate: Exercise and Baroreceptor Stimuli

NGSSS:
SC.912.L.14.36 Describe the factors affecting blood flow through the cardiovascular system. (**AA**)

Purpose of Lab/Activity: The purpose of this lab is to observe how the heart rate changes according to exercise and baroreceptor stimuli. The lab includes two separate stations, each focusing on a different stimulus.

Prerequisite: Prior to this activity, the student should be able to:

- Determine the constant breathing rate
- Determine the constant heart rate
- Determine the resting breathing rate
- Determine the resting heart rate
- Know how to get consistent and realistic readings for heart rate

Materials (per station or per group):

- *CBL2* with *TI 83* calculator
- *DataMate App*
- *Vernier Respiration Rate Monitor*
- *Vernier Hand-Grip Heart Rate Monitor* or *Vernier Exercise Heart Rate Monitor*
- saline solution in dropper bottle for the exercise heart rate monitor

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. The teacher will have to gather all materials and should trouble shoot the different heart rate monitors to determine if a constant and realistic heart rate reading is observed. b. The teacher will prepare 4 sets of stations, each set focusing on different stimuli: (1) Exercise, and (2) Baroreceptor stimuli. c. Engage students by eliciting prior knowledge and asking questions pertinent for each station: 1. What effect does exercising have on the heart rate? 2. How does the heart rate change as a person stands up starting from a squatting position? (This motion produces a sudden increase in the amount of blood circulation, how does this change affect the heart rate?) d. Review general procedures for using the respiration and heart rate monitors. It is expected that all students be involved and participate during the lab. This means that all students must take turns in running the heart rate monitor or in being the patient who is being monitored. Students need to know what parts of the body are affected by stimulation of the sympathetic nervous versus stimulation from the parasympathetic nervous system. e. As you start the lab, students need to be sure to have consistent and realistic heart rates at the beginning of each experiment. Make sure that students correctly gather and record their data.

Teacher

<table>
<tr>
<td>During activity:</td>
<td>
What the teacher will do:
a. Once the base line reading has been established, the student can be directed to undergo the treatment phase. Treatment consists of performing specific exercise as determined by the procedures. After the exercise phase, the student can be directed to stand quietly next to the lab station to begin the recovery phase.
b. As you walk around the room, question students on general concepts and ideas. Examples:
1. What is the resting heart rate?
2. How a person’s vital sign can be an indicator about their health?
3. What are realistic base line values for vital signs?
4. What are some vital sign values that indicate if the person is in good physical shape?
5. What are some vital sign values that indicate that the person’s vital signs are showing a person in poor health?
c. As you walk around the room, question students on station specific concepts and ideas. Examples:
<u>Exercise Stimuli:</u>
1. What are some of the reasons that the heart rate changes with increase exercise?
2. Does the level of physical fitness have an effect on how quickly a person’s heart rate recovers after exercise?
3. Describe what is changing within the muscles as you exercise.
4. What organs, besides the heart have increased use during exercise?
5. Do you expect to have an upper limit on increasing heart rate as you exercise? Why/why not?
<u>Baroreceptor Stimuli:</u>
1. How much and in which direction (increase or decrease) did the heart rate change as a result of standing? Squatting?
</td>
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<tr>
<td>After activity:</td>
<td>
What the teacher will do:
a. The teacher will propose the following questions:
<u>Exercise</u>:
1. Normal resting heart rates range from 55−100 beats per minute. What was the subject’s resting heart rate? How much did the subject’s heart rate increase above resting rate with exercise? What percent increase was this?
2. How does the subject’s maximum heart rate compare with other students in the group or class? Is this what you expected?
3. Recovery time has been shown to correlate with degree of physical fitness. How does the subject’s recovery rate compare to that of your classmates? Is this what you expected?
4. Congestive heart failure is a condition in which the strength of contraction with each beat may be significantly reduced. For example, the ventricle may pump only half the usual volume of blood with each beat. Would you expect a person with congestive heart failure to have a faster or slower heart rate at rest? With exercise?
<u>Baroreceptor</u>:
1. Changing the heart rate is only one of a variety of homeostatic
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</table>

	mechanisms that maintain a fairly constant blood pressure during changes in body position. The sympathetic nervous system helps by adjusting peripheral resistance in the arterial system. As this occurs the heart rate is able to normalize again. 2. Compare the duration of the initial direction of heart rate change after standing to the recovery time. 3. What does your data tell you about the relative speed of the change in peripheral vascular resistance as compared to that of the heart rate response? Dizziness may result from low blood pressure and can occur in patients who take medicines which impair the ability of the heart to increase its rate. 4. Given what you have learned from your data, which daily activities would be most likely to cause dizziness in people who take these medications?

Extension:

- Gizmo: Human Homeostasis

Student

Stimuli Effects on Heart Rate: Exercise and Baroreceptor Stimuli

(Adapted from Vernier Labs – www.Vernier.com)

NGSSS:
SC.912.L.14.36 Describe the factors affecting blood flow through the cardiovascular system. (**AA**)

Background: One of the homeostatic mechanisms of the human body serves to maintain a fairly constant blood pressure. Major determinants of blood pressure are heart rate, amount of blood pumped with each beat (*stroke volume*), and the resistance of the arterial system which is receiving the blood. The heart rate is influenced by *baroreceptors*, special sensors in tissues in the aortic arch and carotid arteries which contain nerve endings that respond to stretching (see Figure 1). An increase or decrease in stretch sends signals to the medulla in the brain which in turn acts on the heart through the vagus nerve, completing what is called a *feedback loop*. Sudden increase in pressure in the heart or carotid arteries causes an increase in stretch of the baroreceptor sensors and results in a decrease in heart rate. Sudden lowering of pressure causes the opposite effect. This feedback loop enables us to function in a gravity environment.

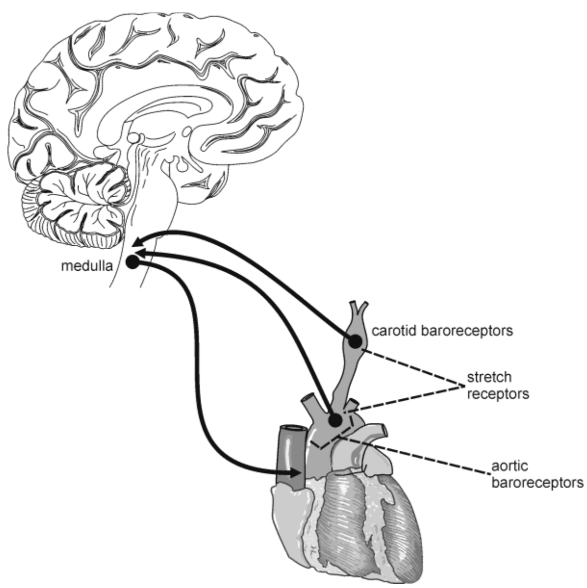


Figure 1

Most people have experienced the sensation of dizziness after standing abruptly from a seated or squatting position. This effect can be seen in healthy individuals, but it is accentuated in the elderly and in certain conditions including dehydration and Parkinson's disease. In these cases, the increase in heart rate may be significant but is still not able to make up for an insufficiency of the other two contributors to blood pressure (i.e., low blood volume or poor regulation of the resistance of the arterial system by the sympathetic nervous system). One of the first tests performed by doctors on patients who complain of dizziness is to check the blood pressure and pulse with the patient lying down and then standing. A drop in blood pressure of 20 points or an increase in heart rate of 20 points with standing is considered significant. This condition is called *orthostatic hypotension*.

Student

The adaptability of the heart can be observed during exercise, when the metabolic activity of muscle tissue increases. The cardiovascular system, consisting of the heart and blood vessels, responds to exercise with an increase in heart rate and strength of contraction with each beat, resulting in a higher *cardiac output* (quantity of blood pumped through the heart per unit of time). Physically fit people can deliver a greater volume of blood in a single heartbeat than unfit individuals and can sustain a greater work level before reaching a maximum heart rate. Being more physically fit also leads to a more rapid recovery of resting heart rate.

In this experiment, you will observe heart rate response to squatting and to standing from a squatting position. In the former, there is a rapid increase in venous return to the heart as veins in the leg muscles are compressed. This causes a sudden increase in stroke volume and pressure sensed by the baroreceptors. In standing from a squatting position, there is a sudden reduction in venous return to the heart because of “pooling” of blood in the legs. This results in a decrease in stroke volume and pressure.

Purpose or Problem Statement: This lab measures how the number of heart beats changes with increased exercise. The lab is important because heart rate is influenced by the autonomic nervous system, which, in turn, responds to environmental cues. In this experiment, you will observe how the heart responds to the increased metabolic demand of muscles during exercise and will evaluate how the heart rate is influenced by *baroreceptors*, special sensors in tissues in the aortic arch and carotid arteries which contain nerve endings that respond to stretching of the blood vessels that are receiving blood.

Safety: Do not attempt this experiment if physical exertion will aggravate a health problem. Inform your instructor of any possible health problems that might be exacerbated if you participate in this exercise.

Vocabulary: metabolic activity, Cardiac output, resting heart rate, recovery time, homeostatic mechanisms, blood pressure, heart rate, stroke volume, hypotension, hypertension, baroreceptors, muscle compression against blood vessels

Materials (per group):

- *CBL2* with *TI 83* calculator
- *DataMate App*
- *Vernier Respiration Rate Monitor*
- *Vernier Hand-Grip Heart Rate Monitor* or *Vernier Exercise Heart Rate Monitor*
- saline solution in dropper bottle for the exercise heart rate monitor

Procedures:

1. Identify among the group members who will be the test subject(s) and who will collect data. Make sure to switch places when changing stations.
2. Connect the receiver module of the *Heart Rate Monitor* to CBL2, channel 1, and from the *Apps* menu choose *DataMate*.
3. Once you have entered the program, choose change time settings then press enter. Change the interval between samples to 5 seconds, and change the number of samples to 30. The duration of the experiment is 150 seconds. Then, select OK.
4. Set up the *Heart Rate Monitor:* Follow the directions for your type of *Heart Rate Monitor*.

Student

a. Depending upon your size, select a small or large size elastic strap. Secure one of the plastic ends of the elastic strap to the transmitter belt. It is important that the strap provide a snug fit of the transmitter belt.
b. Wet each of the electrodes (the two textured oval areas on the underside of the transmitter belt) with 3 drops of saline solution.
c. Secure the transmitter belt against the skin directly over the base of the rib cage (see Figure 2). The POLAR logo on the front of the belt should be centered. Adjust the elastic strap to ensure a tight fit.
d. Take the receiver module of the Heart Rate Monitor in your right hand. Remember that the receiver must be within 80 cm of the transmitter in the *Heart Rate Monitor* belt.
e. Stand quietly facing your table or work bench within the reception range of the receiver module.

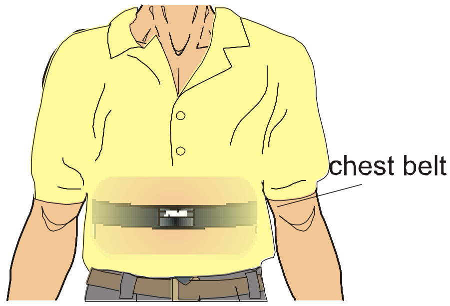


Figure 2

5. Set up the Hand-Grip Heart Rate Monitor: The receiver and one of the handles are marked with a white alignment arrow as shown in Figure 3. Locate these two arrows.
   a. Have the subject grasp the handles of the Hand-Grip Heart Rate Monitor so that their fingers are in the reference areas indicated in Figure 3. Hold the handles vertically.
   b. Have someone else hold the receiver near the handles so that the two alignment arrows are pointing in the same direction and are at approximately the same height as shown in Figure 3. Note: The receiver must stay within 60 cm of the handles during data collection.

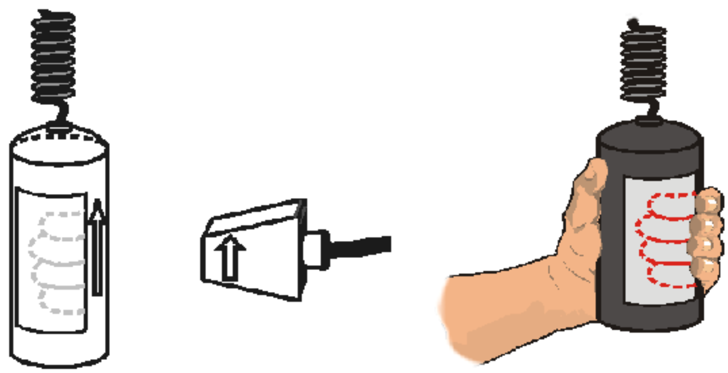


Figure 3

Exercise:

6. To determine that everything is set up correctly, click Collect to begin monitoring heart rate. **Note** that there may be up to a 30 second delay before data are seen. The readings should be within the normal range of the individual, usually between 55 and 90 beats per

minute. Click Stop when you have determined that the equipment is operating properly, and proceed to the next step.

7. Start data collection. If the baseline appears stable, begin to run in place at 40 s. Continue data collection while running in place for the next 60 s.
8. At approximately 100 s, stop running and stand in place while your heart rate slows toward its resting pre-exercise value. Data will be collected for a total of 150 s.
9. Determine the maximum heart rate.
    a. Choose Statistics from the Analyze menu and record the maximum heart rate in Table 1.
    b. Choose Statistics from the Analyze menu to turn off statistics.
10. Determine the resting heart rate.
    a. Tap and drag over the area of the graph where the resting heart rate is displayed (from 0 to approximately 40 s). This will highlight the region of interest.
    b. Choose Statistics from the Analyze menu and record the mean resting heart rate, to the nearest whole number, in Table 1.
    c. Choose Statistics from the Analyze menu to turn off statistics.
11. Determine the recovery time.
    a. For your data, examine the region of the graph beginning with the maximum heart rate and ending with the first data point that matches the initial baseline value (or the last point graphed, if baseline is not achieved). To determine the time for a data point, tap on the point and read its corresponding time value to the lower right of the graph.
    b. Determine the recovery time, Δx, by subtracting the initial time for this region from the final time for this region. Record this value in Table 1.

<u>Baroreceptor stimuli</u>:

12. To determine that everything is set up correctly, click Collect to begin monitoring heart rate. **Note** that there may be up to a 30 second delay before data are seen. The readings should be within the normal range of the individual, usually between 55 and 80 beats per minute. Click Stop when you have determined that the equipment is operating properly, and proceed to the next step.
    a. After at least 30 s of stable baseline data has been collected, rapidly lower yourself into a squatting position. Maintain this position until your heart rate returns to the initial baseline rate. Press start to begin data collection.
13. After obtaining 10–20 s of stable heart rate values, rise rapidly to a standing position. Continue to record data until the baseline heart rate has been achieved, or until the end of the run. Data will be collected for at least 200 s.
14. Determine the baseline heart rate.
    a. Tap and drag over the area of the graph where the resting heart rate is displayed to select the data.
    b. Choose Statistics from the Analyze menu and record the mean heart rate, to the nearest whole number, in Table 2.
    c. Choose Statistics from the Analyze menu to turn off statistics.
15. Determine the maximum heart rate over the entire run.
    a. Choose Statistics from the Analyze menu and record the maximum heart rate in Table 2.
    b. Choose Statistics from the Analyze menu to turn off statistics.
16. Determine the baroreceptor response time for squatting.

a. Tap the data point that represents the heart rate immediately prior to squatting and record the time component of this point.
b. Tap the point that represents the maximum or minimum heart rate (first peak or valley) that follows squatting and record the time component of this point.

17. Determine the difference between the two time values, Δx, and record this value in Table 3 (to the nearest whole number) as “Response time 1.”
18. Repeat Step 10 for the following regions:
    a. From the maximum or minimum heart rate following squatting to the beginning of a new stable heart rate. Record the Δx value (time) in Table 3 as “Recovery time 1.”
    b. The region just prior to standing and the maximum heart rate after standing. Record the Δx value (time) in Table 2 as “Response time 2.”
    c. The region between the maximum heart rate after standing and the point at which the heart rate has re-stabilized (i.e., stable for at least 40 s). Record the Δx value (time) in Table 3 as “Recovery time 2.”

Observations/Data:

Table 1 - Exercise

Resting Heart Rate (bpm)	**Maximum Heart Rate (bpm)**	**Recovery Time (s)**

Table 2 – Baroreceptor Stimuli

Baseline Heart Rate (bpm)	**Minimum Heart Rate (bpm)**	**Maximum Heart Rate (bpm)**

Table 3 – Baroreceptor Stimuli

Baroreceptor response time 1: Squatting (s)	**Recovery time 1 (s)**	**Baroreceptor response time 2: Standing (s)**	**Recovery time 2 (s)**

Data Analysis/Results:

Exercise:

1. Normal resting heart rates range from 55−100 beats per minute. What was the subject’s resting heart rate? How much did the subject’s heart rate increase above resting rate with exercise? What percent increase was this?
2. How does the subject’s maximum heart rate compare with other students in the group or class? Is this what you expected?
3. Recovery time has been shown to correlate with degree of physical fitness. How does the subject’s recovery rate compare to that of your classmates? Is this what you expected?
4. Congestive heart failure is a condition in which the strength of contraction with each beat may be significantly reduced. For example, the ventricle may pump only half the usual

volume of blood with each beat. Would you expect a person with congestive heart failure to have a faster or slower heart rate at rest? With exercise?

5. Medications are available which can slow the heart or speed it up. If a patient complains of feeling poorly and has a heart rate of 120 beats/min, should you administer a medicine to slow the rate?

Baroreceptor Stimuli:

1. How much and in which direction (increase or decrease) did the heart rate change as a result of
   a. standing?
   b. squatting?
2. Changing the heart rate is only one of a variety of homeostatic mechanisms that maintain a fairly constant blood pressure during changes in body position. The sympathetic nervous system helps by adjusting peripheral resistance in the arterial system. As this occurs the heart rate is able to normalize again. Compare the duration of the initial direction of heart rate change after standing to the recovery time. What does your data tell you about the relative speed of the change in peripheral vascular resistance as compared to that of the heart rate response?
3. Dizziness may result from low blood pressure and can occur in patients who take medicines which impair the ability of the heart to increase its rate. Given what you have learned from your data, which daily activities would be most likely to cause dizziness in people who take these medications?

Conclusion: Write a report following the directions delineated by *"Parts of a Lab Report" or "Power Writing Model 2009"*.

Teacher

Investigating Bacterial Growth

NGSSS:
SC.912.L.14.52 Explain the basic functions of the human immune system, including specific and nonspecific immune response, vaccines, and antibiotics. (**AA**)

Purpose of Lab/Activity: The purpose of this activity is to observe how bacteria grow in a culture medium through time, and observe if antiseptics, antibiotics, and disinfectants will inhibit bacterial growth. The lab will take place over 2 days. After preparing for day 1, you will need to prepare for the second day, 5 days later.

Prerequisites:
- The students will know the differences between prokaryotic cells and eukaryotic cells
- The students will understand how under certain conditions populations could grow exponentially.
- The students will have prior knowledge of characteristic structures and functions that make cells distinctive.
- The students will know processes in a cell classified broadly as growth, maintenance, reproduction, and homeostasis.

Materials (per group):
- 1 agar plate
- Sample of bacteria
- Inoculating loop or cotton swab
- Forceps
- Tape
- 1 wax pencil/Sharpie
- 1 metric ruler
- Distilled water
- Blank paper disk
- 3 disks immersed in either antibiotic, antiseptic, or disinfectant solutions
- 1 paper disk not immersed with any fluid
- Penicillin or similar antibiotic
- Bleach
- Mouthwash

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Prepare 1 clean Petri dish with agar for each group along with the remaining materials needed for the lab. b. Introduce the activity by asking the following questions: 1. What effect will a microbe inhibitor have on the growth of bacteria colonies? 2. Are there differences in the efficacy of the different microbial inhibitors used in the lab? 3. What are some ways that you can measure the differences of the efficacy of each solution?
During activity:	**What the teacher will do:** a. Engage student thinking during activity by asking the following questions: 1. What is the role of agar? 2. Why do you need to label the Petri dish so carefully? 3. Why do you need to keep the Petri dish covered? 4. Why do you need to control the temperature of the bacteria culture so

	that temperature is not too cold (near zero ^{o}C or too hot, above 42 ^{o}C)? 5. What could happen if you handled the paper holes with your hands and not with forceps? Is this lab a quantitative or a qualitative lab? 6. What is the function of keeping all objects as clean as possible before touching the bacteria? b. Provide expectations during Observations, Data Analysis, and Results: 1. Ask and answer questions during the lab to promote student assimilation and understanding of lab ideas and scientific concepts. 2. Draw the circle of inhibition for each agar plate in the data table.
After activity:	**What the teacher will do:** a. Design questions to engage student thinking after activity. (e.g., Are there differences in the effectiveness of microbe inhibitor in killing bacteria for each disk? How can you tell that bacteria were killed or that the bacteria survived? b. Provide directions (expectations) for student writing of lab/activity, *"Parts of a Lab Report"* or *"Power Writing Model 2009"* c. Assess student understanding by discussing factors that keep bacteria population in control. (Ask students to write several factors that prevented the bacteria population from increasing exponentially and thereby leaving the Petri-dish).

Extension:

- Isolation and Screening of Antibiotic Producers Animation: http://www.sumanasinc.com/webcontent/animations/content/antibioticproducers.html

Student

Investigating Bacterial Growth

NGSSS:
SC.912.L.14.52 Explain the basic functions of the human immune system, including specific and nonspecific immune response, vaccines, and antibiotics. (**AA**)

Background: Most bacteria (and other microorganisms) are harmless. In fact, many bacteria are beneficial. Cheesemaking, decay, and soil building are a few of the important processes that depend on the action of decomposing bacteria, which thrive on decaying organic matter. Bacteria are also important in the process of digestion for many organisms, including humans. Bacteria in termites and ruminants (such as cows) help break down the cellulose in the food they eat so it can be used for energy and nutrients. Bacteria in the human digestive system help with the synthesis of vitamin K, which is essential for blood clotting. However, some bacteria are pathogens (disease causers). Tuberculosis, tetanus, strep, diphtheria, anthrax, syphilis, and some pneumonias are a few of the serious diseases caused by bacteria.

Chemical substances that either kill bacteria or inhibit bacterial growth are called *antimicrobial agents*. Alcohol and some mouthwashes are antiseptics, and are used on cuts or wounds to inhibit bacterial infection. Others, like chlorine bleach, are too concentrated or toxic for use on living tissue. These are called disinfectants and are used on clothes, surfaces, or other non-living objects. These agents generally work either by disrupting the cell membrane, causing the bacterium to lyse, or binding to the bacterium enzymes, which inhibit its activity. Even though antiseptics and disinfectants are very useful in helping to prevent infections, we cannot use them internally to treat an infection. If bacteria enter our bodies, we rely on another class of chemicals called antibiotics to kill them. Although their use is now commonplace, antibiotics were only discovered about 85 years ago. Before then, more people died from infections than from all the wars in history combined. Antibiotics were the first of the "miracle drugs" and they have permanently altered the course of history.

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.

The procedure of placing bacteria on agar plates is called <u>inoculation</u>. Organisms so small that they can only be seen with a microscope are living all around, on, and in us. They include bacteria, viruses, molds, and yeasts.

In the laboratory, you will test the effectiveness of antibiotics in inhibiting the growth of bacteria. You will grow samples of bacteria until they form colonies so big that you can see them with the naked eye. You will grow your samples on sterile nutrient agar in a sterile petri dish. "Sterile" means that there is nothing alive in the agar or on the dish. Nutrient agar supplies the nutrients that microorganisms (not just bacteria) need to live and reproduce.

When you allow bacteria to grow, they will grow uniformly wherever their growth is not effectively inhibited by a bactericide. This uniform growth is called a bacterial lawn and the regions where no growth occurs are zones of inhibition. A large zone of inhibition is created by a bactericide that is more effective at inhibiting the strain’s growth than a bactericide that creates a smaller zone of inhibition.

Purpose or Problem Statement: What are the effects of antiseptics, antibiotics, and disinfectants on bacterial growth?

Safety:
- Wear goggles and an apron throughout this lab.
- Do not touch your face until you have thoroughly washed your hands with soap.
- Wash your hands for a minimum of 30 seconds (count in your head!) with soap and running water before leaving lab.
- Use aseptic technique to avoid contamination of your culture and environment.
- Many antimicrobials are caustic or toxic; use caution when working with these reagents.
- No eating, drinking, gum-chewing, or horseplay in the lab!

Vocabulary: bacterial lawn, antiseptic, disinfectant, antibiotic, inoculation, zones of inhibition

Hypothesis: Develop a hypothesis for this lab based on the reagents you are assigned to use in the procedure. It should be written as an “If – Then – Because” statement.

Materials (per group):
- 1 agar plate
- Sample of bacteria
- Inoculating loop or cotton swab
- Forceps
- Tape
- 1 wax pencil/Sharpie
- 1 metric ruler
- Distilled water
- 1Blank paper disk
- 1 antibiotic disk (previously soaked) in penicillin
- 1 disinfectant disk (previously soaked) in disinfectant
- 1 antiseptic disk (previously soaked) in antiseptic

Procedures:

Day 1: **Keep petri dish closed at all times except when inoculating and placing disks in quadrants!!**

1. On the outside bottom of the petri dish, close to the edge of the dish, write the names of you and your partner(s) and your class period in small letters with the Sharpie/wax pencil.
2. On the outside bottom, draw lines to divide the dish into quadrants and number them 1, 2, 3, and 4.

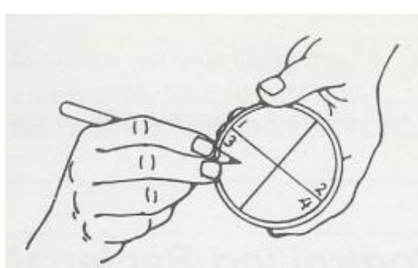
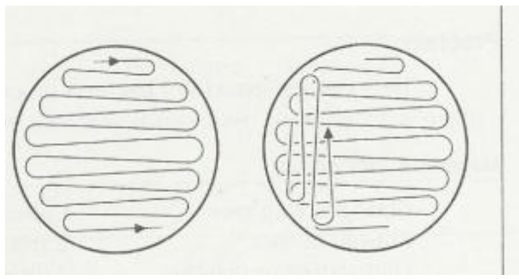


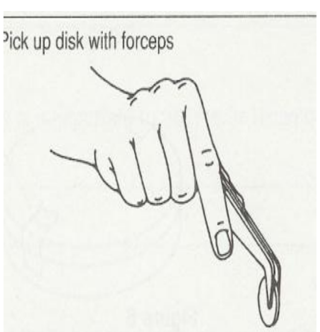
Figure 1

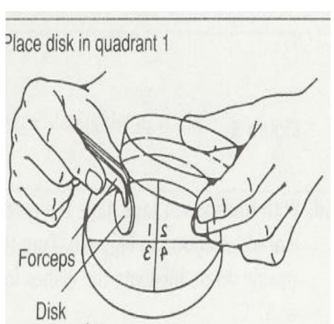
Student

3. To inoculate your agar plate, obtain a sterile cotton swab. Wet the swab with sterile water and gently roll the swab on one surface to obtain a sample of any bacteria present. (**Note**: Agar is like Jello. If you press too hard on the agar with the swab, the agar will tear.)
4. Raise the petri dish cover slightly. Starting at one edge, rub the cotton swab across the entire surface. Use back-and-forth motion to ensure that the entire surface has been covered with the culture. You are creating a lawn.
5. Turn the petri dish a quarter of a turn and re-streak the swab across the agar surface to ensure that bacteria are on the entire surface. (Remember, bacteria are microscopic so you won't be able to see them!)



6. Replace the cover of the petri dish. To dispose of the swab, place it in the Ziploc bag containing bleach. Be careful not to place the swab on any surface or allow the swab to come into contact with anyone.
7. To assay bacterial effectiveness, you will conduct a sensitivity test. You will place the 3 antibiotic disks one blank (plain) disk soaked in sterile water on your plate, one per quadrant.
   a. Raise the cover of the petri dish slightly and place one disk that has been soaked in sterile water in quadrant #1 and record it in the data table. Follow the same procedure of the other 3 disks placing them in quadrants 2 (penicillin), 3 (antiseptic), and 4 (Disinfectant). Press lightly on the antibiotic disks so that they are stuck to the agar. Record this information in the data table.





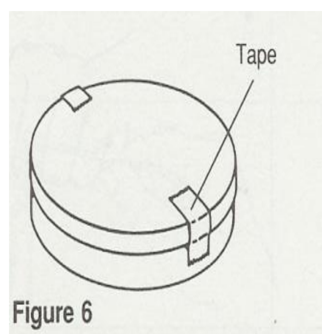
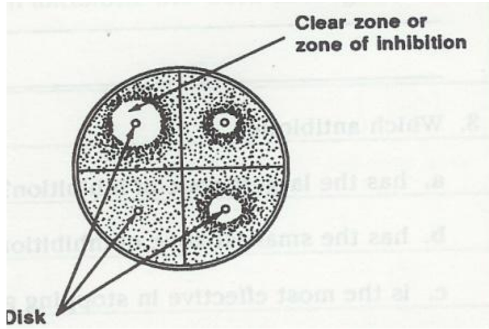


Figure 6

8. Tape the petri dish shut and return it to your teacher.

<u>Day 5:</u> **DO NOT OPEN YOUR PETRI DISH!!!!**

1. Observe your petri dish after the incubation period. Hold your dish up to the light to see the zones of inhibition more clearly.
2. Use a metric ruler to measure the zone of inhibition (the diameter of the clear zone).

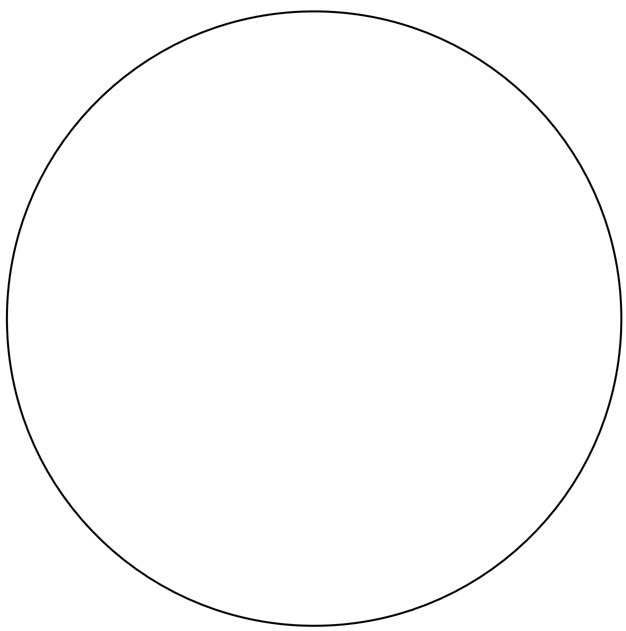


3. Draw, label, and color a diagram of your petri dish **to scale** in the space provided below. Use a petri dish and a ruler to draw the dish. **<u>DO NOT OPEN YOUR PETRI DISH!!!!</u>**
4. Underneath the drawing, write what location you swabbed. Label each quadrant with the appropriate number. Color the drawing the correct colors that you observed. The zones of inhibition should be the <u>correct size</u> (use a ruler!) and should be labeled. Put a title for your figure on the line provided.
5. Return the taped UNOPENED petri dish to your teacher.

Observations/Data:

<u>Day 5: Source of bacteria</u>

Title:________________________________



Day 5 - Figure 1

Table 2 –Zone of Inhibition

Quadrant	Antimicrobial Reagent	Zone of Inhibition (mm)
1	Blank Disk	
2	Penicillin Disk	
3	Antiseptic Disk	
4	Disinfectant Disk	

Student

Data Analysis/Results:
Answer the following questions. Refer to the background section of this lab, as well as your notes, text, and other available references for help.

Day 1:
1. Predict what will happen in each quadrant. Why?
2. What is the difference between decomposing bacteria and pathogenic bacteria?
3. What was the control used in this experiment? Why is a control needed?

Day 5
1. Based on your observations, did you have only one type of organism grow on your plate, or more than one. Explain how you know.
2. Did you have any indication that any of your organisms were fungi instead of bacteria? Explain.
3. Did you expect to find as much growing in your plate as you did based on what you chose to swab? Explain.
4. Over time some bacteria can fail to die even when treated with an antibiotic. What genetic change is happening to the bacteria over time?
5. What do the results of your lab tell you about the importance of washing your hands?
6. Based on your data, rank your test reagents in order from most effective to least effective at killing the bacteria you were given. Explain.

Conclusion:
Write a conclusion using the following as a guide:
- Start with what you did (purpose and the gist of the procedure),
- Then describe what you saw (REFERENCE your data table and figure; DESCRIBE every piece of information you recorded!),
- Then describe what it means (then analyze and conclude by DISCUSSING every piece of data and explaining what it means!).
- State whether your hypothesis was supported or not supported by the results of your lab. EXPLAIN why or why not.
- Include information about your bacteria and how the characteristics of your bacteria might be related to the results of your lab.
- Who needs to know the kind of information you found out about the effectiveness of antimicrobials on a specific bacteria?
- Why do people need to know this kind of information?
- How might you change this experiment to find out more, find out something different, ***or*** improve it?

DNA Electrophoresis Simulation

(Adapted from: Mike Basham, El Dorado High School)

NGSSS:
SC.912.L.16.10 Evaluate the impact of biotechnology on the individual, society and the environment, including medical and ethical issues. (**AA**)

Purpose of Lab/Activity:
- To give students a simulation of DNA electrophoresis.
- To describe the relationship between fragment size and migration rate in a gel via a simulation with student groups in a large field.

Prerequisites:
- Students should be able to recognize the different uses and methods involved in biotechnology.
- Students should be able to describe the different techniques used in biotechnology (e.g. gel electrophoresis).
- Students should be able to explain how DNA fingerprinting can serve as a useful tool in creating genomic libraries, conservation, forensics, and court cases.

Materials:
- Football, soccer or other large grass field (It is important to use a grass field in case students fall during the activity.)
- 50 m or 100 m measuring tape
- Stopwatch or other timing device

Procedures: Day of Activity:

Before activity:	**What the teacher will do:** a. Review procedures of a gel electrophoresis. Refer to web stimulation: http://learn.genetics.utah.edu/content/labs/gel/ b. Discuss uses of biotechnology i.e. industry, forensics, and research. c. Introduce essential question: Will a small fragment of DNA move faster than a larger fragment of DNA? d. Check weather forecasts to ensure the weather permits activity. Have alternative activity just in case of unforeseen circumstances. e. Have students set up a table to record their results while doing the activity. Table should include number of students, distance traveled. f. Address Misconceptions: Because DNA is negatively charged, some students might think that the larger DNA strands will move faster towards the positive end of the electrophoresis chamber because they have a larger affinity/attraction for the positive charge.
During activity:	**What the teacher will do:** a. Monitor the time, you will need a 40 minute class period for the activity b. Select two students to be "spotters". Ask the class the following questions: 1. What do the two student spotters represent in a DNA gel electrophoresis? Spotters represent the dye in the gel electrophoresis. Dyes allow you to see how far the DNA fragments have travelled.

	2. Why do you need to have the one student run as a standard?" The standard needed to be measure so the class has a reference point for comparison. c. Be sure each student lock arms in each run; each time increasing the number of tightly locked students until the entire class is involved.
After activity:	**What the teacher will do:** a. Using the assumption that each student = 1000 DNA base pairs, have the students plot the data on a graph. (y axis = # base pairs and x axis = distance traveled in meters). Students should then draw the curve of best fit. As an option, you may want to have the students use semi-log graph paper as would be used with an actual gel. Graph should show that as the number of base pairs/#of students increase; distance traveled will decrease. b. Discuss the process of electrophoresis to examine DNA samples. 1. Review the questions from the student worksheet

Extension:

- Gizmo: DNA Fingerprinting Analysis

Student

DNA Electrophoresis Simulation

(Adapted from: Mike Basham, El Dorado High School)

NGSSS:

SC.912.L.16.10 Evaluate the impact of biotechnology on the individual, society and the environment, including medical and ethical issues. (**AA**)

Background Information:

Methods of DNA identification have been applied to many branches of science and technology, including medicine (prenatal tests, genetic screening), conservation biology (guiding captive breeding programs for endangered species), and forensic science. One of these techniques involves gel electrophoresis.

DNA samples are often subjected to gel electrophoresis to characterize the size and number of different fragments in the sample. Gel electrophoresis is used to analyze DNA or proteins. Enzymes are used to cut the long DNA or protein samples at specific locations to form the fragments. Then, the DNA or protein fragments are placed in a "well" with a DNA dye along the top of the jello-like gel (agarose gel). Next, a current is applied to the gel, and the electrically charged fragments of the sample migrate through the gel away from the wells. Strongly charged pieces tend to migrate more quickly and, larger pieces migrate more slowly, since they have more difficulty slipping through the gel's matrix. Because DNA is a negatively charged molecule, it will always move toward the positive end of the gel electrophoresis box (red electrode). By comparing the banding patterns of the samples with known substances (standard), scientists can learn about the DNA or protein fragments. Repeated experiments with different enzymes that cut at different locations help scientists determine the makeup of the DNA or protein sample.

Problem Statement: Will a small fragment of DNA move faster than a larger fragment of DNA?

Safety:

- Take precautions to avoid injuring yourself or others when the experiment involves physical activity.
- Alert your teacher if there is any reason you should not participate in the activity.

Vocabulary: biotechnology, genetic engineering, gel electrophoresis, DNA fingerprinting, DNA base pairs, restriction enzyme, genome, genetic marker

Materials:

- Football, soccer or other large grass field (It is important to use a grass field in case students fall during the activity.)
- 50m or 100m measuring tape
- Stopwatch or other timing device

Student

Procedures:

1. The class is taken out to the football field and assembled in the end zone.
2. One student is selected as the timer.
3. Two students are chosen as "spotters" to mark how far each group of students is able to migrate in the 10-second time period.
4. Two students are selected to operate the measuring tape and determine how far each group of students migrates in the 10-second time period.
5. All students will record the data on a table.
6. Select one student and have him/her line up on the goal line. Using the standard "ready, set, go" command, have the student run as fast as he/she can for 10 seconds.
7. Have the markers determine how far the student was able to travel in the 10-second period. Finally, have the measurement team determine how far the student was able to migrate in the time period. Have all students record the data.
8. For the next run, select 2-3 students and have them stand back-to-back and lock arms tightly. Have this group of students migrate as far as they can in 10 seconds. Again, have the marking and measurement teams determine the distance traveled. Have all students record the data.
9. Repeat step 7 several more times, each time increasing the number of tightly locked students in the group. For the last run, try to involve the entire class.

Student

Name: ______________________________________ **Period:** _____________

DNA Electrophoresis Simulation Worksheet

1. Construct a graph which plots the number of base pairs on the "Y" axis (remember each person represents 1000 base pairs on the DNA ladder) vs. distance traveled on the "X" axis. Draw the "curve of best fit" to represent the data.

2. Draw a diagram of the "gel" of what this DNA fingerprint would look like in the box below. Be sure to label each band (how many base pairs in each band).

3. Using your graph, how many base pairs would you predict there would be in a DNA segment that traveled 36m?
4. How far would you expect a segment of DNA which was 600-base-pairs long to migrate? Explain how you arrived at your answer.
5. How far would you expect a segment of DNA which was 6000-base-pairs long to migrate? Explain how you arrived at your answer.

Teacher

Identifying Organic Compounds

NGSSS:
SC.912.L.18.1 Describe the basic molecular structures and primary functions of the four major categories of biological macromolecules. (**AA**)

Purpose of Lab Activity:
Note: This lab activity does not fulfill the AA benchmark but can be used to increase student understanding of the role of macromolecules.

- To predict which types of macromolecules are present in various foods.
- To use several indicators to test for the presence of carbohydrates, proteins, and lipids in some common foods.
- To become familiar with the sources of three of the four macromolecules of life.

Prerequisites: It is important that students are able to describe the molecular structures and primary functions of the four major categories of biological molecules.

Materials (per group):

- 10 Test tubes
- Test-tube rack
- Test-tube holder
- Masking tape
- Glass-marking pencil
- 10-mL graduated cylinder
- Bunsen burner or hot plate
- Iodine solution Dissolve 5 g potassium iodide and 1.5 g iodine crystals in 500 mL of distilled water.
- 20 mL Honey solution Dissolve 20 mL honey in 500 mL distilled water.
- 20 mL Egg white and water mixture Mix egg whites from 3 eggs with 500 mL distilled water.
- 20 mL Corn oil
- 20 mL Lettuce and water mixture Mix 20 mL macerated lettuce with 500 mL distilled water.
- 20 mL Gelatin and water solution Dissolve 3.5 g gelatin in 346.5 mL distilled water. Refrigerate until needed.
- 20 mL Melted butter
- 20 mL Potato and water mixture Mix 20 mL macerated potato with 500 mL distilled water.
- 20 mL Apple juice and water mixture Mix 250 mL unsweetened apple juice with 250 mL distilled water.
- 20 mL Distilled water
- 20 mL Unknown substance
- 10 Dropper pipettes
- Paper towels
- 600-mL Beaker
- Brown paper bag
- Sudan III stain
- Biuret reagent
- Benedict’s solution

Procedure: Day of Activity:

Before activity:	**What the teacher will do:** a. Prep work: Prepare the following solutions at least one day before the lab investigation. 1. Iodine solution - Dissolve 5 g of potassium iodide and 1.5 g iodine crystals in 500 mL distilled water. 2. 20 mL Honey solution - Dissolve 20 mL of honey in 500 mL of distilled water.

	3. 20 mL Egg white and water mixture - Mix egg whites from 3 eggs with 500 mL of distilled water. 4. 20 mL Lettuce and water mixture - Mix 20 mL of macerated lettuce with 500 mL of distilled water. 5. 20 mL Gelatin and water solution - Dissolve 3.5 g of gelatin in 346.5 mL of distilled water. Refrigerate until needed. 6. 20 mL Potato and water mixture - Mix 20 mL of macerated potato with 500 mL of distilled water. 7. 20 mL Apple juice and water mixture - Mix 250 mL of unsweetened apple juice with 250 mL of distilled water. 8. Biuret solution must be fresh. 9. Benedict's solution will not react with sucrose. Avoid materials that contain sucrose. b. Before beginning this activity, it is suggested that you review the basic molecular structure and primary function(s) of the four main biological macromolecules. c. Students should read the entire investigation, and work with a partner to answer the pre-lab questions. Once the students have completed the pre-lab questions, initiate a class discussion asking different students to share their answers. Continue the discussion by asking the following questions: 1. Explain how carbohydrates, proteins, and lipids are classified. 2. How are lipids different from the other classes of macromolecules? 3. Explain how one would determine which food substances contain more protein than others. 4. What materials in your bodies are made out of proteins? (hair, fingernails, muscles, tendons, cartilage, enzymes, antibodies, hemoglobin, hormones, etc.), fats? (cell membranes, insulating layer around nerve cells, steroids, etc.) and carbohydrates? (energy source = blood sugar, stored as glycogen in liver and muscles etc.). d. Continue the discussion to include where we get the materials from to build the structures and molecules inside of our bodies (through our food). e. Have students brainstorm sources of proteins, carbohydrates and fats in their diet. f. Tell students that they will test various food items for the presence of these three macromolecules. g. Show students the available foods for testing. Ask them which ones they expect to contain protein. h. Demonstrate to students how to perform the tests for carbohydrates, proteins, and lipids. f. Grouping: Students should be divided up into three groups which rotate between the stations (carbohydrate station, protein station, and lipid station). There, students can work independently or in pairs. If you don't use stations, students should work in pairs. g. Time needed: At each station, students will need about 30 minutes. The time required for this lab is 90 minutes.If you wish to shorten this investigation, you may want to have your students omit Part D of the Procedures (testing of an unknown substance). It is also possible to have students test fewer than the eight listed food substances. If you wish to

	have students complete the entire investigation but do not feel that the time within one class period is adequate, schedule Parts A, B, and C for one class period and Part D for part of another class period.
During activity:	**What the teacher will do:** a. Monitor students as they carry out proper lab procedure. b. The following questions can be used to engage student thinking during the activity. 1. What is the purpose of this lab? The purpose of this lab is to determine the presence of biological macromolecules in some common foods. 2. You have added Sudan III stain to each of the test tubes. What change indicates the presence of lipids? The Sudan III stain will dissolve in lipids and stain them red. 3. How do you know a food substance contains sugar by adding Benedict's solution? Benedict's solution will change color from blue to green, yellow, orange, or red in the presence of a simple sugar, or monosaccharide. 4. How do you test for the presence of a protein in a food sample? Using a biuret reagent to test for the presence of protein. The solution will change color from yellow to blue-violet in the presence of a protein.
After activity:	**What the teacher will do:** a. The following questions may be used to engage student thinking after the lab and asses their understanding. 1. Which test substances contain lipids? Corn oil and butter (possibly the unknown). 2. Which test substances contain starch? Potato (possibly the unknown). 3. Which test substances contain simple sugar? Honey and apple juice (possibly the unknown). 4. Which test substances contain protein? Egg white and gelatin (possibly the unknown). 5. Which test substances did not test positive for any of the organic compounds? Lettuce (possibly the unknown). 6. People with diabetes are instructed to avoid foods that are rich in carbohydrates. How could your observations in this investigation help you decide whether a food should be served to a person with diabetes? The food could be tested using iodine and/or Benedict's solution. If a color change occurs, the food might not be appropriate for diabetics. 7. Your brown lunch bag has a large, translucent spot on the bottom. What explanation could you give for this occurrence? Some food item in the lunch bag contains lipids. (Students might say the bag accidentally rested on a substance containing lipids.) 8. What conclusion could you make if a positive test for any of the organic compounds occurred in the test tube containing only distilled water? The test tube, distilled water, or indicators may have been contaminated. The tests should be conducted again to achieve accurate results. 9. A very thin slice is removed from a peanut and treated with Sudan III stain. Then a drop of Biuret reagent is added to the peanut slice. When you examine the peanut slice under a microscope, patches of red and blue-violet are visible. What conclusions can you draw from your

	examination? Peanuts contain lipids and proteins. b. In order to connect concepts of the activity to the NGSS, have the students develop a Venn Diagram on a large poster board to show the similarities and differences of the three biological macromolecules investigated in this activity. Make sure they include representative food substances as well as molecular structures and functions for each of the three main categories. This can be assigned as a home learning experience. The next day, have students present their results before the class.

Extension:

- Gizmo: Identifying Nutrients

Student

Identifying Organic Compounds

(Adapted from Prentice Hall Biology Laboratory Manual A)

NGSSS:
SC.912.L.18.1 Describe the basic molecular structures and primary functions of the four major categories of biological macromolecules. (**AA**)

Background:
All living things contain organic macromolecules: lipids, proteins, carbohydrates and nucleic acids. Characteristic for these organic molecules is that they are made up of only a small number of elements: carbon, hydrogen, oxygen, and to smaller amounts nitrogen, phosphorus and sulfur. They are called "macromolecules" because they are very large, containing long chains of carbon and hydrogen atoms and often consist of repeating smaller molecules bonded together in a repeating pattern (polymers).

Macromolecule	Building Block
Protein	amino acids
Carbohydrate	monosaccharides
Lipid	glycerol + fatty acids
nucleic acid	nucleotides

In this investigation, you will determine which macromolecules are components of the foods you eat. Substances, called indicators, can be used to test for the presence of organic compounds. An indicator is a substance that changes color in the presence of a particular compound. You will use several indicators to test for the presence of carbohydrates, lipids and proteins in various foods.

Purpose of Lab Activity:

- To predict which types of macromolecules are present in various foods.
- To use several indicators to test for the presence of carbohydrates, proteins, and lipids in some common foods.
- To become familiar with the sources of three of the four macromolecules of life

Safety: Wear safety goggles at all times in the science laboratory. Be careful to avoid breakage when working with glassware. Always use special caution when using any laboratory chemicals, as they may irritate the skin or cause staining of the skin or clothing. Never touch or taste any chemical unless instructed to do so. Use extreme care when working with heated equipment or materials to avoid burns. Wear plastic gloves when handling eggs or egg whites or tools that have been in contact with them. Wash hands thoroughly after carrying out this lab.

Vocabulary: Macromolecule, Carbohydrates, Lipids (fats), Proteins, Sugar, Starch, Amino acid, Glucose, Sucrose, Monosaccharide, Disaccharide, Polysaccharide, Enzyme, Fatty acids, Polar/non-polar molecules, Nucleic acid, Polymer

Student

Materials (per group):

- 10 test tubes
- Test-tube rack
- Test-tube holder
- Masking tape
- Glass-marking pencil
- 10-mL graduated cylinder
- Bunsen burner or hot plate
- Iodine solution
- 20 mL Honey solution
- 20 mL Egg white and water mixture
- 20 mL Corn oil
- 20 mL Lettuce and water mixture
- 20 mL Gelatin and water
- 20 mL Melted butter
- 20 mL Potato and water
- 20 mL Apple juice and water mixture
- 20 mL Distilled water
- 20 mL Unknown substance
- 10 Dropper pipettes
- Paper towels
- 600-mL Beaker
- Brown paper bag
- Sudan III stain
- Biuret reagent
- Benedict's solution

Pre-Lab Discussion:
Read the entire investigation, and work with a partner to answer the questions below.

1. What is an indicator how are indicators used in this experiment?
2. What is the purpose of using distilled water as one of your test substances?
3. What is the controlled variable in Part C?
4. What is the purpose of washing the test tubes thoroughly?
5. You have added Sudan III stain to each of the test tubes. What change indicates the presence of lipids?

Procedures:
<u>Part A. Testing for Lipids</u>

1. Place 9 test tubes in a test-tube rack. Use masking tape to make labels for each test tube. Write the name of a different food sample (listed in Materials) on each masking-tape label. Label the ninth test tube "distilled water."
2. Use a graduated cylinder to transfer 5 mL of distilled water into the test tube labeled "distilled water." Use a glass-marking pencil to mark the test tube at the level of the water. Mark the other test tubes in the test-tube rack at the same level.
3. Use a separate dropper pipette to fill each of the other test tubes with 5 mL of the substance indicated on the masking-tape label. Add 5 drops of Sudan III stain to each test tube. Sudan III stain will dissolve in lipids and stain them red.
4. Gently shake the contents of each test tube. **CAUTION:** *Use extreme care when handling Sudan III to avoid staining hands or clothing.* In the Data Table, record any color changes and place a check mark next to those substances testing positively for lipids.
5. Wash the test tubes thoroughly but leave the labels on.
6. For another test for lipids, divide a piece of a brown paper bag into 10 equal sections. In each section, write the name of one test substance, as shown in Figure 2. (Note:The empty square can be used to test an unknown substance)

Honey	Egg white	Corn oil	Lettuce	Gelatin
Butter	Potato	Apple juice	Distilled water	

Figure 2

7. In each section, place a small drop of the identified food onto the brown paper. With a paper towel, wipe off any excess pieces of food that may stick to the paper. Set the paper aside until the spots appear dry—about 10 to 15 minutes.
8. Hold the piece of brown paper up to a bright light or window. You will notice that some foods leave a translucent spot on the brown paper. The translucent spot indicates the presence of lipids.

Part B. Testing for Carbohydrates

1. Sugars and starches are two common types of carbohydrates. To test for starch, use the same dropper pipettes to refill each cleaned test tube with 5 ml of the substance indicated on the masking-tape label. Add 5 drops of iodine solution to each test tube. Iodine will change color from yellow-brown to blue-black in the presence of starch.
2. Gently shake the contents of each test tube. **CAUTION:** *Use extreme caution when using iodine as it is poisonous and can also stain hands and clothing.* In the Data Table, record any color changes and place a check mark next to those substances testing positive for starch.
3. Wash the test tubes thoroughly.
4. For a sugar test, set up a hot-water bath as shown in Figure 3. Half fill the beaker with tap water. Heat the water to a gentle boil. **CAUTION:** *Use extreme care when working with hot water. Do not let the water splash onto your hands.*
5. While the water bath is heating, fill each cleaned test tube with 5 mL of the substance indicated on the masking-tape label. Add 10 drops of Benedict’s solution to each test tube. When heated, Benedict’s solution will change color from blue to green, yellow, orange, or red in the presence of a simple sugar, or monosaccharide.
6. Gently shake the contents of each test tube. **CAUTION:** *Use extreme caution when using Benedict’s solution to avoid staining hands or clothing.*
7. Place the test tubes in the hot-water bath. Heat the test tubes for 3 to 5 minutes. With the test-tube holder, remove the test tubes from the hot-water bath and place them back in the test-tube rack. **CAUTION:** *Never touch hot test tubes with your bare hands. Always use a test-tube holder to handle hot test tubes.* In the Data Table, record any color changes and place a check mark next to any substances that test positive for a simple sugar.
8. After they have cooled, wash the test tubes thoroughly.

Part C. Testing for Proteins

1. Put 5 mL of the appropriate substance in each labeled test tube. Add 5 drops of biuret reagent to each test tube. **CAUTION:** *Biuret reagent contains sodium hydroxide, a strong base. If you splash any reagent on yourself, wash it off immediately with water. Call your teacher for assistance.*
2. Gently shake the contents of each test tube. Biuret reagent changes color from yellow to blue-violet in the presence of protein. In the Data Table, record any changes in color and place a check mark next to any substances that test positively for protein.
3. Wash test tubes thoroughly.

Part D. Testing an Unknown Substance for Organic Compounds

1. Obtain a sample of an unknown substance from your teacher and pour it into the remaining test tube. Repeat the tests described in Parts A, B, and C of the Procedure to

determine the main organic compounds in your sample. Record your results in the Data Table.
2. Wash the test tube thoroughly.
3. Wash your hands with soap and warm water before leaving the lab.

Observations/Data:

	Lipid Test		**Carbohydrate Test**				**Protein Test**	
Substance	Sudan color	Lipids Present (X)	Iodine color	Starches present (X)	Benedict's color	Sugars Present (X)	Biuret color	Proteins Present (X)
Honey								
Egg white								
Corn oil								
Lettuce								
Gelatin								
Butter								
Potato								
Apple juice								
Distilled water								
Unknown								

Results/Conclusions:

<u>Classifying</u>

1. Which test substances contain lipids?
2. Which test substances contain starch?
3. Which test substances contain simple sugar?
4. Which test substances contain protein?
5. Which test substances did not test positive for any of the organic compounds?

<u>Drawing Conclusions</u>

6. People with diabetes are instructed to avoid foods that are rich in carbohydrates. How could your observations in this investigation help you decide whether a food should be served to a person with diabetes?
7. Your brown lunch bag has a large, translucent spot on the bottom. What explanation could you give for this occurrence?
8. What conclusion could you make if a positive test for any of the organic compounds occurred in the test tube containing only distilled water?
9. A very thin slice is removed from a peanut and treated with Sudan III stain. Then, a drop of Biuret reagent is added to the peanut slice. When you examine the peanut slice under

a microscope, patches of red and blue-violet are visible. What conclusions can you draw from your examination?

10. Develop a Venn diagram on a large poster to show the similarities and differences of the three macromolecules investigated in this activity. Include representative food substances as well as molecular structures and functions for each of the three macromolecules. Be prepared to present your results before the class in a five minute presentation.

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Revised 9/2008