Required
ESSENTIAL Laboratory Activities

For the Middle School
Comprehensive Science 2 Course

Revised July 2010
THE SCHOOL BOARD OF MIAMI-DADE COUNTY, FLORIDA

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## Lab Activities

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Introduction

The purpose of this packet is to provide the Comprehensive Science 2 teachers with a list of basic laboratory and hands-on activities that students should experience in class. Each activity is aligned with the Comprehensive Science 2 Curriculum Guide and the Next Generation Sunshine State Standards (NGSSS). Emphasis should be placed on those activities that are aligned to the Annually Assessed benchmarks, which are consistently assessed in the Florida Comprehensive Assessment Test (FCAT).

All hands-on activities were designed to cover most concepts found in Comprehensive Science 2. In some cases, more than one lab was included to cover a specific benchmark. In most cases, the activities were designed as simple as possible without the use of advanced technological equipment to make it possible for all teachers to use these activities. All activities and supplements (i.e., Parts of a Lab Report) should be modified, if necessary, to fit the needs of an individual class and/or student ability.

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

Acknowledgement:

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

Each list corresponds to the amount of materials needed per station (whether one student or a group of students uses the station). Safety goggles should be assigned to each student and lab aprons on all labs requiring mixtures of chemicals.

Temperature Changes Everything

- one small party balloon
- one small bottle/flask
- hot plate/Bunsen burner
- balance
- Safety goggles

Chemical Change in a Bag

<table>
<thead>
<tr>
<th>Materials per lab group</th>
<th>Substitute materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Ziploc bags</td>
<td>2 tbsp. Damp Rid (calcium carbonate)</td>
</tr>
<tr>
<td>2 plastic spoons</td>
<td>2 tbsp. baking soda</td>
</tr>
<tr>
<td>1 0°-100° C thermometer</td>
<td>1 small paper cup</td>
</tr>
<tr>
<td>2 tbsp. calcium chloride</td>
<td>30 mL red cabbage juice</td>
</tr>
<tr>
<td>2 tbsp. sodium hydrogen carbonate</td>
<td></td>
</tr>
<tr>
<td>1 test tube</td>
<td></td>
</tr>
<tr>
<td>30 mL indicator solution (phenol red or phenolphthalein)</td>
<td></td>
</tr>
<tr>
<td>Safety goggles</td>
<td></td>
</tr>
</tbody>
</table>

Materials for teacher’s demonstration:
- Matches and wooden splint

Analyzing Energy Transformations

- Dry beach sand
- Marble
- Golf ball
- Ping pong or plastic golf ball
- Substitute materials: 3 balls of different sizes
- Ruler
- Meter stick
- Tooth pick
- Safety goggles

Shaking Sand

- One plastic (or glass) container with lid (200 mL)
- 225 ml of sand
- Thermometer (Celsius)
- Safety goggles
- Graduated cylinder
- Stop watch or clock
- 250 ml beaker

Lab 4: Solar Energy vs. Color

- pieces of construction paper (recommended size 12cm by 16cm)
- suggested colors- white, black, gray, brown
- Celsius thermometers
- tape
- stop watch
- Safety goggles
Wave Speed

- 2-Liter clear plastic bottles with caps (remove label)
- stop watch
- Grease pencil/permanent marker
- Metric ruler
- Water
- Oil
- Eye protection

Density of Rocks

- Graduated cylinder
- 250 mL beaker
- medicine dropper
- food coloring (not essential but helpful)
- 100 mL Graduated cylinder
- Eye dropper
- Calculator
- Electronic balance or triple-beam balance
- 5 different type of rocks
- Tap water at room temperature
- ruler
- Safety goggles

Density Driven Fluid Flow

- (2) opaque, shoe-box sized plastic container
- (2) large test tube
- (1) test tube rack
- (2) rubber cork (to fit the top of the test tube; your thumb can serve as an alternate)
- plastic spoon or stirring rod (plastic straws will work here)

Extension Materials: Hot plate
(2) 250 mL beakers

Classifying Rocks

- Different rock samples (at least 16)

Fossils and the Law of Superposition

- Pencils
- Colored Pencils
- Drawing Paper
- Cardstock
- Handouts:
  - Nonsense Cards Set A
  - Fossils Cards Set B (1)
  - Fossils Cards Set B (2)
  - Stratigraphic Section for Set B

Becoming Whales

- Handouts
- Scissors

Moth Catcher

- Tape
- Crayons and/or Markers
- Scissors
- Drawing paper
Modeling the Greenhouse Effect

- 2 Clear plastic cups
- 2 Thermometers
- Potting soil
- Clear Plastic wrap
- Lamp with 100 Watt light bulb
- 2 Rubber bands
- Watch or clock
- Safety goggles

Dissecting a Flower

- Gladiolus and/or hibiscus (1 per group)
- Razor blades, scalpels or plastic knives
- Toothpicks
- Glass slides
- Newspaper
- Paper towels
- Flower model (if available)
- Lab sheets (directions and data log)
- Markers
- Dissecting microscopes (optional)
- Glue or scotch tape
- Safety goggles

Spontaneous Generation

- Colored pencils or markers
- Poster board
- Computer with Internet access; and/or library access
- Worksheet
- Scissors

Human Variations

- 2 coins
- 2 students
- Construction paper for face features
- Colored pencils or Markers
- Crayons (skin-color set)
- Curling ribbon for hair (brown, yellow, and black)
- Paper plates
- Scissors

Incomplete Dominance

- 2 purple plastic eggs
- 2 pink plastic eggs
- 2 orange plastic eggs
- 2 blue plastic eggs
- 2 yellow plastic eggs
- 2 green plastic eggs
- 7 purple plastic items/candy
- 7 pink plastic items/candy
- 10 orange plastic items/candy
- 7 blue plastic items/candy
- 7 yellow plastic items/candy
- 10 green plastic items/candy
Grade 7 Science Next Generation Sunshine State Standards
Benchmarks included in Essential Labs

SC.7.N.1.1 Define a problem from the seventh grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions. (Assessed as SC.8.N.1.1)

SC.7.N.1.2 Differentiate replication (by others) from repetition (multiple trials). (AA)

SC.7.N.1.3 Distinguish between an experiment (which must involve the identification and control of variables) and other forms of scientific investigation and explain that not all scientific knowledge is derived from experimentation. (Assessed as SC.8.N.1.1)

SC.7.N.1.4 Identify test variables (independent variables) and outcome variables (dependent variables) in an experiment. (Assessed as SC.8.N.1.1)

SC.7.N.1.5 Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics. (AA)

SC.7.N.1.7 Explain that scientific knowledge is the result of a great deal of debate and confirmation within the science community. (Assessed as SC.7.N.2.2)

SC.7.N.2.1 Identify an instance from the history of science in which scientific knowledge has changed when new evidence or new interpretations are encountered. (Assessed as SC.6.N.2.2)

SC.7.E.6.2 Identify the patterns within the rock cycle and relate them to surface events (weathering and erosion) and sub-surface events (plate tectonics and mountain building). (AA)

SC.7.E.6.3 Identify current methods for measuring the age of Earth and its parts, including the law of superposition and radioactive dating. (Assessed as SC.7.E.6.4)

SC.7.E.6.4 Explain and give examples of how physical evidence supports scientific theories that Earth has evolved over geologic time due to natural processes. (AA)

SC.7.E.6.6 Identify the impact that humans have had on Earth, such as deforestation, urbanization, desertification, erosion, air and water quality, changing the flow of water. (Assessed as SC.7.E.6.2)

SC.7.P.10.2 The student observes and explains that light can be reflected, refracted, and absorbed. (Assessed as SC.7.P.10.3)

SC.7.P.10.3 The student recognizes that light waves, sound waves and other waves move at different speeds in different materials. (AA)

SC.7.P.11.1 Recognize that adding heat to or removing heat from a system may result in a temperature change and possibly a change of state.

SC.7.P.11.2 Investigate and describe the transformation of energy from one form to another. (AA)

SC.7.P.11.3 Cite evidence to explain that energy cannot be created nor destroyed, only changed from one form to another. (Assessed as SC.7.P.11.2)

SC.7.P.11.4 Observe and describe that heat flows in predictable ways, moving from warmer objects to cooler ones until they reach the same temperature. (AA)

SC.7.L.15.1 Recognize that fossil evidence is consistent with the scientific theory of evolution that living things evolved from earlier species. (Assessed as SC.7.L.15.2)

SC.7.L.15.2 Explore the scientific theory of evolution by recognizing and explaining ways in which genetic variation and environmental factors contribute to evolution by natural selection and diversity of organisms. (AA)

SC.7.L.16.1 Understand and explain that every organism requires a set of instructions that specifies its traits, that this hereditary information (DNA) contains genes located in the chromosomes of each cell, and that heredity is the passage of these instructions from one generation to another. (AA)

SC.7.L.16.2 Determine the probabilities for genotype and phenotype combinations using Punnett Squares and pedigrees. (Assessed as SC.7.L.16.1)

(AA)= Annually Assessed Benchmarks
Lab Roles and Their Descriptions

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

<table>
<thead>
<tr>
<th>Role</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Director (PD)</strong></td>
<td>The project director is responsible for the group.</td>
</tr>
<tr>
<td><strong>Roles and responsibilities:</strong></td>
<td>- Reads directions to the group</td>
</tr>
<tr>
<td></td>
<td>- Keeps group on task</td>
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<tr>
<td></td>
<td>- Is the only group member allowed to talk to the teacher</td>
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<tr>
<td></td>
<td>- Shares summary of group work and results with the class</td>
</tr>
<tr>
<td><strong>Materials Manager (MM)</strong></td>
<td>The materials manager is responsible for obtaining all necessary materials and/or equipment for the lab.</td>
</tr>
<tr>
<td><strong>Roles and responsibilities:</strong></td>
<td>- The only person allowed to be out of his/her seat to pick up needed materials</td>
</tr>
<tr>
<td></td>
<td>- Organizes materials and/or equipment in the work space</td>
</tr>
<tr>
<td></td>
<td>- Facilitates the use of materials during the investigation</td>
</tr>
<tr>
<td></td>
<td>- Assists with conducting lab procedures</td>
</tr>
<tr>
<td></td>
<td>- Returns all materials at the end of the lab to the designated area</td>
</tr>
<tr>
<td><strong>Technical Manager (TM)</strong></td>
<td>The technical manager is in charge of recording all data.</td>
</tr>
<tr>
<td><strong>Roles and responsibilities:</strong></td>
<td>- Records data in tables and/or graphs</td>
</tr>
<tr>
<td></td>
<td>- Completes conclusions and final summaries</td>
</tr>
<tr>
<td></td>
<td>- Assists with conducting the lab procedures</td>
</tr>
<tr>
<td></td>
<td>- Assists with the cleanup</td>
</tr>
<tr>
<td><strong>Safety Director (SD)</strong></td>
<td>The safety director is responsible for enforcing all safety rules and conducting the lab.</td>
</tr>
<tr>
<td><strong>Roles and responsibilities:</strong></td>
<td>- Assists the PD with keeping the group on-task</td>
</tr>
<tr>
<td></td>
<td>- Conducts lab procedures</td>
</tr>
<tr>
<td></td>
<td>- Reports any accident to the teacher</td>
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<tr>
<td></td>
<td>- Keeps track of time</td>
</tr>
<tr>
<td></td>
<td>- Assists the MM as needed</td>
</tr>
</tbody>
</table>

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.
- 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 not working to expectations, re-assign the members to another group.
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 fire fighting equipment.

• Conduct myself in a responsible manner at all times in a laboratory situation.

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

Student’s Signature: _________________________________ Date: ___________________

Parent’s Signature: _________________________________ Date: ___________________
Pre-Lab Safety Worksheet and Approval Form

This form must be completed with the teacher’s collaboration before the lab.

Student Researcher Name: __________________________________________  Period # _____

Title of Experiment: ____________________________________________________________

Place a check mark in front of each true statement below:

1. ☐ I have reviewed the safety rules and guidelines.
2. This lab activity involves one or more of the following:
   ☐ Human subjects (Permission from participants required. Subjects must indicate willingness to participate by signing this form below.)
   ☐ Vertebrate Animals (requires an additional form)
   ☐ Potentially Hazardous Biological Agents (Microorganisms, molds, rDNA, tissues, including blood or blood products, all require an additional form.)
   ☐ Hazardous chemicals (such as: strong acids or bases)
   ☐ Hazardous devices (such as: sharp objects or electrical equipment)
   ☐ Potentially Hazardous Activities (such as: heating liquids or using flames)
3. ☐ I understand the possible risks and ethical considerations/concerns involved in this experiment.
4. ☐ I have completed an Experimental/Engineering Design Diagram.

Show that you understand the safety and ethical concerns related to this lab by responding to the questions below. Then, sign and submit this form to your teacher before you proceed with the experiment (use back of paper, if necessary).

A. Describe what you will be doing during this lab.

B. What are the safety concerns with this lab that were explained by your teacher?
   How will you address them?

C. What additional safety concerns or questions do you have?

D. What ethical concerns related to this lab do you have?
   How will you address them?

Student Researcher’s Signature/Date: ___________________________  Teacher Approval Signature: ___________________________

Human Subjects’ Agreement to Participate:

Printed Name/Signature/Date   Printed Name/Signature/Date

Printed Name/Signature/Date   Printed Name/Signature/Date
Parts of a Lab Report
A Step-by-Step Checklist

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

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

**Benchmarks Covered:**
Your teacher should provide this information for you. It is a summary of the main concepts that you will learn about while conducting the experiment.

**Problem Statement:**
Identify the research question/problem and state it clearly in the form of a question.

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

**Materials:**
Record precise details of all equipment used.
   o For example: a balance that measures with an accuracy of +/- 0.001 g.
Record precise formulas and amounts of any chemicals used
   o For example: 5 g of CuSO\(_4\) or 5 mL H\(_2\)O

**Procedure:**
1. Do not copy the procedures from the lab manual or handout.
2. Summarize the procedures in sequential order; be sure to include critical steps.
3. Give accurate and concise details about the apparatus and materials used.

**Variables and Control Test:**
Identify the variables in the experiment. State those over which you have control. There are three types of variables.
1. Independent variable: (also known as the manipulated variable) the factor that can be changed by the investigator (the cause).
2. Dependent variable: (also known as the responding variable) the observable factor of an investigation that is the result or what happened when the independent variable was changed.
3. Constant variables: the other identified independent variables in the investigation that are kept or remain the same during the investigation.

Identify the control test. A control test is the separate experiment that serves as the standard for comparison to identify experimental effects, changes of the dependent variable resulting from changes made to the independent variable.

**Data:**
Ensure that all data is recorded.
   o Pay particular attention to significant figures and make sure that all units are stated.

Present your results clearly. Often it is better to use a table or a graph.
If using a graph, make sure that the graph has a title, each axis is labeled clearly, and the correct scale is chosen to utilize most of the graph space. Record qualitative observations. Also list the environmental conditions.

Include color changes, solubility changes, and whether heat was released or absorbed.

**Results:**
1. Ensure that you have recorded your data correctly to produce accurate results.
2. Include any errors or uncertainties that may affect the validity of your result.

**Conclusion and Evaluation:**
A conclusion statement answers the following 7 questions in at least three paragraphs.

**I. First Paragraph: Introduction**
1. What was investigated?
   a) Describe the problem or state the purpose of the experiment.
2. Was the hypothesis supported by the data?
   a) Compare your actual result to the expected result (either from the literature, textbook, or your hypothesis)
   b) Include a valid conclusion that relates to the initial problem or hypothesis.
3. What were your major findings?
   a) Did the findings support or not support the hypothesis as the solution to the restated problem?
   b) Calculate the percentage error from the expected value.

**II. Middle Paragraphs: These paragraphs answer question 4 and discuss the major findings of the experiment using data.**
4. How did your findings compare with other researchers?
   a) Compare your result to other students’ results in the class.
      i) The body paragraphs support the introductory paragraph by elaborating on the different pieces of information that were collected as data that either supported or did not support the original hypothesis.
      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 will always refer back to the findings in the first paragraph.

**III. Last Paragraph: Conclusion**
5. What possible explanations can you offer for your findings?
   a) Evaluate your method.
   b) State any procedural or measurement errors that were made.
6. What recommendations do you have for further study and for improving the experiment?
   a) Comment on the limitations of the method chosen.
   b) Suggest how the method chosen could be improved to obtain more accurate and reliable results.
7. What are some possible applications of the experiment?
   a) How can this experiment or the findings of this experiment be used in the real world for the benefit of society.
## Experimental Design Diagram
This form should be completed before experimentation.

<table>
<thead>
<tr>
<th>Title:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Statement:</td>
<td></td>
</tr>
<tr>
<td>Null Hypothesis:</td>
<td></td>
</tr>
<tr>
<td>Research Hypothesis:</td>
<td></td>
</tr>
<tr>
<td>Manipulated Variable (MV): or Independent Variable (IV)</td>
<td></td>
</tr>
<tr>
<td>Number of Tests:</td>
<td>Subdivide this box to specify each variety.</td>
</tr>
<tr>
<td>Control Test:</td>
<td></td>
</tr>
<tr>
<td># of Trials per Test:</td>
<td></td>
</tr>
<tr>
<td>Responding Variable (RV): or Dependent Variable (DV)</td>
<td></td>
</tr>
<tr>
<td>Variables Held Constant</td>
<td>1.</td>
</tr>
<tr>
<td></td>
<td>2.</td>
</tr>
<tr>
<td></td>
<td>3.</td>
</tr>
<tr>
<td></td>
<td>4.</td>
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<tr>
<td></td>
<td>5.</td>
</tr>
<tr>
<td></td>
<td>6.</td>
</tr>
</tbody>
</table>
Experimental Design Diagram Hints:

Title: A clear, scientific way to communicate what you’re changing and what you’re measuring is to state your title as, "The Effect of ____________ on ____________." The manipulated variable is written on the first line above and the responding variable is written on the second line.

Problem Statement: Use an interrogative word and end the sentence with a question mark. Begin the sentence with words such as: How many, How often, Where, Will, or What. Avoid Why.

Null Hypothesis: This begins just like the alternate hypothesis. The sentence should be in If ............, then............ form. After If, you should state the MV, and after the then, you should state that there will be no significant difference in the results of each test group.

Research Hypothesis: If ____________ (state the conditions of the experiment), then ____________ (state the predicted measurable results). Do not use pronouns (no I, you, or we) following If in your hypothesis.

Manipulated Variable (MV): This is the condition the experimenter sets up, so it is known before the experiment (I know the MV before). In middle school, there is usually only one MV. It is also called the independent variable, the IV.

Number of Tests: State the number of variations of the MV and identify how they are different from one another. For example, if the MV is "Amount of Calcium Chloride" and 4 different amounts are used, there would be 4 tests. Then, specify the amount used in each test.

Control Test: This is usually the experimental set up that does not use the MV. Another type of control test is one in which the experimenter decides to use the normal or usual condition as the control test to serve as a standard to compare experimental results against. The control is not counted as one of the tests of the MV. In comparison experiments there may be no control test.

Number of Trials: This is the number of repetitions of one test. You will do the same number of repetitions of each variety of the MV and also the same number of repetitions of the control test. If you have 4 test groups and you repeat each test 30 times, you are doing 30 trials. Do not multiply 4 x 30 and state that there were 120 trials.

Responding Variable(s): This is the result that you observe, measure and record during the experiment. It’s also known as the dependent variable, DV. (I don’t know the measurement of the DV before doing the experiment.) You may have more than one DV.

Variables Held Constant: Constants are conditions that you keep the same way while conducting each variation (test) and the control test. All conditions must be the same in each test except for the MV in order to conclude that the MV was the cause of any differences in the results. Examples of Constants: Same experimenter, same place, time, environmental conditions, same measuring tools, and same techniques.
1. Identify the need or problem
2. Research the need or problem
   a. Examine current state of the issue and current solutions
   b. Explore other options via the internet, library, interviews, etc.
   c. Determine design criteria
3. Develop possible solution(s)
   a. Brainstorm possible solutions
   b. Draw on mathematics and science
   c. Articulate the possible solutions in two and three dimensions
   d. Refine the possible solutions
4. Select the best possible solution(s)
   a. Determine which solution(s) best meet(s) the original requirements
5. Construct a prototype
   a. Model the selected solution(s) in two and three dimensions
6. Test and evaluate the solution(s)
   a. Does it work?
   b. Does it meet the original design constraints?
7. Communicate the solution(s)
   a. Make an engineering presentation that includes a discussion of how the solution(s) best meet(s) the needs of the initial problem, opportunity, or need
   b. Discuss societal impact and tradeoffs of the solution(s)
8. Redesign
   a. Overhaul the solution(s) based on information gathered during the tests and presentation

Source(s): Massachusetts Department of Elementary and Secondary Education
TEMPERATURE CHANGES EVERYTHING
Adapted from Science NetLinks Activity Sheet - Temperature Changes Everything

NGSSS:
SC.7.P.11.1 Recognize that adding heat to or removing heat from a system may result in a temperature change and possibly a change of state.
SC.7.P.11.4 Observe and describe that heat flows in predictable ways, moving from warmer objects to cooler ones until they reach the same temperature. (AA)

Background:
One of the most important concepts for students to understand is that temperature affects the motion of molecules. As air is warmed, the energy from the heat causes the molecules of air to move faster and farther apart. Some students may have difficulty with this concept because they lack an appreciation of the very small size of particles or may attribute macroscopic properties to particles. Students might also believe that there must be something in the space between particles. Finally, students may have difficulty in appreciating the intrinsic motion of particles in solids, liquids, and gases; and have problems in conceptualizing forces between particles. In order to clarify student thinking about molecules and their relationship to temperature, instruction has to make the molecular world understandable to students.

Materials:
- one small party balloon
- one small bottle/flask
- hot plate/Bunsen burner
- balance
- oven mitt
- water

Engage:
Play the “Behavior of Matter” interactive video for students to see how the molecules in solids, liquids, and gas behave as heat is added or removed (http://www.bbc.co.uk/schools/ks3bitesize/science/chemical_material_behaviour/behaviour_of_matter/activity.shtml).

Explore:

Procedure:
1. Pour about 15 ml. of water into an empty glass bottle/flask.
2. Calculate the mass of the bottle, water, and balloon using the balance. Record the mass on the data table.
3. Partially blow up the balloon, and then let the air out of it. Do this several times as this helps to stretch the balloon.
4. Stretch the open balloon over the top of the bottle.
5. Heat the bottle until the water boils vigorously. Write down your observations of the water and the balloon on the data table.
6. Using an oven mitt, place the bottle with balloon on the balance; record the mass on the data table.
7. Allow the bottle to cool. Write down observations of the balloon and the bottle.
8. Place the bottle with balloon on the balance. Record information on the data table.
Data Table

Mass and Observations of Bottle, Balloon and Water Set-up

<table>
<thead>
<tr>
<th>Temperature of Bottle, Balloon, and Water</th>
<th>Mass (grams)</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cool</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Explain:

1. What do you think caused the balloon to expand?
2. What is happening inside the balloon that is causing this to happen?
3. How does adding heat affect the liquid water?
4. Why do you think the balloon was pulled into the bottle? What is happening outside the balloon that is causing this to happen?
5. What did you observe inside the bottle as it cooled?
6. What is happening to particles inside the balloon? Are they moving? How are they moving?
7. How did this experiment demonstrate water changing from liquid to gas?
8. What would have happened if the bottle were placed in the freezer?
9. Sketch a model of the water molecules in liquid state in the flask and in gas state in the flask and balloon.

Elaborate/Extension:

Students can research how a hot air balloon works? They can draw a diagram of how the gas particles move and why?
CHEMICAL CHANGE IN A BAG
Adapted from: Chemistry in a Bag Demonstration (http://www.middleschoolscience.com/bag.htm) and Ziptop Bag Chemistry (http://www.science-house.org/learn/CountertopChem/exp5.html)

NGSSS:
SC.7.N.1.2 Differentiate replication (by others) from repetition (multiple trials). (AA)
SC.7.N.1.4 Identify test variables (independent variables) and outcome variables (dependent variables) in an experiment.

Objectives/Purpose:
- Describe physical changes.
- Identify when a chemical change has taken place.
- Compare/contrast physical and chemical changes.
- Measure changes in temperature.
- Compare endothermic and exothermic reactions.

Background Information for the teacher:
Chemistry is the study of the composition of and the changes that occur in matter. A chemist must be able to identify the changes that occur in a chemical reaction. When a chemical reaction occurs, the particles that make up matter reorganize in some way. This reorganization of particles leads to modifications such as color changes, release or absorption of heat, and gas release or “fizzing,” among others. If a chemical reaction occurs, a new substance with different properties always forms.

Engagement
Chemical reactions happen all around us. Can you name some chemical reactions that we observe in our everyday lives?

Materials:

Materials per lab group
- 4 Ziploc bags
- 2 plastic spoons
- 1 0°-100° C thermometer
- 2 tbsp. calcium chloride
- 2 tbsp. sodium hydrogen carbonate
- 1 test tube
- 30 mL indicator solution (phenol red/phenolphthalein)

Substitute materials
- 2 tbsp. Damp Rid (calcium chloride)
- 2 tbsp. baking soda (sodium hydrogen carbonate)
- 1 small paper cup
- 30 mL red cabbage juice

Materials for Teacher’s Demonstration only
- Matches and wooden splint
Procedures:

Part 1:
1. Add 2 tsp. of sodium hydrogen carbonate (NaHCO₃) to a Ziploc bag.
2. Record temperature with a 100°C Celsius thermometer.
3. Gently place a test tube with approximately 30 mL of phenol red inside the bag in the upright position.
4. Squeeze out any excess air and seal the bag.
5. Do not open the bag, but pour the phenol red from the test tube into the bag by gently tilting the bag.
6. Gently massage the bag to mix the contents.
7. Look, listen, feel, and record the temperature again.
8. Record your observations in the data log below.

Part 2:
1. Add 2 tsp. of calcium chloride (CaCl₂) to a second Ziploc bag.
2. Record temperature with a 100°C Celsius thermometer.
3. Gently place a test tube with approximately 30 mL of phenol red inside the bag in the upright position.
4. Squeeze out any excess air and seal the bag.
5. Do not open the bag, but pour the phenol red from the test tube into the bag by gently tilting the bag.
6. Gently massage the bag to mix the contents.
7. Look, listen, feel, and record the temperature again.
8. Record your observations in the data log below.

Part 3:
1. Place 2 tsp. of sodium hydrogen carbonate (NaHCO₃) into a third Ziploc bag.
2. Place 2 tsp. of calcium chloride (CaCl₂) into the third Ziploc bag.
3. Add 30 mL of Phenolphthalein into the third Ziploc bag.
4. Seal the bag and then gently massage the bag to mix the contents.
5. Very carefully lower the test tube containing 30 mL of phenol red upright into the bag. This can be done using 50 mL of cabbage juice as a substitute. Do not let any spill out.
6. Have a student help you by holding the test tube gently from the outside of the bag while you squeeze the excess air out and seal the bag.
7. Hold the test tube and sealed bag up and then slowly pour the phenol red out of the test tube into the bag (while the bag is still sealed).
8. Look, listen, feel, and record the temperature again.
9. Record your observations in the data table.

Data Log: Chemical Change in a Bag

<table>
<thead>
<tr>
<th>Trials</th>
<th>Temperature(°C) of liquid before reaction</th>
<th>Temperature(°C) After reaction</th>
<th>Foam or Bubbles Present? yes/no</th>
<th>Color Change?</th>
<th>Gas Emitted? (Yes or No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bag 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bag 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bag 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Data and Observations:
Describe in a complete sentence the changes that happened in each bag when you combined:
1. sodium hydrogen carbonate (NaHCO₃) plus phenol red:
2. calcium chloride (CaCl₂) plus phenol red:
3. sodium hydrogen carbonate (NaHCO₃) plus calcium chloride (CaCl₂) plus phenol red:

Analysis and Results:
1. What happened to the contents of the bags?
2. Without opening the bags, how can you tell if a gas was produced?
3. This equation tells us what chemical reaction happened in bag #3. Identify and count the elements on each side of the “yield” sign: 2NaHCO₃ + CaCl₂ → CaCO₃ + 2NaCl + H₂O + CO₂
4. Place a circle around the calcium chloride. Place a square around the salt. Place a triangle around the water.
5. Study the chemical equation list the name of the gas that was produced in this reaction.
6. Was there a change in temperature? How can you tell?
7. Classify each of these changes as chemical or physical. Use your observations to help you make your decisions.
8. In the third bag, what did the indicator tell you about the observed reaction?
9. Which was an endothermic reaction? Which was endothermic? Explain your answers.

Teacher’s Closure Activities:
1. After a class discussion about the changes in the three bags, light a match.
2. Light the splint with the match.
3. Hold the third bag, open it, and quickly place the burning splint into the bag.
4. Ask students to describe what happened during this demonstration.

Teacher’s notes:
You might want to double the bags. Small tears in the bag might occur. The third bag may burst; it gets pretty full and tight. The flame will go out (even though the kids hope for a huge explosion) and you can have them guess why it went out.
The phenolphthalein turns pink in a base and clear for an acid or neutral substance.
Cabbage juice will turn greenish blue for a base, purplish for neutral, and pink for acid.
Some students are afraid of matches or have never used them before. Advise them regarding the safety procedures pertaining to the use of matches

Cautions! Do not do a flame test for bags 1 and 2. It will ignite. Phenolphthalein is flammable.
SHAKING SAND
Observing the Transfer of Energy

NGSSS
SC.7.P.11.2 Investigate and describe the transformation of energy from one form to another.
SC.7.P.11.3 Cite evidence to explain that energy cannot be created nor destroyed, only changed from one form to another.
SC.7.N.1.2 Differentiate replication (by others) from repetition (multiple trials).

Objectives:
Students will
• observe the transfer of mechanical energy;
• recognize the conservation of energy;
• recognize that energy transfer takes place from more energy to less energy;
• recognize and control variables;
• use the following skills: observing, inferring from observations, predicting, recognizing and controlling variables.

Background Information:
Before beginning the activity the students should be familiar with the different forms of energy: heat, light, mechanical, electrical etc. In the activity, students will observe one form of energy change into another form. They will be shaking sand in a container letting the friction of the particles cause the sand to heat up. They will be shaking two containers with different masses of sand in each to determine which will have the greatest temperature.

Engage
Write the following problem statement on the board and solicit student responses: If you shake two containers of sand for two minutes, one with 75 mL and the other with 150 mL, which will one reach the highest temperature?

Materials
• One plastic (or glass) container with lid (200 mL)
• 225 ml of sand
• Thermometer (Celsius)
• Graduated cylinder
• Stop watch or clock
• 250 ml beaker

Answers to Data Sheet
1. There was more sand in one sample and the amount of heat transferred had to be distributed over more particles.
2. Shaking is mechanical energy because it involves movement.
3. Mechanical energy was changed to heat energy.
4. a. The variable being manipulated/tested here is the mass of sand. b. outcome/dependent variable is the temperature.
5. They both must have had the same amount of heat because they were shaken for the same length of time. Temperature and heat are not the same thing. The temperature was different but the heat was the same.
6. Person shaking the sand may not have used the same amount of vigor.
7. This experiment is replicable (able to be reproduced by others) because there are clear procedures and several other groups in the class performed the experiment with similar results. There was no repetition because it was done only once by each group.
**Explore**  
**Procedure**
1. Find the temperature of the sand provided and enter it in the data table for the starting temperature of both samples.
2. Measure 150 mL of sand in the graduated cylinder and pour it in the plastic container.
3. Put the lid on the container and shake it for two minutes vigorously.
4. Take the temperature again after shaking and record it in the table.
5. Dump the sand out of the plastic container into the empty 250 mL beaker.
6. Measure out 75 mL of new sand and place it in the plastic container.
7. Cover the container and shake it again for two minutes. (Be sure to shake vigorously and in the same manner as before.)
8. Take the temperature after shaking and enter the value in the table.

**Explain**  
**Data Sheet**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Temp. before shaking</th>
<th>Temp after shaking</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 mL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75 mL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Why do you think one sample of sand in this experiment had a higher temperature than the other?
2. What form of energy was involved while you were shaking the sand?
3. What form of energy did the moving sand change to?
4. What variable was changed in this experiment?
   a. Test/Independent Variable (s)
   b. Outcome/Dependent Variable
5. Which container do you think contained the most heat? (remember they were both shaken for two minutes)
6. Explain how there could be error in data collected.
7. Does this experiment demonstrate repetition and/or replication? Explain why.
ANALYZING ENERGY TRANSFORMATIONS

NGSSS:
SC.7.P.11.2 Investigate and describe the transformation of energy from one form to another. (AA)
SC.7.P.11.3 Cite evidence to explain that energy cannot be created nor destroyed, only changed from one form to another.
SC.7.N.1.2 Differentiate replication (by others) from repetition (multiple trials). (AA)
SC.7.N.1.3 Distinguish between an experiment (which must involve the identification and control of variables) and other forms of scientific investigation and explain that not all scientific knowledge is derived from experimentation.

Objectives:
• Illustrate how transferred energy can be measured by its effects on an impressionable surface.
• Measure the depth of a crater created by different spheres, and relate this measurement to the weight of the object.
• Observe the energy released from a falling object and how this energy is transferred from one form to another.
• Differentiate replicate (by others) from repetition (multiple trials)

Background Information:
The laws of thermodynamics are very important not just to scientists but also in our everyday lives. The first law of thermodynamics explains that the amount of energy that is present before and after work is the same. Energy is conserved. For example, if you drop a ball, scientists are able to measure the energy before, during, and after the fall. The amount of energy remains constant throughout the procedure. Similarly, when a ball is thrown or a spring released or a match is burned, the energy can be measured. This is the reason behind the first law of thermodynamics: “Energy can neither be created nor destroyed; it can only be converted from one form to another.” Scientists have found that the amount of energy in a closed system remains constant.

Teacher’s Notes:
Once the chemical potential energy stored in food is converted into kinetic energy (energy in use or motion), the organism will get no more until energy is input again, i.e., one eats. In the process of energy transfer, some energy will dissipate as heat. During energy transfers, it might seem that energy does go away or become reduced. For example, a bouncing ball stops bouncing, a battery dies, or a car runs out of fuel. The energy still exists but it has become so spread out that it is essentially unavailable. Burning a piece of wood releases light and thermal energy (commonly called heat). The light and heat become dispersed and less useful. Another way to describe this process is to say the energy is concentrated in the wood (chemical energy) and becomes less concentrated in the forms of thermal and light energy.

One example of increasing entropy is water falling over a dam. When the water is above the dam it has some potential energy due to gravity, which can be used to generate electricity or turn a wheel to perform some useful task. When the water has fallen to the level below the dam, its total energy remains the same. As the water falls, the water itself is warmed, thus increasing its thermal energy, but it no longer has the same capacity to do work. The water has moved from what is referred to as an "available" or "free" energy state (high-grade energy) to an "unavailable" or "bound" energy state (low-grade energy). This change in the energy state of the water as it falls over the dam is an increase in entropy.

A process can be driven, or forced to happen, only by increasing the entropy of the universe. A driven process is said to be "spontaneous". A few spontaneous processes are a falling brick, a bouncing ball, a crashing car, an ice cube melting on a warm day, a lake freezing on a cold day, or the chemical transformations of a burning match. The entropy of the universe increases during each of these spontaneous processes. Entropy is also a measure of possibilities. A messy room has high entropy because there are many possible ways to be messy. Toys and clothes can be lying around anywhere within the room. A neat room has low entropy because there are few ways to be neat.
Problem Statement:
What would happen if you drop three different objects from the same height into a box containing beach sand?

Materials:
- Dry beach sand
- Marble
- Golf ball
- Ping pong (plastic golf ball)

Substitute materials: 3 balls of different sizes

Procedure:
Part A: Designing the Experiment
- Based on both, the materials given by your teacher and the problem statement of this activity, you and your team will design an experiment that will help you to find out how energy transferred can be measured by its effects on an impressionable surface. You also will have a chance to measure the depth of a crater made by different spheres, and relate this measurement to the weight of the object.
- Your experimental design should include the steps form Parts of a Lab Report:
  - Note: Be sure to obtain your teacher’s approval before setting up your experiment. Your teacher’s approval will be based on your experimental design.

Part B. Set up your experiment using the given materials.
Part C. Collect and analyze data. Write about your results and conclusions.
Part D. Present your findings to your teacher. Be ready for a class discussion based on the following questions:
  1. Which ball had the most kinetic energy as it hit the surface? Explain.
  2. How did the depths of the craters depend on the potential energy of the balls? Explain.
  3. Cite evidence that energy was not created or destroyed
  4. Indicate which part of your experimental design demonstrated repetition?
  5. How will your experiment be replicable (by others)?

Suggested Data and Observations:

Table 1: Type of Object vs. Depth of Crater Formed

<table>
<thead>
<tr>
<th>Object</th>
<th>Depth of Crater (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
</tr>
<tr>
<td>Marble</td>
<td></td>
</tr>
<tr>
<td>Golf ball</td>
<td></td>
</tr>
<tr>
<td>Plastic golf ball</td>
<td></td>
</tr>
</tbody>
</table>

Data Analysis:

Table 2: Average Depth of Each Object

<table>
<thead>
<tr>
<th>Object</th>
<th>Average Depth (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Trial 1 + 2 + 3)/3</td>
</tr>
<tr>
<td>Marble</td>
<td></td>
</tr>
<tr>
<td>Golf ball</td>
<td></td>
</tr>
<tr>
<td>Plastic golf ball</td>
<td></td>
</tr>
</tbody>
</table>
Step 1: Stating the Purpose/Problem
- What do you want to find out? Write a statement that describes what you want to do. It should be as specific as possible. Often, scientists read relevant information pertaining to their experiment beforehand.
- The purpose/problem will most likely be stated as a question such as: “What are the effects of __ on ___?”

Step 2: Defining Variables
- **TEST/INDEPENDENT VARIABLE (IV)** – The variable that is changed on purpose for the experiment; you may have several levels of your independent variable.
- **OUTCOME/DEPENDENT VARIABLE (DV)** – The variable that acts in response to or because of the manipulation of the independent variable.
- **CONSTANTS (C)** – All factors in the experiment that are not allowed to change throughout the entire experiment. Controlling constants is very important to assure that the results are due only to the changes in the independent variable; everything (except the independent variable) must be constant in order to provide accurate results.

Step 3: Forming a Hypothesis
- A hypothesis is an inferring statement that can be tested.
- The hypothesis describes how you think the independent variable will respond to the dependent variable. (See “Forming a Hypothesis” handout for additional help in writing a hypothesis).
- It is based on research and is written prior to the experiment…never change your hypothesis.
- For example: If the temperature increases, then the rate of the reaction will increase.
- Never use “I” in your hypothesis (i.e. I believe that…)
- It is OK if the hypothesis is not supported by the data from the experiment. An explanation for the unexpected results should be provided in the conclusion.

Step 4: Designing an Experimental Procedure
- Select only one thing to change in each experimental group (independent variable).
- Change a variable that will help test the hypothesis.
- The procedure must tell how the variable will be changed (what are you doing?).
- The procedure must explain how the change in the variable will be measured.
- The procedure should indicate how many trials will be performed (usually a minimum of 3–4).
- It must be written in a way that someone can copy your experiment, in step by step format.

Step 5: Results (Data)
- Qualitative Data is comprised of a **description** of the experimental results (i.e. larger, faster…). 
- Quantitative Data is comprised of **numbers** (i.e. 5 cm, 10.4 grams).
- The results of the experiment will usually be compiled into a **table/chart** for easy interpretation.
- A graph of the data (results) may be made to more easily observe trends.
- Refer to “Making a Data Table” and “Making a Graph” skill sheets.

Step 6: Conclusion
- The conclusion should be written in paragraph form. It is a summary of the experiment, not a step-by-step description. Does the data support the hypothesis? In the summary you will summarize data in a concluding statement (ex: To conclude, the increase in temperature caused the rate of change to increase as shown by the above stated data.) You also will refer to the implications for further study. Could this experiment be used for additional studies? How does the experiment relate to situations outside the lab? (How could you apply it to real world situations?)

**Closure Activity:** Each group member will contribute to a discussion about their findings. **Extension:** Students could perform research to discover and describe how this activity relates to a "real life" occurrence. How is the energy transferred?
SOLAR ENERGY VS. COLOR
How does color affect how much solar energy is absorbed?
Adapted from Sharon Goldblatt Greco Middle School Project CLASS

NGSSS:
SC.7.P.10.2 The student observes and explains that light can be reflected, refracted, and absorbed. (Assessed as SC.7.P.10.3)
SC.7.P.11.2 Investigate and describe the transformation of energy from one form to another. (AA)
SC.7.P.11.3 Cite evidence to explain that energy cannot be created nor destroyed, only changed from one form to another. (Assessed as SC.7.P.11.2)
SC.7.P.11.4 Observe and describe that heat flows in predictable ways, moving from warmer objects to cooler ones until they reach the same temperature. (AA)
SC.7.N.1.1 Define a problem from the seventh grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions. (Assessed as SC.8.N.1.1)
SC.7.N.1.3 Distinguish between an experiment (which must involve the identification and control of variables) and other forms of scientific investigation and explain that not all scientific knowledge is derived from experimentation. (Assessed as SC.8.N.1.1)
SC.7.N.1.4 Identify test variables (independent variables) and outcome variables (dependent variables) in an experiment. (Assessed as SC.8.N.1.1)

Objectives:
• The student will demonstrate the efficiency of a solar collector is based on its design and color selection.
• The student will explain the different temperatures obtained in various solar collectors.
• The students will demonstrate that certain materials absorb solar energy better than others while certain colors reflect more energy than others.
• The students will identify variables in a solar energy-collection investigation.

Engage (hook, demonstration, free write, brain-storming, analyze a graphic organizer, KWL, etc)
Give your students the scenario below as employees of DOE or home owners and have them brain storm how to create a lab and collect data to help resolve the following situation:
To Whom it may concern at the Department of Energy,
I am putting a new roof on my house and want to make it energy efficient. I live in southern Florida and have tried to find out about what roof colors will absorb the least amount of heat. I believe that white is best, but white doesn't go with our house color. Also, the builders in this region of the country are not at all concerned with energy conservation. They have been of no help. What color choice would be best a brown roof or medium grey or can you suggest another color?
Thank you,
Rita who needs a roof

Possible/Suggested Materials per group:
• pieces of construction paper (recommended size 12cm by 16cm) suggested colors- white, black, gray, brown
• Celsius thermometers
• tape
• stop watch
Explore:

1. Fold each sheet of construction paper hamburger style and tape on 2 sides to make a pocket

2. Place one thermometer in the center of each paper pocket.
3. Place the four paper pockets in a row on cement (what most homes in South Florida are constructed)
4. Place one thermometer on the cement surface without any construction paper.
5. Make sure all of the thermometers are exposed to the light equally and can be read easily.
6. Take the temperature then every 5 minutes for 25 minutes.

Explain/Assessment:

1. Have students create a data table and graph their results
2. Discuss why there was a thermometer with out construction paper.
3. What color construction paper did you select and why?
4. Discuss the findings of your experiment.
5. List the colors in order of most to least absorption.
6. Would you want your roof to absorb a high or low amount of thermal energy?
7. List the colors in order of most to least reflection.
8. Would you want your roof to reflect a high or low amount of thermal energy?
9. Follow the energy transformations from the sun to your thermometer.
10. Discuss the benefits to the homeowner be of having a roof that is low absorption and high reflection? Which colors would this be in our experiment?
11. Discuss the drawbacks to the homeowner having a roof that would be high in absorption and low in reflection? Which colors would this be in our experiment?
12. Based on this investigation, what observations support the statement: heat flows from warmer objects to cooler objects?

Elaborate:

1. Have students redesign the experiment to investigate the effectiveness of insulation in your roof

AHA! Moment: Explain why dark colored clothing is worn in the winter and light colored clothing is worn in the summer!
**WAVE SPEED**

How does the material/medium affect the speed (frequency) of waves?

**NGSSS:**

**SC.7.P.10.3** The student recognizes that light waves, sound waves and other waves move at different speeds in different materials. (AA)

**SC.7.N.1.3** Distinguish between an experiment (which must involve the identification and control of variables) and other forms of scientific investigation and explain that not all scientific knowledge is derived from experimentation. (Assessed as SC.8.N.1.1)

**SC.7.N.1.4** Identify test variables (independent variables) and outcome variables (dependent variables) in an experiment. (Assessed as SC.8.N.1.1)

**Objective(s):**

- The student will be able to compare the speeds of two different waves.
- The student will determine that wave speed does affect the speed of ships.

**Advanced Prep /Time: 30 minutes**  
**Activity: 50 minutes**

**Materials:** (per group)

- 2-Liter clear plastic bottles with caps (remove label)
- metric ruler
- stop watch
- water
- Grease pencil/permanent marker
- oil

**Engage** (hook, demonstration, free write, brain-storming, analyze a graphic organizer, KWL, etc)

- Start class at the bell with clip from deadliest catch [http://science.howstuffworks.com/rogue-wave.htm](http://science.howstuffworks.com/rogue-wave.htm)
- Discuss waves. What are some examples of waves? 
  Possible answers: earthquakes, ocean waves, tsunamis, light.
- What travels in waves? sound, light, energy
- What are the different mediums that waves travel in? 
  Possible answers and discussion: solid layers of the earth (mantel, crust) liquids (water, oceans, liquid layers of the earth) including: primary- solids and liquids and seismic-solids
- Discuss and define with students the terms frequency, wavelength, trough, and crest.
- Have students draw a diagram labeling the crest, wavelength and trough.

**Explore** (investigation, solve a problem, collect data, construct model, etc.)

How does the material/medium affect the speed of waves?

**Procedures:**

1. Label two plastic bottles. Bottle 1 and Bottle 2.
2. Fill bottle 1 with water to a depth of 5 cm. Fill Bottle 2 with oil to the same depth. Replace the top on each bottle. Close the bottles tightly. (this can be done ahead of time to save class time or an opportunity to allow more time for discussion of constants and variables).
3. Lay each bottle on its side on a flat table. Allow the bottles to sit undisturbed until the water stops moving.
4. Measure the height of your water/oil in each bottle from the surface of each table. Record your observations.
5. Lift both bottles 3cm from the surface of the table at the same time. Count the number of waves you see in 20 seconds.
6. Repeat step number five for a total of five (5) trials.
**Explain** (student analysis, structured question- ing, reading and discussion, teacher explanation, compare, classify)

- Read the article at (science.howstuffworks.com/rogue-wave2.htm)
- Allow students in groups to discuss their findings.
- Real world application:
  - In a thunder storm do you hear the thunder before, after or at the same times as you see the lightening? **In air as the material/medium light travels faster than sound.** Same material/medium different waves.
  - When you are in a room and there is a noise do you know where it is coming from?
  - If you are in the ocean/pool swimming under water and you hear a noise do you know where it is coming from? Why or why not? Discussion **sound travels faster in water than in air!** Same wave different material/medium.

**Elaborate/Extend** (problem solving, decision making, experimental inquiry, compare, classify, apply)

The faster the waves move, the faster a ship traveling in the same direction as the waves, will reach its destination.

**What is the relationship between depth of water and wave speed?**

Procedures:

1. Label two 2-liter plastic bottles. Bottle 1 and Bottle 2.
2. Fill bottle 1 with water to a depth of 10 cm. Fill Bottle 2 with water to a depth of 30 cm. Replace the top on each bottle. Close the bottles tightly.
3. Lay each bottle on its side on a flat table. Allow the bottles to sit undisturbed until the water stops moving.
4. Measure the height of your water in each bottle from the surface of each table. Record your observations.
5. Lift both bottles 3cm from the surface of the table at the same time. Count the number of waves you see in 20 seconds.
6. Repeat step number five for three trials.

**Evaluate** (any of above, develop a scoring tool or Rubric, performance assessment, produce a product)

Questions:

1. What are the different materials/mediums in each bottle?
2. How can you calculate the speed (frequency) of the waves?
3. What can you conclude from analyzing your data?
4. Compare the speed of the waves produced inside Bottle 1 with the speed of the waves in Bottle 2.
5. Identify the relationship of the material/medium to that of speed of waves.
6. Relate how the speed of waves moves in different material/medium to a real world application.

**ESE/ELL**

**Accommodations** Small groups, hands on activities, extended time

**References:**

**Text Reference(s):** Holt Science and Technology Level Green

**Electronic References** (web sites, Gizmo, other, paste hyper-links or URLs here)

[www.glenbrook.k12.il.us/gbssci/phys/Class/waves/](http://www.glenbrook.k12.il.us/gbssci/phys/Class/waves/)

[http://science.howstuffworks.com/rogue-wave](http://science.howstuffworks.com/rogue-wave)

Adapted from Project C.L.A.S.S. Author **Sharon Goldblatt Proofed: Keeney Hayes**
How Rogue Waves Work

by Ed Grabianowski

Introduction to How Rogue Waves Work

During the second season of "Deadliest Catch," a documentary television series about crab fishing in Alaska's Bering Sea, cameras recorded footage of a giant wave striking the ship "Aleutian Ballad." The 60-foot (18-meter) wave rolled the boat onto its side and caused significant damage, though fortunately none of the crew was seriously hurt. The Ballad limped back to port for repairs. The footage captures the suddenness of the massive wave, and just before the impact sends the camera operator tumbling, the "wall of water" breaking over the boat can be seen with frightening clarity.

What was this colossal wave that appeared seemingly out of nowhere? It was a rogue wave. Rogue waves sound like something straight out of a sailor's tall tale: ominous, mysterious, solitary waves of enormous height crashing down on ships at sea in seemingly calm waters. But as improbable as they might seem, recent studies suggest these rogues are more common than anyone previously guessed.

Imagine having an 80-foot wall of water barreling toward you. Actually, that might be too tall an order. It's easy to throw around heights like 50 feet or 90 feet without really grasping how huge a wave of such height would be. Here are some handy comparisons:

- The average room in your house is probably about 8 feet high.
- A typical two-story house is between 20 and 30 feet high.
- The Statue of Liberty is 111 feet tall from her toes to the top of her head, not counting the pedestal or her arm and torch.

Understanding these giant waves is more than just a scientific curiosity -- being able to predict and avoid them could save dozens of lives and hundreds of millions of dollars in cargo every year.

In this article, you'll find out what separates rogue waves (also called freak waves) from other large waves and what causes them, and you'll learn about some of the better-known rogue wave incidents.
Video Gallery: Waves
UC Davis and NASA are working together with high-tech wireless sensors and networked buoys to measure readings from Lake Tahoe to track water clarity, wind speed and wave height.
Watch this video about an exhibit that gives an interactive look at how waves affect beach erosion, as well as the larger impact of hurricanes on beachfronts.
In April 2007, an earthquake and tsunami devastated the coastal regions of the Solomon Islands. See how tsunami and earthquake recovery works in this video from Reuters.

A Rogue by Definition
There are many kinds of ocean waves, and some of them are definitely huge. However, not all large waves are rogue waves. Strong storms, such as hurricanes, can cause large waves, but these waves tend to be relatively regular and predictable, though certainly capable of causing serious harm to ships and coastal areas. Undersea earthquakes, coastal landslides and glacial calving (when a large chunk of a glacier breaks off and falls into the ocean) can also create enormous and catastrophic waves. Undersea earthquakes can produce tsunamis, and coastal landslides can produce tidal waves. These could be considered rogues, but, to a certain extent, they are predictable -- as long as someone noticed the event that caused them. So, that pretty much rules them out of rogue status.

A true rogue wave arises seemingly out of nowhere and is significantly higher than the other waves occurring in the area at the time. Exactly how much higher is open to interpretation -- some sources suggest anything twice as large as the current significant wave height is a rogue, while others think anything 33 percent larger counts. It is probably sufficient to say that any wave so large that it is unexpected based on current conditions can be counted as a rogue. A craft navigating 3-foot waves could encounter an 8-foot rogue wave -- while not a record-breaker, it would certainly cause problems for a small boat.

Rogue waves also tend to be steeper than most waves. The average ocean waves may take the form of massive swells, allowing vessels to maneuver up and down them even if they are many feet high. By contrast, consider this report of the Queen Elizabeth II's encounter with a freak wave:

At 0410 the rogue wave was sighted right ahead, looming out of the darkness from 220°, it looked as though the ship was heading straight for the white cliffs of Dover. The wave seemed to take ages to arrive but it was probably less than a minute before it broke with tremendous force over the bow [source: Science Frontiers].

The phrase "wall of water" is very common in rogue wave reports -- they are usually much steeper than other waves, and therefore slam into ships with tremendous force, often breaking over them.
The Explorer
In January 2005, the Explorer, a 591-foot research vessel, was struck by a 50-foot rogue wave in the Pacific Ocean. The wave disabled much of the ship’s equipment, including three of four engines. Those on board suffered only minor injuries, and the ship made it to Hawaii for repairs. Had the wave been larger, almost 1,000 people could have died [source: The Denver Channel].

While scientists have gained a greater understanding of rogue waves in the last decade, they are still quite enigmatic. No one has ever filmed the formation of a rogue wave in the ocean or followed one through its entire life cycle. There are very few photographs of rogue waves. For centuries, the best evidence for their existence was anecdotal -- the countless stories told by sailors who had survived one.

Gallimore and another crewman were in the wheelhouse. The wind had been blowing fiercely at 100 knots for more than a day, and "Lady Alice" was struggling in rough seas with waves 16 to 23 feet high … At 8:00 A.M. Gallimore looked up and saw a huge wall of water bearing down on "Lady Alice." From his view in the wheelhouse, he could not see the top of the wave …The wave crashed down on top of the wheelhouse, driving the vessel underwater …The crewman in the wheelhouse with him was thrown down with such force that he suffered two fractured vertebrae. To top the radar antennas with enough force to rip them from the steel mast where they are bolted … the wave had to be 40 feet or higher [source: Smith, 195].

What Causes Rogue Waves?
To understand what causes a rogue wave, first you must learn a little about regular waves. Think about waves you're familiar with -- such as the waves you bodysurf in at the beach or at the local water park's wave pools. A wave has several characteristics that can be used to define it.

- The crest is the highest portion of the wave.
- The trough is the lowest portion of the wave (the "dip" in between waves).
- The distance from the trough to the crest represents a wave's height.
- The distance between crests represents a wave's length.
- The amount of time that passes between one crest and the next is the wave period or wave speed.
- The amount of kinetic and potential energy carried by the wave is known as wave energy [source: Bryant, 156].

A huge number of variables influence these factors, including the depth of the water, tidal forces, wind blowing across the water, physical objects such as islands that reflect waves, and interaction with other waves and ocean currents. At any given moment, thousands of waves are passing and interacting through a specific area of ocean. The faster the wind is and the longer it blows, the stronger and larger the waves. Fetch is the unobstructed distance of ocean over which the wind can blow on the water -- it's how much ocean the wind is blowing on. More fetch means bigger waves.

Weather reports list the significant wave height, which is the height of the highest one-third of the waves. Why do rogue waves exceed the significant wave height by so much? Scientists aren't completely sure, but they have some good theories.

One possibility is that ocean currents cause waves to "pile up" when waves run into currents head on. Powerful storms can cause significant wave heights of 40 to 50 feet (12 to 15 meters). When such waves run into a strong current, the current can increase wave heights and cause the waves to break. This would explain monster waves 98 feet (30 meters) high or more, and account for the "wall of water" effect. Rogue waves frequently occur in areas known for strong ocean currents. For example, the Agulhas Current runs southward along the east coast of Africa. Storm waves moving up from the south crash into the current --
mathematical predictions suggest rogue waves there could reach 190 feet in height, and 20 ships have reported rogue wave strikes in that area since 1990 [source: Smith, 188]. The Gulf Stream, which runs up the east coast of the United States, is another potential rogue wave source. Rogues originating in the Gulf Stream could be responsible for much of the legend of the Bermuda Triangle.

Not all rogue waves occur in strong ocean currents, however. Scientists think some waves may be caused by randomly occurring wave reinforcement. Whenever two waves interact, their wave height is added together. If a 5-meter wave passes over a 10-meter wave, the result is a briefly occurring 15-meter wave. This can happen in the opposite manner as well. A 15-meter wave moving across a 10-meter trough results in a 5-meter wave. Dozens of waves could be interacting and reinforcing each other. Once in awhile, several waves may come together at just the right moment and create one huge wave in relatively calm seas. If 10 waves that are only 5 feet high come together, they will result in a 50-foot wave. This fits descriptions of rogue waves that seem to appear out of nowhere and disappear after just a few minutes.

**The Queen Elizabeth**

During World War II, British cruise liners were converted to carry troops from the United States to Europe. One such vessel was the "RMS Queen Elizabeth." A rogue wave struck the ship near Greenland in 1942, shattering windows 90 feet above the waterline and nearly rolling the ship. It recovered and narrowly averted an unprecedented maritime disaster -- the ship was carrying more than 10,000 troops at the time [source: Sverre Haver].

Common Rogues-Most reports of rogue waves rely on size estimates by witnesses. These estimates are based on the height of the ship above the waterline and how far up the ship the wave reached when it hit. It was commonly assumed that tales of waves 100 feet tall or taller were exaggerations (and some of them certainly were). At best, such waves were incredibly rare.

Beginning in the 1990s, sailors and scientists began to suspect that rogue waves were responsible for many more losses at sea than they had previously guessed. The Queen Elizabeth II, Caledonian Star and Bremen cruise ships were all hit by monstrous waves in a span of six years. Previously, data collected by weather ships suggested that such waves would occur only every 50 years or more [source: Smith, 210]. In 2004, the European Space Agency (ESA) used data from two radar-equipped satellites to see how frequent rogue waves actually are. After analyzing radar images of worldwide oceans taken over a period of three weeks, the ESA's MaxWave Project found 10 waves 82 feet (25 meters) or higher. That was an astonishingly high number for such a relatively short time span; it forced scientists to seriously rethink
their ideas on rogue waves [source: ESA]. The ESA is undertaking another project, WaveAtlas, to survey the oceans over a much longer period and develop the most accurate estimate possible for the frequency of rogue waves.

Other hard evidence of monster waves comes from instruments designed to measure wave heights. One such instrument was mounted on an offshore oil rig known as the Draupner Platform. On New Year's Day 1995, the platform was measuring waves no more than 16 to 23 feet (5 to 7 meters) high. Then it suddenly registered a single wave almost 66 feet (20 meters) high [source: Smith, 208]. Canadian weather buoys near Vancouver recorded waves 100 feet high and higher throughout the 1990s [source: Smith, 211].

The Wreck of the Edmund Fitzgerald
Rogue waves may not be restricted to the world's oceans. Extremely large inland waters (such as North America's Great Lakes) may also develop rogue waves, although little scientific data exists to confirm this. Anecdotal evidence abounds, however. One of the most infamous sinkings in Great Lakes history, the "Edmund Fitzgerald," may have been caused by one or more rogue waves. In November 1975, the 729-foot bulk cargo vessel was struggling through a horrendous storm along with the "Arthur Anderson." Blinded by the storm, the Anderson was hit by two 35-foot waves (truly massive even for Lake Superior) and then lost sight of the Fitzgerald on radar [source: Cush, 111]. The Edmund Fitzgerald was eventually found at the lake's bottom, broken in two. Though there are many theories, some suggest that a combination of factors, including the rogue waves that hit the Anderson and drove the Fitzgerald violently under the water, never to resurface.

Wave Defense-If the MaxWave study is correct, and rogue waves are much more common than previously thought, does that mean oceangoing vessels are far riskier than we thought? It might. Ships and offshore structures, such as oil rigs, are built to withstand a certain significant wave height, whatever is determined that the ship is likely to encounter in its lifetime. Few are built to handle 100-foot waves. Furthermore, a ship's ability to withstand a strike by a rogue wave depends in large part on the ballast, or stability. If a ship has the right amount of ballast and is floating at the proper level, it will be more likely to right itself after being pushed over by a wave [source: Smith, 233]. Today's international shipping laws don't necessarily take frequent rogue waves into account where ship construction and maintenance are concerned. But that's not to say all ships are unsafe -- perhaps it would be impossible to build a ship that could withstand any wave.

And it's not just ships and offshore structures that need to worry about rogue waves. These walls of water may pose a serious threat even to people who aren't on the water. The U.S. Navy has expressed concern that some Coast Guard rescue helicopters lost at sea may have been struck by rogue waves [source: U.S. Naval Institute]. And shorelines where there is a steep drop-off to deep ocean close to shore can be dangerous for those exploring the rocks. Unexpected waves have been known to sweep people off the rocks, where the undertow drags them down and away.

Currently, it is impossible to predict a rogue wave. However, MaxWave and WaveAtlas could give scientists and sailors a good look at the conditions that cause rogue waves, as well as indicate areas where they happen most often. This could allow shipping routes to take into account particularly dangerous areas when the weather conditions could lead to rogues. Avoiding these areas could save hundreds of lives every year.

Three Sisters
Rogue waves do not always come alone. A phenomenon well known to sailors is the "Three Sisters." After one huge wave has passed, it may be followed by two more. These trios of monster waves can be especially devastating -- the first can disable a ship and leave it unable to maneuver itself to avoid or ride out the subsequent waves.
**Rogue versus Tsunami**

When you think of giant, frightening, destructive waves, tsunami definitely come to mind. But don't confuse these giant waves with rogues -- while both can be catastrophic, they are quite different. The easiest way to remember the difference is by what causes the "wall of water" and where the destruction from it occurs.

Tsunamis are most often caused by undersea earthquakes, which send tons of rock shooting upward with tremendous force. The energy of that force is transferred to the water. So, unlike normal waves that are caused by wind forces, the driving energy of a tsunami moves through the water, not on top of it. Therefore, as the tsunami travels through deep water -- at up to 500 or 600 miles per hour -- it's barely evident above water. A tsunami is typically no more than 3 feet (1 meter) high. Of course, all that changes as the tsunami nears the coastline. It is then that it attains frightening height and achieves its more recognizable and disastrous form.

Rogue waves, as we've discussed in this article, arise seemingly out of nowhere, and they can attain their massive heights in deep water, not just along the shoreline.

**Lots More Information**

**Related HowStuffWorks Articles**


**More Great Links**

- National Weather Service and Ocean Prediction Center

**Sources**

DENSITY OF ROCKS

NGSSS:
SC.7.E.6.2 Identify the patterns within the rock cycle and relate them to surface events (weathering and erosion) and sub-surface events (plate tectonics and mountain building). (AA)
SC.7.N.1.4 Identify test variables (independent variables) and outcome variables (dependent variables) in an experiment. (Assessed as SC.8.N.1.1)

Background Information for the teacher:
Density is a basic physical property of any sample of matter. It is much more important than other physical properties such as size or shape, in that the numerical value of density for a pure substance at a particular temperature and pressure is a constant and never changes! The density may be determined in the laboratory if the mass and volume of a sample can be determined. Density may be calculated by dividing the mass by the volume (\(d = \frac{m}{V}\)). It also may be thought of as the ratio of the mass to the volume. The density of water is important to know. It is 1.0 g/mL at 4\(^{\circ}\)C.

In this experiment, the student will measure the mass, volume, and the length of several rocks. They will then use their data to explore the relationship between the mass and volume of the rocks and calculate their density.

Materials
- Graduated cylinder
- 250 mL beaker
- medicine dropper
- food coloring (not essential but helpful)
- 100 mL Graduated cylinder
- Eye dropper
- Calculator
- Electronic balance or triple-beam balance
- 5 different type of rocks
- Tap water at room temperature
- ruler

Teacher Pre-Lab Preparation and Presentation: Color the water by adding a few drops of food coloring.

Engage: (students should develop procedures similar to the ones in the Explore section)
Teacher will engage students in discussion with the following questions to determine students pre-conceptions. Record responses on the board:
1. Observe the 5 rocks and estimate which rock could have the largest mass, volume and density?
2. Will the largest rock (largest volume) have the largest mass?
3. What is density? What do you need to know to calculate density?
4. Mass/Volume is a ratio which represents density.
5. Predict which rock would have the greatest density and smallest density.
6. Would the largest rock be the most dense and the smallest rock the least dense?
7. Would all of these rocks sink in water?
Explore (students should come up these procedures and how they can be completed in the engagement)
1. On the electronic or triple beam balance mass each rock in grams (g). Record your measurement in the data table
2. Pour 50 mL of the colored water into the graduated cylinder. Use the dropper to get the exact amount of 50 mL.
3. Drop the first rock into the graduated cylinder and determine the volume of the rock in milliliter (mL) using the water displacement method. Record your measurement in the data table.
   Final volume (water with rock) – Initial volume (50 mL of water) = Volume of the rock (use cm$^3$ since rocks are a solid and 1 mL = 1 cm$^3$). To get a precise measurement, place the cylinder on a flat surface, bring your “eye” down to the level of the liquid, and read the bottom of the meniscus.
4. Repeat step 3 with the other 4 rocks. Record your measurement (cm$^3$) in the data table.
5. Finally calculate the density of each rock, using the following formula:
   Density = Mass/Volume
   Using the unit for density (g/cm$^3$)
6. Record your measurement in the data table.

Data Table: Density of Rocks

<table>
<thead>
<tr>
<th>Rock</th>
<th>Mass (g)</th>
<th>Final-Initial= Volume of rock (cm$^3$)</th>
<th>Density (g/cm$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2</td>
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<td>5</td>
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<td></td>
</tr>
</tbody>
</table>
**Figure 1**

**Densities of Some Common Rocks**

<table>
<thead>
<tr>
<th>Rock</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andesite</td>
<td>2.5 - 2.8</td>
</tr>
<tr>
<td>Basalt</td>
<td>2.8 - 3.0</td>
</tr>
<tr>
<td>Coal</td>
<td>1.1 - 1.4</td>
</tr>
<tr>
<td>Diabase</td>
<td>2.6 - 3.0</td>
</tr>
<tr>
<td>Diorite</td>
<td>2.8 - 3.0</td>
</tr>
<tr>
<td>Dolomite</td>
<td>2.8 - 2.9</td>
</tr>
<tr>
<td>Gabbro</td>
<td>2.7 - 3.3</td>
</tr>
<tr>
<td>Gneiss</td>
<td>2.6 - 2.9</td>
</tr>
<tr>
<td>Granite</td>
<td>2.6 - 2.7</td>
</tr>
<tr>
<td>Gypsum</td>
<td>2.3 - 2.8</td>
</tr>
<tr>
<td>Limestone</td>
<td>2.3 - 2.7</td>
</tr>
<tr>
<td>Marble</td>
<td>2.4 - 2.7</td>
</tr>
<tr>
<td>Mica schist</td>
<td>2.5 - 2.9</td>
</tr>
<tr>
<td>Peridotite</td>
<td>3.1 - 3.4</td>
</tr>
<tr>
<td>Quartzite</td>
<td>2.6 - 2.8</td>
</tr>
<tr>
<td>Rhyolite</td>
<td>2.4 - 2.6</td>
</tr>
<tr>
<td>Rock salt</td>
<td>2.5 - 2.6</td>
</tr>
<tr>
<td>Sandstone</td>
<td>2.2 - 2.8</td>
</tr>
<tr>
<td>Shale</td>
<td>2.4 - 2.8</td>
</tr>
<tr>
<td>Slate</td>
<td>2.7 - 2.8</td>
</tr>
</tbody>
</table>
Explain

Analysis Questions:
1. Which variable is considered the independent (test) variable in this lab activity?
2. Which variable(s) is considered the dependent (responding) variable in this lab activity?
3. If the mass of the rock increases, what could happen to the density of each sample?
4. If the volume of the rock increases, what would happen to the density of each sample?
5. Analyze your data: What do you observe about the relationship between mass and volume for the rocks with the larger densities and smaller densities? Give examples from the lab in your explanation.
6. In terms of density, differentiate between an object which floats in water and an object which sinks in water.
7. Show how one would set up a ratio to determine the mass of a substance with a density of 8.4g/mL and a volume of 2.0 mL. Determine the mass.
8. Show how one would set up a ratio to determine the volume of a substance with a density of 4.0 g/mL and a mass of 8.0 g. Determine the volume.
9. Based on the results of this lab, formulate a hypothesis about how unknown substances can be distinguished from one another by using their densities.

Home Learning

Students collect rock samples from Home Depot, Lowe’s, and around their home and determine density. Use Figure 1 to identify rock samples.

Extensions:
1. Students will explore the density of objects with identical volumes, but different masses (use density cubes). Discover the relationship among mass, volume, and density.
2. Students will explore the density of different liquids and/or solutions, e.g. 5%, 10%, 15% saltwater solution. Discover the relationship between density and the solute concentration.

Elaborate:

Most geologists believe that as the Earth cooled, the most dense materials collected at the center of the Earth and the least dense materials accumulated near the surface of the Earth. In addition to density of materials, temperature and pressure also rapidly increase as you go from the surface of the earth to the center!!! Relate density to the layers of the Earth.

Possible Answers

Explain

Analysis Questions:

1. Which variable is considered the independent (manipulated) variable in this lab activity? Type of rock
2. Which variable (s) is considered the dependent (responding) variable in this lab activity? density
3. If the mass of the rock increases, what could happen to the density of each sample?
4. If the volume of the rock increases, what would happen to the density of each sample? It would stay the same because the mass would also increase
5. Analyze your data: What do you observe about the relationship between mass and volume for the rocks with the larger densities and smaller densities? Give examples from the lab in your explanation. Larger densities have larger mass compared to the object’s volume; smaller densities have larger volume compared to the mass. Examples will vary
6. In terms of density, differentiate between an object which floats in water and an object which sinks in water. An object that floats in water is less dense than the water or less than 1 g/cm³. An object that sinks has a greater density than water.
7. Show how one would set up a ratio to determine the mass of a substance with a density of 8.4 g/mL and a volume of 2.0 mL. Determine the mass. 8.4 g/mL = ?g/2.0 mL
   mass = 16.8 g
8. Show how one would set up a ratio to determine the volume of a substance with a density of 4.0 g/mL and a mass of 8.0 g. Determine the volume. 4.0 g/mL = 8.0 g/?mL
   volume = 2 mL
9. Based on the results of this lab, explain how unknown substances can be identified or distinguished from one another by using their densities. All substances have a specific density. If the mass and volume can be determined, then the substance can be found by comparing with substances of known densities. or If the density of the sample can be determined, then the rock can be identified
Additional Background Information - Density of Rocks

Certain properties of a substance are both distinctive and relative easy to determine. Density, the ratio between a sample’s mass and volume at specific temperature and pressure (like standard ambient temperature and pressure), is one such property. Regardless of the size of a sample, the density of a substance will always remain the same.

The density of a rock sample can, therefore, be used in the identification process. Typical densities for some types of rock are:
- Basalt 3 g/cm³ (187 lbm/ft³)
- Granite 2.7 g/cm³ (169 lbm/ft³)
- Sandstone 2.3 g/cm³ (144 lbm/ft³)

Some rocks are heavier and others much lighter than those listed above. For example, Pumice is a rock formed from solidified foamy volcanic lava. It is full of spaces full of gas, rather like a sponge. Some examples of Pumice are half the density of water, at 0.5 g/cm³. Density varies significantly among different rock types because of differences in mineralogy and porosity. Knowledge of the distribution of underground rock densities can assist in interpreting subsurface geologic structure and rock type.

While density may vary only slightly from rock to rock, detailed sampling and correlation with other factors like depth may reveal important information about the history of a core, or may help to improve the use of seismic profiles. The average density of oceanic crust is 3.0 g/cm³ while continental crust has an average density of 2.7 g/cm³.

If a rock weighs 3 pounds, what would be its volume? (First you need to convert to metric!) This will depend upon the density of the rock, which can vary a lot. Rock is typically about three times denser than water, so a volume of rock will weigh about three times more than the same volume of water.

Literature Connection: “Archimedes and the King’s Crown”

An ancient story tells about a Greek king, a gold crown and an amazing scientist named Archimedes. The king had ordered a solid golden crown made. When the court goldsmiths presented it to him, he asked Archimedes to test it to make sure it was pure gold. Archimedes knew that pure gold was very soft. He could bite a piece of it, and his teeth would leave a dent in it. (But he also knew that the king would be mad if he returned a dented crown. He couldn't use THAT test.) Archimedes also knew that if he took equal volumes of gold and water, the gold would weigh 23 times more than the water. He COULD use this test. (The problem was measuring the volume of the crown, an irregular object.).

One night, while filling his tub, for a bath, Archimedes accidentally filled it to the very top. As he stepped into it, water spilled out over the top. The idea struck him, that if he collected the water, and measured it, he would know the volume of his body. HE COULD USE THIS TO MEASURE THE CROWN! In other words, the amount of displaced water in the bathtub was the same amount as the volume of his body. Archimedes was so excited that he jumped out of the tub. He ran outside and down the street yelling "Eureka! Eureka! (One of the few Greek words I know!) I found the answer!"

www.sciencenet.org.uk/.../Chemistry/StructBond/c00195b.html

All this was fine except in his excitement, Archimedes had forgotten to put on his clothes.

He was running down the street naked! Archimedes was able to get the volume of the crown and an equal volume of pure gold obtained, no doubt, from the King’s treasury. When he placed the two items into separate pans on a two-pan balance, well, I guess you can figure out the answer if I tell you that the goldsmith was put into jail!
DENSITY DRIVEN FLUID FLOW

NGSSS:
SC.7.E.6.2 Identify the patterns within the rock cycle and relate them to surface events (weathering and erosion) and sub-surface events (plate tectonics and mountain building). (AA)

Objective:
• Observe that fluid flow is caused by differences in solution density.
• Model the convection flow occurring in the mantle.

Background Information:
All matter takes up space and has mass. The ratio of an object’s mass to its volume is an important physical property called density. This important property is commonly measured in grams per milliliter if the substance is a liquid or grams per centimeter cubed if it is a solid. Density is a physical property of matter, as each element and compound has a unique density associated with it. Density defined in a qualitative manner as the measure of the relative "heaviness" of objects with a constant volume. The Earth is composed of materials of different densities.

Recall that the rock cycle is, in part, a result of the exchange of materials between the layers of the Earth. The layer below the crust of the Earth is the viscous, hot mantle that drives the movement of the plates as a result of convection currents occurring in the mantle.

Engage:
Discuss the following question with your class: “Why do huge cruise ships float and small rocks sink?”

Materials:
• (2) opaque, shoe-box sized plastic container
• (2) large test tube
• (1) test tube rack
• (2) rubber cork (to fit the top of the test tube; your thumb can serve as an alternate)
• food coloring
• salt
• plastic spoon or stirring rod (plastic straws will work here)

Extensions:
Additional Materials Needed:
- (1) Hot Plate
- (2) 250 mL beaker
Student’s Procedures:

Part A:
1. Fill the plastic container ¾ full with water (H₂O). Then mix in enough salt (NaCl) so the water becomes cloudy. Use the stirring rod to mix in the salt. You are making a salt water solution.
2. Fill the test tube with unsalted water and add two or three drops of food coloring to make it a dark color. Swirl the test tube to mix in the food coloring.
3. Place the rubber cork (or your thumb) over the opening of the test tube and cover completely.
4. Lower the test tube carefully into the salt water in the large container. Remove the cork (thumb), let the test tube sit on the bottom undisturbed and observe the direction the colored water flows.
5. Draw, color and label: Diagram A (Include: container, salt water, test tube, unsalted water, the motion of the colored water)
6. Repeat the steps (#1 - #3). Now, lower the test tube just below the surface of the water. Remove the cork (thumb) while holding the test tube and observe the direction the colored water flows.
7. Draw, color and label: Diagram B (Include: container, salt water, test tube, unsalted water, the motion of the colored water)
8. Remove the test tube from the plastic container. Rinse both with water and dry.

Data and Observations:
(Part A)

Diagram A               Diagram B

PART B:
1. Fill the plastic container ¾ full with water (H₂O).
2. Fill the test tube ½ full with water. Then mix in 3-5 spoonfuls of salt (NaCl) so the water becomes cloudy.
3. Add two or three drops of food coloring to make it a dark color. Swirl the test tube to mix in the food coloring and salt.
4. Place the rubber cork (or your thumb) over the opening of the test tube and cover completely.
5. Lower the test tube carefully into the unsalted water in the large container. Remove the cork (thumb), let the test tube sit on the bottom undisturbed and observe the direction the colored water flows.
6. Draw, color and label: Diagram C (Include: container, salt water, test tube, unsalted water, the motion of the colored water)
7. Repeat the steps (#1 - #4). Now, lower the test tube just below the surface of the water. Remove the cork (thumb) while holding the test tube and observe the direction the colored water flows.
8. Draw, color and label: Diagram D (Include: container, salt water, test tube, unsalted water, the motion of the colored water)
9. Remove the test tube from the plastic container. Rinse both with water and dry.
Data and Observations:

Diagram C          (Part B)          Diagram D

Explain Results and Conclusions:
1. Based on your observations, which solution is denser: salt water or un-salted, dyed water?
2. What do you think would happen if salt water were in both the test tube and the container?
3. What do you think would happen if unsalted water were in both the test tube and the container?
4. What was the test (independent) variable in Part A?
5. What was a constant variable in Part A?
6. How does this model the convection currents occurring in the mantle?

Extensions:
Additional Materials Needed:
- (1) Hot Plate
- (2) 250 mL beaker

Here are four alternative procedures to try:
A. Repeat the experiment, but replace the water in the test tube with hot, unsalted water.
B. Replace the salt water in the large container with cold, unsalted water.
C. Repeat the experiment with different amounts of salt.
D. Try replacing the salt in the experiment with sugar and/or baking soda.

Modified & adapted from NASA's "A Teacher's Guide With Activities", produced by the Microgravity Science and Applications Division, Office of Space Science and Applications, and NASA's Education Division, Office of Human Resources and Education. (3/25/97)
Website: http://science.nasa.gov/msl1/ground_lab/ground_lab.htm
author/curator: Bryan Walls

NASA Official: Dr. Gregory S. Wilson
CLASSIFYING ROCKS

NGSSS:
SC.7.E.6.2 Identify the patterns within the rock cycle and relate them to surface events (weathering and erosion) and sub-surface events (plate tectonics and mountain building). (AA)
SC.7.N.1.3 Distinguish between an experiment (which must involve the identification and control of variables) and other forms of scientific investigation and explain that not all scientific knowledge is derived from experimentation. (Assessed as SC.8.N.1.1)
SC.7.N.1.5 Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics. (AA)

Objectives/Purpose:
- Use rock properties to classify rocks to introduce rock- igneous, sedimentary, or metamorphic and the rock cycle.
- Discuss the rock cycle as a means of the Earth for change.

Background Information:
The Earth and the rocks from which it is made has been a symbol for stability. The Earth is far from stable. It is a dynamic place, constantly changing, moving, and being dramatically rearranged. Rocks are the solid material of the outer Earth. Rocks, composed of one or more minerals, are the cool skin of the Earth keeping us insulated from the heat within. Rocks are constantly changing from one form to another. The rock cycle shows this change and separates the rocks in three distinctive groups: igneous, sedimentary, and metamorphic. Igneous rocks form from cooling lava. Weathering processes break this rock into small pieces. These pieces that are called sediments are carried out by running water to the ocean. The weight of the sediments exerts pressure on the pieces below, converting them into sedimentary rock. If this sedimentary rock is buried deep inside the Earth, the pressure and heat can change it into a metamorphic rock. Metamorphic rock that stays deep in the Earth can melt and become igneous or can be brought to the surface and erode into sediment to restart the cycle.

More Teacher Background (http://www.mysciencebox.org/files/1rock_cycle_v2.doc)
Link the rock cycle to what we are teaching (the standard)

Engage:
Tell students that they are geologists exploring a newly discovered island. Ask students if they would be able to identify a collection of rock samples found on the island.

Materials:
- Different samples of rocks (at least 16 different samples) Suggested rocks: basalt, gabbro, granite, obsidian, pumice, rhyolite, scoria, coal, rock salt, shell limestone, compact limestone, conglomerate, sandstone, shale, gneiss, schist, slate, quartzite, and marble.
- Crayons – at least two different colors of wax crayons, at least one stick per student
- Source of very hot water
- Aluminum Foil and/or foil cupcake cups
- Container to hold hot water
- Simple scraping device (popsicle sticks, plastic knifes, sporks….)
Part 1: Classifying Rocks by their Physical Properties
Classify Rocks:
Students will classify rocks by properties following the directions and diagram below.

Procedures:
1. Place all rock samples in a pile at the top of the paper.
2. Draw a circle around the pile of rocks.
3. Move all the dark samples to a separate pile.
4. Make a separate pile of light samples.
5. Draw a circle around each pile.
6. Observe the dark samples.
7. Choose a physical property that will allow you to divide the samples into 2 piles.
8. Draw a circle around each pile.
9. Write the property you used by each circle.
10. Repeat step 3 using the light samples.
11. Keep dividing the piles using physical properties.
12. Do this until each mineral is by itself.

Part 2: Classifying Rocks by Performing Physical Tests
Complete the chart below using at least 8 samples of rocks per group. For each of the properties in the left, place an “X” in the chart to which it corresponds.

<table>
<thead>
<tr>
<th>QUESTIONS</th>
<th>Rock Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Does the rock have two or more colors?</td>
<td>1</td>
</tr>
<tr>
<td>2. Does the rock have large mineral pieces?</td>
<td></td>
</tr>
<tr>
<td>3. Does the rock have small mineral pieces?</td>
<td></td>
</tr>
<tr>
<td>4. Is the rock sandy?</td>
<td></td>
</tr>
<tr>
<td>5. Does the rock have many holes?</td>
<td></td>
</tr>
<tr>
<td>6. Does the rock have layers?</td>
<td></td>
</tr>
<tr>
<td>7. Does the rock have bands?</td>
<td></td>
</tr>
<tr>
<td>8. Does the rock have an odor?</td>
<td></td>
</tr>
<tr>
<td>9. Is the rock shiny?</td>
<td></td>
</tr>
<tr>
<td>10. Is the rock rough?</td>
<td></td>
</tr>
<tr>
<td>11. Is the rock heavy?</td>
<td></td>
</tr>
<tr>
<td>12. Does the rock float in water?</td>
<td></td>
</tr>
<tr>
<td>13. Does the rock make marks on paper?</td>
<td></td>
</tr>
</tbody>
</table>

Discussion Questions:
1. Describe how you classified the rocks? How are the rocks alike? How are they different?
2. Describe the textures of the different rocks? Sandy, small and large particles
3. Are there different types of rocks? metamorphic, igneous or sedimentary
4. How are they classified? How they are formed which leads to there physical characteristics
5. Identify is the type of scientists that studies rocks and why? Geologist
Explore:
To do and notice:
To make a Sedimentary Crayon:
1. You need to make small, particles sized sediments out of your crayons. These can be scraped from a new crayons (which can also be considered an igneous crayon), a sedimentary block of crayon, a metamorphic block of crayon or an igneous block of crayon. Scrape crayons with popsicle sticks, plastic knives or other grating tools.
2. Gather a pile of sediments collected from various scraped crayons.
3. Pressing down on this pile will allow the particles to stick together.
   a. Encasing the sediments between sheets of paper, foil, etc will help keep the sediments together.
   b. Using a utensil or stepping on your encase pile will help this process along too.
4. Your coherent bunch of crayon sediments is now equivalent to a sedimentary crayon.

To make a Metamorphic Crayon:
1. Place a small pile of sedimentary, metamorphic or igneous crayons into piece of aluminum foil or foil cupcake cup.
2. Float this foil on hot water.
3. Watch as the heat from the water transfers to the foil and to the crayons. The crayons should start to melt.
4. Remove the foil when the crayon wax is soft to the touch (don’t use your finger, use a probe such as a popsicle stick).
5. Let your crayons cool.
6. Your partially melted and cooled crayons are now equivalent to metamorphic crayons.

To make an Igneous Crayon:
1. Place a small pile of sedimentary, metamorphic or igneous crayons into piece of aluminum foil or foil cupcake cup.
2. Float this crayon containing foil on hot water.
3. Watch as the heat from the water transfers to the foil and to the crayons. The crayons should start to melt.
4. The crayons should be allowed to melt until a smooth liquid forms.
5. Carefully remove molten crayon wax and let cool. Your totally melted and cooled crayons are now equivalent to igneous crayons.

Explain:
This crayon cycle is designed to model the rock cycle. The rock cycle is a continuing process that has occurred throughout geologic time. One type of rock can become another rock type over time. This process can be thought of as a cycle and can be diagramed. The particles that constitute an igneous rock held in one’s hands today may become part of a sedimentary or metamorphic rock in the distant future. Very little rock on the surface of the earth has remained fixed in its original rock type. Most rocks have undergone several iterations of the rock cycle. The oldest known rocks on the surface of the earth are 3.8 billion years old (found in Greenland).

More Teacher Background
Link the rock cycle to what we are teaching (the standard)

Evaluate:
1. Summarize how this experiment is similar to the changes a rock goes through in the rock cycle. Include as many of the following key vocabulary words: sedimentary rock, heat, erosion, sediment, cement, metamorphic rock, igneous rock, magma, compaction, weathering, melting, solidification, burial, and pressure
2. Complete rock cycle diagram (http://www.mysciencebox.org/files/rock_cycle_handout.doc)
Extension:
1. Write a story of your life as a rock as you change over millions of years using vocabulary words covered in the rock cycle.
   - Virtual look at rocks and mineral characteristics
   - Rock Identification Virtual Lab Activity
     (http://www.scienceconnection.ca/Documents/RockIDLab.pdf)
   - And more ideas and activities (http://mjksciteachingideas.com/) and interactive site

Adapted from Crayon Rock (http://www.exo.net/~emuller/activities/Crayon-Rock-Cycle.pdf)
FOSSILS AND THE LAW OF SUPERPOSITION

NGSSS:
SC.7.E.6.3 Identify current methods for measuring the age of Earth and its parts, including the law of superposition and radioactive dating. (Assessed as SC.7.E.6.4)
SC.7.E.6.4 Explain and give examples of how physical evidence supports scientific theories that Earth has evolved over geologic time due to natural processes. (AA)

Objective:
Students will use their knowledge about fossils to arrange fossil pictures in sequence from oldest to youngest.
Explain how fossils can be used to make inferences about past life, climate, geology, and environments.

Materials:
- Pencils
- Colored Pencils
- Drawing Paper
- Cardstock

Handouts:
- Nonsense Cards Set A
- Fossils Cards Set B (1)
- Fossils Cards Set B (2)
- Stratigraphic Section for Set B

Additional Web Sites The Relative Time Scale

Background For Teachers:
Scientists have good evidence that Earth is very old, approximately four and one-half billion years old. Scientific measurements such as radiometric dating use the natural radioactivity of certain elements found in rocks to help determine their age. Scientists also use direct evidence from observations of the rock layers themselves to find the relative age of rock layers. Specific rock formations are indicative of a particular type of environment existing when the rock was being formed. For example, most limestone represents marine environments, whereas, sandstones with ripple marks might indicate a shoreline habitat or riverbed.

The study and comparison of exposed rock layers or strata in different areas of Earth led scientists in the early 19th century to propose that the rock layers could be correlated from place to place. Locally, physical characteristics of rocks can be compared and correlated. On a larger scale, even between continents, fossil evidence can help in matching rock layers. The Law of Superposition, which states that in an undisturbed horizontal sequence of rocks the oldest rock layers will be on the bottom, with successively younger rocks on top of these, helps geologists correlate rock layers around the world. This also means that fossils found in the lowest levels in a sequence of layered rocks represent the oldest record of life there. By matching partial sequences, the truly oldest layers with fossils can be worked out.

By correlating fossils from various parts of the world, scientists are able to give relative ages to particular strata. This is called relative dating. Relative dating tells scientists if a rock layer is “older” or “younger” than another. This would also mean that fossils found in the deepest layer of rocks in an area would represent the oldest forms of life in that particular rock formation. In reading Earth history, these layers would be “read” from bottom to top or oldest to most recent. If certain fossils are typically found only in a certain rock unit and are found in many places worldwide, they may be useful as index or guide fossils in finding the age of undated strata. By using this information from rock formations in various parts of the world and correlating the studies, scientists have been able to construct the geologic time scale: This relative time scale divides the vast amount of Earth history into various sections based on geological events (sea encroachments, mountain-building, and depositional events), and notable biological events (appearance, relative abundance, or extinction of certain life forms).
Instructional Procedures:

Invitation to Learn?
Teaching about Earth’s history is a challenge for all teachers. The idea of millions and billions of years is difficult for children and adults to comprehend. However, “relative” dating or time can be an easy concept for students to learn.

In this activity, students begin a sequencing activity with familiar items—letters written on cards. Once they are able to manipulate the cards into the correct sequence, they are asked to do a similar sequencing activity using fossil pictures printed on “rock layer” cards. Sequencing the rock layers will show students how paleontologists use fossils to give relative dates to rock strata.

Engage:
Part 1:
1. Hand out *Nonsense Cards*, Set A in random order. Students place on the table and work in small groups to sequence the eight cards by comparing letters that are common to individual cards, and therefore, overlap. There should be lots of discussion. The first card in the sequence has “Card 1, Set A” in the lower left-hand corner and represents the bottom of the sequence. If the letters “T” and “C” represent fossils in the oldest rock layer, they are the oldest fossils, or the first fossils formed in the past for this sequence of rock layers. Optional: *PowerPoint of this activity* (http://middleschoolscience.com/superposition-fossils.ppt) & *student handout* (http://middleschoolscience.com/superposition-ppt-worksheet.pdf).
2. Now, look for a card that has either a “T” or “C” written on it. Since this card has a common letter with the first card, it must go on top of the “TC” card. The fossils represented by the letters on this card are “younger” than the “T” or “C” fossils on the “TC” card and indicates fossils in the oldest rock layer. Sequence the remaining cards by the same process. When done you should have a vertical stack of cards with the top card representing the youngest fossils of this rock sequence and the “TC” card at the bottom of the stack indicating the oldest fossils.

Discussion:
1. After putting the cards in order, write down the sequence for easy checking. Start at the bottom going oldest to youngest.
2. How do you know “X” is older than “M”?
3. Explain why “D” in the rock layer represented by DM is the same age as “M.”
4. Explain why “D” in the rock layer represented by the OXD is older than “D” in the rock layer represented by DM.

Explore:
Part 2:
1. Look carefully at the second set of cards with sketches of fossils on them. Each card represents a particular rock layer with a collection of fossils that are found in that particular rock stratum. All of the fossils represented would be found in sedimentary rocks of marine origin. Figure A gives some background information on the individual fossils.
2. The oldest rock layer is marked with the letter “M” in the lower left-hand corner. Don’t worry about the other letters at this time. Ask students to find a rock layer that has at least one of the fossils you found in the oldest rock layer. This rock layer would be younger as indicated by the appearance of new fossils in the rock stratum. Keep in mind that extinction is forever. Once an organism disappears from the sequence it cannot reappear later. Use this information to sequence the cards in a vertical stack of fossils in rock strata. Arrange them from oldest to youngest with the oldest layer on the bottom.
Extensions:
- Students research different fossils to see where they are on the geologic time scale.
- Research the internet for fossil trivia, then write a question and answer game for the class.
- Students write a story telling the life of an animal that is facing extinction.
- Draw a fossil pop up book. Write a short definition below each picture.
- Students may take family field trips to a nearby fossil bed.
- Visit virtual dinosaur quarries
- Take home card sets A and B and teach a family member about the Law of Superposition

Assessment:
- Checking individual stacks of cards.
- Verbal answers to the discussion questions.
- Students write a short paragraph explaining the Law of Superposition.
- Sequence information using items which overlap specific sets; students will relate sequencing to the Law of Superposition and then show how fossils can be used to give relative dates to rock layers.

Bibliography:
Schmoker, M. 1999. The key to continuous school improvement. Results 2nd Edition Association for Supervision and Curriculum Development pg. 71

“We labor under the incorrect notion that students must master basic skills before they can learn higher-order skills or engage in complex activities. Studies in math, reading, and writing clearly demonstrate that the opposite is true. Students learn best when basic skills are taught in a vital challenging context that makes the skills meaningful. The very thing that keeps students from achieving in these areas is the dry irrelevant teaching strategies we often employ, especially with students who most need real challenges. “ (Means, Chelemer, and Knapp, Teaching Advanced Skills to at Risk Students: Jossey-Bass 1991)

Schmoker, M. 1999 The key to continuous school improvement Results 2nd Edition ASCD pg. 73

Virtually every teacher has acquired some semblance of training in this highly effective method (cooperative learning), estimates are that only about 10 percent of teachers use cooperative learning. One of the simplest forms of cooperative learning—having students occasionally work in pairs to ensure each other’s understanding of difficult concepts— can be expected to bring immediate effects especially among low-achievers. They also found that such simple pairings are especially effective in helping students to succeed in math and science.” (Joyce B. Weil and Showers 1992 Models of Teaching. New York: Allyn and Bacon.)

Adapted from Utah Lesson Plans
<table>
<thead>
<tr>
<th>TC</th>
<th>CGA</th>
</tr>
</thead>
<tbody>
<tr>
<td>AU</td>
<td>UBN</td>
</tr>
<tr>
<td>BN</td>
<td>NO</td>
</tr>
<tr>
<td>OXD</td>
<td>DM</td>
</tr>
</tbody>
</table>
Fossil Cards - Set B (1)

M
- Trilobite
- Brachiopod

S
- Eurypterid
- Graptolite

I
- Horn Coral
- Trilobite
- Eurypterid

N
- Eurypterid
- Horn Coral
- Crinoid
- Placoderm
Fossil Cards - Set B (2)

A
- Crinoid
- Foraminifer

G
- Gastropod
- Foraminifer
- Crinoid

R
- Ammonite
- Foraminifer
- Pelecypod

O
- Ichthyosaur
- Pelecypod
- Shark's Tooth
BECOMING WHALES: FOSSIL RECORDS

Source: http://www2.edc.org/weblabs/ExploringEvolution/evolution.swf

NGSSS:
SC.7.L.15.1 Recognize that fossil evidence is consistent with the scientific theory of evolution that living things evolved from earlier species. (Assessed as SC.7.L.15.2)
SC.7.N.1.3 Distinguish between an experiment (which must involve the identification and control of variables) and other forms of scientific investigation and explain that not all scientific knowledge is derived from experimentation. (Assessed as SC.7.N.1.1)
SC.7.N.1.5 Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics. (AA)
SC.7.N.1.7 Explain that scientific knowledge is the result of a great deal of debate and confirmation within the science community. (Assessed as SC.7.N.2.2)

Purposes:
1. Examine evidence of evolutionary history of modern whales by investigating the fossil record (paleontological evidence) of several whale “cousins” from the Eocene Epoch (~58-35 mya).
2. Construct the evolution of modern whales along a timeline of the history of the Earth and discuss the age of the Earth along with the time frame in which macroevolution occurs.
3. Compare the evidence to the understanding evolution of whales to the scientific theory of evolution.

Engage:
1. Has anyone seen a real whale? Where? What kind? See smaller whales and larger whales (Examine “Some Modern Whales”. Compare the baleen and toothed)
2. What kind of animal is a whale? What are some of their mammalian features
3. How big are these whales? As big as a room? Bigger? Smaller?
4. Examine the size of whales from smallest to largest-about 1.4 m to 21 m) use a meter tape/stick or rope to visualize the size humpback or gray whale which is half that of a blue whale or use a Interactive white board if available to view the actual size of a blue whale
5. Math connection: Whale length-table for overhead projector, so students can make full size strips of adding machine tape to match actual whale lengths (modern and extinct) to get a realistic sense of relative sizes (optional).
6. Discuss “What Kind of Creature is a Whale”
   a. [a Mammal]..... some of their features? Big, swim in oceans, nurse their young, hair, ...
   b. Hind limb buds on whale embryo, Hip bones in adult whales
7. How long have whales been on Earth? Where did they come from? Display time line-Cenozoic Time Line
8. Have students individually hypothesize where they believe whales came from and illustrate what whales may have looked like long ago.

Explore:
So how did whales get here? What did they once look like?
If, as it is widely believed by paleontologists, whales did evolve from terrestrial mammals, we should be able to find the fossil remains of early “pre-whales”, probably somewhat whale-like, but with legs of varying degrees of reduction and certain other features of varying degrees of similarity to ancestral and modern whales.

Teacher says “You are being provided with five drawings of fossils whales (either in full or partial), that lived between 55 and 34 million years ago and reconstructions of what these “whales in the making” may
have looked like. You are also provided some brief information on the critical morphological (=shape or form) features that paleontologists used to situate these fossil species when they existed during the Eocene Epoch, an epoch that began approximately 58 million years ago. In groups of 2-4, arrange these early whale “cousins” in the order on the Eocene timeline in which you think they may have appeared in the fossil record. Be sure to write down the evidence upon which you based your decisions.” See also teacher directed or student directed

- Provide each group with the following:
  Cut strips and give each group 5 strips (1-5 NOT strip 6)  
  (http://www.indiana.edu/~ensiweb/lessons/wh.n.mkg.pdf)
- And each student: Data Table for each student to record evidence  
  (http://www.indiana.edu/~ensiweb/lessons/wh.ev.dt.pdf)

**Explain:**
Review and discuss how the arrangement of the whale fossils differed from that suggested by the handouts.

Cite evidence of what you/your group discovered using the following questions:
1. Which typical whale traits seemed to be the earliest to appear and which evolved much later?
2. Looking at the ages of sediments where fossils were found, where would you start looking for fossils that would shed more light on whale origins? Which traits would you expect or hope to find?
3. How closely do the intermediate traits of *Ambulocetus* fit into the sequence between the mesonychids and *Rodhocetus*?
4. Explain why the absence of transitional (intermediate) fossils is not a fair argument against evolution.

**Elaborate/Extension:**
If you have access, view the short (5 minute) PBS video online at:
http://www.pbs.org/wgbh/evolution/library/03/4/l_034_05.html

Using History of Earth timeline, situate the Eocene Epoch and Cenozoic in its proper location along the timeline tape. Discuss the relative length of the history of the Earth compared to the length of the evolutionary history of whales. If it doesn’t arise in the discussion, point out that the evolutionary process is an extremely lengthy process; the common misconception is the confusion of macroevolution with microevolution.

Prepare a Timeline to scale – 3 cm = 1 million years Also available is the timeline for the 4.5 billion year history of our Solar System. And other models. 
Evolution of Whales and Virtual Lab

**Evaluate:**
Return to the explanation of how whales may have evolved from a land-dwelling ancestor. Reflect on what you have learned about the origins of whales and revise your response to this prompt.

**Extension:**
- Whales may be related to deer-like creature:  
  http://www.indiana.edu/~ensiweb/lessons/wh.ph.os.html
- The organsystems of ancient whales that we study:  
  http://www.indiana.edu/~ensiweb/lessons/whalekiosk.html
WHALES IN THE MAKING

1. Archaeocetes (primitive whales, e.g.: Dorudon, Prozeuglodon)

2. Mesonychids (extinct land mammals, with whale-like teeth, e.g. Pachyaena, Sinonyx)

3. (1983) Pakicetus inachus (skull and teeth only)

4. (1990) Basilosaurus isis (hind leg found)

5. (1994) Rodhocetus kasrani

6. (1994) Ambulocetus natans

All figures redrawn from originals for this lesson by Janet Dreyer. See “List of Credits” page for original sources.
1. We have NO fossils of modern whales earlier than about 25 million years ago (mya). However, for many years, we have been finding a number of fossils of various primitive whales (archaeocetes) between 25 and 45 million years old, and somewhat different from modern whales, e.g. with very distinctive teeth. An example of these early whales would be *Dorudon*. Place the fossil picture strip of *Dorudon* at about 36 mya on your timeline (actual range about 39-36 mya); (“mya”=millions of years ago).

2. As more fossils have been discovered from the early Eocene (55 to 34 mya), we searched for a land mammal from which whales most likely evolved. The group of animals that had features like those distinctive teeth that are also found in the earliest primitive whales, was called the Mesonychids. A typical example of these animals was *Pachyaena*. Mesonychids also had hooves, suggesting that whales may be related to other animals with hooves, like cows, horses, deer and pigs. Place the *Pachyaena* strip at about the 55 mya level on your timeline. Mesonychids lived from 58-34 mya.

3. In 1983, all we had were these primitive whales and mesonychids, with a big gap in between. This year, paleontologist Philip Gingerich was searching in Eocene deposits in Pakistan, and found the skull of an amazing fossil. It had teeth like the *Dorudon* whale, with whale-like ear bones and other features, but it was much older (50 mya), and there were indications that it had four legs. He called this *Pakicetus*, so place your *Pakicetus* strip on your timeline at 50 mya. Later, more complete fossils confirmed that it had 4 walking legs, with tiny hooves!

4. In 1990, in Egypt, Gingerich’s team found the tiny hind limb bones of *Basilosaurus*. There were lots of *Basilosaurus* skeletons there (once covered by the Mediterranean). *Basilosaurus* had first been discovered in the Appalachians of America. These new leg fossils were about 37 my old, so place the *Basilosaurus* strip at 37 mya on your time line. The legs were about 2 feet long, and useless for carrying the animal on land.

5. In early 1994, Gingerich was hunting in Pakistan again, in Eocene sediments, and found the fossil remains of a 4-legged early whale that was more recent than *Pakicetus*, and with more aquatic features (shorter legs, whale-like ear bones, skull with nostril between eyes and tip of nose). He called it *Rodhocetus*. Place the *Rodhocetus* strip at 46 mya. *Rodhocetus* also had tiny hooves on its toes!

6. NOW, notice the gap between the very terrestrial *Pakicetus* at 50 mya and the clearly more aquatic *Rodhocetus* at 46 mya. Talk with your partners about what you think an animal intermediate between *Pakicetus* and *Rodhocetus* might look like, and where you would most likely find that animal. Make a sketch of what you think it would look like.

7. After most of you have “made your predictions” (shown your drawings to your teacher), you will be shown the next discovery...

8. In late 1994, Hans Thewissen (one of Gingerich’s students) was searching ....where?.....[right, Pakistan]... in 49 my old deposits, and found a nearly complete fossil of what he called “The Walking Whale” - *Ambulocetus*. Place the *Ambulocetus* strip at 49 mya years ago, between *Pakicetus* and *Rodhocetus*. It was about the size of a large sea lion, and with its huge hind feet, probably swam like an otter. It also had whale-like ear-bones and little hooves on its toes!
MOTH CATCHER
Source: Predator Avoidance: Camouflage (http://www.flmnh.ufl.edu/education/guides/butterfly-guide.pdf)

NGSSS:
SC.7.L.15.2 Explore the scientific theory of evolution by recognizing and explaining ways in which genetic variation and environmental factors contribute to evolution by natural selection and diversity of organisms. (AA)
SC.7.N.1.3 Distinguish between an experiment (which must involve the identification and control of variables) and other forms of scientific investigation and explain that not all scientific knowledge is derived from experimentation. (Assessed SC.8.N.1.1)
SC.7.N.1.5 Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics. (AA)

Materials:
• Tape
• Crayons and/or Markers
• Scissors
• Drawing paper

Engage:
1. Review camouflage briefly with the class. Some animals (for example, birds, bats, spiders, dragonflies, and mice) rely heavily on Lepidoptera for food. Butterflies and moths have evolved several strategies to keep from being eaten. These include:
Warning coloration- a bold pattern and bright contrasting colors. Bright warning coloration, especially yellow-and-black, orange, or red, warn birds and other predators that such insects may bite, sting, or taste bad.
Camouflage- Moths and many butterflies, particularly females, have earth-tone colors or patterns that resemble tree bark, lichens, or leaves. This “cryptic coloration” allows them to avoid predators by blending into their surroundings.
Mimicry- Some butterflies and moths deter predators by mimicking the color pattern of other less edible species or other insects, plants, and animals. Two types of mimicry:
1) Batesian Mimicry- Some harmless Lepidoptera species mimic the appearance of other species that are poisonous or distasteful. They “pretend” to be poisonous and predators avoid them.
2) Mullerian Mimicry- Sometimes two species look alike and both are poisonous or distasteful. When a predator attacks one of the two, it remembers the color pattern and is unlikely to attack either, avoiding insects with that color pattern.
Defense patterns- Alarm Patterns: Eyespots on wings intimidate predators, especially small birds, who think they see the eye of a larger bird that might harm them.

Explore:
1. Tell the class that they are going to play a camouflage game.
2. Pass out a couple of pieces of drawing paper, scissors, and some crayons and/or markers to each child.
3. Ask each child to make a butterfly that would be camouflaged in some part of the classroom.
4. Have students color their butterflies and cut them out.
5. When everyone is finished with their butterfly break the class.
into groups of 5-8.

6. While the rest of the class has their eyes closed put a folded piece of tape on the back of the first group’s butterflies. Have the students hide their butterflies around the room in places where their butterflies would be difficult to see. Tell the students “Color your moth cutouts and place them on the room’s perimeter (environment) to best camouflage them. Your challenge is to have the moth survive an outside predator! All moths must be in plain sight. (They can’t be partially covered by objects!) Moths can’t be placed on the ceiling or the floor! Predators can only make 1 complete trip around the room, once they have passed a spot they can’t go back to it.”

7. When the first group is done have the rest of the class get up and try to find the camouflaged butterflies.

8. When all butterflies have been found, let the next group hide their butterflies.

9. Continue this process until all the children have had a chance to hide their butterflies.

**Explain:**

1. Asses what this experiment shows about how prey is selected by predators?
2. Infer how this activity models natural selection?
3. Explain how luck and location are important factors?
4. Which moth coloration (light or dark) would be the best adaptation for a newspaper background?
5. Compare and contrast advantage(s)/disadvantage(s) of using camouflage as a survival strategy.
6. In England during the industrial revolution, factories burned so much coal that the countryside gradually became coated with dark soot over a long period of time. Infer how do you think the moths in this area responded/adapted to their slowly changing environment?

7. Examine the table and construct a graph to represent the data. Plot the years of study on the x-axis and the number of moths captured on the y-axis. You should have 2 lines on your graph –one for light moths, and one for dark moths.

<table>
<thead>
<tr>
<th>Year</th>
<th># of Light Moths Captured</th>
<th># of Dark Moths Captured</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>537</td>
<td>112</td>
</tr>
<tr>
<td>3</td>
<td>484</td>
<td>198</td>
</tr>
<tr>
<td>4</td>
<td>392</td>
<td>210</td>
</tr>
<tr>
<td>5</td>
<td>246</td>
<td>281</td>
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<td>6</td>
<td>225</td>
<td>337</td>
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<td>7</td>
<td>193</td>
<td>412</td>
</tr>
<tr>
<td>8</td>
<td>147</td>
<td>503</td>
</tr>
<tr>
<td>9</td>
<td>84</td>
<td>550</td>
</tr>
<tr>
<td>10</td>
<td>56</td>
<td>599</td>
</tr>
</tbody>
</table>

9. Analyze the graph

**Extension:**
- Research more about the Peppered Moth and the debate and Virtual Lab ([http://www.biologycorner.com/worksheets/pepperedmoth.html](http://www.biologycorner.com/worksheets/pepperedmoth.html))
- Additional resources including a template for the moth and information-power point ([http://www.darwin.rcuk.ac.uk/CMS/files/IAHDarwinNotes%5B1%5D.pdf](http://www.darwin.rcuk.ac.uk/CMS/files/IAHDarwinNotes%5B1%5D.pdf))
- Adapted from Florida Museum of Natural History [http://www.flmnh.ufl.edu](http://www.flmnh.ufl.edu) lesson 13
MODELING THE GREENHOUSE EFFECT

NGSSS:
SC.7.E.6.6 Identify the impact that humans have had on Earth, such as deforestation, urbanization, desertification, erosion, air and water quality, changing the flow of water. (Assessed as SC.7.E.6.2)

Background Information for the teacher:
Greenhouse gases are carbon dioxide, methane, nitrous oxide, ozone (in the lower atmosphere), water vapor and CFCs. One greenhouse gas that has been increasing in the past 50 years is carbon dioxide. Loss of rainforests that take in carbon dioxide and the burning of fossil fuels by cars, factories and plants which releases carbon dioxide are part of the causes. This continued urbanization, increase in cities with respect to the region’s rural areas, contributes to decreased water quality for humans and increased carbon dioxide and pollutants in the air.

Teacher’s notes:
This activity could be divided into 2 sessions. One session for the engage and explore with testing then Explain and allow students to return with more materials or work on at home then retest and evaluate.

Purpose:
In this investigation students will create models of Earth with and without heat-reflecting greenhouse gases.

Materials:
- 2 Clear plastic cups
- 2 Thermometers
- Potting soil
- Clear Plastic wrap
- 2 Rubber bands
- Lamp with 100 Watt light bulb
- Watch or clock

Engage:
Read or write on the board "Why does the light energy from the Sun pass through the greenhouse gases unhindered and the infrared energy radiated from the Earth is absorbed?"

Explain how a greenhouse is able to maintain a temperature at which plants are able to grow even though the temperature outside the greenhouse sometimes will not support plant life. Relate a greenhouse to how the Earth’s atmosphere traps heat. Identify the gases in the atmosphere that “act” like the glass in a greenhouse.
Explore:
Based on both, the materials given by your teacher and the main purpose of this activity you and your team will design an experiment that will measure the different amount of heat retained in a glass jar beneath a heat lamp. This activity will model how the greenhouse effect influences the temperatures in our Earth’s atmosphere. You will investigate “**How does the greenhouse effect influence temperature on Earth**”. Include: your problem statement for this activity. Formulate a hypothesis. Using the given materials design and complete an experiment to test your hypothesis. Explain how you tested your hypothesis. It should be as specific as possible. Often, scientists read relevant information pertaining to their experiment beforehand.

Explain and Redesigning the Experiment
Students will share their findings from the explore activity. Summarize the results of your activity. What happened to the temperature of the jar over time? Relate how the set up of the glass jar beneath a heat lamp models the greenhouse effect on Earth. Can you identify the independent (manipulated), and dependent (responding) variables in your activity? Did you only change (test) only one variable? Identify what you could do to improve this activity.

After discussion, have students complete this investigation: Have students write a problem statement and form a hypothesis before testing.
Basically, during this investigation, the students should perform the following procedures:
1. Place equal volume of soil in the bottom of each plastic cup.
2. Place the thermometer inside of each container at the same height relative to the soil. Record the initial temperature in degrees Celsius (°C)
3. Seal the top of one container with plastic wrap held in place with the rubber band while leaving the second container open.
4. Place the lamp with the exposed 100 watt bulb between the two containers. The light bulb should be kept on during the whole experiment.
5. Record the temperature in each container every 2 minutes for the next 20 minutes.
6. Construct a multiple line graph with both sets of data on the same axes (temperature on Y, time on X)
7. A possible format of data table:
Data Table 1: Changes in Temperature

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Temperature in open container (°C)</th>
<th>Temperature in sealed container (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
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<tr>
<td>4</td>
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<tr>
<td>18</td>
<td></td>
<td></td>
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<tr>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Evaluate:
1. Interpret the graph and identify a trend for the change in temperature for each container during the experiment? Did both jars show the same change in temperature? Calculate the change in temperature for each jar.
2. Did your results support your hypothesis?
3. Explain why the temperature of the covered jar showed an increase in temperature. What part of this setup contributed to the increase in temperature?
4. Explain how the covered jar setup represents an experimental model of the influences of the greenhouse effect on the temperature of the Earth’s atmosphere. Identify what the light bulb and plastic wrap represent in this experimental model.
5. Identify the independent (manipulated), dependent (responding) and constant variables in this experiment.
6. In this experiment we only tested each setup one time (20 minute interval), explain why this will affect the validity of the data. How can we change this experiment so the data will be more valid?
7. Based on what you learned in this activity, can you connect this knowledge to the environmental issue of the dangers of the greenhouse effect? Explain
8. Think about what humans do that increases the amount of greenhouse gases released into the atmosphere and develop a list of ways that we can reduce the level of these gases.

Optional Extensions:
1. Activity # 1. Students may want to continue the experiment and record the two temperatures every day at the same time for a week. Graph the data and discuss how the temperatures fluctuate from day to day.
There is no scientific dispute about the presence of "greenhouse gases" (including carbon dioxide--CO₂) in the earth’s atmosphere that function to trap heat from the sun. There is also no dispute that the amount of CO₂ in the atmosphere has increased 25%. Does this mean that global warming is occurring? Nobody knows for certain, but many atmospheric scientists are becoming concerned about the increasing amount of CO₂ in the atmosphere.

What does this mean to you? Despite the uncertainties, if global warming does occur (or if it has already begun), it will profoundly affect human societies. Global warming may result in severe droughts, reducing crop production necessary to feed billions of people. Rising sea levels will threaten beaches, coastal cities, and people. The migration of millions of people would strain economic, health, and social services. Conflicts over remaining resources could escalate. Wildlife habitat will be destroyed, with countless species facing extinction. With the potential devastating effects of global warming, it is reasonable and prudent to examine alternatives to fossil fuels to decrease the amount of CO₂ in the atmosphere. The transportation sector is one area that can, generally speaking, use alternative methods of fuel, since there are already a variety of alternate fuels available. The good news is that this transition can be done relatively easily, cheaply, and painlessly.

Activity: With a parental supervision, students will visit two parking lots in different areas, and list the types of cars present to determine the amounts of CO₂ these cars release.
(1) Select two areas in your town with substantial parking lots. These parking lots can be in different parts of town, surrounding different types of stores (food stores, clothing stores, discount stores), or can be of different sizes (shopping malls, "mom and pop" stores, specialty shops).
(2) Walk through each parking lot, writing down the following information for 10 cars (it helps if at least one person knows about cars):
   • Car type (Be specific! For example: Ford F350 pickup truck)
   • The condition of the car (new, used but excellent, badly used, etc.)
   • The size of the car (very big, large, medium, compact, etc.)
   • Approximately weight of the car in tons. Since CO₂ emissions are tied to the weight of the car, assume that each car emits as much CO₂ per year as it weighs. Record this amount for each car.

Questions:
(1) Were there significant differences in the types and ages of the cars you saw in the different parking lots? Why or why not?
(2) Did there seem to be a correlation between the cars and the type of store?
(3) Did there seem to be a correlation between the size and age of the cars?
(4) Which parking lot had the cars with the most estimated CO₂ emissions? Why might this be?
(5) Look up the weight information for your car. What type of CO₂ emissions does it have?
(6) Would you consider emissions of air pollutants in the purchase of your next car? Why or why not?

Sources:
- http://www.climatechangenorth.ca/section-lp/LP_06_1_B_greenhouse.html
DISSECTING A FLOWER

NGSSS:
SC.7.L.15.2 Explore the scientific theory of evolution by recognizing and explaining ways in which genetic variation and environmental factors contribute to evolution by natural selection and diversity of organisms. (AA)
SC.7.N.1.3 Distinguish between an experiment (which must involve the identification and control of variables) and other forms of scientific investigation and explain that not all scientific knowledge is derived from experimentation. (Assessed as SC.7.N.1.1)

Objective/Goal:
Upon completion of this lab activity you will be able to identify each flower part. You will observe the inside and outside parts of a flower, explain the role of each flower part, and hypothesize how the many parts might aid in its reproduction.

You will be able to identify this lab as an experiment or other form of scientific investigation and explain the distinction between these two methods of discovering scientific knowledge,

Background Information:

All flowers are variations on a simple, basic plan. Some flowers are tiny and hard to see; others are showy and flamboyant, like orchids and roses. Some flowers grow in clusters, some bloom alone. Most flowers, however, have a protected ovary that contains the ovules, and stamen to produce the pollen (sperm cells).

Land plants developed flowers. Showy petals and sweet nectar are often produced to lure insects to the blossoms. Insects carry the pollen from flower to flower, ensuring exchange of the information encoded in the chromosomes. Flowers have a well-defined structure. When the bud appears on the stem, we see the green sepals. Sepals are the green parts that protect a flower bud before it opens. There is usually one sepal for each petal. All together the sepals are called the calyx (pronounced kay’ licks). After the flower opens, the sepals can still be seen behind the petals. The sepals protect and sometimes support the corolla (all the petals together).

The petals are really advertisements for insects, signaling "Nectar Here!" Nectar is secreted at the base of the petals on the inside of the flower. The nectar is used to lure insects to the flower, and it is placed so that the insects get a dusting of pollen as they crawl to the nectar and lap it up. Then the insects fly off to other flowers, taking the pollen from the first flower with them.

Let's look more closely at the parts of the flower that make the seeds. The inside of the flower holds the reproductive parts. The stamens produce the pollen (sperm cells), which is represented by yellow dots. The pistil, in the center of the flower, is considered to be the female part: you can see the unfertilized eggs waiting in the ovary at the bottom of the pistil.
The Pistil

The pistil is the part of the flower that produces the seeds. It consists of three parts:

- The stigma -- The pollen grains (sperm cells) stick to this small sticky pad.
- The style -- The pollen grains (sperm cells) grow down through this stem-like cylinder.
- The ovary -- This is where the pollen (sperm cells) join the egg cells in a process known as fertilization. The fertilized eggs develop into seeds.

The wall of the ovary protects the developing seeds. When the seeds are mature, they are often found in some sort of seed case, such as a pod, or within a fruit. Animals and birds that eat the fruit scatter the seeds abroad.

The Stamen

Stamens are slender structures that hold the pollen (sperm cells). They consist of two parts:

- The anther -- A small case in which the pollen grains form.
- The filament -- A slender stem that supports the anther.

The pollen grains form in the anthers, which open when the pollen is mature. The pollen is a fine, powdery, golden dust that is easily picked up by an insect or a finger.

A flower may receive pollen from many different kinds of plants. However, only pollen grains from the same kind of plant will begin to grow. The pollen sticks to the stigma and a tiny tube, the pollen tube, grows down from the pollen grain. The sperm then travels down the pollen tube and fertilizes the egg which is now known as a zygote. The zygote develops into a plant embryo. The plant embryo stays in the ovary and develops into a seed. The seed will always have two parts: a cell that is ready to grow into a new plant and a food supply to help the new plant to grow.

The next time you eat a peanut, think about the parts of the seed. When the shelled peanut breaks apart, look inside where the two halves come together. If you look carefully you can see the embryo, it almost looks like a little plant. The two sides of the seed are the endosperm or the initial food supply.

Materials:
- Gladiolus and/or hibiscus (1 per group)
- Scalpels or plastic knives
- Glass slides
- Dissecting microscopes (optional)
- Paper towels
- Flower model (if available)
- Toothpicks
- Markers
- Lab sheets (directions and data log)
- Glue or scotch tape
- Newspaper
- Scoring Rubric
  http://school.discovery.com/schrockguide/assess.html#rubrics
Procedure to follow during the whole laboratory activity:

- Answer all questions throughout the lab activity and in the analysis section.
- During this lab you will be working with a partner on the Data Chart (questions with letters) and a separate sheet of paper (questions with #'s).
- Record all number counts in column 2 of the Data Log.
- Sketch all drawings neatly in the Data Log.
- Neatly record all parts of the flower to your Data Log as indicated.
- Describe the function of each flower part in the Data Log.


Place your specimen on a piece of newspaper. Carefully examine your specimen.

1. Trace the stem to the base of the flower. Does the stem appear wider as it nears the base of the flower? Explain.
2. What is the function of the stem?
3. Locate the outermost layer; and locate the green leaf-like structures surrounding the bottom of the flower.
   i. Count and record in the data log the number of sepals. What is their function?

Part 2: The petals: Observe the colored petals of your flower.

b. Count and then record in the data log the number of petals.
4. What advantage do colored petals offer?
   c. What is the function of petals?

Part 3: The Pistil and Stamen.

Carefully remove enough sepals and petals from your flower so that you can observe the inner parts. Attach a sampling of the sepals and petals to the data log.

Find the large stalk-like part in the center of the flower. This part is called the pistil. It is divided into three areas.

- The large, bottom part is called the ovary.
- The middle area is called the style.
- The top part is called the stigma.

d. Draw and label in the data log the three areas of the pistil: stigma, style, and ovary.
e. Record in the data log the number of parts into which the style is divided.

Carefully touch the stigma. It should feel a bit sticky.

5. Suggest a reason for the stigma to be sticky.
   Surrounding the pistil are several upright stalks that make up the stamen.
   f. Count and then record the number of stamen in the data log.

Use a hand lens to observe carefully, the structures attached to the tops of the stalks.

Find the yellow powder.

1. What are these structures called? The structures produce a yellow powder.
2. What is the yellow powder composed of?
   g. In the data log, draw the stamen; label the anther and filament.
   h. Count the number of stamen present in your specimen and record in the data log.
   i. Carefully remove each stamen. Attach some to your data log.

Part 4: The Ovary

Carefully remove the pistil from your flower. Following the teacher’s instructions, use your cutting utensil to carefully cut across the ovary.

8. What do you see inside the ovary?
   a. Draw the inside of the ovary on your data log.
b. Count and then record in the data log the number of ovules (eggs) found in your specimen.

9. What is the function of the ovary?

**Part 5: The Pollen Grain**

Carefully shake a small amount of pollen onto a glass slide.

Prepare a wet mount and view under the microscope at 100x and 400x.

a. Draw a single pollen grain on the data log.

10. What is the function of pollen?

Your group will be evaluated on the basis of your answers to the questions in parts 1, 2, and 3, your data log and responses to the following “analye and conclude questions”:

1. What is the main function of flowers?
2. Identify the parts of the flower which produce the sperm and the part which produces the eggs.
3. Most night-blooming flowers are white in color, hypothesize why this is true.
4. Formulate a hypothesis about why flowers are colorful and some have a pleasant odor.
5. Does the flower you have dissected reproduce sexually or asexually? Explain your answer.
6. Compare and contrast sexual and asexual reproduction in plants. Identify two examples of each type of reproduction.
7. Identify two trees that have flowers and two that do not have flowers.
8. Why is it an advantage for flowers to produce multiple seeds?
9. How do you think your flower is pollinated, by wind, butterflies, and/or bees? Explain your answer.
10. Was this lab an experiment? Explain your answer.

**Extension Questions**:

1. What do you think is Florida’s most economically important plant and explain what factors led you to distinguish this plant from other plants for this title.
2. Compare and contrast our state flower to our wildflower.
3. Describe/Draw the type of flower structure you would expect for a flower pollinated by:
   A. Wind  B. Butterflies  C. Bees
4. What are two most important products that plants give us?
5. Identify two edible flowers.
## Data Log: Dissecting a Flower

### Student Names:
Student Names: ________________________ and ________________________

<table>
<thead>
<tr>
<th>Flower Part</th>
<th>No. Found in Flower</th>
<th>Function of Flower Part</th>
<th>Drawing of Flower Part</th>
<th>Attach Flower Part Here</th>
</tr>
</thead>
<tbody>
<tr>
<td>sepal(s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>petal(s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PISTIL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stigma</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>style</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ovary (x-sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ovules</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>STAMEN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anther</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>filament</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Pollen grain under microscope (___X)</td>
<td></td>
<td>NA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Resources:
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SPONTANEOUS GENERATION

NGSSS:
SC.7.N.2.1 Identify an instance from the history of science in which scientific knowledge has changed when new evidence or new interpretations are encountered. (Assessed as SC.6.N.2.2)

Background Information for the teacher and to Engage:
(Portions reprinted with the permission of authors D. B. Fankhauser and J. Stein Carter. URL http://biology.clc.uc.edu/courses/bio114/spontgen.htm)

Today we take many things in science for granted. Many experiments have been performed and much knowledge has accumulated that people weren’t always aware of. For centuries, people based their beliefs on their interpretations of what they saw going on in the world around them without testing their ideas to determine the validity of these theories — in other words, they didn’t use the scientific method to arrive at answers to their questions. Rather, their conclusions were based on untested observations. In the public eye, controversy is considered an act that illustrates that a response is needed or that the "new" claims are inadequate because they cannot "prove" anything. It is important to remember that SCIENCE NEVER PROVES anything! Only models are disproved. One selects among the alternative explanations (models) and may feel highly confident that one is "correct" and then use supporting scientific evidence to support the conclusion.

Materials:
• Computer with Internet access; and/or library access
• Colored pencils or markers
• Poster board

Engage:
1. The teacher will read to students or post on the board the Background Information provided above.
2. Present the following observations (without conclusions) to students.

Observation: Every year in the spring, the Nile River flooded areas of Egypt along the river, leaving behind nutrient-rich mud that enabled the people to grow that year’s crop of food. However, along with the muddy soil, large numbers of frogs appeared that weren’t around in drier times. (Conclusion: It was perfectly obvious to people back then that muddy soil gave rise to the frogs.)

Observation: In many parts of Europe, medieval farmers stored grain in barns with thatched roofs (like Shakespeare’s house). As a roof aged, it was not uncommon for it to start leaking. This could lead to spoiled or moldy grain and, of course there were lots of mice around. (Conclusion: It was obvious to them that the mice came from the moldy grain.)

3. Allow students to brainstorm their own conclusions.
4. One student will be assigned to list all student-generated conclusions on the board or poster paper.
5. Read aloud to students the following recipes for bees and mice.

Recipe for bees:
Kill a young bull and bury it in an upright position so that its horns protrude from the ground. After a month, a swarm of bees will fly out of the corpse.

Jan Baptista van Helmont’s recipe for mice:
Place a dirty shirt or some rags in an open pot or barrel containing a few grains of wheat or some wheat bran, and in 21 days, mice will appear. There will be adult males and females present, and they will be capable of mating and reproducing more mice.

6. Allow students to suggest plausible explanations for the publishing of these recipes.
7. Place students into groups of 4 or 5 students.
8. Each group will research the subject of spontaneous generation using either the Internet or library resources.
Explore
9. Provide the following URL, as a main source of information as well as providing a worksheet for documenting knowledge gained through research (click on Life Science). http://www.kent.k12.wa.us/staff/rlynch/sci_class/chap01/spontaneous.html
10. Provide the following URL for a detailed explanation as well as more observations and conclusion activities., http://biology.clc.uc.edu/courses/bio114/spontgen.htm

Explain
Class Discussion:

1. Summarize the early beliefs about spontaneous generation.
2. If you lived during that time, would you have believed that frogs came from muddy soil or mice came from moldy grain? Why or why not?
3. Francesco Redi, an Italian physician, was the person who performed an experiment which investigated whether rotting meat turned into or produced flies. Citing evidence from Redi’s experiment, explain why the early beliefs about spontaneous generation were disproved for larger organisms.
4. Explain the importance of experimentation to prove or disprove hypotheses which are generated from observations.
5. Identify each of the following for Red’s experiment:
   i. Independent (test) variable, dependent (outcome) variable, constant variable, experimental groups and control group.

Evaluate:
1. Each group must complete the following:
   a. Either a timeline, graphic organizer or a freeform map of events leading to the disproving of spontaneous generation, including names, dates, pictures, and illustrations.
   b. An essay based upon the following statement:
      Louis Pasteur was a very important scientist in the understanding of Spontaneous Generation. One very important point to note is that Pasteur did not seek to find an answer to the broad question, “Has spontaneous generation ever occurred?” Write an essay on whether or not spontaneous generation has ever occurred.

The students will be evaluated according to the amount of effort, their specific job performance, participation within the team, and on the final product (timeline, graphic organizer or freeform web). For scoring, use rubrics which may be found at the following URL, http://school.discovery.com/schrockguide/assess.html#rubrics

Optional Extensions:
1. Students will research Pasteur’s experiment and then carry out a recreation of his experiment.
2. Students will create a time-line which shows the development of an understanding of spontaneous generation from the original beliefs that frogs came from muddy soil or mice came from moldy grain through the findings of Louis Pasteur.
3. Students will investigate life on Mars and submit a report on their findings.
4. Student will research the work of Oparin, Haldane, and Stanley Miller. A freeform map demonstrating their significant accomplishments will be created.
Human Variations

NGSSS:
SC.7.L.16.1 Understand and explain that every organism requires a set of instructions that specifies its traits, that this hereditary information (DNA) contains genes located in the chromosomes of each cell, and that heredity is the passage of these instructions from one generation to another. (AA)
SC.7.L.16.2 Determine the probabilities for genotype and phenotype combinations using Punnett Squares and pedigrees. (Assessed as SC.7.L.16.1)

Background Information:
Have you ever wondered why everybody looks different from everyone else? Even brothers and sisters can look different. This is because a large variety of traits exist in the human population. Perhaps this still doesn't explain why brothers and sisters might look very different or, on the contrary, very much alike. This lab exercise will help your students understand the many possible combinations available to offspring as they are being produced. Each student will pair off with a peer to become parents and produce a baby. What the baby will look like will depend on the laws of genetics. In this activity students will determine the appearance of their child's face by flipping coins to determine the pairing of the alleles for each of the major characteristics.

Materials:
- 2 coins
- 2 students
- Construction paper for face features
- Colored pencils or markers
- Crayons (skin-color set)
- Curling ribbon for hair (black, brown, yellow)
- Paper plates
- Scissors

Student Procedures:
1. Choose a partner for this experiment.
2. Determine with your partner who will be the father and the mother.
3. Each of you received a coin. The head side is the dominant side; and the tail side is the recessive side.
4. The father will flip the coin to determine the sex of the child. Heads indicates the child will be a boy; tails, a girl.
5. You and your partner will flip your coin at the same time, to determine which of the traits below pertain to your baby. Two heads indicate a homozygous dominant trait. A head and a tail equal a heterozygous dominant trait. Two tails represents a recessive trait.
6. Record the results for the two babies on the table provided.
7. Once the chart is completed, create a 3-dimensional representing the collected characteristics of the offspring, using a paper plate and other materials provided by your teacher. Note: Be sure to cut the paper plate into the actual shape of the face and chin.
Characteristics:
TRAIT
GENE
(GENOTYPE FOR TRAIT)
1. FACE SHAPE
Round (AA, Aa)
Square (aa)
2. CHIN SIZE
Very prominent
(really sticks out) (BB, Bb)
Less prominent (bb)
3. HAIR COLOR
Black (C_1C_1)
Brown (C_1C_T)
Blonde (C_T C_T)
4. HAIR TYPE
Curly (D_1D_1)
Wavy (D_1D_T)
Straight (D_TD_T)
5. WIDOWS PEAK
Present (EE, Ee)
Absent (ee)
6. EYE COLOR
Brown (F_F)
Blue (bb)
7. EYE DISTANCE
Close (G_1G_1)
Average (G_1G_T)
Far apart (G_TG_T)
8. EYE SIZE
Large (H_1H_1)
Medium (H_1H_T)
Small (H_TH_T)
9. EYE SHAPE
Almond ([i, i])
Round ([i])
10. EYE SLANTEDNESS
Horizontal (JJ, Jj)
Upward Slant (jj)
Short (kk)
11. EYELASHES
Long (KK, Kk)
12. EYEBROW COLOR
Darker than hair
Color (L_1L_1)
Same as hair
color (L_1L_T)
Lighter than hair
color (L_TL_T)
13. EYEBROW THICKNESS
Bushy (MM, Mm)
Fine (mm)
14. EYEBROW LENGTH
Not connected (NN, Nn)
Connected (nn)
15. MOUTH SIZE
   Long (O₁O₄)
   Medium (O₂O₃)
   Short (O₃O₄)

16. LIP THICKNESS
   Thick (PP, Pp)
   Thin (pp)

17. DIMPLES
   Present (QQ, Qd)
   Absent (qq)

18. NOSE SIZE
   Large (RₓRₓ)
   Medium (RₓRₜ)
   Small (RₜRₜ)

19. NOSE SHAPE
   Rounded (SS, Ss)
   Pointed (ss)

20. EARLOBE ATTACHMENT
   Free (TT, Tq)
   Attached (t)

21. FRECKLES ON CHEEKS
   Present (UU, Uu)
   Absent (uu)

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A human pedigree

Key:

- Dd: Normal, carrier for deafness
- dd: Deaf
- D: Hearing
- d: Carries the normal gene
- ?: Unknown or unknown condition

- Male
- Female
- Hearing
- Deaf
- Carrier

[Pedigree diagram with symbols for each individual and their genetic status]
<table>
<thead>
<tr>
<th>Trait</th>
<th>Possible Genotypes</th>
<th>Child #1</th>
<th>Child #2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Father's Genes</td>
<td>Mother's Genotype</td>
<td>Child's Genotype</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>face shape</td>
<td>AA, Aa, aa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>chin size</td>
<td>BB, Bb, bb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hair color</td>
<td>$C_H C_H$, $C_H C_T$, $C_T C_T$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hair type</td>
<td>$D_H D_H$, $D_H D_T$, $D_T D_T$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>widow's peak</td>
<td>EE, Ee, ee</td>
<td></td>
<td></td>
</tr>
<tr>
<td>eye color</td>
<td>FF, Ff, ff</td>
<td></td>
<td></td>
</tr>
<tr>
<td>eye distance</td>
<td>$G_H G_H$, $G_H G_T$, $G_T G_T$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trait</td>
<td>Possible Genotypes</td>
<td>Father's Genes</td>
<td>Mother's Genes</td>
</tr>
<tr>
<td>--------------------</td>
<td>--------------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>eye size</td>
<td>H_H, H_H, H_T, H_T</td>
<td></td>
<td></td>
</tr>
<tr>
<td>eye shape</td>
<td>II, Ii, ii</td>
<td></td>
<td></td>
</tr>
<tr>
<td>eye slanted-ness</td>
<td>J_J, J_j, jj</td>
<td></td>
<td></td>
</tr>
<tr>
<td>eyelashes</td>
<td>K_K, K_k, k_k</td>
<td></td>
<td></td>
</tr>
<tr>
<td>eyebrow color</td>
<td>L_H, L_H, L_T, L_T</td>
<td></td>
<td></td>
</tr>
<tr>
<td>eyebrow thickness</td>
<td>M_M, M_m, m_m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>eyebrow length</td>
<td>N_N, N_n, n_n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mouth size</td>
<td>O_H, O_H, O_T, O_T</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trait</td>
<td>Gene</td>
<td>Father's Genes</td>
<td>Mother's Genes</td>
</tr>
<tr>
<td>------------</td>
<td>------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>lip thickness</td>
<td>PP, Pp, pp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimples</td>
<td>QQ, Qq, qq</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nose size</td>
<td>$R_H R_H$</td>
<td>$R_H R_T$</td>
<td>$R_T R_T$</td>
</tr>
<tr>
<td>nose shape</td>
<td>SS, Ss, ss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>earlobe attachment</td>
<td>TT, Tt, tt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>freckles</td>
<td>UU, Uu, uu</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Evaluation:
1. How did you determine which piece of information would contribute to the genotype of the child?
2. Using your experience in the lab today, explain why this is a true statement: “Every child is a product of his/her parents.”
4. Look around at all the other paper-plate babies. Do any of your classmate’s created children look alike? ______________. Justify your answer.
5. After examining all the children created, describe how sexual reproduction contributes to variation within a species.
6. Do you think that everyone has a “twin,” that is, someone living somewhere in the world who looks exactly like him/her? Explain your reasoning.

Use the characteristic sheet to answer the following questions. Show all your work, including Punnett Squares.
1. What is the probability of a mother with genotype (HH) and a father with genotype (HH) having a child with free earlobes?
2. What is the probability of a mother with genotype (FF) and a father with genotype (ff) having a child with a pointed nose?
3. What is the probability of a mother heterozygous for freckles and a father homozygous for no freckles having a child with freckles?

Assessment:
• Successful completion of data table.
• Successful creation of baby face.
• Answers to questions for discussion.

Home Learning:
Students will chart human traits such as widow’s peak, tongue roller, hitchhiker thumb, and attached ear lobes found in two generations of their family members. Go to the following URL to view examples of each trait:
http://krupp.wcc.hawaii.edu/BIOL100/present/hmngenet.htm

Extensions:
2. Research genetic diseases such as Tay-Sachs, sickle-cell anemia, or cystic fibrosis.
3. Create a pedigree chart for your family of one characteristic such as attached/unattached ear lobes, tongue roller/tongue non-roller, hair/no hair on knuckles.
4. Students can complete their Genetic wheel online and print it.

Common Misconceptions:
• Students often think that every person is unique because each has different genes. This is not true. Emphasize that all humans have the same genes. In fact, our genes are even in the same order along chromosomes. We are each unique because we inherit different combinations of alleles, resulting in a unique combination of traits.
• Students may interpret disease gene discovery to mean that only those who have the disease have the gene. This is not true. Emphasize that each of us has the newly discovered gene, but none of us will develop symptoms of that disease unless we inherit a form of the gene that is faulty due to mutation.
Incomplete Dominance Lab

NGSSS

SC.7.L.16.2 Determine the probabilities for genotype and phenotype combinations using Punnett Squares and pedigrees. (Assessed as SC.7.L.16.2)

SC.7.N.1.3 Distinguish between an experiment (which must involve the identification and control of variables) and other forms of scientific investigation and explain that not all scientific knowledge is derived from experimentation. (Assessed as SC.7.N.1.1)

Materials: (per group)

- 2 purple plastic eggs
- 2 pink plastic eggs
- 2 orange plastic eggs
- 2 blue plastic eggs
- 2 yellow plastic eggs
- 2 green plastic eggs
- purple plastic items/candy
- pink plastic items/candy
- 10 orange plastic items/candy
- blue plastic items/candy
- 7 yellow plastic items/candy
- green plastic items/candy

Engage: Introduce the concepts of dominance, recessiveness, Punnett Squares, genotype, phenotype, homozygous, heterozygous, pedigree, trait, allele, hybrid, pure-bred, etc. Play “What is Heredity?” short introductory video.

Explore:

Teacher information page:

Setting up eggs:

1. Make all 12 color combinations per lab group of 4 students.
2. Inside each egg, place the 4 correct colored pieces to show the offspring. You can use candy, but I would use plastic pieces of some type, like buttons, centimeter cubes, or any colored manipulative that will fit. If you use candy, you will have to restock each egg, if you use plastic, you can use it from class to class and year to year.
3. From the basket at each lab table, each student will select 5 eggs, one at a time.
4. Students may work independently or with a partner, or a combination of both. Maybe have them do 3 together, and 2 on their own.
5. Collect your eggs back for next year.

Answer key:

purple x purple = (PP x PP)= all (PP) or purple possibilities
purple x pink = (PP x pp)= all (Pp) or orange possibilities
pink x pink = (pp x pp)= all (pp) or pink possibilities
orange x orange = (Pp x Pp)= 1 purple (PP), 2 orange (Pp) and 1 pink (pp)
orange x purple = (Pp x PP)= 2 purple (PP) and 2 orange (Pp)
orange x pink = (Pp x pp)= 2 orange (Pp) and 2 pink (pp)
blue x blue = (BB x BB) = all (BB) or blue possibilities
blue x yellow = (BB x bb) = all (Bb) or green possibilities
blue x green = (BB x Bb) = 2 blue (BB) and 2 Green (Bb)
yellow x yellow = (bb x bb) = all yellow (bb) possibilities
green x yellow = (Bb x bb) = 2 green (Bb) and 2 yellow (bb)
green x green = (Bb x Bb) = 1 Blue (BB), 2 Green (Bb), and 1 yellow (bb)
Student Name: ________________________________ Date:_______________ Period:______

### Plastic Egg Genetics

<table>
<thead>
<tr>
<th>½ Egg Phenotype</th>
<th>½ Egg Genotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purple</td>
<td>PP</td>
</tr>
<tr>
<td>Orange</td>
<td>Pp</td>
</tr>
<tr>
<td>Pink</td>
<td>pp</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>½ Egg Phenotype</th>
<th>½ Egg Genotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue</td>
<td>BB</td>
</tr>
<tr>
<td>Green</td>
<td>Bb</td>
</tr>
<tr>
<td>Yellow</td>
<td>bb</td>
</tr>
</tbody>
</table>

½ egg + ½ egg = 1 whole plastic egg

### Directions:
1. On your lab table, there are a variety of plastic eggs.
2. **Choose** one egg, but do not open it yet.
3. **Record** the Phenotypes and Genotypes of your egg.
4. **Place** the genotypes of your egg into the Punnett Square.
5. **Determine** the genotypes and phenotypes of the offspring.
6. **Open** your egg – do your results match the results inside the egg?
   a. If yes, then place the egg back together and pick another egg!
   b. If no, check your work and make corrections.
7. Continue until you have completed **5 eggs**.

### Example of how to fill in data:

- **Phenotype:**
  - My egg is ½ **Blue** and ½ **Green**

- **Genotype:**
  - ( ____ B ____ ) x ( ____ B ____ )

Punnett Squares:

<table>
<thead>
<tr>
<th>B</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>BB</td>
<td>BB</td>
</tr>
<tr>
<td>Bb</td>
<td>Bb</td>
</tr>
</tbody>
</table>

My Results: 2 (BB) Blue and 2 (Bb) Green
Inside the Egg: 2 Blue Pieces and 2 Green Pieces
### My Results:

My egg is $\frac{1}{2}$ ________ and $\frac{1}{2}$ ________

### Inside the Egg:

(_______) x (_______)

---

### My Results:

My egg is $\frac{1}{2}$ ________ and $\frac{1}{2}$ ________

### Inside the Egg:

(_______) x (_______)
Phenotype:

My egg is $\frac{1}{2}$ __________ and $\frac{1}{2}$ __________

Genotype:

(_______) x (_______)

My Results: _____________________________________________________________

Inside the Egg: _______________________________________________________

Phenotype:

My egg is $\frac{1}{2}$ __________ and $\frac{1}{2}$ __________

Genotype:

(_______) x (_______)

My Results: _____________________________________________________________

Inside the Egg: _______________________________________________________
Phenotype:
My egg is $\frac{1}{2}$ ____________
and $\frac{1}{2}$ ____________
Genotype:
(_________) x (_________)  

Punnett Squares

My Results: ____________________________________________

Inside the Egg: _______________________________________

Results:

<table>
<thead>
<tr>
<th>Egg</th>
<th>½ Color</th>
<th>Genotype</th>
<th>½ Color</th>
<th>Genotype</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#XX</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#Xx</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#xx</td>
</tr>
<tr>
<td>Example</td>
<td>Blue</td>
<td>BB</td>
<td>Green</td>
<td>Bb</td>
<td>2 BB</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Blue</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2Bb</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Green</td>
</tr>
</tbody>
</table>

1

2

3

4

5
**Explain:**
1. Which phenotypes had the greatest probability of occurring and why?
2. 

**Elaborate/Extension:**
Pass out plastic eggs from above but use white items/candy to represent albinos or smush some of the candies to represent the incidence of mutation or genetic disease.

**Evaluate:**

Students complete a Bikini Bottom Genetics worksheet about Incomplete Dominance.
Title VI of the Civil Rights Act of 1964 - prohibits discrimination on the basis of race, color, religion, or national origin.

Title VII of the Civil Rights Act of 1964, as amended - prohibits discrimination in employment on the basis of race, color, religion, gender, or national origin.

Title IX of the Education Amendments of 1972 - prohibits discrimination on the basis of gender.

Age Discrimination in Employment Act of 1967 (ADEA), as amended - prohibits discrimination on the basis of age with respect to individuals who are at least 40.

The Equal Pay Act of 1963, as amended - prohibits sex discrimination in payment of wages to women and men performing substantially equal work in the same establishment.

Section 504 of the Rehabilitation Act of 1973 - prohibits discrimination against the disabled.

Americans with Disabilities Act of 1990 (ADA) - prohibits discrimination against individuals with disabilities in employment, public service, public accommodations and telecommunications.

The Family and Medical Leave Act of 1993 (FMLA) - requires covered employers to provide up to 12 weeks of unpaid, job-protected leave to "eligible" employees for certain family and medical reasons.

The Pregnancy Discrimination Act of 1978 - prohibits discrimination in employment on the basis of pregnancy, childbirth, or related medical conditions.

Florida Educational Equity Act (FEEA) - prohibits discrimination on the basis of race, gender, national origin, marital status, or handicap against a student or employee.

Florida Civil Rights Act of 1992 - secures for all individuals within the state freedom from discrimination because of race, color, religion, sex, national origin, age, handicap, or marital status.

School Board Rules 6Gx13- 4A-1.01, 6Gx13- 4A-1.32, and 6Gx13- 5D-1.10 - prohibit harassment and/or discrimination against a student or employee on the basis of gender, race, color, religion, ethnic or national origin, political beliefs, marital status, age, sexual orientation, social and family background, linguistic preference, pregnancy, or disability.

Veterans are provided re-employment rights in accordance with P.L. 93-508 (Federal Law) and Section 295.07 (Florida Statutes), which stipulate categorical preferences for employment.