Exploring Meteorite Mysteries

Lesson 11 — Changes Inside Planets

"How did they form?"

Objectives

Students will:

- observe and describe differentiated meteorite samples.
- conduct experiments to model the separation of light and heavy materials within a planetary body.
- relate meteorites to the core, mantle and crust of asteroids.
- model the break-up of a differentiated body to expose the interior layers.

Background

Achondrites are stony meteorites without chondrules or metal. Metal-rich meteorites include irons with little stony material and stony-irons which are part iron and part stone. Most of these meteorites are, like chondrites, 4.5 billion years old. However, their compositions are usually different from those of chondrites and different from the Sun. Thus, they are grouped together as differentiated meteorites. There are three of these differentiated meteorites in the Meteorite Sample Disk. One of the meteorites is an achondrite consisting mostly of two silicate minerals. It is a basalt similar to basalts existing on Earth. The second sample is a metal meteorite made of two types of iron/nickel crystals. The third sample is a stony-iron meteorite made of metal and a single silicate mineral, olivine. See Teacher's Guide, pages 13-17, for more information.

Scientists think that these meteorites formed by differentiation in asteroids or other planetary bodies. Heat in the asteroid caused the body to melt. Heavy metal sank to the interior to form a core. Light silicate minerals floated to the surface to form the crust. Moderate density silicates crystallized in the mantle. Basalts can also form by incomplete melting in the mantle of a planetary body and rise to the surface as volcanic rocks.

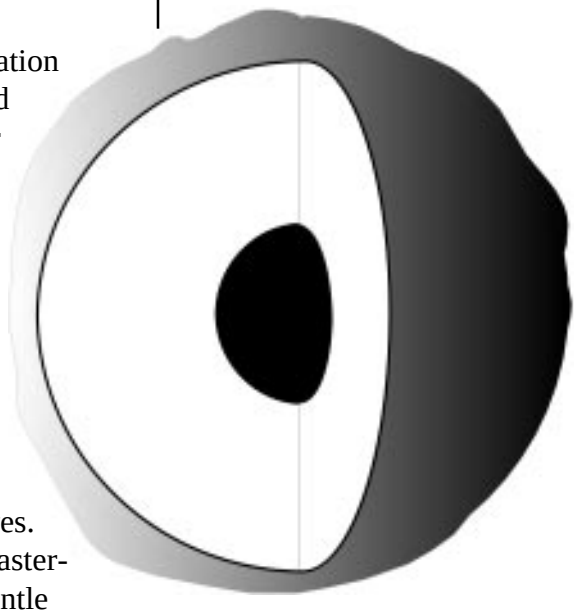
Earth is differentiated into core, mantle and crust, but we cannot see the mantle or core. Researchers believe that those inner layers exist because differences in the internal structure of Earth have been measured using seismic waves. Scientists think that iron meteorites are from the cores of asteroids and some stony-iron meteorites are from the core-mantle

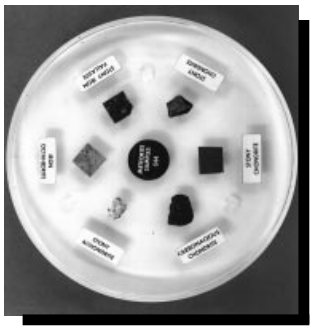
About This Lesson

In this lesson students will observe and describe differentiated samples in the Meteorite Sample Disk (or photographs). They will conduct an experiment using gelatin and food that illustrates planetary differentiation. Hard boiled eggs model the break-up of differentiated planetary bodies.

Vocabulary

achondrite, iron, stony iron, asteroid, metal, silicate, crystallization, differentiation, crust, mantle, core, basalt, density





About This Activity
Students will observe and describe differentiated meteorites in the Meteorite Sample Disk or in the photographs.

Materials for Activity A
- ❑ Meteorite Sample Disk or photographs
- ❑ Student Sheet *(pg. 11.5)*
- ❑ magnifier
- ❑ binocular microscope *(optional)*
- ❑ Slide Set, Classification and Formation
- ❑ projector

boundary. Achondrites may represent the crustal material of asteroids. In order for the deep-seated rocks from the core and mantle to be exposed, impacts in the asteroid belt must break up the parent asteroids.

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Activity A: Differentiated Meteorites

Objective
Students will:

- observe and describe differentiated meteorites.

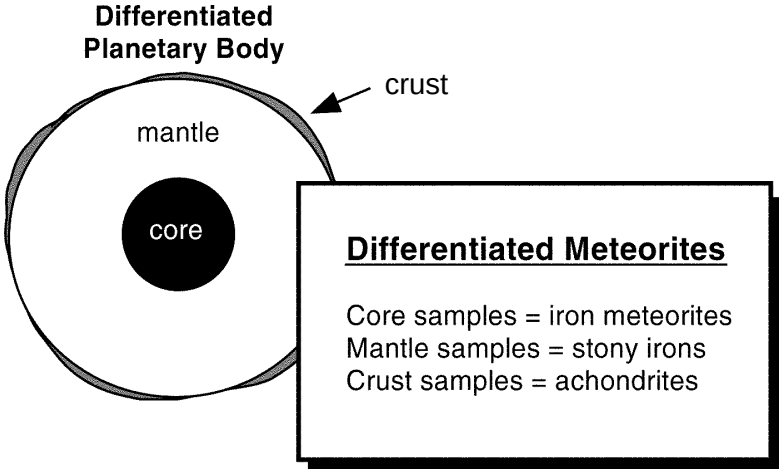
Procedure

Advanced Preparation

1. Assemble materials.
2. Place Meteorite Sample Disk or photographs in an easily accessible location so students may view and draw samples.
3. Preview slide set, slide narrative, and descriptions of meteorites in the Meteorite ABC's Fact Sheet, pages 29-30.

Classroom Procedure

1. Show slide set and discuss meteorite classification.
2. Examine achondrite, stony-iron, and iron in Meteorite Sample Disk or photographs. Use magnifier or microscope.
3. On the Student Sheet, sketch and describe each of the samples listed above.
4. Complete the questions on the Student Sheet.
5. Reserve discussion until after Activity B.



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Activity B: Food Differentiation

Objectives

Students will:

- conduct experiments to model the separation of light and heavy materials within a planetary body.
- relate meteorites to the core, mantle, and crust of asteroids.

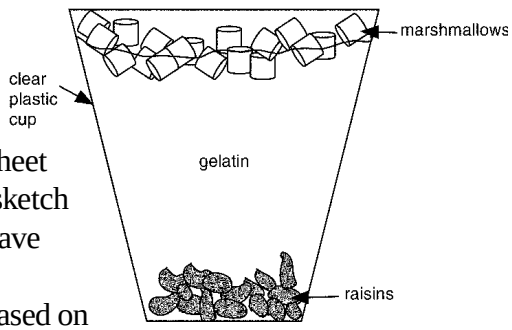
Procedure

Advanced Preparation (See options below.)

1. Read classroom procedure and options to determine best method for class.
2. Assemble materials. Either teacher will provide necessary foods for experiments or assign students to bring items. Be sure to provide several items that float and several that sink. Use items that may be eaten to minimize waste, and increase enjoyment.
   - Option 1. Working in groups each student makes predictions and experiments with their own cup of food and gelatin. See Classroom Procedure.
   - Option 2. Prior to class make a model(s) for students to use. The predictions and observations may still be made by the students prior to viewing the model. Student Sheet questions, drawings and discussions may be used to complete the activity.
   - Option 3. Conduct experiment by having students make predictions and record information and observations. Then make only one or possibly two large samples as a demonstration for the entire class. Continue with Student Sheet questions and discussion.

Classroom Procedure

1. Divide class into groups of three to five students. Distribute Student Sheets and materials.
2. Conduct experiments according to the procedure on Student Sheet
3. Answer questions and sketch experimental results. Have groups report findings.
4. Conduct a discussion based on questions on the Student Sheet. Relate layers—in the experiment to differentiation in an asteroid or planet.



About This Activity

Students will conduct experiments with food in gelatin to simulate the differentiation of planetary bodies into a core, mantle, and crust.

Materials for Activity B

Per Group of Students, except where noted.

- ❑1 box of light colored gelatin dessert *(yellow shows process clearly)*
- ❑ metric measuring cup for liquids
- ❑ bowl
- ❑ mixing spoon
- ❑ 270 ml (9 oz.) clear plastic cups *(one per student)*
- ❑ 470 ml (2 cups) boiling water *(this keeps gelatin hot for a longer time)*
- ❑ heating source for water *(teakettle, hot plate or microwave in central location)*
- ❑ pen or pencil
- ❑ Student Sheet *(pgs. 11.5-11.7, one per student)*
- ❑ food items that sink* raisins, fresh grapes, orange slices, canned peaches, pears, pineapple,** olives
- ❑ food items that float* marshmallows, peanuts, fresh apples, bananas, pears

**temperature of gelatin may cause some foods to change sinking and floating behavior.*

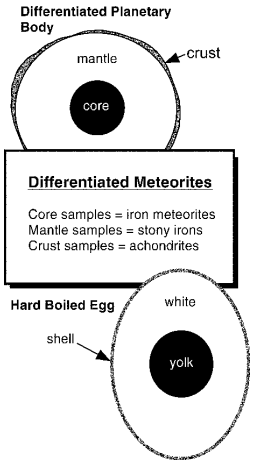
***canned mixed fruit in light syrup floats, but mixed fruit in heavy syrup sinks.*

About This Activity

Students will discover, by smashing hard-boiled eggs, how impacts break up a differentiated body so that the core and mantle are exposed. They will relate the meteorites in the Meteorite Sample Disk to parts of a differentiated body.

Materials for Activity C

- ❑ frozen hard boiled egg *(one per student if possible — stores may donate out of date eggs —wasting food is not the objective of this exercise)*
- ❑ dry ice *(easily obtainable at some grocery and ice cream stores)*
- ❑ picnic cooler to hold dry ice
- ❑ safety goggles
- ❑ thermal protective gloves
- ❑ lab apron
- ❑ liquid nitrogen and container *(optional)*
- ❑ Student Sheet *(pg. 11.8)*
- ❑ large plastic tarp approximately 4m x 4m
- ❑ duct tape
- ❑ wall
- ❑ broom
- ❑ waste container



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Activity C: Egg Smash: The Break-up of a Differentiated Body

Objectives

Students will:

- relate meteorites to the core, mantle and crust of asteroids.
- model the break-up of a differentiated body to expose the interior layers.

Procedure

Advanced Preparation

1. Boil eggs, then freeze eggs using one of the following methods. **Do not** freeze longer than suggested or the texture will not be ideal. Freezing methods:
   - 10-15 minutes in or on dry ice (depends on number of eggs frozen at one time). Preferred method.
   - 2 minutes in liquid nitrogen (one egg at a time). Ideal, but difficult method.
   - 48 hours in freezer. Simplest method, but least satisfactory.

   Use proper lab safety precautions!! Always handle dry ice, or something frozen by dry ice, with thermal protection gloves. Lab apron, face protection, and thermal protection gloves must be worn when using liquid nitrogen or something frozen by liquid nitrogen. Consult the Materials Safety Data Sheet for full safety precautions.
2. Choose a hard surface like a concrete driveway where eggs may be broken, and clean-up will not be difficult. **OR** Choose an area of wall away from windows and doors where the concrete floor meets the side of a building.
   Tape a plastic tarp securely to the wall. Make sure that part of the cover extends to cover the ground. (This makes clean up more efficient.)

Classroom Procedure

1. **Safety goggles and thermal protective gloves should be worn.**
2. With classmates at a safe distance, one student throws a frozen, hard boiled egg at the designated area (repeat if it does not break the first time). Repeat with other eggs.
3. Using Student Sheet, all students write observations and illustrate the broken egg, labeling the crust, core and mantle.
4. Use questions to focus discussion and relate broken pieces to meteorite types.

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Student Sheet: Activities A, B and C

Activity A: Differentiated Meteorites

Carefully observe the achondrite, iron, and stony-iron samples in the Meteorite Sample Disk or photographs. Describe and sketch them using the space below.

How do you think these meteorites formed?

Activity B: Food Differentiation

<u>Materials</u> Per Group of Students (except where noted)

- ❑ 1 box of light colored gelatin dessert
- ❑ metric measuring cup for liquids
- ❑ bowl
- ❑ mixing spoon
- ❑ 270 ml (9 oz.) clear plastic cups *(one per student)*
- ❑ 470 ml (2 cups) boiling water
- ❑ food items
- ❑ Student Sheet and pencil *(one per student)*

<u>Procedure</u>

1. Groups collect materials for experiment (see list above).
2. Each group member will predict and record information below.
   - Each member will select two food items: one you predict will sink and one you predict will float. Make sure your group uses a variety of food items.
   - Record predictions. _____ will float in gelatin
     _____ will sink in gelatin
   - Each member place a spoonful or less of both food items in your individual plastic cup.

3. The teacher, or a group member, will mix gelatin and 470 ml (2 cups) of boiling water in the bowl. Using all boiling water will keep the gelatin hot for all team members. Stir gelatin until powder is dissolved.
4. Carefully pour gelatin into each cup, filling about 2/3 full. Do not stir.
5. Observe and record movement of food in gelatin.
6. In your group discuss the results and draw conclusions. Discussion should include consistency of sinking and floating and why items sink or float.
7. Answer questions below.
8. Using the information from the Student Sheets, one group member shares the group's findings with the class. Discuss results.
9. Allow gelatin to harden. Observe and record any changes. Eat the results.

Questions

1. Describe the gelatin cup in your own words. Sketch and label your experimental results.

2. How do you think the different layers formed?

3. Could the same layers occur in a different order? Why or why not?

4. Why did you choose the particular foods in your experiement? Have you ever had an experience with this food and its floating properties before? Describe.

5. Were some foods used by your group not consistent in their floating behavior? Why do you think this happened?

   Could you change the conditions to make the floating more consistent?

6. Compare what happened in the gelatin experiments with the core, mantle and crust of differentiated planetary bodies like Earth. Be sure to discuss which parts of the gelatin represent parts of Earth.

7. Which meteorites in the Meteorite Sample Disk relate to each of the gelatin layers?

Activity C: Egg Smash

Questions

1. What parts of a differentiated asteroid do the yolk, egg white, and shell represent? Sketch and label an egg and include the comparable planetary layers.

2. How is the core or the inside of a differentiated asteroid exposed?

3. If you wanted to study the metal in an asteroid, which section of the asteroid would you study?

4. How are Earth and an achondrite asteroid alike? Different?