Exploring Meteorite Mysteries

Lesson 10 — Building Blocks of Planets

Objectives

Students will:

- experiment with simulations that illustrate how chondrites and asteroids formed in the early solar system.
- observe and describe the meteorites in the Meteorite Sample Disk.

Background

Chondrites are the most primitive type of rock available for study. They are 4.5 billion years old, as old as the solar system. Their compositions are similar to the heavier elements found in the Sun (not including the abundant H and He gases). Chondrites are made up of chondrules (spherical balls of rock), metal, and a fine matrix that holds them together. Chondrules are considered the building blocks of the planets. Chondrites have many variations, due partly to differences in the chondrules. Some of the differences are in the number, size, shape, and mineral content of the chondrules. Chondrites have various amounts of metal too. Metamorphism causes some of the variations in chondrules. One of the chondrites in the Meteorite Sample Disk is metal-rich and metamorphic, another is metal-poor and has distinct chondrules. The third chondrite is carbonaceous. This special type of meteorite contains water and carbon and some organic compounds (amino acids) that are the building blocks of life. They do not contain living creatures or fossil material. (See Lesson 12)

Chondrites provide our best information on the earliest history of the solar system. Scientists think that chondrites formed by condensation and accretion in the solar nebula, the disk of gas and dust that rotated in a plane around the early Sun. Dust particles condensed from the gas and accreted (came together) into larger and larger bodies: chondrules, then small rocks, and then asteroids and planets. The forces that hold particles together include static electricity, gravity, and magnetism. Some asteroids were large enough to be hot inside thus causing some metamorphism.
Most meteorites are formed by the breakup of asteroids.

See additional information in the Teacher's Guide, pages 16-17.

"How did they form?"

About This Lesson

In Activity A students will observe and describe chondrite meteorites.

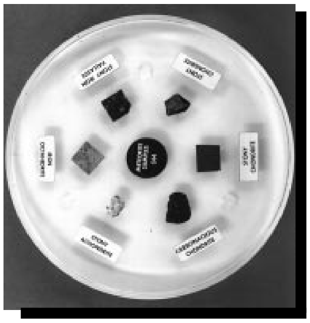
In Activity B they will experiment with balloons and static electricity to illustrate the theories about how dust particles collected into larger clusters.

In Activity C students will manipulate magnetic marbles and steel balls to dramatically illustrate the accretion of chondritic material into larger bodies like planets and asteroids.

> **NOTE:** The use of magnets in Activity C is intended to simulate all three forces. **Do not** let students equate magnetism, a minor force, with the major forces, gravity and electrostatic charge.

Vocabulary

chondrule, chondrite, sphere, matrix, solar nebula, condense, accrete, accretion, metamorphism, organic, static electricity, gravity, magnetism



Lesson 10 — Building Blocks of Planets
Activity A: Chondrites

About This Activity
Students will observe and describe chondrite meteorites.

Materials for Activity A
- ❑ Meteorite Sample Disk
- ❑ Magnifier
- ❑ Slide Set, Classification and Formation
- ❑ Slide projector
- ❑ Student Sheet *(pg. 10.5, one per student)*

Objective
Students will:

- observe and describe chondrite meteorites.

Procedure

Advanced Preparation
1. Assemble materials and place Meteorite Sample Disk in an easily accessible location.
2. Preview slide set, slide narrative and the meteorite descriptions in the Meteorite ABC's Fact Sheet, pages 29-30.

Classroom Procedure
1. Show meteorite classification and formation slide set and discuss.
2. Examine the three chondrite samples in the Meteorite Sample Disk or photographs. Use magnifier.
3. Sketch and describe each sample on Student Sheet.
4. Complete questions. Reserve discussion until end of activity.

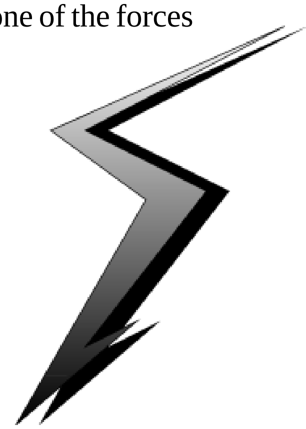
Activity B: ZAP! Electrostatic Small Particle Accretion

About This Activity
Students will experiment with balloons and static electricity to illustrate the theories about how dust particles collected into larger clusters.

Materials for Activity B
Per Group of Students
- ❑ 1 small balloon, inflated *(extras to allow for popped balloons)*
- ❑ 1 handful of small (1-2 mm) styrofoam pellets *(from crushed packing material or a bean bag chair)*
- ❑ 1 22 cm glass pan
- ❑ Student Sheet *(pgs. 10.5-10.6, one per student)*

Objectives
Students will:

- experiment with static electricity to illustrate one of the forces in the early solar nebula.
- observe, record, and relate their observations to physical processes.



Procedure

Advanced Preparation
1. Read Teacher's Guide, pages 16-17.
2. Blow up each balloon just before class time.

Classroom Procedure
1. Students place styrofoam balls in glass pan.
2. Student rubs the balloon in one direction on hair to create electrostatic field.
3. Student places the balloon in dish and observes the activity of the styrofoam. Record each step and observations.
4. Try experiment again and rub the balloon both ways on your hair. Record observations.
5. Discuss questions and relate experiments to concepts.

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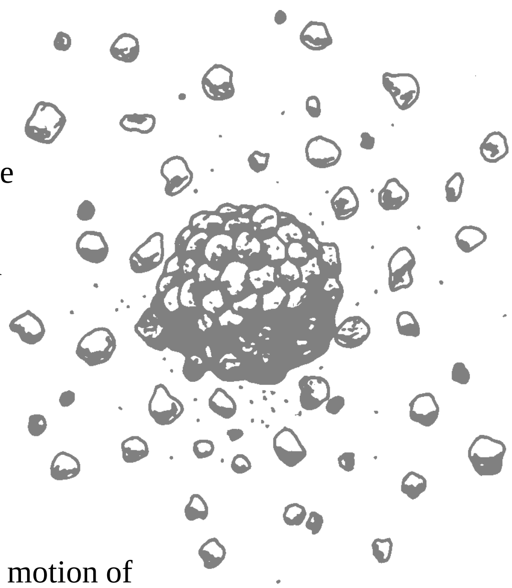
Activity C: CRUNCH! Accretion of Chondrules and Chondrites

About This Activity
Students will manipulate magnetic marbles and steel balls to dramatically illustrate the accretion of chondritic material into larger bodies like planets and asteroids.

> **NOTE:** The use of magnets in Activity C is intended to simulate all three forces. **Do not** let students equate magnetism, a minor force, with the major forces, gravity and electrostatic charge.

Objectives
Students will:

- manipulate materials to illustrate planetary accretion.
- observe, record, and relate their observations to physical processes.



Procedure

Advanced Preparation

1. Practice the circular motion of the pie pan and the addition of each type of ball.
2. This simulation may be done on an overhead if a demonstration is necessary.

Classroom Procedure

1. Divide class into groups of 3-5 students and assign individual tasks. One student holds the pan; one to three students add balls to the pan; one records observations and one or more reports findings. Teacher might quickly demonstrate the procedure for the small balls.
2. First student picks up the pan and practices orbital movement of the pan (slow circular pattern in only one direction).
3. Another student adds the small balls to the pan and the first student continues to rotate the pan until balls start separating and moving in a circular pattern. Observe the movement and clustering and record observations.
4. Another student adds medium sized balls, one at a time while first student continues rotating the pan. Experiment with adding different numbers of these balls. Observe the movement and clustering of the small balls and record observations.
5. Another student adds one magnetic marble and quickly adds the other one. First student continues to rotate the pan. Observe the movement and clustering around the marbles and record observations.

Materials for Activity C
Per Group of Students

- ❑ 50-100 small steel balls *(4.5 mm steel BBs work well and a mixture of copper-and zinc-plated BBs provides color contrast)*
- ❑ 5 medium steel balls *(1 cm or 3/8" steel hunting shot about double the diameter of BBs)*
- ❑ 2 magnetic marbles (*found in museum gift shops, and gift or science catalogs)*
- ❑ round glass or aluminum pie or cake pan *(glass is best; flat bottom is essential; vertical-sided pans contain BBs better, but slant-sided pans produce more action)*
- ❑ Student Sheet *(pg. 10.6, one per student)*

6. Have student groups share results with class. Conduct a class discussion of how this simulation illustrates the formation of meteorites and asteroids by accretion of dust in the solar nebula. Do not let students equate magnetism with gravity—the magnets allow a dramatic visual simulation only. Small balls represent dust, medium balls are chondrules, large balls are chondrites and clusters are asteroids.

Questions

1. What happened to the small balls when the pan was moved?

2. How did the medium balls interact with the small ones? Was the movement of the two sizes the same or different?

3. Was there an immediate reaction when the magnetic marbles were added? Did the reaction continue or change?

4. What did you notice about the small balls at the end of the activity?

5. How does this simulation relate to the accretion of meteorites in the early solar system?

6. **Extra:** Which way does our solar system rotate: clockwise or counter clockwise? (Draw the solar system on a thin sheet of paper and place an arrow to indicate that the solar system moves in a counterclockwise motion, as viewed from above. Now look through the other side of the paper and determine which direction of movement is indicated by the arrow —clockwise. **The rotation direction is relative to the viewing perspective!**

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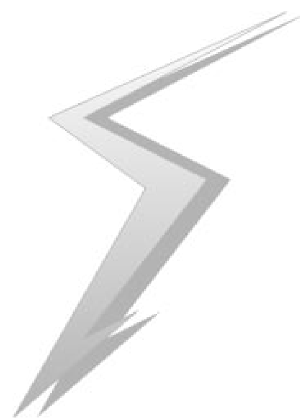
Student Sheet: Activities A, B and C

Activity A: **Chondrites**

Carefully observe the three chondrites in the Meteorite Sample Disk. Describe and sketch them using the space below.

How do you think chondrites may have formed?



Activity B: **ZAP! Electrostatic Particle Accretion**

Procedure

1. Place styrofoam balls in glass pan.
2. Rub the balloon in one direction on hair to create electrostatic field.
3. Place the balloon in the dish and observe the activity of the styrofoam.
4. Try the experiment again and rub the balloon both ways on your hair.

In the space provided below record observations from each step of the procedure.

Questions

1. How did the balloon and styrofoam balls react when you first put them together?

2. Why does this reaction happen?

3. Why do you think the balloon reacts differently when you rub it both ways in your hair rather than when you rub it one way?

4. How could you relate this exercise to accretion in the solar nebula?

Activity C: **Crunch! Accretion of Chondrules and Chondrites**

Procedure:

1. Practice circular motion as demonstrated by the teacher. Continue until the simulation is complete. Predict what will happen as each set of balls is added.
2. Other students add small balls, continue rotation and observe.
3. Add medium steel balls (experiment with number of balls), continue rotation and observe.
4. Add two magnetic marbles at different spots, continue rotation and observe.

Questions

1. What happened to the small balls when the pan was moved?

2. How did the medium balls interact with the small ones? Was the movement of the two sizes of balls the same or different?

3. When the magnetic marble was added, what was the immediate reaction? Did the reaction continue or change?

4. What did you notice about the small balls at the end of the activity?

5. How does this simulation relate to the accretion of the meteorites in the early solar system? What does each type of ball represent? Why is this activity only a simulation? *(Hint: consider the major forces the marbles represent.)*