ACTIVE ACCRETION—An Active Learning Game on Solar System Origins

In *Active Accretion*, middle school students model the accretion of specks of matter in our early solar system into chondrules and chondrites – and they do it dynamically. *Active Accretion* is a great way to teach cool science concepts about our solar system's early formation and the development of asteroids and planets while burning off energy. Students will end by discussing the strengths and limits of their model.

Introduction

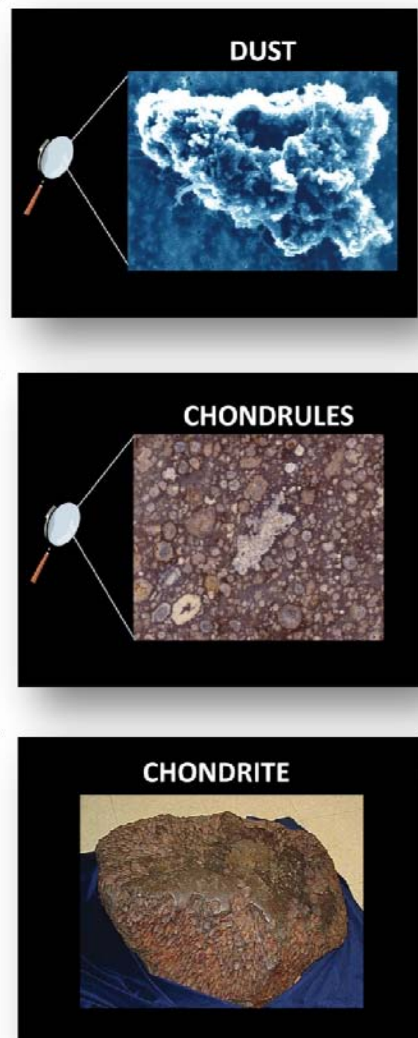
Ask students how they think bodies in the solar system formed.

Explain that they will be watching a short music video that shows the diversity of bodies that make up the solar system.

- Show the *Space School Musical* clip, "Planetary Posse." (http://discovery.nasa.gov/musical/)
- How did this music video expand your thinking about the solar system? What did you learn?

Explain that scientists think that in the beginning of its formation, our solar system was a big cloud of gas and dust. Some event made it begin to spin, and it eventually spun down into a disk of matter swirling around our protosun (think of it as a baby Sun).

As material moved around the protosun, dust grains in the disk collided with each other and started sticking together to form larger rocks. These rocks in turn collided with other rocks and either gravity held them together or they broke into smaller pieces, depending on the nature of the collision and the relative gravity of the individual rocks. **Over the next few million years, these rocks combined into larger and larger bodies and eventually, formed the planets and other large bodies we have today.** Evidence of these collisions is seen on the surface of the planetary bodies, including asteroids, in the form of craters left by the impacts.



Student Role Cards

Ask if students have ever seen dust in their home or in their bedroom. Ask if students have ever seen clumps of dust – dust bunnies – under their bed. Explain that this is similar to what it was like in the early solar system. The dust particles "accrete" – or gather together. In today's activity, we will actively model one of the theories called "Accretion" which describes how scientists think asteroids and planets formed.

The Activity

Setting: A large open area where students can run.

Materials:
Student Role Cards:

- Dust for each child, half the number of Chondrules, and half again the number of Chondrites (30, 15, 7, for example)

Directions:

This game is similar to "tag." When you tag a person they have to stay near you as you form an asteroid!

The goal is to tag as many students as you can as the game progresses. Learn how dust particles form chondrules, which form into chondrites, which form into asteroids.

- Distribute Dust Cards to each student
- All students will represent **dust** at the start of the game. Make sure that everyone has a dust sign
- Have one student (or teacher/parent) be the Sun. Have that person stand in the middle of a circle of student

- Have the students start by standing close for directions. Explain that the dust particles will jog (not run) in a counter-clockwise circular path around the "Sun" which is in the center of the large open area. As students jog, they should keep their arms to their sides until they come close to another student.
- Move out so that the ring is large enough for safe orbiting. If one dust particle tags another, they form a pair and can now extend their arms in order to tag other dust particles.
    - Allow this to continue for several minutes and then call time.

- Explain that the students who are paired up are called **chondrules**. Hand the new "chondrule" sign to each of the students who have paired up. When the chondrules tag the dust particles (one or more) the group will stay together and can try to tag others.

- After a few more minutes, call time again. At this point, students will notice that there are groups of various sizes…some dust, some chondrules, and some even larger! For students that have four or more students per group, they will be called **chondrites**.

- Hand a new "chondrite" sign to each of the student groups of four or more. As they tag the chondrules or dust particles, they form much larger clusters.
    - The chondrite that forms the largest cluster after the allotted time can be designated "Ceres" the largest asteroid, while the second can be designated "Vesta."
- Repeat the game and see if the results change.
- Review the explanation and ask students the follow-up questions.


Cheerful dust particle

Provide the following explanation to students following the game:

Chondrules (spherical balls of minerals)***:***
- are considered the building blocks of the planets.
- provide very good information on the earliest history of the solar system.

Chondrites:
- are the most primitive type of rock available for study. They are 4.5 billion years old, as old as the solar system.
- many are made up of chondrules, metal, and a fine matrix that holds them together.
- 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.


Chondrules accreting into chondrites

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. Just as in our game, dust particles formed from the gas condensing into a solid and accreted (came together) into larger and larger bodies: chondrules, then small rocks, and then asteroids and planets.

The initial forces that hold particles together include electrostatics and gravity.
- During classroom trials, one student asked how dust could become a rock. One way to think about this is for students to consider the tremendous amount of time involved in solar system formation. Over thousands and thousands of years, billions of dust particles eventually form into tiny grains like sand, then into little pebbles, and so forth.

Post-Activity Discussion Questions:

Wiped out dust particle

1. What happened to the student dust particles at the beginning of the game?
2. How did the student chondrules interact with the student dust particles? Was the movement of the two students the same or different?
3. What happened when there were chondrites? Was the movement of the two students *after the interaction* the same or different? Was the movement of student dust particles the same as that of the student chondrules?
4. What did you notice about the dust particles at the end of the activity?
5. How does this simulation relate to the accretion of asteroids in the early solar system?
   a. In what ways do you think it is similar?
   b. In what ways do you think it is different?

6. What would happen if another large group of (maybe 100) students, which might represent a large planet like Jupiter, entered the circular path where you have been running?

Show this website

- ideal if student can play the interactive in pairs in the tech lab after a demonstration: http://www.alienearths.org/online/starandplanetformation/planetfamilies.php

- Place several small bodies onto the screen. Have students generate a list of questions they would like to ask about how these bodies move through space.

- Place Jupiter in the mix and allow students to observe what happens. What force would explain this?

- What other combinations of planets would you like to try?

Compare the virtual simulation with the physical modeling.

- How are they similar? How are they different?
- How are both of these different than the real thing?
- Why are models and simulations useful?
- What questions do you have?

Wrap-up:

Ask students what comes to mind when they hear the term “asteroid.”

- In classroom trials, fifth grade students said, “large rocks that orbit the Sun,” “meteor shower”, or “comet.”

Ask students how asteroids have been depicted in movies and TV.

- Students may refer to films like *Star Wars*, where asteroids are violent or hazards that spacecraft must zip through.

- Explain that in the asteroid belt today, these bodies are very far apart and that NASA mission spacecraft like Dawn can fly safely through the belt without worrying about maneuvering to safety, rarely coming within even hundreds of kilometers of another body of any size.

Share another music video from *Space School Musical*, “The Asteroid Gang.”

- How does this music video expand your thinking about asteroids? What did you learn?
- Give us a critique!
    - Are there any misconceptions this model might inadvertently promote?
    - What does this asteroid gang model about asteroids that seems accurate?

***Space School Musical's* Asteroid Gang**

Additional Resource

Concept adapted from the Lesson 10: Building Blocks of Planets Activity C: “Crunch! Accretion of Chondrules and Chondrites” activity from *Exploring Meteorite Mysteries* http://ares.jsc.nasa.gov/Education/Activities/ExpMetMys/ExpmetMys.htm

Standards Addressed

Grades 5-8
Earth in the Solar System

- The Earth is the third planet from the Sun in a system that includes the moon, the Sun, other planets and their moons, and smaller objects, such as asteroids and comets.
- Most objects in the solar system are in regular and predictable motion.
- Gravity is the force that keeps planets in orbit around the Sun and governs the rest of the motion in the solar system.

Grades 9-12
The Origin and Evolution of the Earth System

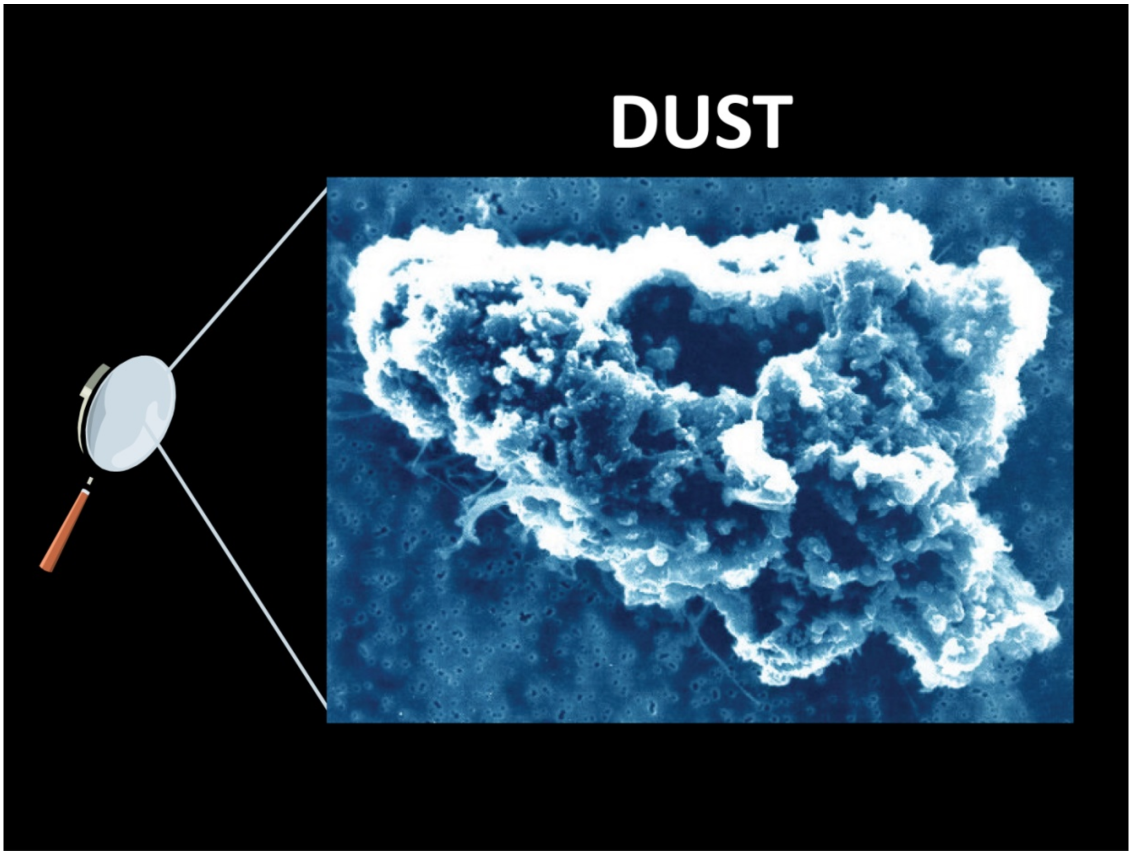
- The Sun, the Earth, and the rest of the solar system formed from the solar nebula – a vast cloud of dust and gas – 4.6 billion years ago.

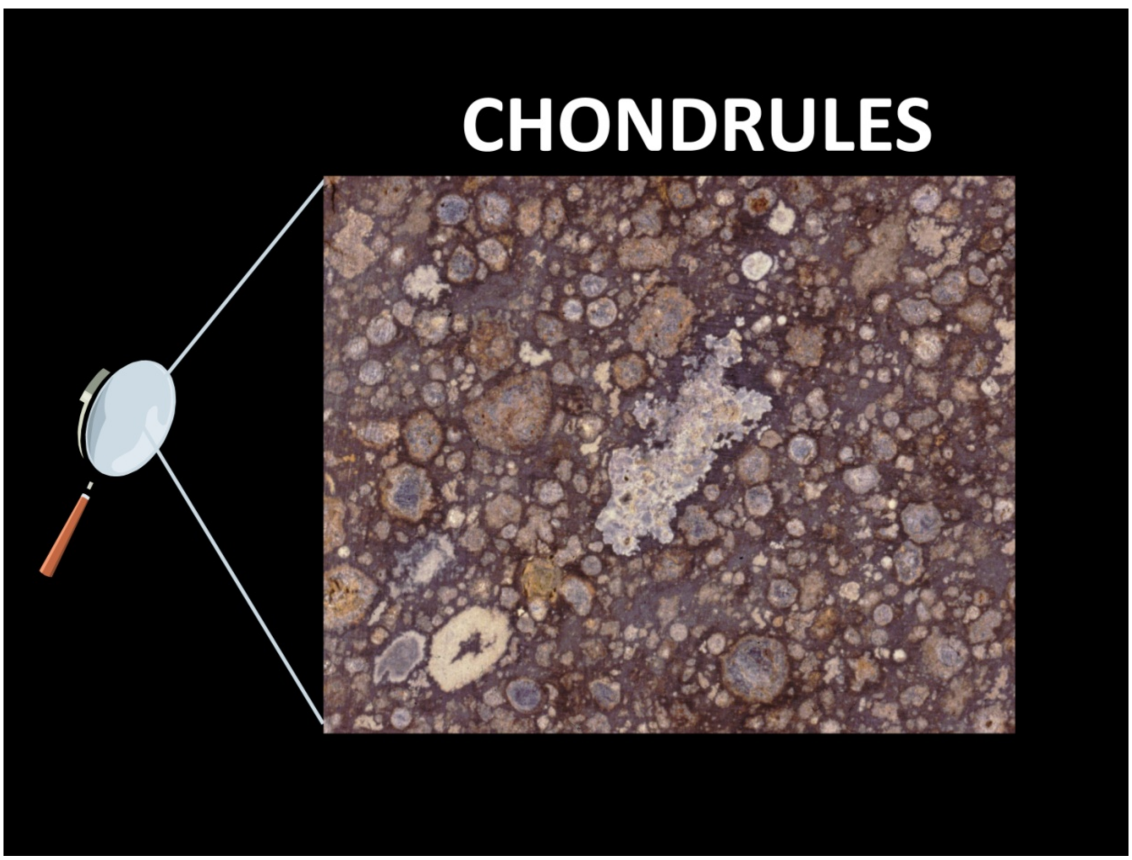
Grades K-12
Evidence, Models, and Explanation

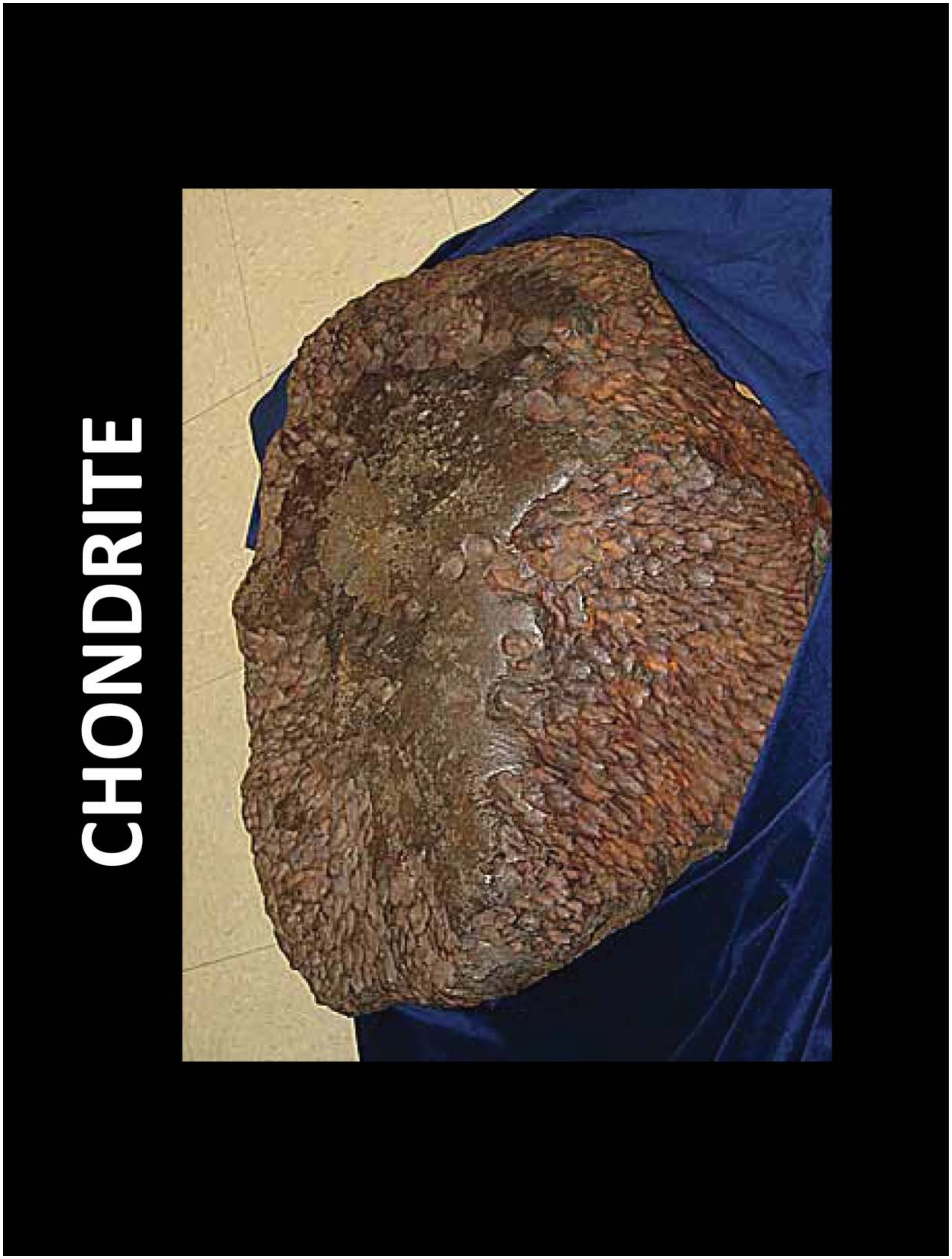
- Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power.

Active Accretion was developed by John Ristvey and Whitney Cobb,
Mid-Continent Research for Education and Learning (McREL), Denver, Colorado.

Student Role Cards






CHONDRITE