Formation and Structure of the Solar System

Name: Carolyn Robertson
Contact Information: Snowcrest Jr. High, 2755 N Hwy 162, Eden, UT 84310, 801-476-5360, crobertson@weber.k12.ut.us

Course Name: Earth Systems

Core Curriculum Standard Fulfilled: Standard I: Students will understand that scientific evidence supports theories that explain how the universe and solar system developed.

Core Curriculum Objective Fulfilled: Objective 2: Relate the structure and composition of the solar system to the processes that exist in the universe.

Intended Leaning Outcomes (ILO's) Fulfilled
1c. Evaluate, sort and sequence data according to given criteria.
4a. Provide relevant data to support their inferences and conclusions.

Time needed to Complete Inquiry: 1-2 days

Research Question: How is the structure and composition of the solar system related to processes that exist in the universe? Guided inquiry will be used followed by structured inquiry.

Prior Knowledge needed: Students will need to understand the processes related to the development of stars and elements, specifically gravity, inertia, mass and density. Students should be able to classify objects based on physical properties.

Introduction:
Teacher begins with a class discussion to gage what students know about the composition and structure of the solar system. Construct a table of solar system objects and physical properties identified by students. Have student or teacher write on the board.

Guided questions to get the discussion rolling…

What are the planets/objects in our solar system?
What physical features can be used to describe, compare/contrast these objects?
How would you describe the features of the Earth to someone in another galaxy?
Shown below is a sample chart that can be more or less comprehensive

Solar System Objects	Physical Properties
Mercury	distance to the sun
Venus	temperature day/ night
Earth	# of moons
Moon	# of rings
Mars	density
Jupiter	composition
Saturn	revolution period, direction
Uranus	rotation period, direction
Neptune	Path of orbit around the sun

Materials /Resources Needed for the Investigation: Student handout found at the end of this unit, Copy of Sciber text information or access to Sciber text.

Procedures of the Investigation:
1. Explain that you have found some specific data related to the planets.
2. Pass out the data table and have the students organize into teams of 3-4.

Data Collection:
1. Have students organize the planets according to distance from the sun, density and element composition.

Data Analysis:
1. Have the teams note the order of the planets from the sun as compared to unique planet properties.
2. Is there a pattern related to the properties of the planets? Have the students describe the patterns they have found. As groups finish with their investigations, have them complete the worksheet and discuss their findings. Using a "round robin", have student groups present their conclusions to the class. As a class, discuss the merits (validity) of these conclusions – do the data collected support them?
3. Come to a class consensus that the most dense planets (heaviest elements, smallest sized) are closest to the Sun and the least dense (lightest elements, largest size) are farther away. They should also speculate that gravity is the force that helped determine this pattern because the most dense objects are closer to the Sun. This is a time to use formative assessment techniques to ensure that consensus is reached.

Extension:
Use the Sciber text site for Earth Systems found at the USOE science web page:
http://www.schools.utah.gov/curr/science/core/earth/sciber9/index.htm
Click on the box marked Universe Development and then Where Did They Come From?

Use the computer lab and have the students read through the explanation and answer the analysis questions or show the site on a projector in the room and read together as a class. Here is the information cut and pasted in case you don't have a computer.

Where Did They Come From?

Inside stars, the process of nuclear fusion takes hydrogen atoms and fuses them together to form helium and heavier elements. Eventually, when the star dies, it will explode and send the material it formed, including carbon, iron, and even heavier elements outward into space. Watch the video below to see how this happens. That material from the explosion forms a **nebula**, or cloud of dust and gas in space. When something disturbs the nebula, the matter that it is made of will begin to come together.

Video courtesy of NASA and STScI, copyright permission

This is what happened approximately 4.6 billion years ago. A massive star underwent a massive supernova (explosion), sending out a shockwave that disturbed a nearby nebula.

This picture, taken by the Hubble Space Telescope, shows a nebula where new stars are forming. Photo courtesy NASA and STScI.

The nebula was disturbed enough that it began to spin. As it began to spin, the matter inside

started to stick together, much like snow when making a snowball. The gas and dust inside the nebula began to flatten as its speed increased, forming a disk. Eventually, the matter had formed into larger clumps, with the largest in the center. When the matter in the center was so compressed that there was enough pressure to cause hydrogen atoms to fuse, the beginnings of a new star formed. This was the formation of our sun and its solar system. As the clumps of material that orbited this early sun continued to rotate, all in a counterclockwise direction (if you are looking from the north), they picked up more and more matter and eventually became planets. During the early process of planet formation, while most of the material was still very hot, the heavier elements collected in the middle of the planets (the core of Earth, for example), while the lighter elements stayed closer to the surface.

Eventually, the planets were formed. The inner four planets (Mercury, Venus, Earth, and Mars) were smaller and formed primarily from rocky material. This is because all of the gaseous material and light elements such as hydrogen and helium that the planets started with could not withstand the heat that was put out by the sun. Instead, those materials such as the light gases and ice collected on the next four planets (Jupiter, Saturn, Uranus, and Neptune) and they came to be known as the gas giants. The heat from the sun is primarily responsible for the four inner “terrestrial” planets and the four outer “gaseous” planets. Pluto is an exception to the formation of the outer planets.

Most of the moons formed at the same time as the solar system. However, our moon is believed to have formed afterward when an object larger than Mars struck Earth and caused a large piece of the molten Earth to bounce out into space, cool, and begin orbiting our planet.

Analysis:

1. Why are the inner planets primarily rock?
2. Draw an illustration showing the sequence described above in the formation of our solar system.
3. Where did the heavy elements that formed Earth and other planets come from?
4. Do all the planets orbit the sun in the same direction? Why is this the case?

Names: _____

_____

Planet Data Chart

Planet	Distance from the Sun AU	Density g/cm^3	Core Elemental Composition (amu)
Earth	1	5.52	iron (55.8)
Mars	1.5	3.91	iron (55.8)
Neptune	280	1.64	water, ice (18)
Saturn	88.7	.69	hydrogen (1), helium (2)
Jupiter	48.4	1.33	hydrogen (1), helium (2)
Venus	0.7	5.2	iron (55.8)
Uranus	178.6	1.32	hydrogen (1), helium(2)
Mercury	0.4	5.43	iron (55.8)

Ordering Planet Data

Instructions: Use the Planet data chart and organize the planets according to the properties defined at the top of the column.

Closest to the Sun to Farthest from the Sun	Most to Least Dense	Core Composition Heaviest to Lightest Elements

Determining patterns

1. Describe any patterns you see evident in the information above.

2. What force could have caused the pattern(s) you observed above to emerge during the formation of the planets?