GENESIS SEARCH FOR ORIGINS Education

Cosmic Chemistry: Planetary Diversity

Solar Nebula Supermarket

TEACHER NOTES: POWERPOINT PRESENTATION

BACKGROUND INFORMATION

The PowerPoint presentations, provided as a supplement to the student texts from which they were derived, are always offered in a pdf format for those teachers who do not have the Microsoft PowerPoint application.

As teacher use of the presentation slide notes as talking points is vital for complete understanding of the concepts, the slide notes from the PowerPoint are provided here for those teachers using the pdf presentation. Therefore it is important to read and print out these talking points before presenting the material to your students. You may wish to use the Teacher Guide that accompanies this presentation for additional tips, delivery strategies, and correlation to the national standards.


NASA

SLIDE NOTES/TALKING POINTS

Slide 1: None.

Slide 2: These two lightest elements now form the first period of our current periodic table.

Slide 3: Hydrogen and helium nuclei fused to form heavier elements and released light energy. The stars began to shine!

Slide 4: Even at these high temperatures, fusion reactions did not produce nuclei of elements heavier than the iron-group, but some of these heavier elements could have been produced by processes involving neutrons formed in helium fusion.

Slide 5: Space among the stars was enriched with heavy elements as a result of these two processes.

Slide 6: The Great Nebula in Orion is an immense starbirth region. Located in the constellation Orion the Hunter, it is probably the most famous of all astronomical nebulae.

Slide 7: Almost 70 of the currently known elements have been observed in the sun's photosphere, chromosphere, or the corona. About 99% of the original solar nebula has been preserved in these outer layers of the sun, so the components of these layers are presumed to be similar to that of the whole solar system. Although nuclear processes may have modified the composition at the sun's core, little mixing has occurred among the surface layers and the inner layers.

Slide 8: This graph shows the spectroscopically derived concentration of chemical elements in the solar atmosphere plotted on a logarithmic scale vs. their atomic numbers.

Figure 1. Note. The data in Figure 1 are from *Geochemistry Pathways and Processes* by S.M. Richardson & H. Y. McSween Jr., 1989, Englewood Cliffs, NJ: Prentice Hall and *Solar System Evolution: A New Perspective* by S. R. Taylor, 1992, Cambridge, MA: Cambridge University Press.

Slide 9: This image shows the sun and one of the most spectacular solar flares ever recorded.

Slide 10: By mass, the mixture was probably 74% hydrogen and 24% helium. This means that out of 100 grams of nebula, there were 74 grams hydrogen and 24 grams helium.

If the temperature of the nebula was below 200 K, hydrogen was probably in the form of molecules, rather than as charged particles— protons and electrons as it is found now in the sun's interior.

Slide 11: At average nebular temperatures, these elements probably formed compounds with hydrogen, such as methane, ammonia, and water. In the colder portions of the nebula, carbon may have formed "ices," such as solid carbon monoxide and carbon dioxide, rather than methane.

Slide 12: The metals probably included iron, magnesium, calcium, aluminum, nickel, chromium, manganese, potassium, and titanium.

Slide 13: How do the currently observed abundances of the chemical elements in the sun compare with the abundances of those elements thought to be major constituents of the primordial solar nebula?

Hydrogen and helium are the elements found in the greatest abundance in both our sun and in the primordial nebula. Oxygen, carbon and nitrogen atoms are the next most abundant elements in both sources. Metal elements that formed the remaining solid "rock" of the nebula are also found in the sun.

Slide 14: At some point the gravitational forces balanced the combined forces of gas pressure and outward centrifugal force. Near the center of the disc, where most of the mass was found, our infant sun formed and nuclear fusion started, heating nearby regions by radiation.

Slide 15: What would cause these elemental differences in the planets?

Slide 16: As they cooled, condensation of these nebular constituents could have been an important process in establishing the chemical characteristics of the early solar system.

Slide 17: The first substances condensed were metallic oxides, such as aluminum oxide and calcium titanium oxide. Grains began to form at rates that could have been as much as 1 cm/yr. As temperatures began to drop, iron/nickel alloys condensed and at temperatures below 1600 K, magnesium silicates formed as rocky particles.

Figure 2. Temperature (K) and distance from sun (AU) at which major planetary constituents would condense from primordial solar nebula. Note. [*Note that the shaded region on the horizontal axis represents only 1.0 AU, whereas the other axis units are 10 AUs*.] The data in Figure 2 are from *The New Solar System* by J. K. Beatty & A. Chaikin, (Eds.), 1990, Cambridge, MA: Cambridge Publishing Press; *Geochemistry Pathways and Processes* by S. M. Richardson & H. Y. McSween Jr., 1989, Englewood Cliffs, NJ: Prentice Hall; and *Solar System Evolution: A New Perspective* by S. R. Taylor, 1992, Cambridge, MA: Cambridge University Press.

Slide 18: Hydrated minerals were formed when water in the gas cloud reacted with some of the grains of calcium, iron, and magnesium minerals. Water ice and ices of methane and ammonia formed at temperatures below 200 K.

Slide 19: The planetesimals collect in clusters to form protoplanets which evolve into planets.

Image adapted from *Astronomy, The Evolving Universe* by Michael Zelik, 1991, University of New Mexico: John Wiley & Sons, Inc.

Slide 20: Planetesimals were probably surrounded by an atmosphere of lighter gases, such as hydrogen and helium, which did not condense but were gravitationally attracted to the protoplanets.

Slide 21: What type of objects are beyond Neptune? How should objects like Pluto be classified?

Slide 22: Because of the characteristic high density of metals, one would predict a direct relationship between the abundance of metals in a planet's structure and its density.

Slide 23: NASA's Genesis scientists wish to collect and study pristine samples of today's solar wind particles in order to give us better data about the composition of the original solar nebula, and, possibly, help us determine the validity of the condensation theory.