CHAPTER TWO: THE FORMATION OF THE EARTH

THE FORMATION OF THE UNIVERSE

The 'Big Bang' Theory

The 'Big Bang Theory' is the most widely accepted theory of the origin of the universe. About 15 to 20 billion years ago, the primeval atom, a massive collection of particles and energy, exploded with tremendous force. The particles flew off into space, gradually coalescing into hydrogen and helium atoms. The gases expanded and cooled, condensing into galaxies.

This information may be told to children as a story with or without experiments as in 'The God With No Hands' by Maria Montessori. The story is in the History I and Functional Geography manuals.

Presentation: The Formation of the Planets

Gather a group of children and tell the following information in story form:

The primordial material for the sun and planets is thought to have been a huge **nebular cloud** consisting of about 80 percent hydrogen, 15 percent helium, and a few percent of all other elements. The heavier elements in the frigid cloud of dust and gases were mostly silicon, aluminum, iron, and calcium. Oxygen, carbon, and nitrogen were also present in organic compounds.

About 5 billion years ago, this huge cloud of minute rocky fragments and gases began to contract under its own gravitational influence. Gradually the atoms pulled closer and closer together and the cloud became smaller and smaller.
It then developed some component of rotational motion, rotating faster and faster as it contracted, forming a disk-like shape.The greatest concentration of material was gravitationally pulled towards the center to form the **protosun**. The cloud continued shrinking, causing the center to become hot. The core got hotter and hotter, until it began to glow with a dim red light. The pressure and temperature in the core increased, causing a nuclear fusion reaction: hydrogen atoms collided so violently that they fused together to form helium. The star glowed with a bright yellow light. It had become our sun.

The rotation of the nebular cloud forming the sun caused it to assume a flattened disk shape. Within the disk, small contractions occurred, forming the nuclei of the planets. As the sun got hotter, the temperature in the remainder of the rotating disk got lower. This allowed metals like iron and nickel with their high melting temperatures to solidify. Then rock minerals condensed and collided, forming larger and larger bodies until **planets, moons, and asteroids** formed. The Solar System began to clear of debris, allowing the sun to shine on the inner planets of Mercury, Venus, Earth and Mars. Their surface temperatures rose. Because of their relatively weak gravitational fields, these planets lost hydrogen, helium, ammonia, methane, and water to the outer planets of Jupiter, Saturn, Uranus, and Neptune. The colder temperatures of these planets allowed the materials to condense, forming the larger and less dense planets.

STELLAR NUCLEOSYNTHESIS

Materials:

Piece of black felt 12′ x 3′

8 yellow felt circles with a diameter of 8″ representing Hydrogen

7 light pink felt circles with a diameter of 7″ representing Helium

6 red felt circles with a diameter of 6″ representing Carbon

5 light green felt circles with a diameter of 5″ representing Oxygen

4 dark green felt circles with a diameter of 4″ representing Neon

3 light blue felt circles with a diameter of 3″ representing Magnesium

2 light purple felt circles with a diameter of 2″ representing Silicon

1 dark purple felt circle with a diameter of 1″ representing Iron

7 yellow felt arrows with a length of 3″ and width of 1/2″

3 yellow felt arrows with a length of 6 1/2″ and width of 1/2″

8 card stock arrows with a length of 4″ and width of 2″: yellow says Hydrogen; light pink says Helium; red says Carbon; light green says Oxygen; dark green says Neon; light blue says Magnesium; light purple says Silicon; dark purple says Iron

109 disks with the symbols of the elements written in black

Pictures of stars, nebulae, galaxies

Periodic Table of the Elements

Presentation:

1. Say, "Stellar nucleosynthesis is the term for the nuclear reactions taking place in stars to build the nuclei of the heavier elements. In our sun, the prime energy producer is the fusion of Hydrogen to Helium, occurring at a minimum temperature of 5 million degrees F."
2. "First, 2 hydrogen nuclei fuse to form deuterium. One proton changes into one neutron, releasing one neutrino and one positron. This process takes about 10 billion years."
3. Then one deuterium atom fuses with another hydrogen atom to make the ^{3}Helium isotope. Then two ^{3}Helium atoms fuse to form one ^{4}Helium atom and two ^{1}Hydrogen atoms, releasing energy as heat and light. A Helium core forms.
4. Because Hydrogen continues to be produced, there is still a Hydrogen burning shell around the Helium core.
5. Helium burning occurs in older stars with a Helium core and at a temperature of 100,000,000 K. The star needs to collapse to reach this temperature.
6. Two ^{4}Helium atoms fuse to form one ^{8}Beryllium atom. One ^{8}Beryllium atom immediately fuses with another ^{4}Helium atom to form one ^{12}Carbon atom, releasing energy. A Carbon core forms.
7. $^{4}He + ^{4}He \rightarrow ^{8}Be$
8. $^{8}Be + ^{4}He \rightarrow ^{12}C$
9. No Carbon was produced in the Big Bang because the temperature dropped too quickly.

10. Because Helium continues to be produced, there is still a Helium burning shell around the Carbon core.
11. Carbon burning occurs in massive stars, four times the mass of our sun and at a temperature of 600,000,000 K.
12. ^{12}Carbon fuses with ^{4}Helium to form ^{16}Oxygen, releasing energy.
13. $^{12}C + {}^{12}C \rightarrow {}^{16}O + 2\,{}^{4}He$
14. $^{12}C + {}^{12}C \rightarrow {}^{24}Mg$ + alpha particle
15. During the Helium burning process, stars build up an inert core of Carbon and Oxygen. When all the Helium is consumed, the core collapses due to gravitation. Temperature and density increase and Carbon can be burned.
16. The star becomes a red supergiant.
17. As Carbon burns, Oxygen, Magnesium, and Neon accumulate in a new inert core. It takes only 1,000 years to burn all the Carbon. Then the core cools and contracts.
18. Because Carbon continues to be produced, there is still a Carbon burning shell.
19. Neon burning occurs in very massive stars, eight times the mass of our sun and at a temperature of 1,200,000,000 K.
20. ^{20}Ne + alpha particle $\rightarrow {}^{16}O + {}^{4}He$
21. $^{20}Ne + {}^{4}He \rightarrow {}^{24}Mg$ + alpha particle
22. After all the Carbon in the core is consumed, the core cools down, gravitation compresses it, and increases the density. Then the temperature increases so Neon can burn.

23. Oxygen and Magnesium accumulate in the central core. It takes only a few years for Neon to be consumed.
24. Because Neon continues to be produced, there is still a Neon burning shell.
25. The star is a white dwarf.
26. Oxygen burning occurs in very massive stars at a temperature of 1,500,000,000 K.
27. As Neon is consumed, the core contracts, and becomes denser. The temperature increases so Oxygen can burn.
28. $^{16}O + ^{16}O \rightarrow ^{28}Si + ^{4}He$
29. $^{16}O + ^{16}O \rightarrow ^{24}Mg + 2\,^{4}He$
30. After six months to one year, all the Oxygen is consumed, leaving a Silicon core.
31. Because Oxygen continues to be produced, there is still an Oxygen burning shell.
32. Silicon burning occurs in very massive stars at a temperature of 2,700,000,000 K.
33. As Oxygen is consumed, the core contracts and becomes denser. The temperature increases so Silicon can burn.
34. $^{28}Si + ^{28}Si \rightarrow ^{56}Fe$ + energy
35. After one day, all the Silicon is consumed.

36. ^{56}Fe (iron) is very stable. No more energy is released, and the star cools down. The star becomes denser through gravitation. SUPERNOVA! (As you say this, scatter the discs with all the element symbols on them. Do not use the element symbols for the elements that are man-made, #43, #61, #93 - #109.) A huge amount of energy is released and all the other elements are formed.

THE PLANETS

Mercury:

Distance from sun:	57,900,000 km
Diameter:	4,880 km
Revolution around the sun:	88 days
Rotation:	59 days
Surface gravity (earth = 1):	0.39
Surface temperature:	430° C on dayside; -180° C on nightside
Surface composition:	nickel-iron, silicates
Atmosphere:	very thin of sodium and helium
Moons:	none
Mass:	0.055 x that of the earth
Density:	5.4 x that of water
Points of interest:	Mercury is heavily cratered.

Venus:

Distance from sun:	108,200,000 km
Diameter:	12,100 km
Revolution around the sun:	225 days
Rotation:	243 days
Surface gravity (earth = 1):	0.91
Surface temperature:	480° C
Surface composition:	nickel-iron, silicates
Atmosphere:	carbon dioxide, sulphuric acid
Moons:	none
Mass:	0.8 x that of the earth
Density:	5.2 x that of water
Points of interest:	Venus has a dense atmosphere with a greenhouse effect that keeps the surface extremely hot. Clouds are of thick sulphuric acid. There are many impact craters and many large volcanoes.

Earth:

Distance from sun:	149,600,000 km
Diameter:	12,756 km
Revolution around the sun:	365.2 days
Rotation:	23.9 hours or 1 day
Surface gravity:	1.0
Surface temperature:	averages 15° C
Surface composition:	water, nickel-iron, silicates
Atmosphere:	nitrogen, oxygen, water
Moons:	1
Mass:	6 x 10 metric tons
Density:	5.5 x that of water
Points of interest:	The earth is the only planet known to support life. The surface is 70 % water. There are active earthquakes and volcanoes with continental and oceanic plates in motion.

Mars:

Distance from sun:	227,900,000 km
Diameter:	6,787 km
Revolution around the sun:	687 days
Rotation:	24.6 hours
Surface gravity (earth = 1):	0.38
Surface temperature:	averages -50° C
Surface composition:	iron, silicates
Atmosphere:	carbon dioxide
Moons:	2 - Phobos and Deimos
Mass:	0.1 x that of the earth
Density:	3.9 x that of water
Points of interest:	Mars is a red planet from windblown iron-oxide dust. The polar caps are of water and carbon dioxide ice. There is a volcano 25 km high, a canyon 5,000 km long, sand dunes and channels probably carved by water in the past.

Asteroid Belt:

Between Mars and Jupiter, there is a belt of asteroids consisting of rocky debris left over from the formation of the planets. When asteroids collide, chips may break off to become meteoroids which may fall onto the earth as meteorites. Two groups of asteroids, called the Trojans, follow the same orbit as Jupiter.

Jupiter:

Distance from sun:	778,300,000 km
Diameter:	142,800 km
Revolution around the sun:	11.86 years
Rotation:	9.9 hours
Surface gravity (earth = 1):	2.3
Surface temperature:	-130° C at cloud tops
Surface composition:	liquid hydrogen
Atmosphere:	hydrogen, helium, ammonia, methane
Moons:	16 Io, Europa, Ganymede and Callisto are the largest
Mass:	318 x that of the earth
Density:	1.3 x that of water
Points of interest:	Jupiter is the largest planet, 1/10 the size of the sun. It is a whirling ball of gas compressed to liquid in the interior. It has a faint ring around it. The Great Red Spot is an intense windstorm 3 times larger than the earth. The moon Io has an atmosphere and volcanoes that eject sulphur and sulphur compounts hundreds of kilometers above the surface. The moon Europa is covered with a layer of ice that may contain oceans of liquid water beneath it.

Saturn:

Distance from sun:	1.427,000,000 km
Diameter:	120,600 km
Revolution around the sun:	29.46 years
Rotation:	10.7 hours
Surface gravity (earth = 1):	0.93
Surface temperature:	-185° C at cloud tops
Surface composition:	liquid hydrogen
Atmosphere:	hydrogen, helium, methane, ammonia
Moons:	17 Titan is the largest
Mass:	95 x that of the earth
Density:	0.7 x that of water
Points of interest:	Saturn has many rings made up of ice. It is the second largest planet. Saturn has raging storms in its atmosphere. The moon Titan has a dense atmosphere of mostly nitrogen.

Uranus:

Distance from sun:	2,870,000,000 km
Diameter:	51,300 km
Revolution around the sun:	84 years
Rotation:	17.2 hours
Surface gravity (earth = 1)	0.8
Surface temperature:	-200° C at cloud tops
Surface composition:	ice, hydrogen, methane
Atmosphere:	hydrogen, helium, methane
Moons:	15 Oberon, Titania, Umbriel, and Ariel are the larg est.
Mass:	14.4 x that of the earth
Density:	1.3 x that of water
Points of interest:	Uranus rotates on an axis of 98°. The methane in the atmosphere absorbs the red wavelengths of sunlight, resulting in the greenish color. The narrow rings are probably held in place by tiny moons. The moon Miranda has deep scars and a jumbled surface that was shattered by collisions and reassembled under the force of gravity.

Neptune:

Distance from sun:	4,497,000,000
Diameter:	49,100 km
Revolution around the sun:	165 years
Rotation:	16.1 hours
Surface gravity (earth = 1):	1.15
Surface temperature:	-200° C at cloud tops
Surface composition:	ice, hydrogen, helium
Atmosphere:	hydrogen, helium, methane
Moons:	15 Triton is the largest
Mass:	17.2 x that of the earth
Density:	1.6 x that of water
Points of interest:	The atmosphere of methane results in the greenish color. There are many great storms in the atmosphere. Neptune has rings. Triton has a thin atmosphere of nitrogen and geyser-like plumes that jet up to 10 km above the nitrogen frost of the surface.

Extensions:

1. The children do research reports on a planet and present the information to the class. The report should include drawings or a model of the planet. Photographs are available on the Internet through NASA and also through NASA Ames Research Center, Moffett Field, Mountainview, CA.
2. The children do nomenclature cards of the planets.
3. The children make models of the planets from fruit, styrofoam, or paper mache.
4. The children set up a solar system model in the classroom, to scale, except for the sun. The distances between the planets should be measured and to scale.
5. The children make a solar system book with illustrations and information on each planet.

PLANET REPORT

Child's Name: ______________________________

Name of Planet: ______________________________

Location: ______________________________

Distance from the Sun: ______________________________

Diameter: ______________________________

Revolution around the Sun: ______________________________

Rotation: ______________________________

Surface Gravity: ______________________________

Surface Temperature: ______________________________

Surface Composition: ______________________________

Atmosphere: ______________________________

Moons: ______________________________

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Mass: ______________________________

Density: ______________________________

Points of Interest: ______________________________

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