***Origin of the Universe - The Big Bang Theory***

An astonishing observation was made in the late 1920's. The light from distant galaxies is shifted to lower frequencies *(red shift)* similiar to the way the sound of a horn on a passing train or car shifts to a lower pitch. The light frequency shift can be explained in the same way; the distant galaxies are moving away from us. In fact, all of the galaxies (clusters of billions of stars) are moving away from our own Milky Way Galaxy and from one another, and the farther away they are the faster they are moving away from us. This is exactly like a gigantic explosion. All of the bits move outward away from the center of the explosion. In the standard theory, space and time and all the matter and energy in the universe were formed in the **Big Bang** some 10 to 15 billion years ago. The conditions in the rapidly expanding and cooling universe following the Big Bang were such that only simple matter was formed. The universe was filled with hydrogen (H) and small amounts of helium (He). As the universe expanded, galaxies formed in areas of higher concentrations of H and He and stars formed within the galaxies in areas of highest concentrations of H and He.

***Stellar Evolution***

***- birth***

A nebula (gas cloud) slowly contracts under the mutual gravity of all of the atoms in the cloud. Contraction causes the pressure to increase which causes the cloud to heat up. Most of the mass falls into the center of mass and pressures here become the greatest. The core of the nebula, the proto-star, heats up the most and starts to glow red hot. Soon the pressure and temperature are so great that the nuclei of hydrogen atoms begin to fuse together to form helium. This nuclear reaction releases huge amount of energy. The "thermonuclear fires" are lit; a star is born! The energy release yields an outward pressure and the gravitational contraction stops.

***- death***

Eventually the star fuses so much H into He that the H concentration in the core is reduced and the thermonuclear reactions becomes sluggish. The star's core cools and begins to contract again. This secondary contraction increases the pressure and temperature of the star's core.

Most stars smaller than our sun will slowly cool and fade.

Intermediate mass stars (0.8 - 8 times the size of our sun) will begin to fuse He; this **red giant** phase of stellar evolution produces elements of the periodic table through iron (Fe). The star's atmosphere is blown off as an expanding ring (planetary nebula) and the remainder of the star becomes a white dwarf.

In high mass stars (8 - 20 times our sun) the pressures and temperatures generated in the secondary contraction phase is so great that massive nucleii fuse together forming the largest elements of the periodic table in a stupendous explosion called a **supernova**. Supernovae spread these elements through interstellar space where they can merge with other nebulae and form new stars. The remaining 10% of its mass remains as a neutron star.

In very high mass stars (20 - 100 times the size of our sun), the mass, and therefore gravity is so great that when it goes into its late contraction phase the pressure in the interior is so great that matter cannot withstand it. Matter collapses. A black hole is born.

***Origin of the Earth - The Solar Nebular******Hypothesis***

About 4.6 billion years ago our solar system formed from a cloud of gas and dust which slowly contracted under the mutual gravity of all of its particles. The cloud was made largely of hydrogen (H) with some helium (He) and small amounts of the remaining naturally occurring chemical elements. The initial rotation or tumbling motion was accelerated as the nebula contracted, like a spinning skater who pulls in his arms spins faster. The cloud became a disc. Within the disc, the largest concentration of matter was in the center. This became the sun. Matter collected in smaller clumps out in the disc. These became the planets. The proto-sun and proto-planets grew by accretion of the matter that was falling in toward the center of mass. The solar nebula got hotter as the contraction increased the pressure, especially in the inner nebula. Eventually the pressures and temperatures in the core of the proto-sun became great enough that hydrogen nuclei fused together to form helium. This nuclear reaction released huge amounts of energy, as it continues to do today. The sun was born. Most of the gas and finest particles were swept from the solar system leaving only the proto-planets and asteroids. The planets had attained most of their mass by this time but heavy meteor bombardment continued for another half-billion years or so.

The Moon is believed to have formed by the collision of a Mars-size planetesimal with the Earth during the time when the planets were still forming/growing.

At the high temperatures of the inner solar nebula the small proto-planets (Mercury, Venus, Earth, Mars) were too hot to hold the volatile gases that dominated the solar nebula. Only refractory (high melting point) materials like iron and rocky silicates were stable, so the terrestrial planets are made primarily of metallic cores and silicate mantles with atmospheres thin or absent. In the outer solar nebula temperatures were cool enough for the abundant gases to accumulate and be held by proto-planets. As a result the Jovian planets (Jupiter, Saturn, Uranus, and Neptune) are gas giants, made mostly from hydrogen, helium, and hydrogen compounds like ammonia and methane.

***Segregation of the Earth's Layers and Atmosphere***

The materials that accreted into the early Earth were probably added piecemeal, without any particular order. But the early Earth was very hot from gravitational collapse, impacts, and radioactive heating. Consequently the early Earth was probably partially or largely molten. In this molten state, the denser metallic liquids sank to the center of the Earth.  The core also contains most of the Earth’s heavy precious metals like gold and platinum.  The less dense silicate liquids rose to the top, like oil rises to the surface of water. Through igneous (volcanic and intrusive) activity the outer crust of the Earth eventually formed. The crust today is made up of materials with lower density and lower melting points than the mantle.

Volatile materials, carried by certain types of meteors and by comets, were injected into the mantle by impacts that penetrated the interior. The hot early Earth cooled in much the same way as the Earth's interior cools today - by convection. Today this convection is tied to seafloor spreading and hotspots. In the early Earth seafloor spreading probably wasn't as well organized as today; the pattern of spreading and subduction was probably more vigorous and chaotic. There must have been rapid convective turnover of the mantle that must have resulted in rapid release of the volatiles stored in the mantle, because gases don't like to stay in the solid or liquid state. Gases in the mantle prefer to go into any melt that forms and happily escape into the atmosphere if the melt erupts at the surface. Even today volcanic activity, especially at the midocean ridges, releases large amounts of carbon dioxide, water vapor, and other gases into the atmosphere. Of course most of the released water vapor condensed to form the oceans. This outgassing formed the oceans and the primitive reducing atmosphere. Since the evolution of life on Earth, biological processes have given rise over the past three and a half billion years or so to our oxygen rich atmosphere.