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THE EARTH'S ORIGIN

THE EARLY SOLAR SYSTEM

No one can go back in time to view the formation of the Solar System and the Earth. Therefore, scientists will never be able to describe the sequence of events with certainty. The hypothesis given here is based on calculations about the behavior of dust and gas in space and on observations of stars and dust clouds in our galaxy. Refer to the "Focus On" box on page 12 for a discussion of how scientists formulate a hypothesis. The hypothesis states that about 5 billion years ago the matter that became our Solar System was an immense, diffuse, frozen cloud of dust and gas rotating slowly in space. This cloud formed from matter ejected from an exploding star. More than 99 percent of the cloud consisted of hydrogen and helium, the most abundant elements in the Universe. The temperature of this cloud was about 270ºC. Small gravitational attractions among the dust and gas particles caused the cloud to condense into a sphere. As condensation continued, the cloud rotated more rapidly, and the sphere spread into a disk.

Some scientists have suggested that a nearby star exploded and the shock wave triggered the condensation. More than 90 percent of the matter in the cloud collapsed toward the center of the disk under the influence of gravity, forming the protosun. Collisions among highspeed particles released heat within this early version of the Sun, but it was not a true star because it did not yet generate energy by nuclear fusion.

Heat from the protosun warmed the inner region of the disk. Then, after the gravitational collapse was nearly complete, the disk cooled. Gases in the outer part of the disk condensed to form small aggregates, much as snowflakes form when moist air cools in the Earth's atmosphere. Over time, the aggregates stuck together as snowflakes sometimes do. As they increased in size and developed stronger gravitational forces, they attracted additional particles. This growth continued until a number of small rocky spheres, called planetesimals, formed, ranging from a few kilometers to about 100 km in diameter.

The entire process, from the disk to the planetesimals, occurred quickly in geologic terms, over a period of 10,000 to 100,000 years. The planetesimals then coalesced to form a few large planets, including Earth. At the same time that planets were forming, gravitational attraction pulled the gases in the protosun inward, creating extremely high pressure and temperature.

The core became so hot that hydrogen nuclei combined to form the nucleus of the next heavier element, helium, in a process called nuclear fusion. Nuclear fusion releases vast amounts of energy. The onset of nuclear fusion marked the birth of the modern Sun, which still generates its energy by hydrogen fusion.

THE MODERN SOLAR SYSTEM

Heat from the Sun boiled most of the hydrogen, helium, and other light elements away from the inner Solar System. As a result, the four planets closest to the Sun— Mercury, Venus, Earth, and Mars—are now mainly rocky with metallic centers. These four are called the terrestrial planets because they are "Earthlike." In contrast, the four outer planets—Jupiter, Saturn, Uranus, and Neptune—are called the Jovian planets and are composed primarily of liquids and gases with small rocky and metallic cores. Pluto, the outermost known planet, is anomalous. It is the smallest planet in the

Solar System and is composed of rock mixed with frozen water and methane.

THE EVOLUTION OF THE MODERN EARTH

Scientists generally agree that the Earth formed by accretion of small particles, as discussed above. They also agree that the modern Earth is layered. The center is a dense, hot core composed mainly of iron and nickel. A thick mantle, composed mainly of solid rock, surrounds the core and contains 80 percent of the Earth's volume. The crust is a thin surface veneer, also composed of rock Earth temperature and pressure increase gradually with depth. Ten meters below the surface, soil and rock are cool to the touch, but at a depth between about 100 kilometers and 350 kilometers, the mantle rock is so hot that one or two percent of it is melted, so that the entire mantle flows very slowly, like cold honey. This movement allows continents to move across the globe, ocean basins to open and close, mountain ranges to rise, volcanoes to erupt, and earthquakes to shake the planet. Rock is even hotter deeper in the mantle, but the intense pressure prevents it from melting. The outer core is composed of molten metal, but the inner core, which is as hot as the surface of the Sun, is under such intense pressure that it is solid.

Although scientists agree that our planet is layered, they disagree on how the layering developed. Astronomers have detected both metallic and rocky meteorites in space, and many think that both metallic and rocky particles coalesced to form the planets. According to one hypothesis, as the Earth began to form, metallic particles initially accumulated to create the metallic core, into the core and mantle at a later date. However, as discussed in "Focus On: Hypothesis, Theory, and Law," future research may change our views about a sequence of events that occurred so long ago.