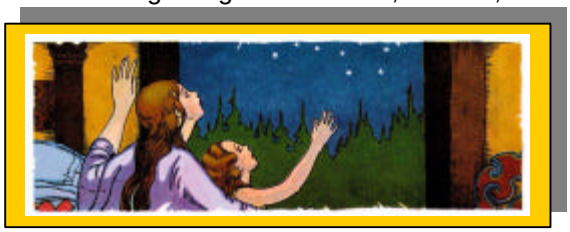
Exploring Origins

The Origins of the Solar System

STUDENT TEXT

People throughout the ages and across cultures have posed questions about the beginnings of the Earth, the sun, the planets and the other members of the solar system we inhabit, such as comets and meteors. These questions have remained unanswered for many years. Extraterrestrial objects are very difficult to study because they are so far away from us. Beginning in the 16th century, Western scientists began to make careful observations about the sun and the planets. This data provided evidence for these scientists to test their ideas about the beginning of the solar system.



When scientists develop theories, they must make sure that all available observations can be explained by the theory, or else the theory has to be modified. An idea that can never be tested by comparing it with collected data is not useful to scientists.

Western scientists have developed several different theories to explain the origins of our solar system. Many different scientists from different subject areas have contributed to the present theory. Ideas about the origin of the solar system have changed based on new data that has been gathered. There are still many questions to be answered.

Heritage from Western Science

One of the first people to address the question of the formation of our sun and planets from a Western scientific perspective was the French philosopher and mathematician René Descartes in the mid-1600's. He thought that the initial material in the universe rotated like a whirlpool. This material formed rotating stars and might have also produced planets.

About 100 years later, the German philosopher Immanuel Kant, who now had the benefit of building upon Issac Newton's ideas of gravity, thought that a rotating cloud of gas would contract in the middle and the rest of the cloud would flatten out like a disk.

Later in the 1700's, a French mathematician named Laplace proposed that this cooling, shrinking, rotating cloud would leave rings of material behind that would eventually become the planets.

While these scientists were developing their ideas, others were proposing that the solar system had a very different beginning. In the mid-1700's Buffon suggested that the sun was hit by a comet and pieces flew off to form the planets. Theories that the solar system was formed from some major cosmic catastrophe continued through the next two hundred years.

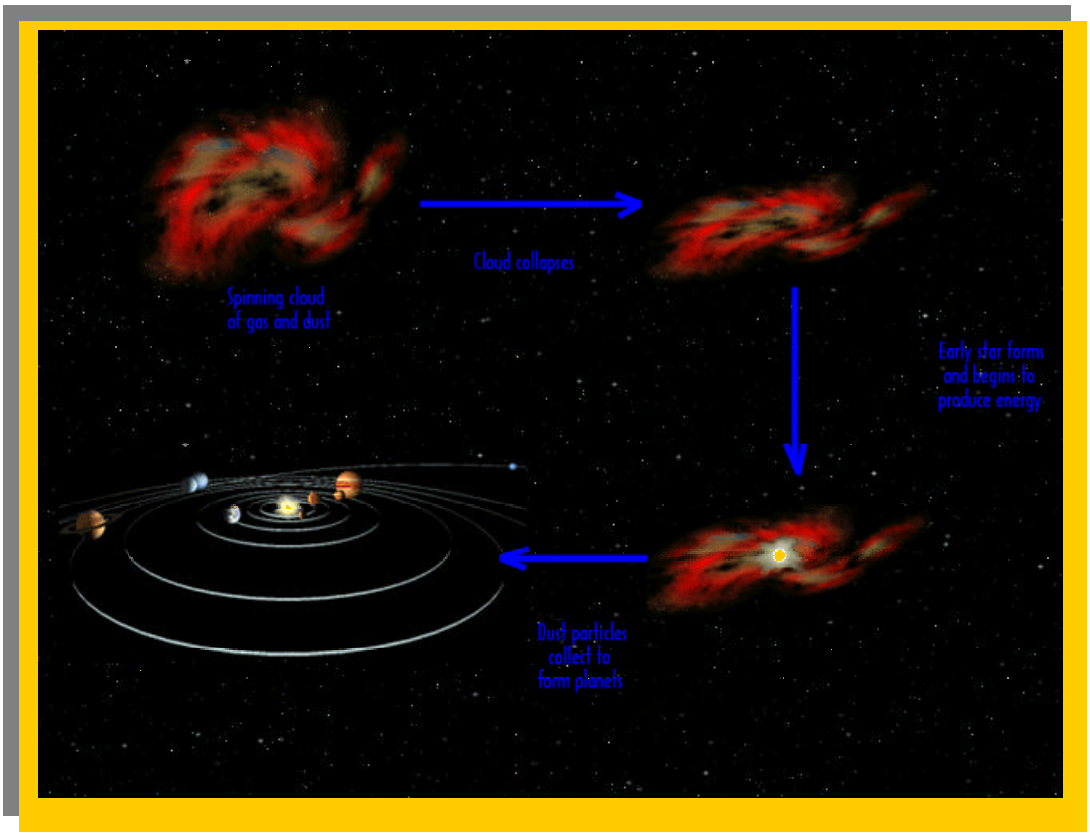
About 1900, astronomer F. R. Moulton and geologist T. C. Chamberlain developed a theory that the planets were formed when a star ten times bigger than the sun passed near the sun, causing bulges from which material broke away. This material was theorized to be the basis for planets.

All of these theories explain some observations of the objects in our solar system and their motions, but all of them have shortcomings. Some predict a sun that spins much faster than our sun does. Others rely on the extremely unlikely chance encounter of massive stars. Some cannot account for the positions of the planets or their roughly circular orbits.

In the middle part of this century, scientists who were developing theories about the origin of the solar system began to have a new source of data: the chemical composition of objects. A Nobel prize-winning chemist, Harold Urey, studied the chemicals that made up meteorites and concluded that these objects contained material that had changed very little from early in the history of the solar system. Most of the evidence that scientists have been gathering for the last 50 years about the sun and the planets is related to the chemical composition of these objects. They believe that very specific chemical information can provide clues to how the objects were formed.

Summary of Current Theory

Using data gathered and ideas developed over the last four centuries, today's scientists have developed the current theory about the beginnings of the sun and planets. This theory explains that our solar system began as a spinning cloud of gas and dust about 4.5 billion years ago. This cloud was mostly made of atoms of hydrogen and helium with very small amounts of heavier elements. Gravity made the cloud contract, causing the atoms to get closer together and become more dense.



As the gas cloud continued to spin and contract, it flattened out and became a disk with a bulge in the middle. Why did it become a disk? It became a disk because it had angular momentum to start with, and as gravitational attraction pulled the cloud together, angular momentum had to be preserved. Gravity caused the material in the center to keep contracting and it began to heat up because potential energy was converted into kinetic energy. Scientists estimate that this process continued for about fifty million years until the center reached a high enough temperature that nuclear reactions began releasing energy and an early sun was formed.

The early sun still had material falling into it. This process caused temperatures near the center of the disk to reach very high levels. After a few thousand years, the sun and the rest of the disk began to cool off. The edge of the disk would have been much cooler than the center of the disk because of its great distance from the sun's heat source. Specific

temperatures present in various parts of the disk caused different materials to become solid, dust-like particles. Rocky dust particles made from metals and other heavier elements formed closer to the sun creating the terrestrial planets from Mercury to Mars. Icy particles containing water and frozen gases such as ammonia and methane formed nearer the outer edge of the solar system where the temperatures were lower.

These first dust grains were fluffy, like snowflakes. As they moved around the sun, they occasionally bumped into each other and stuck together by chemical and physical forces. Eventually, enough of the particles stuck together to form small balls. These balls attracted each other due to gravity and the multi-ball clumps formed together to make large objects. Through continued collisions and gravitational effects, these objects grew into the planets we see today. Scientists estimate that this process took a few hundred thousand years.

Of course, there are many more details to this story that we have not considered. Some of the planets have gaseous atmospheres and some do not. Some have satellites, like our moon, and some do not. Some planets rotate in the same direction that the sun does and some rotate in the opposite direction. Any theory of the beginning of our solar system must explain all of these observations. Many questions remain to be answered before a complete explanation can be made.