FYI Formation of the Solar System

We have observed that our solar system has the following characteristics:

- Planets with various orbital patterns, most of them regular and predictable, but some with unusual features.
- Two major categories of planets—small, rocky terrestrial planets in the inner solar system and large, hydrogen-rich jovian planets in the outer solar system.
- Huge numbers of asteroids and comets in particular regions.

Although we cannot go back in time and observe the formation of our solar system, scientists use the evidence we have to develop a theory of how it was formed. By studying the ratio of the amount of certain types of atoms to the amount of other types, scientists measure how old material is. This is known as radioactive dating. The data gathered can help us form theories about how the solar system came to be.

A widely accepted theory about how the solar system was formed is called the **Nebular theory**. It states that the solar system began as a large, low-density gas cloud of mostly hydrogen and helium, with small traces of heavier elements. About 5 billion years ago, a supernova or another violent event likely occurred near this cloud and triggered the beginning of the cloud's collapse inward upon itself.

Once the cloud started to collapse, the gravitational force between the gas particles furthered the inward motion and the cloud became more and more dense. As the process continued, the gas particles making up the cloud drew closer together. As more particles occupied the same amount of space, the particles became more crowded and began colliding with each other more often. The collisions converted the kinetic energy from the particles' motion to thermal energy, or heat. As the rate of collisions increased during the cloud's collapse, more and more heat was generated, particularly near the core of the collapsing cloud, until eventually the sun formed in the center.

Before its collapse, the cloud was likely rotating in one direction very slowly, maybe even imperceptibly, but it did have some spin — as does virtually everything in our universe. As the cloud collapsed, the rotation increased, just as figure skaters spin faster when they pull their arms in closer to their bodies. The combination of spinning and the gravitational force also caused the cloud to flatten into a disk. The

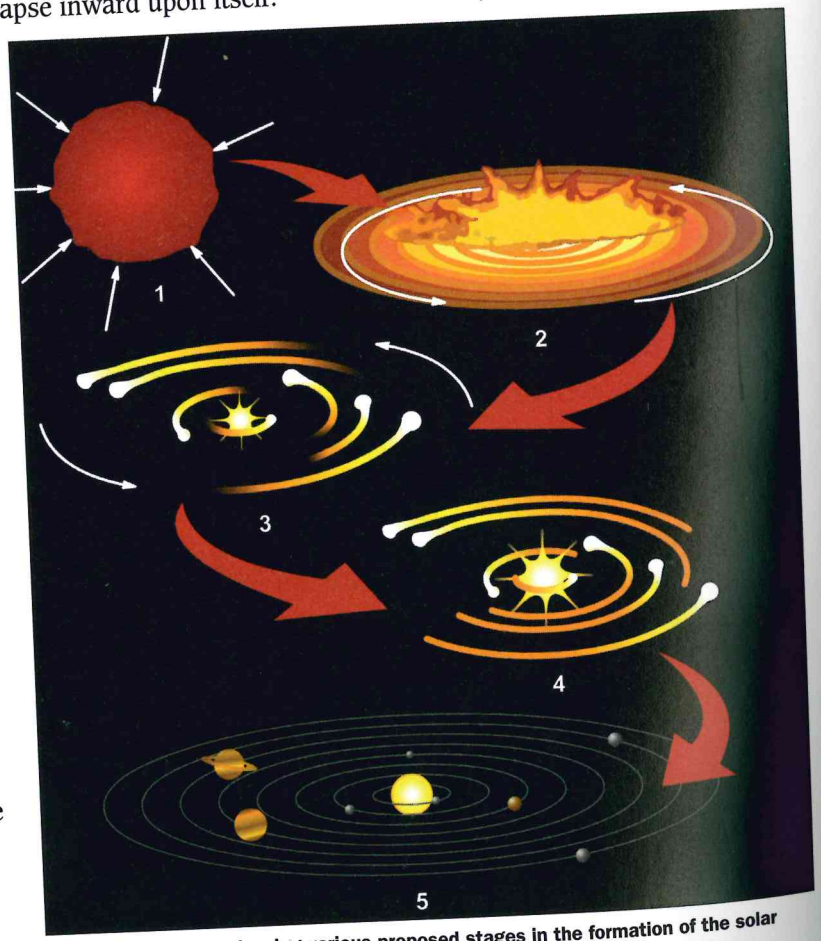

Figure 2-8: Diagram showing various proposed stages in the formation of the solar system

material along the axis of rotation collapsed inward while the material in the plane of the rotation was supported outward by the spinning. The result was a flattened disk of compressed gas with high temperatures and higher-density material near the core and cooler, lower-density gas in the outer regions. Within this disk, material began to form into small clumps of rubble and then into larger bodies that eventually became the planets, moons, asteroids, comets, and debris that now make up our solar system.

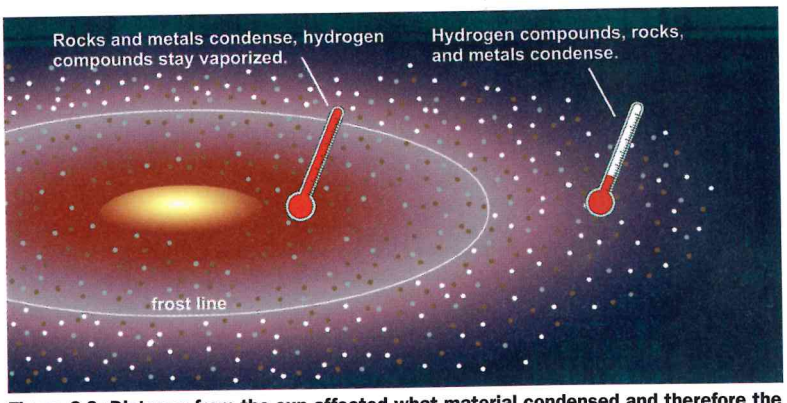

Figure 2-9: Distance from the sun affected what material condensed and therefore the nature of the planets that formed

This model is consistent with observations and data accumulated over time. It accounts for why smaller, rocky planets would form in the inner solar system where temperatures and densities were higher. Metals became the source of materials from which inner planets formed. The model also would support the formation of the outer solar system from ice that became the source of material that constituted the larger, gaseous planets. The Nebular theory explains the regular orbits of most planets and can even be used to clarify unusual orbits like that of Uranus, which is tipped on its side as a result of an impact with a large asteroid long ago.

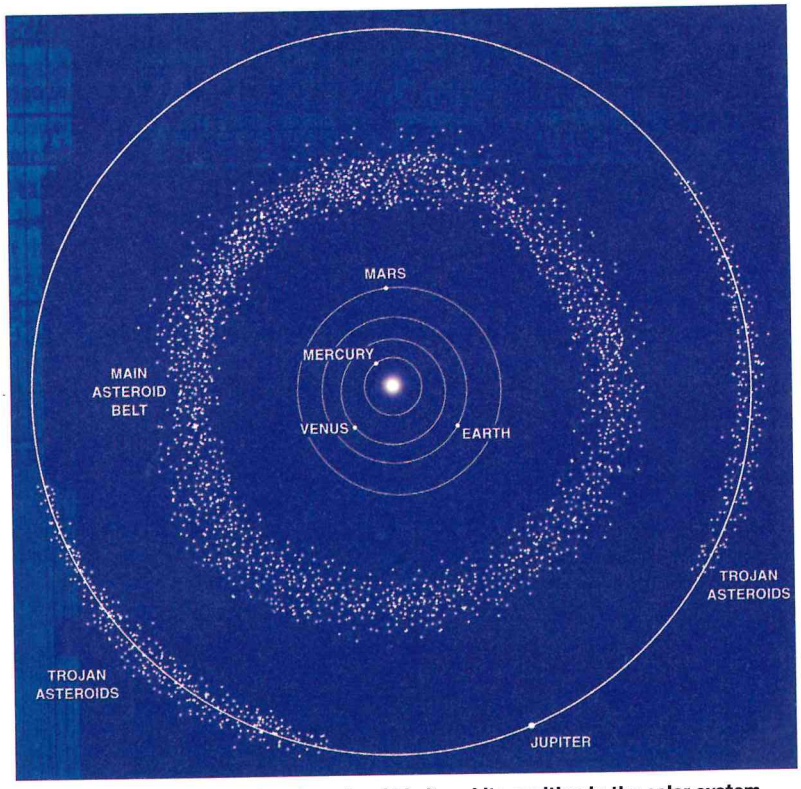

Figure 2-10: Diagram showing the asteroid belt and its position in the solar system

Scientists have used observational evidence to refine the Nebular theory over the past 100 years. More recently, scientists have used computer models to simulate how the particles and other matter should behave under the laws of physics.

Checking In

1. In the Nebular theory of the formation of the solar system, what is the cause of heating that led to the sun's formation?
2. Why is the solar system a flattened disk?