

The Formation of the Solar System

There have been many attempts over the years to explain how the Solar System formed. One early scientific theory involved collisions between celestial objects that left behind debris that eventually came together to form planets. Another theory suggested that the gravitational force of stars close to our Sun pulled matter away from the Sun, which then formed the planets and moons. Today, the theory that astronomers accept is called the Solar Nebula theory, because there is much observational and theoretical evidence to support it.

The Solar Nebula Theory

According to the Solar Nebula theory, the Solar System was formed approximately 5 billion years ago from a massive cloud of gas and dust (the solar nebula) that began to contract. Some astronomers suggest that a shockwave from a nearby supernova may have triggered the collapse of the nebula. Inside this giant nebula, clumps of gas and dust began to form. One of these dense, massive clumps became a protostar, and much of the remaining gas and dust was pulled in by gravity. As the protostar contracted, the temperature and pressure in its core increased. More particles were attracted to the protostar and it continued to contract under its own gravity. The counterclockwise spin of the protostar became amplified, like a figure skater spinning faster as she makes her body more compact (Figure 1). As the cloud collapsed, it spun faster, further increasing the temperature and pressure at its core. Over time, the cloud became hot enough for nuclear fusion to begin. This caused the contracting material to form a disc of gas and dust around the core of the protostar.

Using large telescopes, astronomers have discovered that some nearby young stars have discs that stretch for billions of kilometres into space (Figure 2). This swirling material may be the birth of new planetary systems. These observations that similar processes are occurring elsewhere provides support for the Solar Nebula theory.

READING TIP

Analogies

Analogies are used to help the reader understand an abstract idea by describing something concrete that the reader may already know and be able to visualize. An example of an analogy is “like a figure skater spinning faster.” When summarizing a text, leave out supporting details such as analogies.

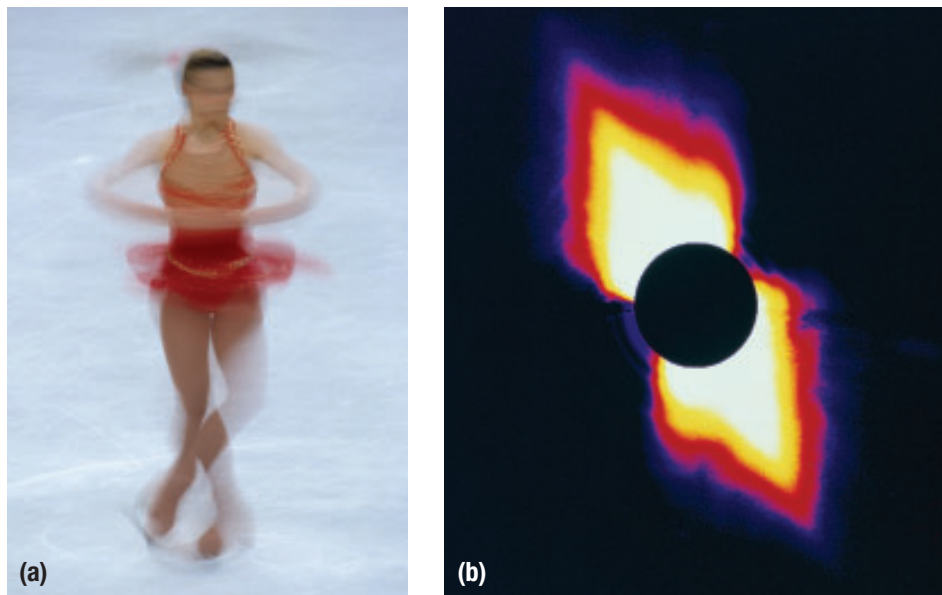


Figure 1 (a) When an ice skater draws in her arms while spinning, her speed increases, similar to what happens in a spinning gas cloud that contracts. (b) This infrared light image of the newly formed star Beta Pictoris reveals a disc of dust around it.

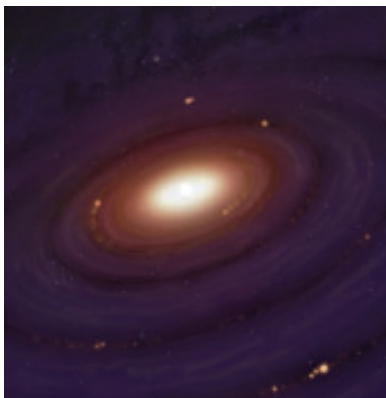


Figure 2 The planets in the Solar System began to form out of the same disc of gases and dust as the Sun. Early in the evolution of our solar system, there may have been millions of small clumps of material, which slowly collided to form the eight planets we see today.

The Sun formed from the disc in the centre of the whirling mass of material. While the Sun was forming, lighter gases (hydrogen and helium) were pushed away from it by intense solar winds. The lighter gases accumulated in the outer solar system, forming the gas giant planets (Figure 2). Denser clumps of solid matter remained behind in the inner solar system. It is from these clumps of solid matter that the terrestrial inner planets—Mercury, Venus, Earth, and Mars—are thought to have formed. Over millions of years, the clumps of matter collided with each other, accumulating more matter and eventually forming planets.

The time it takes the protostar to collapse from a cool, dark gas cloud to a hot, bright star depends on its mass. As you learned in Section 9.4, the more mass a star has, the greater the gravitational force and the faster it contracts. Astronomers estimate that our Sun took about 30 million years to become a newborn star. In comparison, a 15 solar mass star may take less than 200 000 years to contract, while a 0.2 solar mass star can take up to a billion years.

Evidence for the Solar Nebula Theory

The following observational evidence supports the Solar Nebula theory for the formation of planetary systems:

- The theory explains key aspects of the Solar System, including the observation that the planets orbit the Sun in the same direction; the planets are all in the same plane, with the Sun at the centre; most planets rotate in the same direction on their axes; and the terrestrial planets are closer to the Sun than the gas giants are.
- We observe other planetary systems in various stages of this formation process.
- Computer simulations result in planetary systems that look like the systems we see today. 🌍

To see more images and interactive content about the formation of the Solar System,



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UNIT TASK Bookmark

You can apply what you have learned about the Solar Nebula theory to the Unit Task described on page 446.

IN SUMMARY

- According to the Solar Nebula theory, the Solar System formed in a giant disc of spinning gas and dust called the solar nebula.
- Evidence from a variety of sources supports the Solar Nebula theory.

✓ CHECK YOUR LEARNING

1. Create a series of drawings that show how the Solar System formed. Include a written explanation for each drawing. **K/U C**
2. How does observing other planetary systems provide evidence for the Solar Nebula theory? **K/U**
3. What characteristics of our solar system are explained by the Solar Nebula theory? **K/U**
4. According to the Solar Nebula theory, how did the terrestrial planets form? **K/U**
5. What were the main elements that made up the gas giants? **K/U**
6. What caused the nebula that formed our solar system to rotate? What caused the nebula to spin even faster? **K/U**