The diversity of the solar system is a result of its origin and evolution

- The planets, satellites, comets, asteroids, and the Sun itself formed from the same cloud of interstellar gas and dust
- The composition of this cloud was shaped by cosmic processes, including nuclear reactions that took place within stars that died long before our solar system was formed
- Different planets formed in different environments depending on their distance from the Sun and these environmental variations gave rise to the planets and satellites of our present-day solar system

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<th>Table 7.1 Comparing Terrestrial and Jovian Planets</th>
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Guiding Questions

1. What must be included in a viable theory of the origin of the solar system?
2. Why are some elements (like gold) quite rare, while others (like carbon) are more common?
3. How do we know the age of the solar system?
4. How do astronomers think the solar system formed?
5. Did all of the planets form in the same way?
6. Are there planets orbiting other stars? How do astronomers search for other planets?
Any model of solar system origins must explain the present-day Sun and planets

1. The terrestrial planets, which are composed primarily of rocky substances, are relatively small, while the Jovian planets, which are composed primarily of hydrogen and helium, are relatively large
2. All of the planets orbit the Sun in the same direction, and all of their orbits are in nearly the same plane
3. The terrestrial planets orbit close to the Sun, while the Jovian planets orbit far from the Sun
The abundances of the chemical elements are the result of cosmic processes.

- The vast majority of the atoms in the universe are hydrogen and helium atoms produced in the Big Bang.

All the heavier elements were manufactured by stars later, either by thermonuclear fusion reactions deep in their interiors or by the violent explosions that mark the end of massive stars.
The interstellar medium is a tenuous collection of gas and dust that pervades the spaces between the stars. The abundances of radioactive elements reveal the solar system’s age:

- Each type of radioactive nucleus decays at its own characteristic rate, called its half-life, which can be measured in the laboratory.
- This is the key to a technique called radioactive age dating, which is used to determine the ages of rocks.
- The oldest rocks found anywhere in the solar system are meteorites, the bits of meteoroids that survive passing through the Earth’s atmosphere and land on our planet’s surface.
- Radioactive age-dating of meteorites reveals that they are all nearly the same age, about 4.56 billion years old.

The Sun and planets formed from a solar nebula:

- The most successful model of the origin of the solar system is called the nebular hypothesis.
- According to this hypothesis, the solar system formed from a cloud of interstellar material called the solar nebula.
- This occurred 4.56 billion years ago (as determined by radioactive age-dating).
• The chemical composition of the solar nebula, by mass, was 98% hydrogen and helium (elements that formed shortly after the beginning of the universe) and 2% heavier elements (produced much later in the centers of stars, and cast into space when the stars died).

• The nebula flattened into a disk in which all the material orbited the center in the same direction, just as do the present-day planets.

• The heavier elements were in the form of ice and dust particles.

• The Sun formed by gravitational contraction of the center of the nebula. After about 10^8 years, temperatures at the protosun’s center became high enough to ignite nuclear reactions that convert hydrogen into helium, thus forming a true star.
The planets formed by the accretion of planetesimals and the accumulation of gases in the solar nebula.

(a) Within the disk that surrounds the protosun, solid grains collide and clump together into planetesimals.
(a) The computer simulation begins with 100 planetesimals orbiting the Sun.

(b) After 50 million years, the 100 have coalesced into 22 planetesimals...

(c) ...and after a total elapsed time of 451 million years, four planets remain.

(a) A jet from a young star

(b) Winds from young stars
Astronomers have discovered planets orbiting other stars

- Geoff Marcy is using the 10-meter Keck telescope in Hawaii to measure the Doppler effect in stars that wobble because of planets orbiting around them
- So far, he and other teams have found more than 100 extrasolar planets

Finding Extrasolar Planets

- The planets themselves are not visible; their presence is detected by the "wobble" of the stars around which they orbit

Extrasolar Planets

Most of the extrasolar planets discovered to date are quite massive and have orbits that are very different from planets in our solar system
Key Words

- accretion
- astrometric method
- atomic number
- brown dwarf
- center of mass
- chemical differentiation
- chondrule
- condensation temperature
- conservation of angular momentum
- core accretion model
- disk instability model
- extrasolar planet
- half-life
- interstellar medium
- jets
- Kelvin-Helmholtz contraction
- meteorite
- nebulosity
- nebular hypothesis
- Oort cloud
- planetesimal
- protoplanet
- protoplanetary disk (proplyd)
- protosun
- radial velocity method
- radioactive age-dating
- radioactive decay
- solar nebula
- solar wind
- T Tauri wind
- transit
- transit method