

INTEGRATING SPACE SCIENCE**● Our Changing Universe**

If you look at a periodic table, you can see that over 100 different elements exist in the universe. But this has not always been the case. According to the big bang theory, the universe began with an explosion about 10 billion to 20 billion years ago. At that time there were no atoms. Matter existed as isolated protons, neutrons, and electrons. Intense radiation kept these particles from binding together.

After the first minute, the universe cooled to about 10^9 K. At this temperature, nuclear reactions could occur. Soon the protons and neutrons that form the nucleus of an atom began binding together. The temperature was still too high for electrons to bind to these nuclei and form complete atoms.

How the Elements Formed

Nearly 7 million years later, when the temperature of the universe had cooled to 3000 K, electrons began combining with nuclei. Single electrons and protons combined to form hydrogen atoms. Sometimes one or two neutrons were also joined to a single proton and electron, producing the two isotopes of hydrogen—deuterium and tritium. Helium and lithium were also formed in this way.

As a star evolves, it converts hydrogen and helium into heavier elements through nuclear reactions. Such reactions produced all the elements heavier than lithium. Explosions of supernovas —certain stars in very late stages of their evolution —spread these elements into the rest of the universe. These processes continue today, as our universe is still changing.

Your Turn to Think

1. Why didn't protons, neutrons, and electrons bind together immediately after the big bang?
2. What kind of atoms were the first to form?
3. Explain how light elements and heavy elements formed differently.
4. Do you think the distribution of elements 10 billion years from now will be different than it is today? Why or why not?