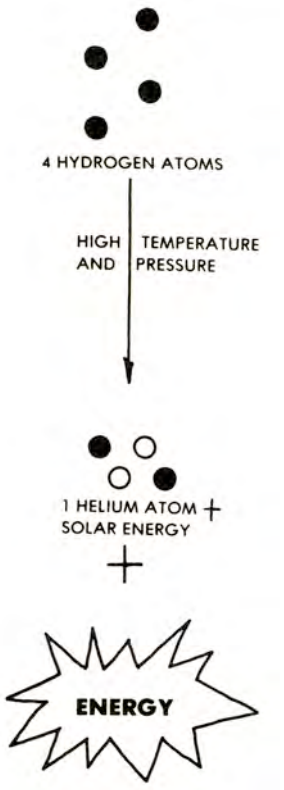

FIGURE 7.1

Hydrogen fusion. Four nuclei of hydrogen atoms are converted into the nucleus of a helium atom. The one nucleus of helium is lighter by roughly 1% than the four nuclei of hydrogen. The mass deficit is converted to energy in accordance with Einstein's formula, $E = mc^2$. Conversion of 1 gram of hydrogen to 0.99 grams of helium releases energy equivalent to approximately 40 tons of TNT. This mass deficit appears as energy, photons of light, which we perceive as sunlight/

There is one major problem with this nuclear reactor in the sky. Like the nuclear power plants on Earth, it also emits harmful radiation. In fact, at one end of its light spectrum, it emits ultraviolet rays that not only can cause cancer, but also can disrupt the genetic mechanisms of life. What protects Earth from these lethal rays?

The Ozone Screen. The shielding barrier that protects the Earth today from the Sun's lethal radiation is called the ozone screen. It is composed of molecules of O_3 (three atoms of oxygen) and forms a highly concentrated invisible layer fifteen miles above the surface of the Earth. It effectively filters out the harmful ultraviolet rays and lets the remaining beneficial light rays pass through the atmosphere to the surface of the Earth (see figure 7.2). The ozone screen has not always been present in the upper atmosphere of the Earth.

When and how was this remarkable shielding barrier erected? Evidence from fossil marine plant life and oxidized mineral components in sedimentary rocks points to the fact that this barrier was erected about 2 billion years ago, after more than one-half of Earth's history had elapsed. The evidence for this date will be explored later in this chapter. For now we need to consider where the oxygen came from that provided the ozone screen and, much later in time, produced the oxygen-rich atmosphere we enjoy today.

THE SOURCE OF OXYGEN

Atmospheric photolysis. One source of oxygen is water. By at least 3.5 billion years ago the Earth contained an abundant supply of water in the oceans and water in vapor form existed in the atmosphere. Although very stable in both its liquid and gaseous forms, a molecule of water (H_2O) can be split into its chemical elements of hydrogen and oxygen. The high-energy ultraviolet radiation from the Sun in the upper atmosphere provides the energy for this reaction.

$$2\,H_2O \xrightarrow[\text{radiation}]{\text{solar}} 2H_2 + O_2$$

The process is called *atmospheric photolysis* and is shown in Figure 7.3. The size or mass of the Earth is very important to the success of this process. The gravitational attraction of the Earth's mass is large enough to retain the heavier element of oxygen while small enough to let the light element of hydrogen escape to outer space. Although