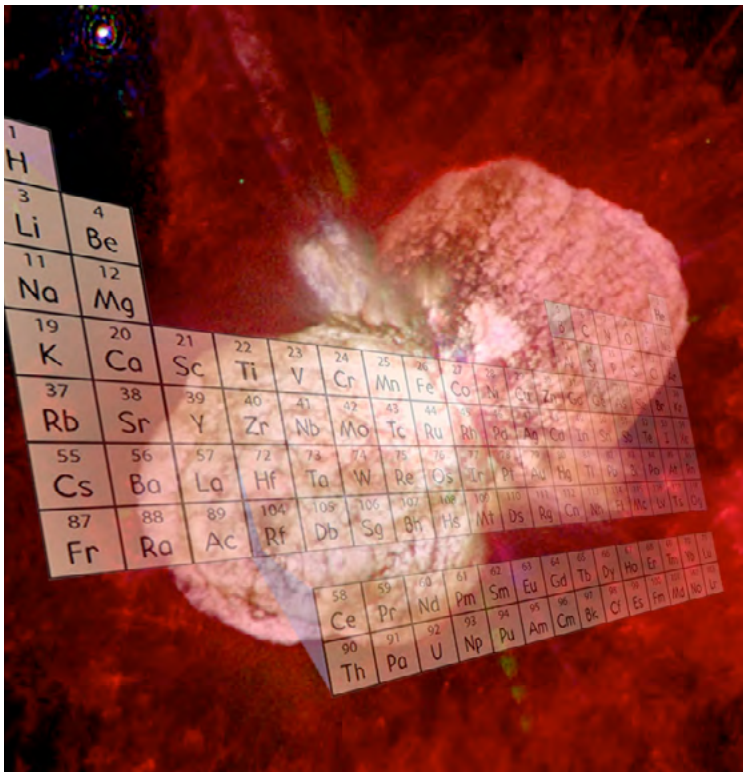


Chapter 2

Particles of Matter

THE MAIN IDEA

Matter is made of particles called atoms

Λ Eta Carinae is a supergiant binary star system within our galaxy some 8000 light years away. Explosive turmoil is already apparent within this system, which is likely to supernova within the next million years. The atoms created within such exploding stars are ejected into the universe where they eventually recombine because of gravity to form new star systems. Amazingly, the atoms here on Earth are the remnants of stellar explosions from long ago. We are literally made of stardust.

Hydrogen atoms are the lightest of all atoms, and they make up more than 90 percent of the atoms in the known universe. Their origin goes back to the birth of the universe. Heavier atoms are produced in stars, which are massive collections of hydrogen pulled together by gravitational forces. The great pressures deep in a star's interior cause hydrogen atoms to fuse together, forming heavier atoms. With the exception of hydrogen, nearly all the atoms that occur naturally on the Earth— including those in your body—are the products of stars. A tiny fraction of these atoms came from our own star, the Sun, but most are from stars that ran their course long before our solar system came into being. You are literally made of stardust.

Atoms are so small that we can't see them directly. How then do we know they exist? How do atoms account for the mass of an object or its temperature? How can we use this idea of tiny particles called atoms to explain the nature of solids, liquids, and gases? We explore these sorts of questions in this chapter.

2.1 The Submicroscopic World is Super Small

From afar, a sand dune appears to be made of a smooth, continuous material. Up close, however, the dune reveals itself to be made of tiny grains of sand. In a similar fashion, everything around us—no matter how smooth it may appear— is made of very small fundamental units you know as atoms. Atoms are so small, however, that a single grain of sand contains on the order of 125 million trillion of them, which is 125,000,000,000,000,000,000. In scientific notation, this huge number is written as 1.25×10^{20}. Interestingly, the number of atoms in a single grain of sand is about a quarter of a million times greater than the number of grains of sand shown in the dune of **Figure 2.1**.

Λ Figure 2.1

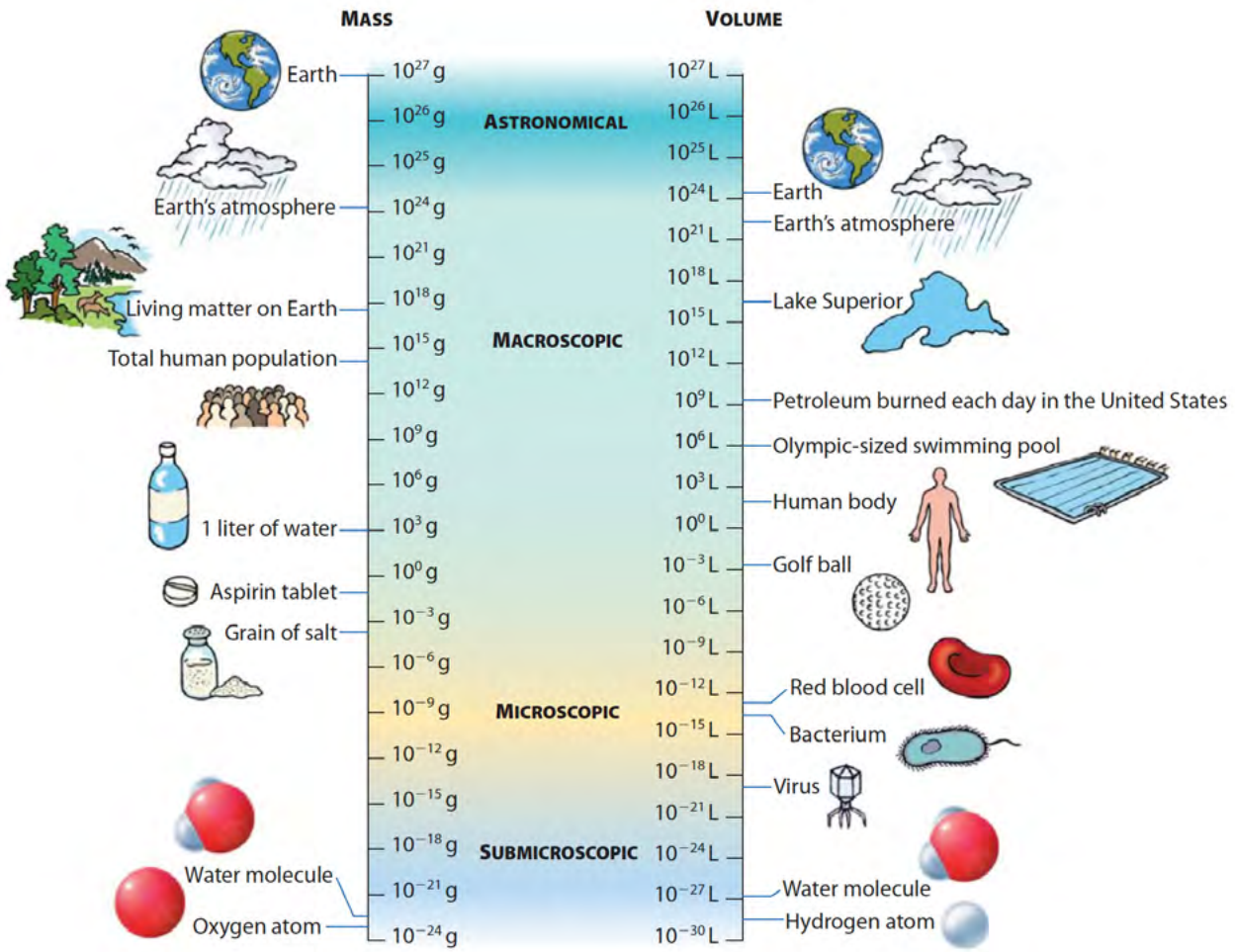
There are far more atoms in a single grain of sand or molecules within a glass of water than there are grains of sand within this towering sand dune.

READING CHECK

Are atoms made of molecules, or are molecules made of atoms?

As small as atoms are, there is much we have learned about them. We know, for example, that there are more than 100 different types of atoms, and we have arranged them in the widely recognized periodic table. Some atoms link together to form larger but still incredibly small units of matter called *molecules*. As shown in **Figure 2.1**, for example, two hydrogen atoms and one oxygen atom link together to form a single molecule of water, commonly recognized as H_2O. Water molecules are so small that an 8-ounce glass of water contains about a trillion trillion of them, which in scientific notation is 1×10^{24}.

Our world can be studied at different levels of magnification, as illustrated in **Figure 2.2**. At the macroscopic level, matter is large enough to be seen, measured, or handled. A handful of sand and a glass of water are macroscopic samples of matter. At the microscopic level, physical structure is so fine that it can be seen only with a microscope. A biological cell is microscopic, as is the detail on a dragonfly's wing. Below the microscopic level is the submicroscopic—the realm of atoms and molecules, and an important focus of chemistry.



Λ Figure 2.2
Ranges of masses (in grams) and volumes (in liters) from atoms to planet Earth. Note that each successive entry differs by 1000 times.