CONCEPT 1

Dalton developed an early atomic theory.

Activity

Explaining Differences in Matter

Your teacher will provide you with three different white solids. Examine the solids using a magnifying glass. How would you describe each solid? How are they different and how are they the same? Add vinegar to a small amount of each and describe what you observe. With your teacher's permission, heat a scoopula-tip's worth of each substance on a piece of foil on a hot plate and describe what you observe. Summarize your observations in a table. Does kinetic molecular theory help you explain the differences you observed?

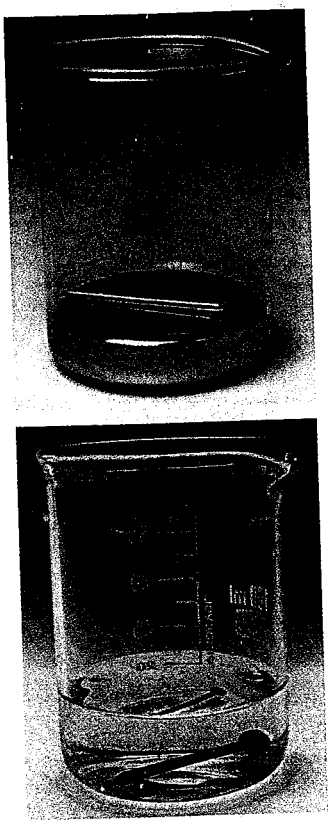

Figure 2.20 The kinetic molecular theory of matter cannot explain why mercury and water are so different.

The kinetic molecular theory of matter is based on the idea that matter is made up of tiny particles in motion. This theory does a good job of explaining why substances can exist in different states, and what happens when matter changes from one state to another. But there are many observations about matter that it cannot explain. For example, it does not explain why water and mercury have such different properties, even though both are liquids. Water is essential to life, while even small amounts of mercury can be deadly. **Figure 2.20** shows the difference in their densities. What causes these differences?

Greek Philosophers and *Atomos*

Various peoples throughout history have used storytelling, philosophical debate, and other modes of communication and analysis to share and explore ideas about the properties and changes of matter. The idea that matter is made up of different kinds of tiny particles is actually thousands of years old. A Greek philosopher named Democritus proposed the idea that matter was made up of tiny particles that exist in empty space. He called these particles *atomos*, which means "uncuttable," because they could not be created, destroyed, or divided any further. Although this idea is similar to the idea of atoms that was developed by scientists in the 19th and 20th centuries, Democritus did not use experiments to support his ideas. As a philosopher, he used only reason and logic.

Philosophies of Matter

A well-respected and very influential philosopher, Aristotle, disagreed with Democritus's ideas, in large part because he did not believe that empty space could exist. Like many disagreements on social media today, the argument was won partly by popularity (**Figure 2.21**). In fact, Aristotle's influence was so great that his denial of the existence of atoms persisted for 2000 years.

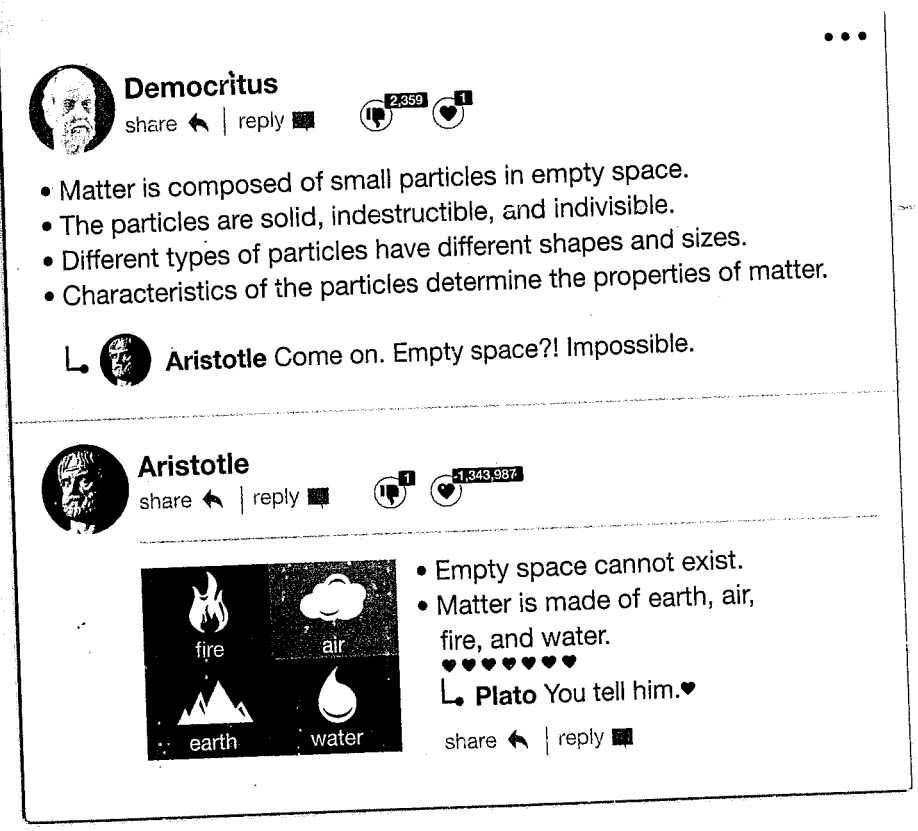

Figure 2.21 If Democritus and Aristotle had been able to use social media thousands of years ago, their posts might have looked like this.

Atomic Theory Begins

Over the centuries, people in different countries read about the idea of *atomos*, and many (including some scientists) agreed with it. However, it was not until the early 1800s in England that the *atomos* idea reappeared with the support of experimental results and analysis. John Dalton (1766–1844), shown in **Figure 2.22**, was a schoolteacher and scholar. Unlike Democritus, he was able to conduct controlled scientific experiments. He could do this because the general methods of scientific inquiry had already been developed. He also had access to instruments such as glassware and accurate balances that enabled him to measure changes in matter.

Figure 2.22 John Dalton

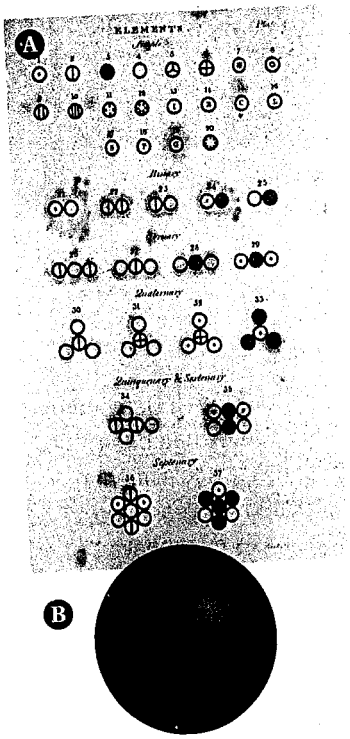

Figure 2.23 Ⓐ This page from Dalton's book, *A New System of Chemical Philosophy*, shows the symbols he used to represent atoms of different elements. Ⓑ According to Dalton's theory, atoms were solid, indestructible spheres.

Dalton's Theory of the Atom

Dalton's experiments allowed him to develop, refine, and support a hypothesis about matter. Studying many chemical reactions, he made careful observations and measurements that led him to propose in 1803 what has now come to be known as *Dalton's atomic theory*. He published his ideas in a book, a page from which is shown in **Figure 2.23**. The key points of his theory are described below.

Dalton's Atomic Theory

- All matter is made of extremely small particles called atoms.
- Atoms cannot be created, destroyed, or divided.
- All atoms of the same element are identical in size, mass, and chemical properties. Atoms of a specific element are different from those of another element.
- Different atoms combine in simple whole-number ratios to form compounds. In a chemical reaction, atoms are separated, combined, or rearranged.

Dalton's Theory Was Just the Beginning

Dalton's theory explained many existing observations about matter and its interactions. One example is the observation that mass is conserved in a chemical reaction—Lavoisier's law of conservation of mass. Since atoms were not created, destroyed, or divided in chemical reactions, it made sense that the mass of reactants and products in a chemical reaction did not change.

As scientists continued to study matter and to develop new technologies to allow them to perform different kinds of experiments, it became clear that Dalton's atomic theory could not explain all of the observations that scientists were making. Scientific theories are always subject to being changed or discarded if they prove insufficient to explain new observations. Dalton's atomic theory was just the beginning.

Before you leave this page . . .

1. Compare and contrast Democritus's *atomos* with Dalton's atomic theory.
2. How is a philosophical idea different from a scientific theory?