3.2.1: Basic Atomic Theory

Learning Objectives

- Give a short history of the concept of the atom.
- Describe the contributions of Democritus and Dalton to atomic theory.
- Summarize Dalton's atomic theory and explain its historical development.

Democritus and the Greek Philosophers

Around 2,500 years ago, early Greek philosophers believed the entire universe was a single, huge, entity. In other words, "everything was one." They believed that all objects, all matter, and all substances were connected as a single, big, unchangeable "thing." Democritus was one of the first people to propose the term "atoms." As an alternative to the beliefs of the Greek philosophers, he suggested that **atomos**, or atomon - tiny, indivisible, solid objects - make up all matter in the universe.

Figure 3.2.1.1: Democritus by Hendrick ter Brugghen, 1628. Democritus was known as the "laughing philosopher." It was a good thing he liked to laugh, because most other philosophers were laughing at his theories.

Early Greek philosophers tried to understand the nature of the world through reason and logic, not through experiment and observation. As a result, they had some very interesting ideas, but they felt no need to justify their ideas based on life experiences. In many ways, you can think of the Greek philosophers as being "all thought and no action." It's truly amazing how much they achieved using their minds, but because they never performed any experiments, they missed or rejected many discoveries that they could have made otherwise. Greek philosophers dismissed Democritus' theory entirely. Unfortunately, it took over two millennia before the theory of atomos (or "atoms," as they're known today) was fully accepted.

Video 3.2.1.1: Since ancient Greek times, philosophers and scientists have tried to figure out what an atom looks like. For a couple thousand years, humans could only speculate on the structure and other properties of the smallest unit of matter. It wasn't until the 1980s that chemists could see individual atoms. Bestselling author Sam Kean takes us through the nearly 2,400-year quest to see the atom in a new episode of the "Legends of Chemistry" series.

While it must be assumed that many more scientists, philosophers, and others studied composition of matter after Democritus, a major leap forward in our understanding of the composition of matter took place in the 1800's with the work of the British

scientists John Dalton. He started teaching school at age twelve, and was primarily known as a teacher. In his twenties, he moved to the growing city of Manchester, where he was able to pursue some scientific studies. His work in several areas of science brought him a number of honors. When he died, over 40,000 people in Manchester marched at his funeral.

Figure 3.2.1.3 British physicist and chemist John Dalton (1766-1844). Unlike the greek philosophers, John Dalton believed in both logical thinking and experimentation.

Dalton studied the weights of various elements and compounds. He noticed that matter always combined in fixed ratios based on weight, or volume in the case of gases. Chemical compounds always contain the same proportion of elements by mass, regardless of amount, which provided further support for Proust's law of definite proportions. Dalton also observed that there could be more than one combination of two elements.

From his experiments and observations, as well as the work from peers of his time, Dalton proposed a new theory of the atom (1803). This later became known as Dalton's **atomic theory**. The published (1808) tenets of this theory were as follows:

- All matter is composed of extremely small particles called atoms.
- Atoms of a given element are identical in size, mass, and other properties. Atoms of different elements differ in size, mass, and other properties.
- Atoms cannot be subdivided, created, or destroyed.
- Atoms of different elements can combine in simple whole number ratios to form chemical compounds.
- In chemical reactions, atoms are combined, separated, or rearranged.
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Dalton's Eyes

As a scientist, John Dalton was also interested in colorblindness. Both he and his brother suffered from red/green colorblindness. At this time (1794), no other scientist had explored this medical issue. He devised theories (although not correct) as to why he could not differentiate between red and green. In addition, he named this medical condition "Daltonism." Upon his death (1844), he donated his eyes to a medical research facility in Manchester, England. Today, his eyes are still on display at the Museum of Science and Industry in Manchester, England.

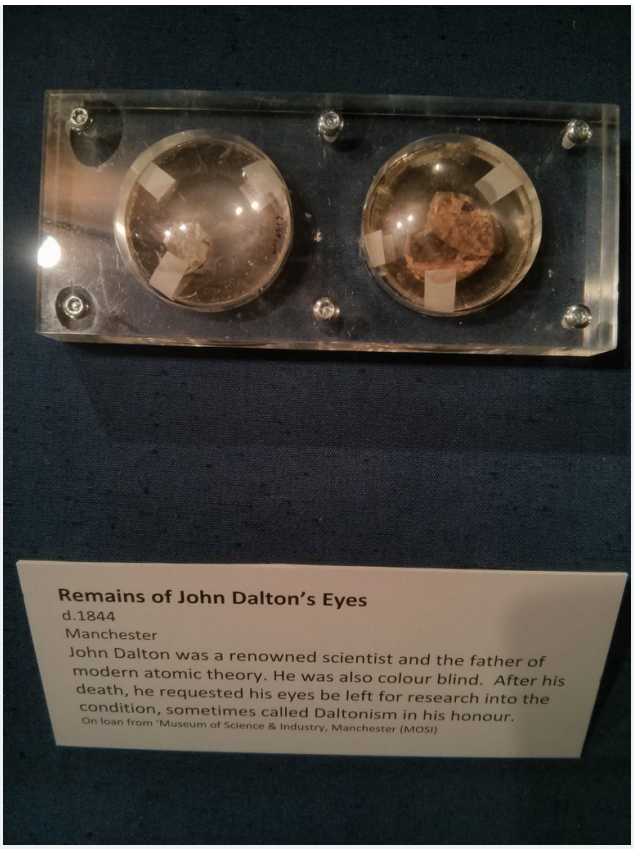

Figure 3.2.1.3: Image taken from: https://c1.staticflickr.com/3/2823/1...37dd23af_b.jpg

The evidence for atoms is so great that few doubt their existence. In fact, individual atoms are now routinely observed with state-of-the art technologies. Moreover, atoms can even be used for making pretty images or as IBM research demonstrate in Video 3.2.1.2 control of individual atoms can be use used create animations. A Boy and His Atom is a 2012 stop-motion animated short film released by IBM Research. The movie tells the story of a boy and a wayward atom who meet and become friends. It depicts a boy playing with an atom that takes various forms. It was made by moving carbon monoxide molecules viewed with a scanning tunneling microscope, a device that magnifies them 100 million times. These molecules were moved to create images, which were then saved as individual frames to make the film.

Video 3.2.1.2: A Boy And His Atom: The World's Smallest Movie

Dalton was not completely correct

Dalton's atomic theory has been largely accepted by the scientific community, with the exception of three changes. We know now that:

1. An atom is composed of smaller particles (electrons, protons, and neutrons).
2. All atoms of an element are not identical. The existence of isotopes illustrates this phenomena.
3. Through the use of nuclear reactions, atoms of one element can be changed into atoms of another element.

The first two will be be discussed later in this chapter, while the last requires introducing "nuclear chemistry" and will be discussed in a different chapter.

References

1. https://pubs.acs.org/subscribe/archi...3chemchron.pdf

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