

1.3: Some History of Atomic Theory

Modern atomic theories have their roots in the thinking of ancient peoples, in particular ancient Greek philosophers who lived over 2500 years ago. At that time the cultural, economic, and intellectual climate in Ancient Greece permitted a huge surge of philosophical and scientific development, the so-called Greek miracle. While most people of that time believed that the world was ruled by a cohort of semi-rational gods a series of philosophers, beginning with Thales of Miletus (died 546 bce),^[2] were intent on developing rational and non-supernatural explanations for observable phenomena such as what we are made of and where we came from. As we know now, they could not possibly have understood the underlying nature of matter because they lacked the tools to observe and experiment at the atomic scale. However, this does not mean that their ideas were simple idle speculation. The ideas they produced, although not scientific as we understand the term today, contained remarkable insights – some of which appear to be true.

This era gave birth to a new way to approach and explore natural phenomena in order to gain understanding of their complexity and diversity in terms of natural explanations. It is worth considering that such a rational approach did not necessarily have to be productive; it could be that the world is really a totally irrational, erratic, and non-mechanistic place, constantly manipulated by supernatural forces; but given that science can not address these kinds of ideas, let us just leave them to fantasy authors. The assumption that the world is ruled solely by natural forces has been remarkably productive; that is, consistent with the way the world appears to behave when we look at it dispassionately.

The ancient Greeks developed complex ideas about the nature of the universe and the matter from which it was composed, some of which were accepted for a long time. However, in response to more careful observation and experimental analysis, these ideas were eventually superseded by more evidence-based theories. In large part this involved a process by which people took old ideas seriously, and tried to explain and manipulate the world based on them. When their observations and manipulations failed to produce the expected or desired outcomes, such as turning base metals into gold, curing diseases, or evading death altogether, they were more or less forced to revise their ideas, often abandoning older ideas for newer ideas that seemed to work.

The development of atomic theories is intertwined with ideas about the fundamental nature of matter, not to mention the origin of the universe and its evolution. Most Greek philosophers thought that matter was composed of some set of basic elements, for example, the familiar earth, air, fire, and water. Some philosophers proposed the presence of a fifth element, known as quintessence or aether.^[3] These clearly inadequate ideas persist today as part of astrology and the signs of the Zodiac—a poor tribute to some very serious thinkers.

The original elements, that is, earth, air, fire, and water, were thought to be composed of tiny indestructible particles, called atoms by Leucippus and Democritus (who lived around 460 bce).^[4] The atoms of different elements were assumed to be of different sizes and shapes, and their shapes directly gave rise to the properties of the particular element. For example, the atoms of earth were thought to be cubic; their close packing made earth solid and difficult to move. The idea that the structure of atoms determines the observable properties of the material is one that we will return to, in a somewhat different form, time and again. Although the particulars were not correct, the basic idea turns out to be sound.

In addition to their shapes, atoms were also thought to be in constant motion, based on watching the movement of dust motes in sunlight, with nothing, or a void, between them.^[5] Many centuries later Einstein's analysis of this type of motion, known as Brownian motion, provided strong experimental support for the physical reality of molecules, larger structures composed of atoms, and the relationship between molecular movement, temperature, and energy, which we will consider later on in this chapter.

All in all the combined notions of the Greek philosophers provided a self-consistent and satisfactory basis for an explanation of the behavior of matter, as far as they could tell. The trap here is one that is very easy to fall into, namely that a satisfying explanation for a phenomenon is not necessarily true. Even if it seems to be self-consistent, useful, or comforting, an explanation is not scientific unless it makes testable, quantitative predictions. For example, it was thought that different materials were made up of different proportions of the four ancient elements. Bones were made of water, earth, and fire in the proportions 1:1:2, whereas flesh was composed of these elements in a ratio of 2:1:1.^[6] While these ideas are now considered strange, they contain a foreshadowing of the “law of multiple proportions”, which would come some 2300 years later and which we will deal with later in this chapter. Some philosophers even thought that the soul was composed of atoms or that atoms themselves had a form of consciousness, two ideas that seem quite foreign to (most of) us today.

Such ideas about atoms and elements provided logical and rational, that is, non-supernatural explanations for many of the properties of matter. But the Greeks were not the only ancient people to come up with explanations for the nature of matter and its

behavior. In fact, it is thought that the root of the words alchemy and chemistry is the ancient Greek word Khem, the Greek name for Egypt, where alchemy and chemistry are thought to have originated.^[7] Similar theories were being developed in India at about the same time, although it is the Greek ideas about atoms that were preserved and used by the people who eventually developed our modern atomic theories. With the passage of time ancient ideas about atoms and matter were kept alive by historians and chroniclers, in particular scholars in the Arab world. During the European Dark Ages and into medieval times, there were a few scattered revivals of ideas about atoms, but it was not until the Renaissance that the cultural and intellectual climate once again allowed the relatively free flowering of ideas. This included speculation on the nature of matter, atoms, and life. Experimental studies based on these ideas led to their revision and the eventual appearance of science, as we now know it. It is also worth remembering that this relative explosion of new ideas was occasionally and sometimes vigorously opposed by religious institutions, leading to torture, confinement, and executions.^[8]

? Questions:

Questions to Answer:

- What properties ascribed by the Greeks to atoms do we still consider to be valid?

Questions to Ponder:

- If earth had atoms that were cubic, what shape would you ascribe to the elements air, water, and fire?

Questions for Later

- If atoms are in constant motion, what do you think keeps them moving?

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