

## 1.4: Early Ideas about the Building Blocks of Matter

The ancient Greek [philosophers](#) did a lot of discussing, with part of their conversations concerning the physical world and its composition. There were different opinions about what made up matter. Some felt one thing was true while others believed another set of ideas. Since these scholars did not have laboratories and had not developed the idea of the experiment, they were left to debate. Whoever could offer the best argument was considered right. However, often the best argument had little to do with reality. One of their ongoing debates had to do with sand. The question posed was: into how small of pieces can you divide a grain of sand? The prevailing thought at the time, pushed by Aristotle, was that the grain of sand could be divided indefinitely, that you could always get a smaller particle by dividing a larger one and there was no limit to how small the resulting particle could be.

Since Aristotle was such an influential philosopher, very few people disagreed with him. However, there were some philosophers who believed that there was a limit to how small a grain of sand could be divided. One of these philosophers was Democritus (~460 - ~370 B.C.E.), often referred to as the "laughing philosopher" because of his emphasis on cheerfulness (Figure 1.4.1). He suggested that **atomos**, or atomon - tiny, indivisible, solid objects - make up all matter in the universe.



Figure 1.4.1: (left) 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. (right): British physicist and chemist John Dalton (1766-1844). Unlike the Greek philosophers, John Dalton believed in both logical thinking and experimentation.

Democritus then reasoned that changes occur when the many atomos in an object were reconnected or recombined in different ways. Democritus even extended this theory, suggesting that there were different varieties of atomos with different shapes, sizes, and masses. He thought, however, that shape, size, and mass were the only properties differentiating the different types of atomos. According to Democritus, other characteristics, like color and taste, did not reflect properties of the atomos themselves, but rather, resulted from the different ways in which the atomos were combined and connected to one another.

Aristotle disagreed with Democritus and offered his own idea of the composition of matter. According to Aristotle, everything was composed of four elements: earth, air, fire, and water. The theory of Democritus explained things better, but Aristotle was more influential, so his ideas prevailed. We had to wait almost two thousand years before scientists came around to seeing the atom as Democritus did.

It is very interesting that Democritus had the basic idea of atoms, even though he had no experimental evidence to support his thinking. We now know more about how atoms hold together in "clusters" (compounds), but the basic concept existed over two thousand years ago. We also know that atoms can be further subdivided, but there is still a lower limit to how small we can break up that grain of sand.

### Greeks Philosophers were not Scientists

Greek philosophers were "all thought and no action" and did not feel the need to test their theories with reality via experiments and the scientific method. Dalton's atomic theory were based on experimentation and testing ideas against reality.

### Summary

The early Greek philosophers tried to understand the nature of the world through reason and logic, but 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 a lot of 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 a lot of discoveries that

they could have made otherwise. Greek philosophers dismissed Democritus' theory entirely. Sadly, it took over two millennia before the theory of atomos (or "atoms," as they're known today) was fully appreciated.

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