

From “An Endless Searching for Substance”
(pp. 13-15 in *Matter* by Ralph E. Lapp and the Editors of LIFE, Time Inc., 1965)

The first people to stop taking matter for granted were the Greeks. Hungry for knowledge, irrepressibly curious, they journeyed far afield, visiting Near Eastern centers of learning and reaping a rich harvest, including much information about the practical chemistry routinely employed in that part of the world. Then, through deduction and debate—they were probably the greatest talkers in history—the Greeks proceeded to work up an imposing body of theory about matter.

What were three ways the Greeks developed their ideas about matter? _____

The first to weigh in with his ideas was the philosopher Thales of Miletus. Wondering about the nature of matter and its properties, he sought for an answer that was all-embracing. His final judgement was that the basic stuff of the universe was water. Thales had good reason to think so. Of all things within his grasp and vision, water was the most changeable—liquid in its natural state, becoming a solid as ice, or turning into vapor on a hot summer day.

Anaximenes, a contemporary of Thales, developed another theory simply by blowing air from his mouth onto his hand. If he blew with his mouth wide open, the air felt hot; if he blew with his mouth almost closed, the air felt cool. He concluded that heat was produced by the swift escape of air, and cooling by its constriction behind tight lips. Anaximenes concluded that air—imbuing all nature with its ever-changing characteristics, permeating everything—was the basic stuff of the universe.

In the Fifth Century B.C., a Greek named Heraclitus put forth the idea that fire was the basic constituent of matter. Fire was forever changing; a flame grew or flickered or died down, yet it was always fire.

What three things did early philosophers believe the universe was made of? _____

To water, air, and fire, Empedocles, a Greek from the Sicilian colonies, added earth, combining all into a theory of the four “elements,” or roots. The Empedoclean theory made a certain amount of sense. Earth, water, and air do represent the three common states of matter—solid, liquid, and gas—and fire is indeed energy, the agency through which matter changes from one form to another.

What were the four ancient elements? _____

Why were the four elements considered a theory and not a law? _____

Of all the Greek ideas of matter, however, the most arresting, in retrospect, was propounded by a philosopher named Leucippus, and later by his student Democritus. Matter, they said, was simply a concentration of tiny particles, or “atoms,” so small that they could not be cut any further (the Greek word *atoma* means indivisible). Democritus held that atoms were in constant motion, that they combined with others in various ways, and that they differed from each other only in shape and in arrangement. Uncanny as it now seems, this excellent atomic theory was little more than a wild speculation, like

dozens of others put forth any afternoon in the Athenian forum. Yet Democritus was headed in the right direction, even though he would not have dared to dream that his indivisible atom would some day be shattered into smaller bits.

What did Democritus and Leucippus believe matter was made of? _____

What does it mean for something to be indivisible? _____

Democritus was destined not only to be 24 centuries ahead of his time but also deprived of contemporary acclaim. When Aristotle came along shortly thereafter to become the leading man of the hour, he not only failed to endorse the theory but bitterly attacked it—thereby, some historians feel, thwarting the development of modern atomic theory for an inexcusable span. Instead Aristotle conferred his favor upon the Empedoclean theory and, indeed, embellished it. In the Aristotelian version, the basis of the material world was a primitive matter which, however, existed only potentially until given form. Form gave rise to the “four elements,” distinguished from one another by their qualities: hot, cold, dry and wet. None of the four elements, Aristotle theorized, was unchangeable; one might pass into another through the medium of the quality they possessed in common. Only the form changed; the prime matter composing the elements never changed.

How many years ahead of his time was Democritus? _____

Why was Aristotle’s theory considered better than Democritus’s at the time? _____

According to Aristotle, how could the four elements be told apart? _____

When darkness descended upon Greek culture, it was this Aristotelian concept which formed the philosophical bases of the next great advance in the science of matter—alchemy. From Aristotle’s assumptions, the alchemists deduced their own postulates about the unity of matter and the existence of a transmuting agent, called the Philosopher’s Stone, which—if produced—could turn base metals into gold and also become man’s perfect medicine, the *elixir vitae*, or elixir of life.

Where and when the strange and often suspect art of alchemy arose is not known. Its practitioners thrived in both East and West. One Wei Po Yang wrote the first Chinese tract on the preparation of an elixir which he labeled the “pill of immortality.” The first Western alchemists were Alexandrian Greeks of about the same era. The word alchemy itself is derived from the Arabic, *alkimia*, in which *al* is the definite article and *kimia* is believed to come either from the Greek, *chyma*, meaning to fuse or cast a metal, or from *chem*, “the dark land”—the ancient Egyptians’ name for their country.

What did alchemists believe the Philosopher’s Stone could do? _____

Name four cultures that were involved in alchemy: _____