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Professor Asimov has to his credit an impressive list of over sixty books in all. Among them are: *The Intelligent Man's Guide to Science, The Chemicals of Life, Life and Energy, The Genetic Code,* and *Inside the Atom.*

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A SHORT HISTORY OF CHEMISTRY

# *A Short History of* CHEMISTRY

BY

ISAAC ASIMOV




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*To*

*Catherine and Sprague de Camp*

*who in twenty-five years have not aged a day*

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# A SHORT HISTORY OF CHEMISTRY

## Chapter 1

# THE ANCIENTS

### *Fire and Stone*

When early forms of man first began to use tools, they took nature as they found it. The thighbone of a large animal made a handy club; so did the branch torn from a tree. A rock was a convenient missile.

As millennia passed, men learned to shape rocks to give them cutting edges, or a gripping end. They learned to fit rocks into wooden handles, shaped for the purpose. Nevertheless, rock remained rock and wood remained wood.

However, there were times when the nature of substances did change. Lightning might set fire to a forest and the blackened or powdery ash was nothing like the wood that had existed before. Again, meat might decay and smell bad; fruit juice might grow sour on standing, or become oddly stimulating to drink.

It is such changes in the nature of substances (accompanied, as mankind eventually discovered, by fundamental changes in structure) that form the subject matter of the science we now call *chemistry*. Fundamental alteration in the nature and structure of a substance is a *chemical change*.

The opportunity to bring about chemical change deliberately for his own benefit arrived when man had mastered the art of starting and maintaining a

fire. (This in historical terms was the "discovery of fire.") That art achieved, man became a practicing chemist, for he had to devise methods for causing wood, or other combustible material, to combine with air at a rate fast enough to produce sensible heat and light, as well as ashes, smoke, and vapors. Thus, wood had to be dried, some of it had to be powdered to tinder, temperatures had to be raised to the ignition point by friction or otherwise, and so on.

The heat produced by fire could be used to bring about further chemical changes. Food was cooked and its color, texture, and taste thereby altered. Clay could be baked into bricks and pottery. Eventually, ceramics, glazes, even forms of glass itself, could be formed.

The first materials used by man were those universals he found all about: wood, bone, hide, rock. Of these, rock is most durable and it is early man's stone implements that remain today as clearest reminders of that long-gone time. So we speak of the *Stone Age.*

Mankind was still in the Stone Age when, about 8000 B.C., a revolutionary change in food production was introduced in certain regions of what is now known as the Middle East. Previously, man had hunted food as any other animal might. Now he learned to domesticate animals and care for them as a reliable food supply. Even more important, he learned to cultivate plants. With animal husbandry and agriculture developed, a more stable and ample food supply was available, and the population increased. Agriculture required men to remain in one place, moreover, so that permanent habitations were built and cities developed. That evolution marks, literally, the beginning of civilization, for the word comes from the Latin term for "city."

For the first couple of thousands of years of this

earliest civilization, stone remained the characteristic tool material, although new techniques for handling it were devised. This *New Stone Age,* or *Neolithic Period,* was characterized by the careful polishing of stone. Pottery, too, reached an advanced stage of development. Slowly, the advances of the Neolithic period spread out from its Middle Eastern center. By 4000 B.C., for instance, the characteristics of the culture had appeared in western Europe. By then, however, the time was ripe for additional changes in the Middle East—in Egypt and in Sumeria (the region now occupied by the modern nation of Iraq).

Mankind began to learn to make use of comparatively rare materials. For the sake of the useful properties of the new materials, men learned to undergo all the inconveniences of tedious searching and processing. We call these materials *metals,* a word which in itself expresses this early change, for it is derived, possibly, from a Greek word meaning "to search for."

## *Metals*

The first metals must have been found existing in the form of nuggets. They must have been pieces of *copper* or *gold,* for these are among the few metals occasionally found free in nature. The reddish color of copper or the yellowish color of gold must have caught the eye; and the metallic luster, which is so much more startling and beautiful than the flat, nondescript coloring of most stones, must then have held it. Undoubtedly the first use of metals was as ornaments, in whatever form the pieces had been found, much as colored pebbles or pearly sea shells might have so been used.

The advantage of metals over other pretty bits of

matter lay in this, however: Copper and gold are *malleable;* that is, they can be beaten flat without breaking. (Stone, so treated, would powder to dust; wood or bone would split and splinter.) This property undoubtedly was discovered by accident, but it could not have been long after the discovery when man's sense of artistry caused him to beat metal nuggets into intricate shapes that would enhance their beauty.

Workers in copper were bound to notice that this metal could easily be beaten into a sharper edge than could be produced on a tool of rock, and that some copper edges would hold their sharpness under conditions that would blunt a rock edge. Furthermore, a copper edge, once blunted, could be sharpened again more easily than a stone edge could. Only the rarity of copper prevented its widespread use for tools as well as ornament.

Copper became less rare, however, when it was discovered that it need not be found as copper. It could be manufactured out of stone. How this discovery was made, or where, or when, is not known exactly and may never be known.

We might guess that the discovery could have been made in a wood fire started in a bed of rocks that included some bluish ones. In the ashes, afterward, globules of gleaming copper might have been found. Perhaps this happened many times before it eventually dawned on someone that if the proper blue rocks were found, heating them in a wood fire would produce copper every time. The final discovery of this fact may have taken place about 4000 B.C. and it may have happened in the Sinai peninsula, just east of Egypt, or in the mountainous area east of Sumeria, in modern Iran. Perhaps it happened independently in both places.

In any case, copper became common enough to

be used for tools, at least in the advanced centers of civilization. A frying pan of copper found in an Egyptian tomb has been dated as 3200 B.C. By 3000 B.C. a particularly hard variety of copper was discovered. It was produced (by accident at first, no doubt) by the simultaneous heating of copper ores and tin ores. (See Figure 1.) The copper-tin *alloy* (the term used for a mixture of metals) is called *bronze,* and by 2000 B.C. bronze was common enough to be used for weapons and armor. Egyptian bronze tools have been found in the tomb of the Pharaoh Iteti, who reigned about 3000 B.C.

The most famous event of the *Bronze Age* was the Trojan War, in which bronze-clad, bronze-shielded warriors flung bronze-tipped spears at each other. An army without metal weapons couldn't possibly stand against the bronze warriors, and the metalworker of that day had something of the prestige of the nuclear physicist of today. The smith was a mighty man indeed, and was even accorded a place among the gods. Hephaestus, the lame god of the forge, was the divine smith of Greek mythology. And even today, it is no accident, that "Smith" or its equivalent is the most common name among the European peoples.

Lightning struck twice. The men of the Bronze Age knew of a metal even harder than bronze. This was *iron.* Unfortunately, it was too rare and precious to use, wholesale, for armor. At least, it seemed rare, for the only samples found in early times were bits of shattered meteorites, which are not common. Nor did there seem to be any way of obtaining iron out of rock.

The trouble was that iron was more firmly bound into its ore form than copper was. It required more intense heat to smelt iron than to smelt copper. A wood fire was insufficient for the purpose. The hot-

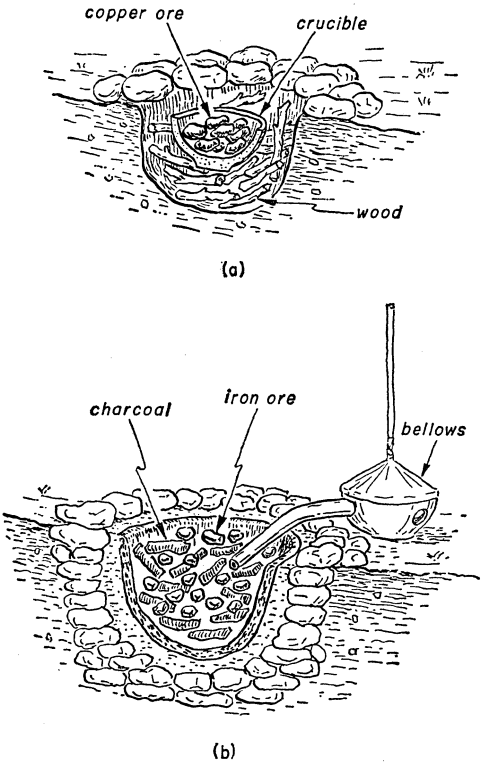


FIG. 1. Ancient smelters were designed to attain temperatures appropriate for reduction of different ores. In copper furnace (a) ore was melted in crucible over wood fire. Reduction of iron ore (b) required greater heat, obtained by lining furnace with charcoal and supplying oxygen with bellows.

ter charcoal fire was required, and even then only under conditions of good ventilation.

The secret of smelting iron was finally stumbled upon in eastern Asia Minor, perhaps as early as 1500 B.C. The Hittites, a people who built a great