THE BIRTH OF CHEMISTRY

IV.

Iron, lead, quicksilver.—Colours used for painting and dyeing.—Glass.—Certain minerals known to the ancients.—Miscellaneous processes.—Association of the seven metals with the seven greater heavenly bodies.—Consequent introduction of symbols into the history of matter.

IRON was not in common use till long after the introduction of copper. It is far more difficult to procure, because it is not met with in the native state, and the fusing point is very high. The metallurgy of iron is more complex than that of copper, and when obtained it is a more difficult metal to work. According to Xenophon the melting of iron ore was first practised by the Chalubes, a nation dwelling near the Black Sea, hence the name Chalups (χάλυψ) used for steel, and hence our word *Chalybeate* applied to a mineral water containing iron. Steel was known to the ancients, but we do not know by what means it was prepared; it was tempered by heating to redness, and plunging in cold water. According to some, kuanos (κύανος) mentioned by Homer was steel; but Mr. Gladstone prefers to conclude that it was bronze. Iron was known at least 1537 B.C. It was coined into money by the Lacedæmonians, and in the time of Lukourgos was in common use. It was used in the time of Homer for certain cutting-instruments, such as woodmen's axes, and for ploughshares. Its value is shown by the fact that Achilles proposed a ball of iron as a prize for the games in honour of Patroklos. Neither iron money nor iron implements of great antiquity have been found, because, unlike the other metals of which we have spoken above, iron rusts rapidly, and comparatively soon disappears. No remains of it have been found in Egypt, yet Herodotus tells us that iron instruments were used in building

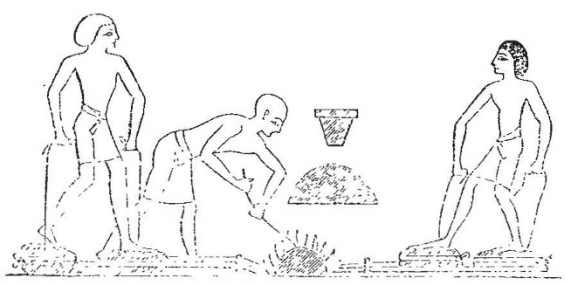

FIG. 3.—Egyptian Bellows. Fifteenth Century B.C.

the pyramids; moreover, steel must have been employed to engrave the granite and other hard rocks, massive pillars of which are often found engraved most delicately from top to bottom with hieroglyphics. Again, the beautifully engraved Babylonian cylinders and Egyptian gems, frequently of cornelian and onyx, must have required steel tools of the finest temper. We have no record of the furnaces in which iron ore was smelted, but we know that bellows were in use in the 15th century B.C. in Egypt, and some crucibles of the same period are preserved in the Berlin Museum. They closely resemble the crucibles in use in the present day. The accompanying woodcut (Fig. 3) represents a double pair of bellows, a furnace, fuel, and above perhaps a crucible.

The native Indians prepare iron from hæmatite at the present time by equally primitive bellows, which indeed resemble the above very closely, and which, without doubt, have been unaltered for centuries. A small furnace, A (see the accompanying section, Fig. 4),* is rapidly constructed of clay, and into the bottom of this two nozzles, B, are introduced; these are connected with the bellows by bamboo tubes. The bellows, C, consist of cup-shaped bowls of wood covered with goat-skin above, and connected with the bamboo below. In the centre of the goat-skin cover a round hole is cut; the blower places his heel upon this, which is thus closed, while at the same time the skin is depressed and a blast is driven from the tube, then he steps upon the second skin, and thus a continual blast is kept up. The bent bamboo and string, D, is for the purpose of raising the goatskin cover of the bellows after depression, which, it will be noticed, is accomplished in the Egyptian bellows by a string raised by the hand. A piece of hæmatite is introduced with some charcoal, and after the lapse of some time, it is reduced by the carbonic oxide to a spongy mass of iron. Undoubtedly a crude furnace and appliance of this nature was used by the first smelters of iron.

* We are indebted to Dr. Percy for permission to copy this figure from his "Metallurgy," and to Mr. Murray for the other woodcuts.

Although we hear less of lead than of the preceding metals, it was known to the Egyptians at an early date, and it is mentioned by Homer. In the time of Pliny leaden pipes were used to convey water; and sheet lead was employed for roofing purposes. The chief supply of the metal came from Spain and Britain. Pliny believed that lead was reproduced in the mine, so that if an exhausted mine were closed it would be fit to work again in a few years' time. This idea of the growth of the metals was very generally accepted by the alchemists. Tin and lead were sometimes alloyed together by the ancients, and tin was used as a solder for lead. Litharge, or protoxide of lead, and *cerussa usta* (burnt ceruss), or red lead, were used by painters. *Cerussa*, which we now call "white lead," or more strictly, carbonate of lead, was prepared by exposing sheets of lead to the fumes of vinegar in a warm place, a heap of decomposing manure for instance. A basic acetate of lead is formed by this means, which is partially converted into carbonate by the carbonic acid given off by the decomposing organic matter. Cerussa was used by Athenian ladies as a cosmetic. Cerussa usta was first formed accidentally from cerussa during the burning of a house near the Piræus. Litharge is easily formed by heating lead above its melting point in air, when it absorbs oxygen gas, and the resulting oxide may be skimmed off.

Mercury was common in the time of Pliny, but it is not mentioned by earlier writers. It was found native in Spain, but was more generally obtained by heating cinnabar (sulphide of mercury)

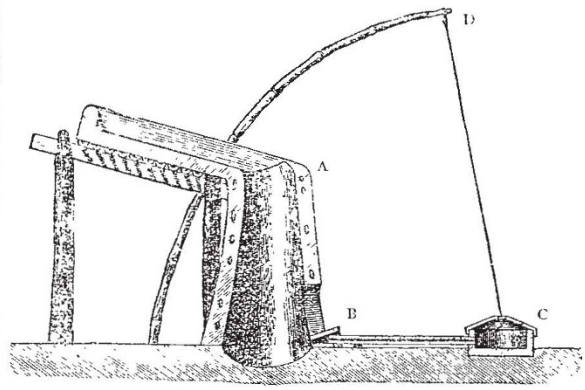

FIG. 4.—Smelting Furnace and Bellows used by native Indians in the present day.

with iron filings in an earthen vessel, to the top of which a cover was luted. The iron decomposed the sulphide, and the liberated mercury was volatilised and condensed on the cover of the vessel, whence it was collected. This method, described by Dioscorides, is the first crude example of *distillation*, which afterwards became a principal operation among the alchemists and chemists for separating the volatile from the fixed. In the time of Dioscorides cinnabar was called *minium*, but it became so largely adulterated with red lead that the term minium was ultimately applied to the latter. Minium is still one of the names for red lead. Pliny was acquainted with the high specific gravity of mercury, and with its power of dissolving gold. Substances were sometimes gilded by a gold amalgam. Mercury was also used, as now, for extracting gold from its earthy matrix; the gold-bearing rock was powdered and shaken up with mercury, which dissolved out the gold; the amalgam of gold and mercury was then squeezed through leather, which separated most of the mercury; the solid amalgam was heated to expel the mercury, and pure gold remained. Vitruvius states that gold was recovered from gold embroidery by burning the cloth in an earthen pot, and throwing the ashes into water to which quicksilver was added. The latter attracted the gold and dissolved it; the amalgam was put into a piece of cloth and squeezed between the hands, and the mercury, on account of its fluidity, was forced through the pores of the cloth, while the gold remained.

Native mercury was called *argentum vivum* (quicksilver), while mercury distilled from cinnabar was called *hydrargyrum*

(ὕδωρἄργυρον, liquid silver), from which we take our present symbol for the metal, *Hg*. The alchemists, among whom, as we shall hereafter see, mercury was a very principal metal, call it by the various names of *mercurius*, *argentum vivum*, *hydrargyrum*, with others of a more fanciful nature.

The ancients were not acquainted with any other metals in an uncombined state, except the seven mentioned above. *Stibium* or sulphide of antimony, was used in the East at an early period for painting the eyelashes. It is still used for that purpose, and is called *kohl*. Native carbonate of zinc was known, and black oxide of manganese. The two sulphides of arsenic were known, and were used as pigments. The yellow sulphide was called *auripigmentum* and *arsenicum*; the red sulphide went by the name of *sandaracha*. Auripigmentum became contracted into *orpiment*, a word which we find both in alchemical treatises and in our most modern treatises on chemistry.

The colours used by the ancients for painting were examined by Sir Humphry Davy at the beginning of this century, and he came to the conclusion that "the Greek and Roman painters had almost all the same colours as those employed by the great Italian masters at the period of the revival of arts in Italy." Various colours have been examined from the frescoes in the Baths of Titus, from Pompeii, and from Egyptian tombs. The colours of the Egyptians were red, yellow, blue, green, black, and white. The red was bole, that is a clay deriving its colour from oxide of iron; the yellow an ochre, also clay, coloured by a paler form of oxide of iron; the green a mixture of this ochre with a blue powdered glass, produced by fusing together sand, carbonate of soda, and oxide of copper. The black was ivory black, prepared by heating bones out of contact with air until completely carbonised; the white was powdered chalk. These various colours were mixed with gum and water before use. The Greeks and Romans used red lead and cinnabar, as well as red ochre, and yellow protoxide of lead. The blue powdered glass mentioned above was called κύανος by the Greeks, *Cæruleum* by the Romans. Vitruvius describes the method of preparing it; and Davy prepared a substance which perfectly resembled the ancient colour, by fusing together fifteen parts of carbonate of soda, twenty parts of powdered flints, and three parts of copper filings. The green of the Romans was carbonate of copper, and for browns they sometimes used dark oxide of iron, sometimes oxide of manganese. The *purpurissum* of the Romans was Tyrian purple, a very valuable colour obtained from a shell fish, and much used for dyeing. In order to obtain the colour for the purposes of painting, clay was placed in the chaldrons of dye, so as to absorb the colour, and was afterwards removed and dried. *Indicum purpurissum* was probably indigo; Pliny mentions that the vapour possesses a fine purple colour. Ivory black was called *Elephantinum*; lamp black, that is soot, was called *Atramentum*. The latter mixed with water constituted the ink of the ancients.

According to Pliny, glass was first discovered by some Phœnician merchants who were returning from Egypt with a cargo of *natron* (carbonate of soda), and who landed on the sandy banks of the river Belus. In order to support the vessels they used for cooking their food over the fire, they used some large lumps of natron, and the fire was sufficiently strong to fuse it, with the fine sand of the river. Hence resulted the first glass. Whatever may be the value of this story, we find representations of glass-blowing on the monuments of Thebes and Beni Hassan; and the Egyptians were well acquainted with it 2450 B.C. The most celebrated manufactory of glass was in Egypt; and, according to Strabo, a peculiar kind of earth found near Alexandria was essential for the finer kinds of glass. The Egyptian glass had nearly the same composition as our "crown glass," which contains 63 per cent. of silica, 22 of potash, 12 of lime, and 3 of alumina. The Phœnicians and Egyptians exported large quantities of glass to Greece and Rome. The Egyptians engraved and cut glass with the diamond; they also possessed extraordinary skill in colouring glass with various metallic oxides, and combining several colours in the same vase, and they imitated precious stones with great success. We read of whole statues made of emerald, but these were undoubtedly of emerald glass, viz., glass coloured by oxide of copper. The Egyptians understood the art of enamelling on metals. Aristophanes is the first Greek author who mentions glass (τὴν ὕαλον); he alludes to the use of a lens of glass, as a burning-glass in the Νεφέλαι, which play was acted in Athens. B.C. 423. Colourless glass was the most valuable, and a small quantity of oxide of manganese was added then as now for the purpose of decolourising it. A very ancient opaque green glass, analysed by Klaproth, was found to contain 65 per cent. of silica, 10 of oxide of copper, 7·5 of oxide of lead, 3·5 of oxide of iron, and about 6 per cent. of both lime and alumina. A red glass was found to be coloured by red oxide of copper.

Dyeing was well understood by the ancients; the Egyptians understood the effect of acid on some colours, and were acquainted with mordants, that is, substances which "fix" the colouring matter in the fabric, and prevent it from being washed out. The most celebrated dye of antiquity was the purple of Tyre, discovered about 1500 B.C., perhaps earlier. It was produced by certain shell fish which inhabit the Mediterranean; these are spoken of as *buccinum* and *purpura* by Pliny. A few drops only of the dye were obtained from each fish, and the colour hence became very valuable, and was monopolised by the emperors of the world. The Egyptians dyed linen with indigo, which they procured from India, for they had considerable intercourse with that country at an early period.

Lime was used for removing the hair from skins about to be tanned. Leather made in the time of Sheshonk, the contemporary of Solomon, has been found in a good state of preservation. For the process of tanning, they used the pods of the Acacia Nilotica, a plant which, according to Sir G. Wilkinson, was also prized for its timber, charcoal, and gum.

Nitrum was a term applied to carbonate of soda, or natron, which, we have already seen, was used in the manufacture of glass. The substance which we now call *nitre* (nitrate of potash) was probably known in India and China before the Christian era. Dr. Thomas Thomson has suggested that when the real nitre was imported into Europe, it received the same name as carbonate of soda (nitrum) from the similarity of its appearance, and retained the name on account of its greater importance. Roger Bacon always speaks of nitrate of potash as nitre. The low Latin name for soda became *natrium*, hence our present symbol for sodium, *Na*.

Soap is first mentioned by Pliny; it was made by mixing wood ashes, which contain carbonate of soda, with animal fat. It was used solely as a kind of pomatum. The Greeks added wood ashes to water to increase its cleansing properties.

The only acid with which the ancients were acquainted was acetic acid, or vinegar. It has been suggested that the Egyptians discovered nitric acid and nitrate of silver, because a silver stain has been found upon some linen, but the evidence is insufficient. We remember the story about Cleopatra dissolving two pearls, valued at ten millions of sestertii, in vinegar; although only a story, it would seem to show that vinegar was the most powerful solvent known. This is further indicated by the story of Hannibal dissolving rocks by vinegar.

A number of minerals are mentioned by Pliny, but we can recognise but few of them. Iron pyrites (sulphide of iron) was used for striking fire with steel in order to kindle tinder, and was hence called pyrites (πῦρ, fire), or fire-stone. Sulphur was well known, and was used for matches; it was also apparently burnt in a current of air, and the sulphurous acid produced employed for bleaching purposes. Asphalt was used for embalming, and undoubtedly also for torches.

Thus far we have become acquainted with the various theories of the Ancients, in which changes in the composition of matter are discussed, and with various processes by which changes were actually effected. Before we leave the Ancients, and pass at one bound to the eighth century A.D., we must notice the commencement of a symbolical system in the history of matter, which in the hands of the Alchemists and early Chemists assumed vast proportions, and still appertains to the science of Chemistry. This system was commenced by the association of the seven metals with the seven greater heavenly bodies. We do not know at what period the metals were designated by the names and symbols of the planets: certainly at a very remote age.

At a very early date the Chaldæans represented the stars by symbols, and these gradually increased until astrology became one mass of symbols. On the occasion of certain religious ceremonies the Kings of Assyria wore a necklace in which the sun, moon, and stars were represented as emblems, for they were first worshipped as emblems of the Deity. Sculptural representations of necklaces with seven discs upon them have also been found. Symbols were carried before Egyptian priests, and their gods were represented with certain signs symbolical of their special attributes. The Assyrian goddess Astarte, carries in her left hand a symbol (*b*) (Fig 5.) not very different from the *crux ansata* of the Egyptians (*a*); and the symbol (*c*) by which the planet Venus was afterwards repre-

sented by the astrologers and is still represented by astronomers. In the celebrated "Book of the Dead" (B.C. 1350), the most perfectly preserved Egyptian ritual which the world possesses, this latter symbol (*c* in the figure) occurs frequently among the hieroglyphics. This is very noticeable in the "Judgment scene"

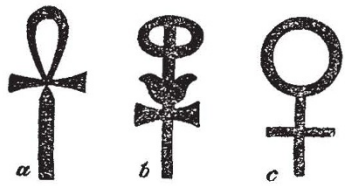

FIG. 5.—*a* Crux ansata of the Egyptians; *b* Assyrian symbol of Astarte; *c* Later symbol of the planet Venus.

of the Turin papyrus, a copy of which exists in the British Museum. The upper portion of the *crux ansata* was frequently made more rounded in form, and it is obvious that if in addition to this the cross was somewhat lowered, we should arrive at the third symbol (*c*) shown above. The *crux ansata* (*a*), if written quickly, could easily pass into this latter symbol (*c*), and this may account for the occurrence of both symbols in the judgment picture, to which we have alluded above.

Plato speaks of the sun, moon, and five planets, but does not distinguish them by the names of gods; Epinomis mentions them in conjunction with the names of gods. It is probable that the Chaldæans also associated the principal heavenly bodies with the names of deities—San with the sun, Hurki with the moon, Bel Merodach with Jupiter, Astarte or Ishtar with Venus, Nergal with Mars, &c. The relative position of the planets was generally as follows: the Earth was the centre of the system; next in order came the Moon, the Sun, Venus, Mercury, Mars, Jupiter, and Saturn; but these positions were sometimes varied. It was known that Saturn completed a revolution in about thirty years, while Jupiter required twelve years, Mars only two, and Mercury and Venus occupied about the same time as the Sun; hence the above order. As Saturn was farthest from the source of heat, and the slowest in his motion, he was supposed to be of an icy character, and to assert an evil influence.

While speaking of the seven greater heavenly bodies, and the seven metals, we may allude incidentally to the curious prominence of that number in many matters—"that mysterious number," as Mr. Layard calls it, "so prevalent in the Sabæan system." Thus (to select a few instances at random) we have seven days of the week, seven wise men of Greece, seven wonders of the world, seven cardinal sins, seven-stringed lyre, seven harmonic proportions, seven heavens, seven walls of Ecbatana, seven gates of Thebes. The list might be extended almost indefinitely. Among the Hebrews the number was specially prominent. Not to mention the frequent allusion to it in the Apocalypse, we may recall the incidents of the fall of Jericho: the town was surrounded for seven days; on the seventh day the walls fell at the blast of seven trumpets, which were carried round the walls seven times by seven priests.

We cannot tell why the seven metals were associated with the seven deified heavenly bodies, unless it was because all things which amounted to the same number were connected with them. This, at least, we know, that long before the time of Geber, the first writer on chemistry, the metals had received the same names and symbols as the planets. "There is abundant evidence," says Mr. Gladstone, "of a correspondence between the seven metals of Homer and the seven metals of the ancient planetary worship of the East." In the time of Homer only six simple metals were known, and the seventh was the compound *kuanos*; quicksilver afterwards became the seventh simple metal, and received the name and symbol of the seventh planet. The metals were apportioned as follows:—

Gold	The Sun	☉
Silver	The Moon	☽
Quicksilver	Mercury	☿
Copper	Venus	♀
Tin	Jupiter	♃
Iron	Mars	♂
Lead	Saturn	♄

Herodotus tells us that Ecbatana had seven walls, the outermost of which was the lowest, and the others gradually ascended like steps to the highest, which enclosed the king's palace. They were each painted of a particular colour; the outermost white, the second black, the third purple, the fourth blue, the fifth red, the sixth the colour of silver, the seventh the colour of gold. Undoubtedly these had reference to the seven greater heavenly bodies. It is impossible to account for the colours, but it is curious to notice the particular colour which would fall to any particular metal. Placing the planets in order as applied to the metals, we should have gold to gold, silver to silver, red to copper, blue to iron, purple to tin, black to lead, the most despised of the metals. It is probable that the Sabæans associated these colours with the seven heavenly bodies. The temple of Bel-Merodach, rebuilt by Nebuchadnezzar, and called by him the "Wonder of Borsippa," appears also to have consisted of seven terraces differently coloured. The following is a portion of the inscription from a clay cylinder found among the ruins of the temple:—"I (Nebuchadnezzar) have completed the magnificence of the tower with silver, gold, precious stones, enamelled bricks, fir, and pine. . . . . This most ancient monument of Borsippa is the house of the seven lights of the earth."

How the symbols conferred upon the planets and afterwards upon the metals arose it is difficult to say; they are undoubtedly of Chaldæan origin, but to what extent they have since been modified no one can tell. They exist in early MSS. on Alchemy. That the sun should be represented by a circle, the symbol of perfection, is no wonder. Again, that the moon should be symbolised by a crescent we can understand; but the others present greater difficulties. Among these, some say we have the looking-glass of Venus, the thunderbolts of Jupiter, the spear and shield of Mars, the scythe of Saturn, and the caduceus of Mercury. In the temple of Hermes at Pselcis he is represented with a staff having a serpent twining around it, from which it has been suggested the caduceus of Mercury may have been derived. Some see in ♃, not the thunderbolts, but the throne of Jupiter; others the *Zeta* of Zeus; others, again, the Arabic 4, indicating that Jupiter was the fourth planet in order. Some, too, have seen in ♄ the K of Kronos. It is less difficult to understand why a particular metal was assigned to a particular heavenly body. Thus gold would naturally be associated with the sun, on account of its colour, perfection, and beauty, and because it was ever regarded as the noblest metal. For the same reason silver would fall to the moon, with its pale, silvery colour and light. So, again, iron, the metal of war, would be associated with Mars; lead, the dull, despised metal, with Saturn, the slowest of the planets; quicksilver, the nimble volatile metal, with Mercury, the messenger of the gods.

These signs became in the hands of the Alchemists the commencement of a symbolic system in chemistry.

(*To be continued.*) G. F. RODWELL

SOCIETIES AND ACADEMIES

LONDON

Royal Geographical Society, Nov. 11.—Major-General Sir H. C. Rawlinson, president, in the chair. The President, in his inaugural address, recapitulated the leading incidents which have occurred in the exploration of Africa since June, at which time we were in receipt merely of a brief telegraphic announcement that Mr. Stanley had arrived at Zanzibar with despatches, having left Livingstone alone and well at Unyanyembe; and stated that, as the Society honestly consider Mr. Stanley's journey to Lake Tanganyika to be in its results the most important geographical achievement of the year, they feel that, in awarding him their medal, they are only discharging their strict duty, while at the same time they are doing honour to Livingstone and promoting the great end of African discovery. The President then passed on to the history of the Society's own Relief Expedition, touching which he said:—"Much disappointment was felt at the abrupt termination of this expedition. The committee of the Geographical Council charged with the management of the Search and Relief Fund, after a most patient investigation, delivered two reports to the subscribers, the purport of which was that they disapproved of the conduct of Lieutenant Dawson in breaking up the expedition, and that they attributed it to a lamentable error of judgment that he did not carry on to the Doctor, as supplementary to Stanley's relief, a supply of arms, instruments, medicines, and other articles of which he manifestly stood in need. The judgment delivered by the committee has since been greatly fortified by letters written by Dr.