constitute a quorum: it will choose a president and secretary, and will meet as often as it deems necessary, but at least once a year. (*b*.) The Committee will direct and superintend the execution of the decisions of the International Commission, in reference to the comparison of the new metric prototypes with each other, as well as the construction of balances and other auxiliary apparatus necessary for these comparisons. (*c*.) The Permanent Committee will perform the work indicated in (*b*) with all appropriate means which may be at its disposal; it will meet for the performance of its task at the International Bureau of Weights and Measures, the establishment of which will be recommended to the nations interested. (*d*.) When the new prototypes will be constructed and compared, the Permanent Committee will give a report of its work to the International Commission, which will sanction the prototypes before distributing them to the different countries.

36. The Commission suggests to Governments interested how great would be the utility of founding at Paris an International Institution of Weights and Measures, upon the following bases:—1st. The establishment would be international and declared neutral. 2nd. Its seat will be at Paris. 3rd. It would be founded and supported at the common cost of all the countries which adhere to the treaty that might be made between the interested states for the creation of the establishment. 4th. The establishment will depend upon the International Metric Commission, and will be placed under the superintendence of the Permanent Committee, who will choose the director. 5th. The International Bureau would serve the following purposes:—(*a*.) It will be at the disposal of the Permanent Committee for the comparisons which will serve as a basis for the verification of the new prototypes with which the Committee is charged. (*b*.) The preservation of the international prototypes, in accordance with the directions laid down by the International Commission. (*c*.) The periodical comparison of the international prototypes with the national standards and with the tests, as well as that of the standard thermometers, according to the rules laid down by the Commission. (*d*.) The construction and verification of the standards which other countries may require in future. (*e*.) The comparison of the new metric prototypes with the other fundamental standards employed in the different countries and in science. (*f*.) The comparison of standards and scales which may be sent for its verification, either by Governments or by scientific societies, or even by mechanicians and servants. (*g*.) The Bureau would execute all the works which the Commission or its Permanent Committee would require of it in the interest of metrology and the propagation of the metric system.

37. The Bureau of the Commission is required to apply to the French Government, and request it to be good enough to communicate diplomatically the views of the Commission concerning the foundation of an International Bureau of Weights and Measures to the Governments of all the countries represented in the Commission, and to invite these Governments to conclude a treaty to create harmoniously, and as soon as possible, such an International Bureau upon the bases proposed by the Commission.

IV. Concerning the means of Preserving the Standards and the Guarantee of their Invariability

38. The Commission is of opinion that the International Standard ought to be accompanied by four identical measures, maintained at a temperature as invariable as possible; another identical measure ought to be preserved, for the sake of experiment, at an invariable temperature in vacuo; it would take means to establish tests in quartz and beryl, to be compared at any time with the complete measure, in whole or by portions. (The other means are reserved.)

39. The Commission thinks that in the interest of geodesy the French Government should cause to be re-measured, at a convenient time, one of the new French bases.

All these resolutions were made by the Commission most harmoniously, and in a spirit of complete confraternity; all the votes were nearly unanimous.

BIRTH OF CHEMISTRY

III.

Practical Chemistry of the Ancients.—Metallurgy; gold, silver, electrum, copper, bronze, tin.

IN the preceding articles we have discussed such theories of the ancients as involve the conception of change of matter (notably the assumed transmutation of the elements), and which hence concern the early history of chemistry. Having done with theory, we have now to inquire to what extent the ancients were acquainted with practical chemistry, what metals or other elements were known to them, and what processes dependent upon chemical action. We do not, of course, use the term "practical chemistry" strictly in its present sense, because chemistry as a science was altogether unknown to the ancients. Some have indeed endeavoured to prove that the Egyptians must have been acquainted with the science, from the skill with which they used various metallic oxides for colouring glass; but we have no proof of this. Neither Herodotus, nor Pliny, nor Vitruvius, indicates any knowledge of chemistry as a science among either Egyptians, Greeks, or Romans. Pliny, in his celebrated "Natural History," has laboriously amassed all the practical science and pseudo-science which the ancients possessed, and we find no mention of either chemistry or alchemy. At the same time it is impossible that the Egyptians and Sidonians can have attained their marvellous skill in the manufacture and colouring of glass, and in the extraction and working of metals, without the acquirement of a considerable amount of knowledge of the properties of matter, and of certain chemical changes. But this knowledge could never be worked up into a comprehensive system; it resulted from the labour of artizans, and the gulf between the philosopher and the manipulator was both wide and deep. There could be no union of practice and theory. Between Herakleitos with his theory that fire is the primal element, the actuating force of the Universe, and the man who wrought metals never so deftly, who applied fire to the use and service of mankind, there was no sympathy, no reciprocal transference of ideas. To reason concerning the properties of matter with one's eyes shut was all very well, but to experiment with matter, to endeavour to determine the cause of such and such a change by experiment, was utterly unworthy of a philosopher. Anaxagoras is said to have made an experiment to prove that there is no vacuum. Aristotle found that a bladder of air weighed in air weighed more than the empty bladder (which, if the experiment be properly made, is by no means the case), and hence concluded that the air has weight. But these are solitary exceptions; the way to study Nature, if she is to be studied at all, is, they maintained, to apply the pure, unaided intellect to the study, and to keep mind and matter as distinct as possible. From all this it resulted that your workers in metals and in curious arts, your makers of glass and pigments, kept their knowledge of matter to themselves, as secrets to be handed down from father to son.

Seven metals were known to the ancients, viz., gold, silver, copper, tin, iron, lead, and mercury. The first six are mentioned by Homer, and appear to have been known from remote antiquity, while mercury was not known till a later date; it was, however, common in the first century B.C. The Greek word μεταλλον, whence *metallum* and *metal*, signifies *a mine*, hence it was applied to anything found in mines, notably metals; μέταλλον is connected with μεταλλάω, "to search for diligently."

Gold has been valued from the earliest ages, on account of the peculiarity of its colour, its lustre, and its unalterability in air. The metal is invariably found in the native state, that is, uncombined with other substances, hence no metallurgical operation is necessary for its extraction. It is very often met with in surface deposits, and in early times was undoubtedly far more common in alluvium and the beds of rivers than now. It would thus be easily extracted by washing, and the grains could readily be fused together into a mass. Gold mines formerly existed in Ethiopia, in which the gold was found in a matrix of quartz, like much of the Australian gold of the present day. These mines were worked by the Egyptians, who employed large gangs of slaves for the purpose. The quartz was crushed, and the gold obtained from it by washing. We find representations of gold washings, and the subsequent fusion of the metal, on Egyptian tombs, at least as early as 2500 B.C., that is to say, about the time of Joseph in Hebrew history. The woodcut (Fig. 1) on the following page is given by Sir Gardner Wilkinson, and is taken from a tomb at Beni Hassan: it represents gold washing, and the fusion and weighing of the metal.

It is obvious that the process is only indicated, and not accurately or minutely portrayed. Another form of furnace is depicted below (Fig. 2), and a blowpipe somewhat different from that shown in Fig. 1. The raised portion of the furnace is doubtless for the purpose of concentrating the heat upon the crucible, on the principle of the reverberatory furnace.

Gold once obtained was soon made into ornaments; very fine gold wire was used by the Egyptians for embroidery 3,300 years ago. Many of the Egyptian and Etruscan gold ornaments are very beautiful; we may notice particularly the gold myrtle wreath found in an Etruscan tomb a few years ago. The Egyptians also used gold for inlaying, and it was beaten into leaf and used for gilding as early as 2000 B.C. In the Odyssey the gilding of the horns of an ox about to be sacrificed is mentioned.

Silver, like gold, is often found native, and from several of its ores the metal may be extracted by the action of heat alone. It has been known from the earliest ages, and was used chiefly for ornaments and embroidery. Gold was used for money before silver, which was first known as "white gold." The oldest silver Greek coin is a coin of Ægina, and was, perhaps, coined in the eighth century B.C. But the oldest coins in existence are the *electrum* staters of Lydia. Electrum consists of about three parts of gold to one of silver. Probably the metals were first found in nature thus alloyed, and as no method of separating them was then known, they were worked up together. Electrum was so called from its resemblance as regards colour to amber (ἤλεκτρον), which received its name from ἠλέκτωρ, the sun. It will be remembered incidentally that the science of Electricity was so called by Gilbert of Colchester, because the attractive force was first observed in amber. Amber is mentioned more than once by Homer. Electrum as a metal is first mentioned in the *Antigone* of Sophocles. It was found naturally alloyed, as in the pale gold of the Pactolus, which contains a good deal of silver; and was also made artificially. Probably all very pale gold was called electrum; Pliny states that gold containing a fifth part of silver is called electrum. In the British Museum there are many coins made of this alloy.

Copper was in use before iron. It is, as is well known, usual to denote various early ages by the substances then used for domestic implements. Thus we have the "age of stone," the "age of iron," &c. The stone age is followed by the age of copper, this by the age of bronze, and the age of bronze by the age of iron. Homer wrote in the age of copper; the shield of Achilles is made of gold, silver, tin, and copper; the arms and implements and utensils of his heroes are of copper. Mr. Gladstone has argued at some length that by chalcos (χαλκος) Homer meant copper, not bronze, as it is so often rendered. Chalcos is spoken of as a cheap and common metal, while tin was very scarce and rare; and it is scarcely probable that so many things, even down to the commoner utensils, could have contained ten or twelve per cent. of tin. Again, Mr. Gladstone points out that Homer speaks of chalcos as ερυθρος, red, a term that could not apply to bronze; and he goes so far as to say, "If chalcos be not copper, then copper is never mentioned in Homer" (*Juventus Mundi*, p. 530). At the same time we must remember that copper is very soft for cutting-instruments, and a small quantity of tin hardens it; some of the Greek bronzes only contain 1 per cent. of tin. Dr. Percy found in a bronze bowl of great antiquity from Nineveh, copper 99·51, tin ·63. Ancient nails have been found containing copper 97·75, tin 2·25; and Mr. Gladstone suggests that, as tin is sometimes found associated with copper in nature, this may account for their composition. Copper is sometimes found native, sometimes in the form of ores, from which the metal is easily extracted. It appears to have been both cheap and plentiful at an early date. Romulus is said to have coined copper; it was also used for money by the Egyptians. Great confusion exists among old writers regarding the words signifying bronze and copper: Pliny clearly did not understand the difference between copper and bronze. The words *æs* and χαλκός appear to have been applied indiscriminately both to copper and to alloys of copper containing a large proportion of that metal. Copper was alloyed with tin at such an early date, because copper is soft and is unsuitable for cutting-instruments, while the addition of tin hardens it. The fusing point of copper is between that of gold and silver, and is far below that of iron, while the fusing point of tin is only 446° F. Thus the two metals could be alloyed without any special metallurgical difficulties or the requirement of an inordinate temperature. Copper was first obtained by the Romans from Cyprus, where it was very plentiful; they called it *Æs Cyprium*, which became corrupted into *Cuprum*, from which we get our present chemical symbol for

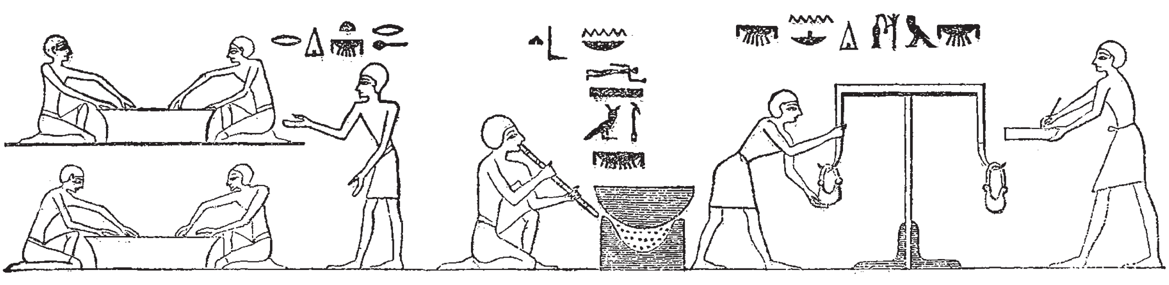

FIG. 1.—Gold Washing: Fusion and Weighing of the Metal, from early Egyptian Tomb

copper, *Cu*. According to Solinus *æs* was found at Chalkis, in Eubœa, hence χαλκος, the Greek word for copper. We read of "ores of æs," and of brass and bronze being dug out of mines, whereas the term *brass* is applied by us to an alloy composed of copper and zinc, and *bronze* to an alloy of copper and tin. Zinc as a metal was unknown to the ancients, and brass appears to

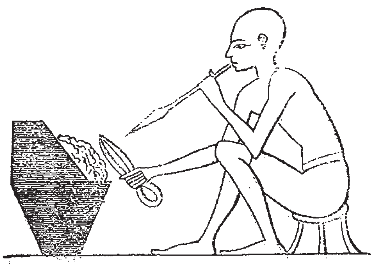

FIG. 2.—Furnace and Blow-pipe from Egyptian Tomb

have been made in Pliny's time by heating together metallic copper, calamine (a native carbonate of zinc), and charcoal; the latter reduces the calamine, and the metallic zinc and copper then combine. According to Dr. Thomas Thomson, *aurichalchum*, or golden copper, was the proper name for brass. *Æs* is to be always translated copper or bronze, *not* brass, of which latter very little use appears to have been made. Among other alloys of copper, the ancients possessed the celebrated *Æs Corinthiacum*, which, according to Pliny, was formed accidentally during the burning of Corinth, by Mummius, B.C. 146. There were four varieties of this, one of which contained equal proportions of gold, silver, and copper; the others were most probably various admixtures of copper and tin. The commonest kind of ancient bronze contained in 100 parts, 88 parts of copper, and 12 parts of tin. Two specimens of bronze from Nineveh were found by Dr. Percy to contain respectively—

	Bronze hook.	A small bell.
Copper	89·85	84·79
Tin	9·78	14·10
	99·63	98·89

The proportion of copper and tin (about 10 to 1) is, remarks Mr. Layard, the composition of our best modern bronze, while the increase of tin in the case of the bell proves that the Assyrians were well acquainted with the increase of sonorousness produced by changing the proportions of the metals. Modern bell metal contains about 80 parts of copper to 20 parts of tin. Sometimes a small quantity of lead was introduced by the ancients into their bronzes. Thus, a certain bronze for statues was formed by fusing together 100 parts of copper, 10 parts of lead, and 5 parts of tin. In a very ancient bronze armlet (probably Phœnician) found in this country, and belonging to a period anterior to the Roman occupation, Prof. Church found—

Copper	86·49
Tin	6·76
Zinc	1·44
Lead	4·41
Oxygen and loss	·90
	100·00

Bronze was very much used in Egypt for vases, mirrors, arms, &c. These, according to Sir G. Wilkinson, usually contain from 80 to 85 per cent. of copper, with from 15 to 20 per cent. of tin. By the use of some acid substance, the surface was sometimes covered with a green or brown patina. Although the casting of the metals was not known in Greece in the time of Homer, bronze was probably cast in Egypt 2000 years B.C.

Several compounds of copper were used by the ancients, both the red and black oxide were obtained by heating copper to redness, and allowing it to cool in the air; they distinguished between the scales which fell off during cooling, and those which were caused to fall off afterwards by blows of a hammer. These oxides were principally used for colouring glass. Verdigris or acetate of copper was obtained as now by covering plates of copper with the refuse of grapes after the expression of the vine juice. Copper pyrites and a rude kind of sulphate of copper would appear from Pliny's obscure account to have also been known.

It follows from the above remarks concerning bronze, that tin, like copper, was known at a very early date. This is the more remarkable, because it has always been a comparatively scarce metal, and it was obtained from distant localities. Formerly it was almost entirely supplied by Spain and Britain. The Phœnicians, who were the earliest traders, obtained it first from India and Spain, and afterwards from Britain. The Greek name for tin, kassiteros (κασσιτέρος), was perhaps derived from the Insulæ Cassiterides, or Scilly Islands, from whence the Phœnicians asserted that they procured tin; but it has been suggested that in all probability they invented the story because they desired a monopoly of the metals, while in reality they procured all their tin from the mainland of Cornwall, where it has always abounded. Tin must have been very valuable, or the Phœnicians would not have traded so far for it. Homer evidently considers it of far greater value than copper. In the time of Pliny it was worth about eight shillings the pound. The metal was known in Egypt 2000 B.C. Pliny mentions that it was found in the form of small black grains in alluvial soils, from which it was obtained by washing; this account would agree with a description of the so-called *stream tin*, which is tin ore separated from the parent vein, and carried down by streams. It is an oxide of tin, and the metal is obtained from it by strong ignition with charcoal. Tin was used for tinning copper vessels, for making mirrors, and in the manufacture of bronze. In the Iliad the greaves of the armour of Achilles are made of tin, and it enters into the composition of the shield; it was also used for coating copper.

G. F. RODWELL

(*To be continued.*)

SCIENTIFIC SERIALS

THE *Bulletin de l'Académie Impériale des Sciences de St. Petersbourg*, xvii., No. 2, commences with a proposed new classification of the Balænoidea, by J. F. Brandt, with the view of including extinct forms recently met with in Central and Southern Europe, and in Central Asia. He bases it mainly on skeleton structure, with special reference to form of cranium. The next paper contains some algological studies by Christopher Gobi. He describes how moisture, with heat and light, acts on chlorophyll in the cells of Chroolepus, accumulating it at the periphery, and leaving a nucleus of red pigment at the centre. He also describes a new species of the plant, which he terms *Chroolepus uncinatus*. It is found on the maple, ash, and linden, and its chief characteristic is a hook-shaped zoosporangium with subsporangial cell at the end of a series of irregular cylindrical-shaped cells forming the stalk. The growth of the zoosporangia takes place only at night. This new species is most closely allied to the *C. umbrinus*. —C. J. Maximowicz gives a full description, in Latin, of certain plants in Japan and Mandshuria.—The last paper is by C. J. Maximowicz, on the influence of strange pollen on the form of fruit. He experimented with two very distinct species of lily, *L. davuricum* and *L. bulbiferum*, kept in a room warmed by sunlight. He fertilised the flower of each with pollen from the other, and the process was repeated in several individuals. When the capsules developed, each was found to have the form characteristic of the other plant. The form of the seeds in both was intermediate between those of the parents.

Annalen der Chemie und Pharmacie, No. 9, 1872.—The first article, by Dr. Schreder, describes a new product of styphnic acid, obtained by reaction of cyanide of potassium with the neutral potassa salt of the acid. He names it *Resorcin-Indophan*, and gives as its formula $C_9H_4N_4O_6$. It is soluble in water, but insoluble in alcohol and ether. The potassa, soda, and baryta salts of the substance are discussed.—In a paper on some combinations of vinyl, Dr. Baumann describes the action of sodium methylate on an excess of iodide and bromide of vinyl at ordinary temperature; experiments on the action of cyanides of potassium and of silver on bromide of vinyl; and the conversion of bromide and chloride of vinyl into isomeric bodies.—An essay on camphoric acid, by F. Weeden, contains an account of a new modification, called meso-camphoric acid, obtained by action of hydriodic and hydrochloric acid on dextro-camphoric acid; its formula is $C_{10}H_{16}O_4$. He also treats of substitution products of camphoric acid anhydride and of amido-camphoric acid.—A paper on "Carbazol," a substance prepared from coal-tar oil, is furnished by C. Graebe and C. Glaser; and Herr Graebe also communicates a note on "Vapour Densities of some Aromatic Compounds of High Boiling-point."

Poggendorff's Annalen der Physik und Chemie, No. 6, 1872.—This opens with a detailed account, by Dr. Rudolph Kœnig, of his various experiments with manometric flames. His apparatus is based on the effects of sound-waves upon a membrane presented to them, which, in its turn, affects a stream of gas flowing to a jet, causing the latter to dance. The jet is imaged on the mirror-covered sides of a revolving box, and its successive motions (caused by the sound and varying with it) appear from the reflection, which, through the box's motion, becomes a luminous line of images. Dr. Kœnig has successfully employed this method in the study of various acoustical effects—combinations of notes, vowel sounds, "overtones," interference, &c., and the varieties of flame-forms produced are fully shown by numerous drawings.—In the paper following, S. Lamansky describes a series of careful experiments on the heat spectra of the sun and the lime light. The absorption bands in the ultra red of the former had the same position, though the prisms were varied, those used being flint glass, bisulphide of carbon, and rock salt. The position and intensity of the heat maximum and the intensity of absorption were found to vary with the time of year and of day at which the observations were made. The heat spectrum of limelight is continuous, and its maximum further removed from the end of the visible spectrum than in the case of sunlight.—E. Hagenbach continues the account of his experiments on fluorescence of various substances; and H. Weber communicates a paper on the Heat Conductivity of Iron and of German Silver.—The serial also contains (of original articles) a short note from Prof. Clausius in reply to Prof. Tait's last communication; a description of an improved Holtz machine, by W. Musaeus; a note on the spectrum of aurora, by A. v. Oellingen; and one or two others not calling for special notice.

THE *Scottish Naturalist* for October opens with an article by Mr. J. Allen Hooker, on "The Study of Entomology," containing some very useful hints to young entomologists as to the direction in which their studies and observations can be most usefully turned, some of which are all but entirely neglected by collectors in this country. Mr. James Hardy then describes his new "Ragwort-seed Fly," *Anthomyia Jacobææ*; and Dr. Buchanan-White concludes his account of the nest of *Formica rufa* and its inhabitants. A number of items of information of especial interest to Scottish zoologists and botanists fill up the number. In both the last two numbers there are instalments of the "Insecta Scotica," the Lepidoptera of Scotland by Dr. Buchanan-White, and the Coleoptera of Scotland by Dr. D. Sharp.