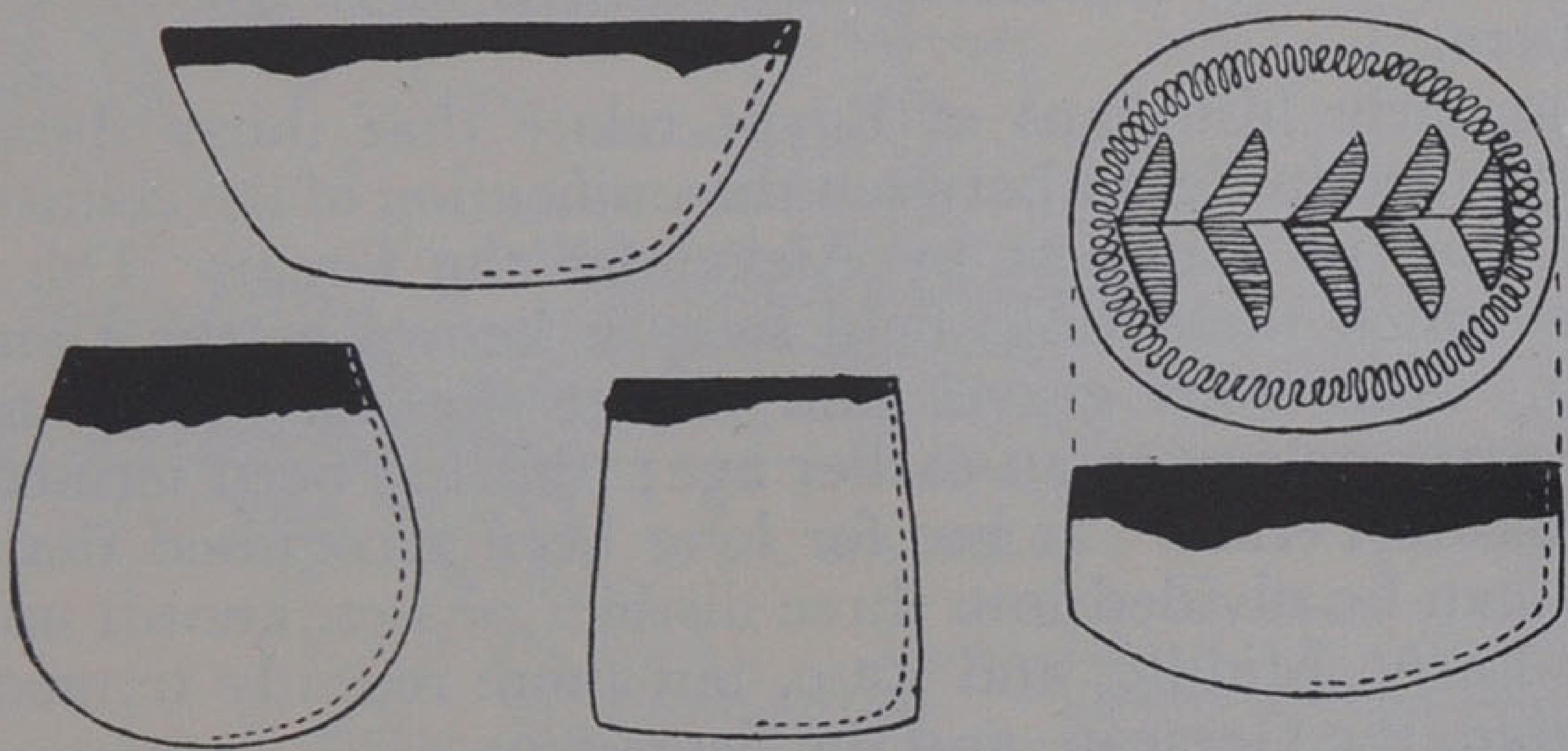
nearest places in Asia, at which it has been noted, are the hills to the east of Lake Tiberias and the Mountains of Moab.

Since, however, arguments based upon the present habitats of wild wheat and barley are not conclusive, we must examine the archæological evidence in the hope of arriving at a more definite conclusion. Let us first begin with Egypt, a country that has been indefatigably explored for more than a century, and in which the archæological record is more complete than elsewhere.

The early historians of Egypt relate that thirty dynasties of kings ruled in Egypt between the unification of the country by Menes and its conquest by Alexander the Great. The time during which these kings held sway is known as the Dynastic Period. Numerous graves and village sites have been found that clearly belong to an earlier age; this has been termed the Predynastic Period. It has for long been recognised that this period can be divided into three distinct phases, known usually as the Early, Middle, and Late, but more recently termed the Amratian, the Gerzean, and the Semainian.

More recently a still earlier civilisation has been discovered by Mr. Guy Brunton near Badari (Fig. 21); this he has termed Badarian. A still earlier phase was distinguished as the result of his work there in 1928–9; this he has called the Tasian. In the meantime Miss Gertrude Caton-Thompson discovered a somewhat similar culture in the Fayûm, which was at first believed to date from a somewhat later time. Further investigation showed that this Fayûm civilisation was approximately co-eval with that of Badari, and, like it, was capable of division into two phases. The Royal Anthropological Institute has recently acquired the right to excavate a fresh site in the Kharga Oasis, where remains of the Fayûm civilisation are in evidence, and, as this site lies much nearer to Badari, it is hoped that its exploration, which is being undertaken by Miss Caton-Thompson in 1930–1, if sufficient funds are forthcoming, will establish with certainty the exact relations that subsisted between the Fayûm and Badari civilisations.

It had been claimed some years ago that barley had been grown by the earliest of the Predynastic Egyptians—that is to say, by the Amratians—but it had also been pointed out that

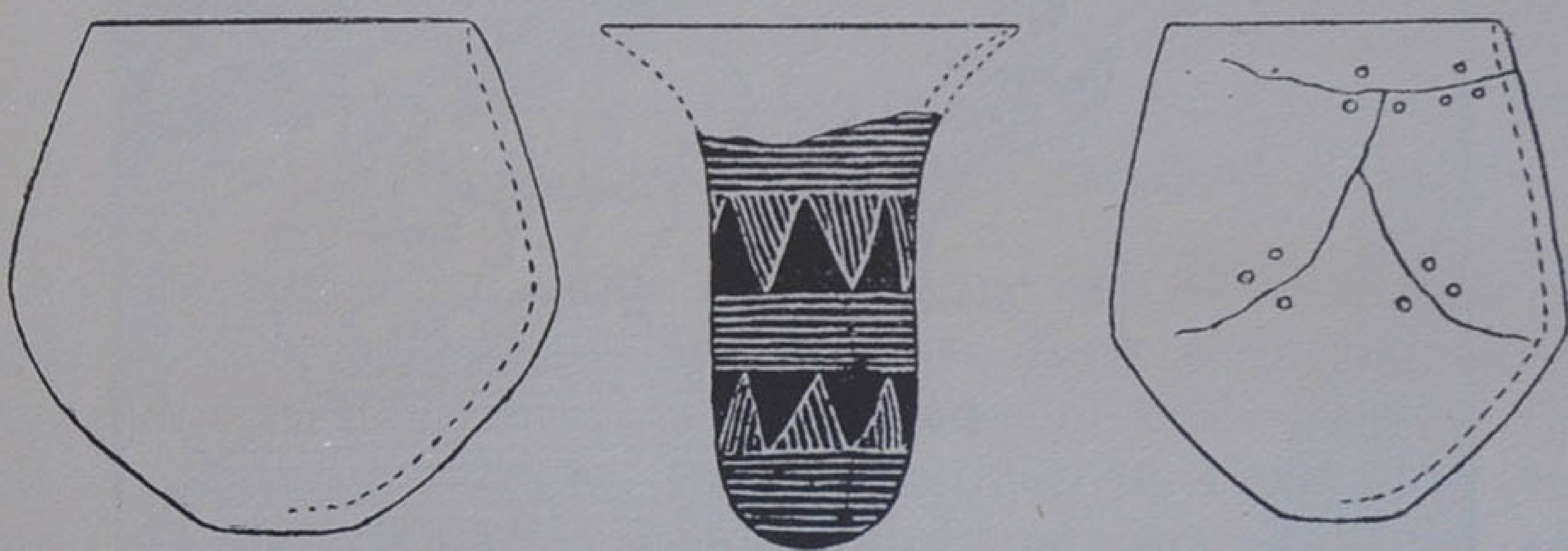


[*Reproduced by permission from "Antiquity," 1929, p. 464.*

FIG. 22.—Badarian Pots.

there was no adequate proof that the graves in which this evidence had been found were of so early a date, for they might equally well have belonged to the Middle Predynastic or Gerzean Period, when new people had arrived in Egypt from South-west Asia. This question, which was hotly debated for a time, has now but an academic interest, for early in 1928 Brunton found a pot containing grain in an untouched Badarian grave (Fig. 22), and this grain has been pronounced by Sir Roland Biffen to be emmer.

We are thus certain that the type of wheat known as emmer was cultivated in Egypt before the Predynastic Period, in the Badarian phase, but can we be sure that it was known earlier? Up to the present no grain, or even undoubted agricultural implements, have been reported from Tasian graves (Fig. 23), but the people seem to have lived in settled villages, which rather suggests that they had food supplies other than the products of the chase. Besides this, in one of their graves Brunton found a " grit-stone grinder," which may be a primitive



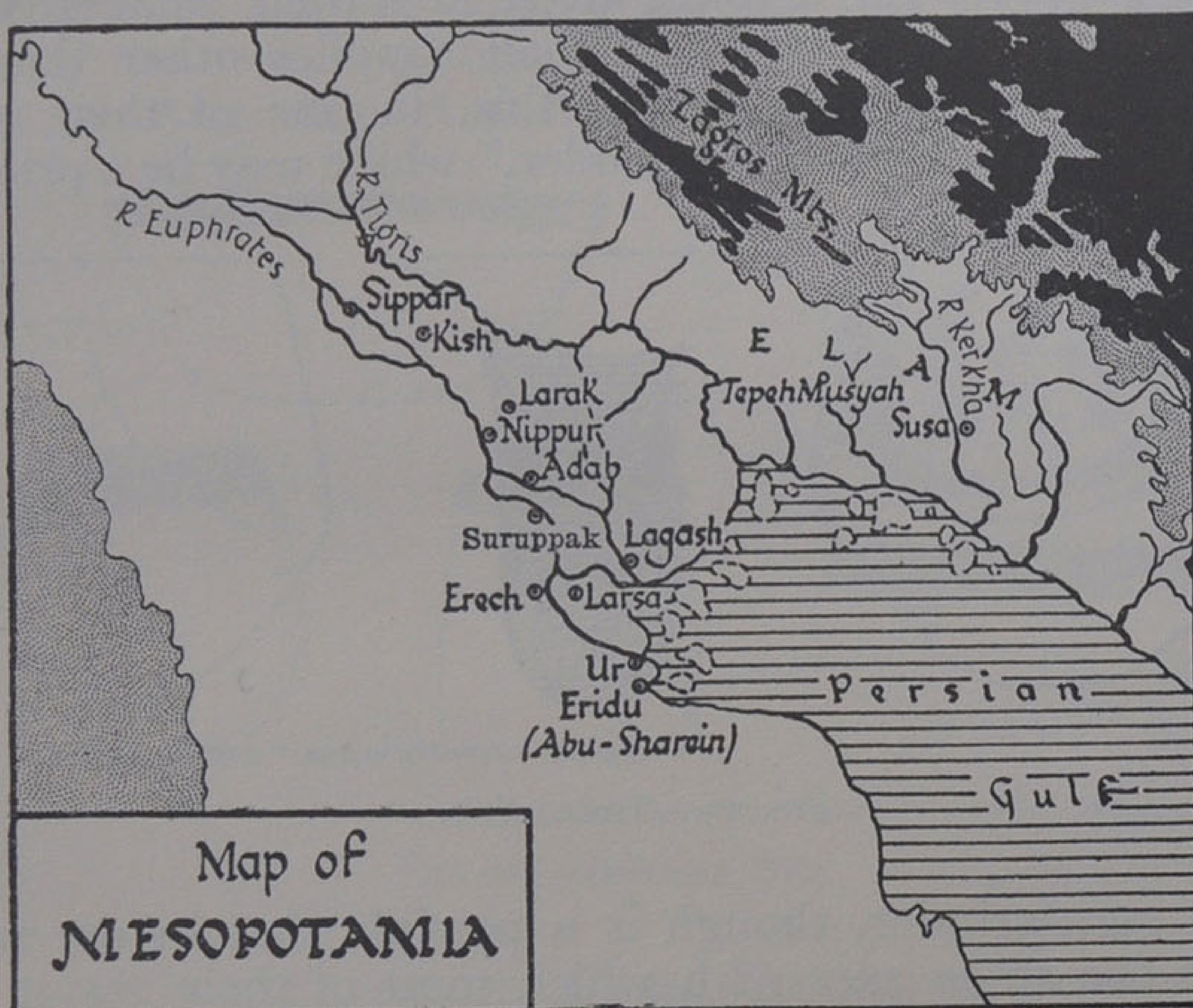
[*Reproduced by permission from " Antiquity," 1929, p. 466.*

FIG. 23.—Tasian Pots.

kind of corn-grinder, though it is possible that its use was to sharpen the stone axes with which most of their graves were furnished.

Let us now turn to South-west Asia, especially to Mesopotamia (Fig. 24), which has in recent years become the centre of interest for those who are studying the earliest phases of civilisation. For long we have known that a succession of peoples, Parthians, Medes, and Elamites, have held possession of the rich lands between the rivers. Before the Persians were the Medes, and before them Babylonians. Earlier we hear of Kassite Kings, and still earlier of a great Babylonian Dynasty.

This was founded in 2169 B.C. by Sumu-Abu, a chief of the Amurru, a nomad people from the north of the Syrian Desert. These Amurru spoke a Semitic tongue, akin to Hebrew and Arabic, but they found in Mesopotamia a kindred people



Reproduced from Peake and Fleure, "Peasants and Potters," Fig. 4, by permission of the Clarendon Press.

FIG. 24.—Map of Mesopotamia.

speaking a similar tongue; these were the Akkadians, who had at one time been masters of the whole country.

The Akkadians were not the only people in the land, nor were they apparently the first to arrive there, for in the cities nearest to the Persian Gulf dwelt the Sumerians, who spoke a language entirely distinct from that of the desert tribes. These

Sumerians had at one time been the chief rulers in the land, and were always the most civilised element in the population. In early days they shared the power with the Elamites, whose capital was at Susa, and who spoke another distinct language, not allied to any at present known, except perhaps to an obscure dialect still spoken in a remote valley in the Caucasus mountains.

When Sumu-Abu established his dynasty at Babylon, many of the Sumerian cities were free from Akkadian rule. There were, in fact, two great Sumerian kingdoms, those of Larsa and Isin. The latter was in 2069 B.C. conquered by Larsa, which had already passed into the hands of the Elamites, from whom it was wrested by Hammurabi, King of Babylon, in 2037 B.C.

As the Sumerian cities were falling one by one into the hands of the conquering Babylonians, their scribes compiled from many ancient sources the outline of their history, that their achievements might not be forgotten by those that came after. These histories consist mainly of lists of kings, and copies of these, mostly in a fragmentary condition, have been recovered, some at Nippur; and the most perfect, the Weld-Blundell prism (Plate X), was written at Larsa about 2098 B.C. These lists give the names of a large number of kings, with the lengths of their reigns, arranged in dynasties, and begin with the first dynasty to rule after the Flood. They also mention a short series of monarchs who ruled before that catastrophe overtook the land.

We need not concern ourselves yet with these kings or with the dynasties to which they belonged, for it is to the antediluvian period that we must go in search of the earliest evidence of agriculture. Until quite recently all we knew of the Flood was derived from these lists, from the fragments preserved in later writers of the history of Berosus, who had

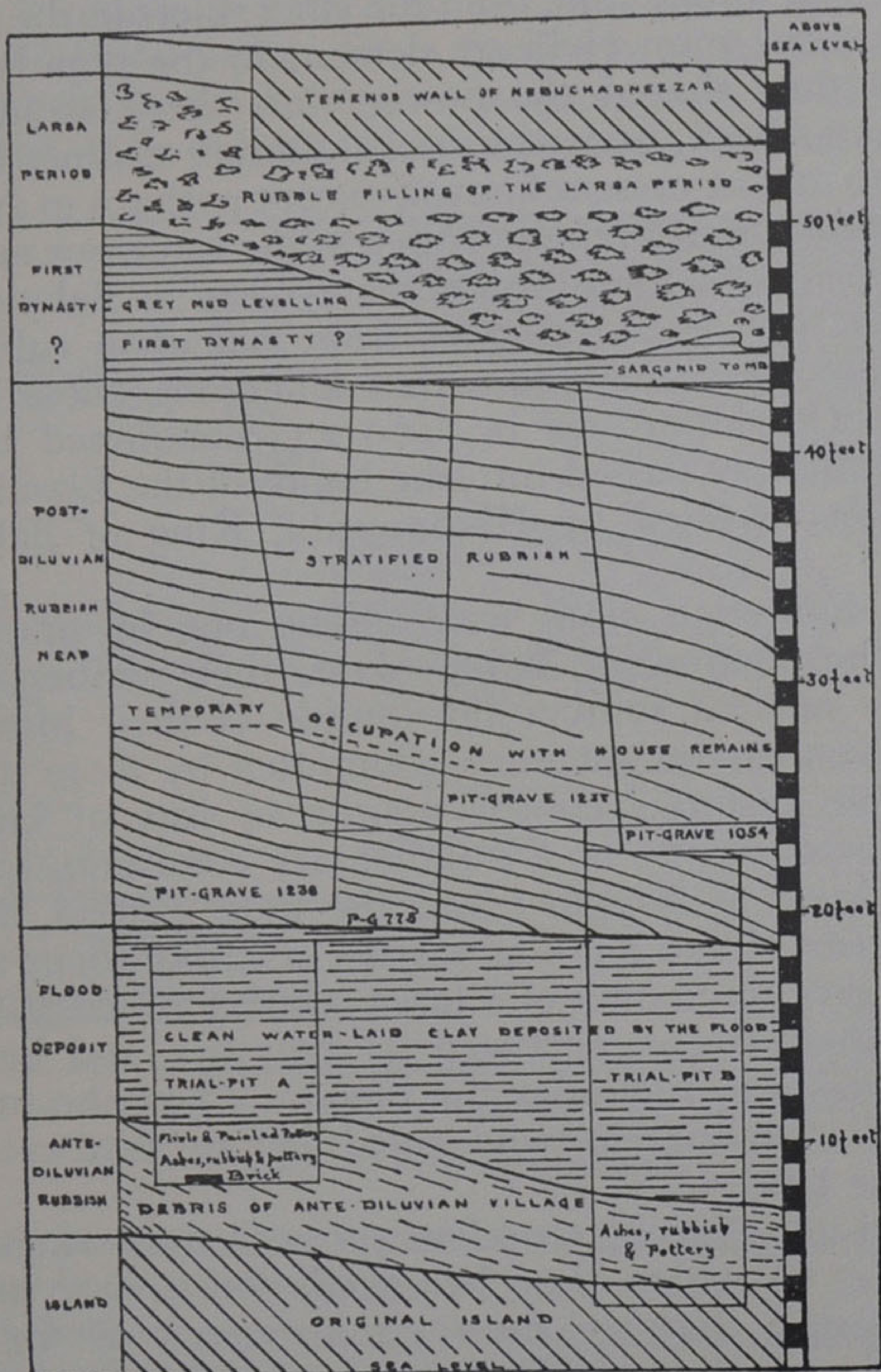
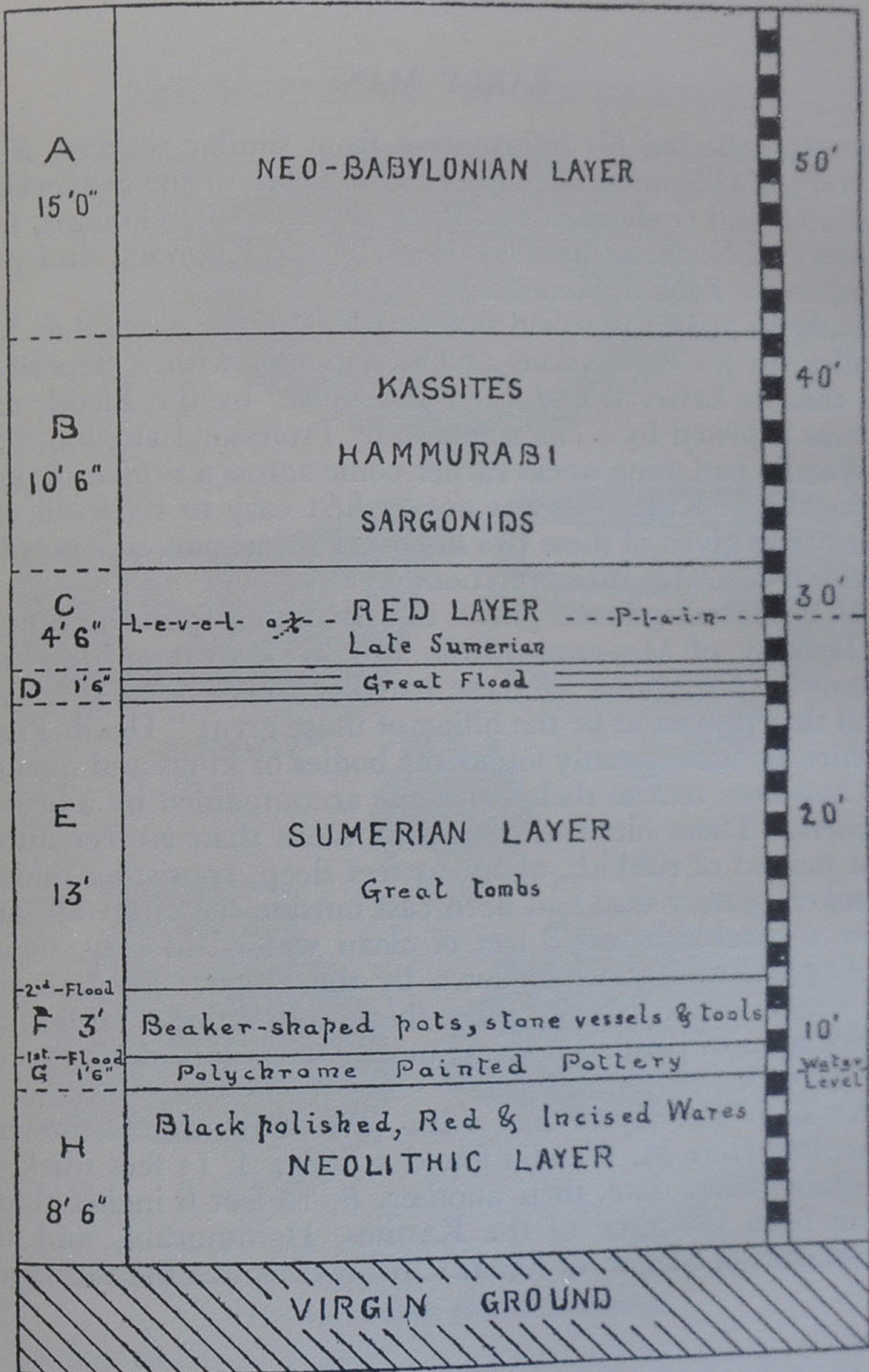


Fig. 25.—Section of Stratified Deposits at Ur.



Reproduced from Peake, "The Flood," p. 103, by permission of Messrs. Kegan Paul, Trench, Trübner & Co.

FIG. 26.—Section of Stratified Deposits at Kish.

evidently collected his information from similar sources, from the story of Gilgamesh, a popular epic poem of the Sumerians, translated and copied frequently by the later Babylonians, and the story of Noah, as handed down by the Hebrews, and preserved in the Book of Genesis.

Early in 1929 the world was startled by the news that Mr. Woolley, in his excavations at Ur, had met with a deposit of clay that he believed had been laid down by the Flood, and this was followed by a claim, made by Professor Langdon, that M. Watelin had some weeks earlier come across a similar deposit on the site of Kish. It was not at first easy to reconcile the descriptions given of these two discoveries, but now it is possible to offer a plausible interpretation.

At Ur, Woolley found graves clearly dating from the time of the Dynasty of Mes-anni-padda, usually known as the First Dynasty of Ur. Some of these had been excavated (Fig. 25) in soil that proved to be the filling of those great "Death Pits," in which he subsequently found the bodies of kings and queens, who had been sent to their last home accompanied by a host of retainers. These pits had been sunk more than 20 feet into a great mound of rubbish, about 24 feet deep, consisting mainly of broken pottery that had been cast outside the city wall, and below this rubbish was 8 feet of clean water-laid clay, which Woolley believed was laid down by the Flood. Beneath this clay was a further deposit, 3 feet thick, containing a large mass of fragments of painted pottery, mostly with dark designs on a buff ground.

At Kish the layers met with (Fig. 26) were somewhat different. Here M. Watelin found a layer, *A*, 15 feet thick, of Neo-Babylonian date, then another, *B*, 10 feet 6 inches thick, dating from the time of the Kassites, Hammurabi, and the descendants of Sargon of Agade. Below this was the red layer,

[*Reproduced from Peake, " The Flood," p. 69, by permission of Messrs. Kegan Paul, Trench, Trübner & Co.*

FIG. 27.—Pottery from Tell-al-Ubaïd.

C, 4 feet 6 inches thick, of Late Sumerian date, then a layer, *D*, 1 foot 6 inches thick, which had clearly been laid down by a great flood. Below this, in layer *E*, 13 feet thick, were great tombs like those met with in the " Death-pits " at Ur, and at the base of this a thin layer deposited by a flood. Then came layer *F*, 3 feet thick, containing beaker-shaped pottery, then another thin layer of flood deposit, below which was layer *G*, 1 foot 6 inches thick, full of fragments of pottery painted in several colours, and lastly at the bottom layer *H*, 8 feet 6 inches thick, from which metal was absent, though fragments of three types of pottery were plentiful.

It would be tedious to discuss at length the arguments which have led me to an interpretation of these two series of deposits, and I have dealt with them fully in *The Flood* (London, 1930). Here I must be content to state that there appears little doubt that the lowest and earliest flood deposit at Kish is contemporary with the thick layer of grey clay found by Woolley at Ur.

The essential point that I wish to emphasise at the moment is that under each of these flood deposits was a layer containing fragments of painted pottery, buff-and-black at Ur and polychrome at Kish. Both these wares had been found before, for example, at Tell-al-Ubaïd (Fig. 27) and early in 1927 I suggested that the buff-and-black ware was antediluvian in date, a view that Woolley himself hazarded the following year.

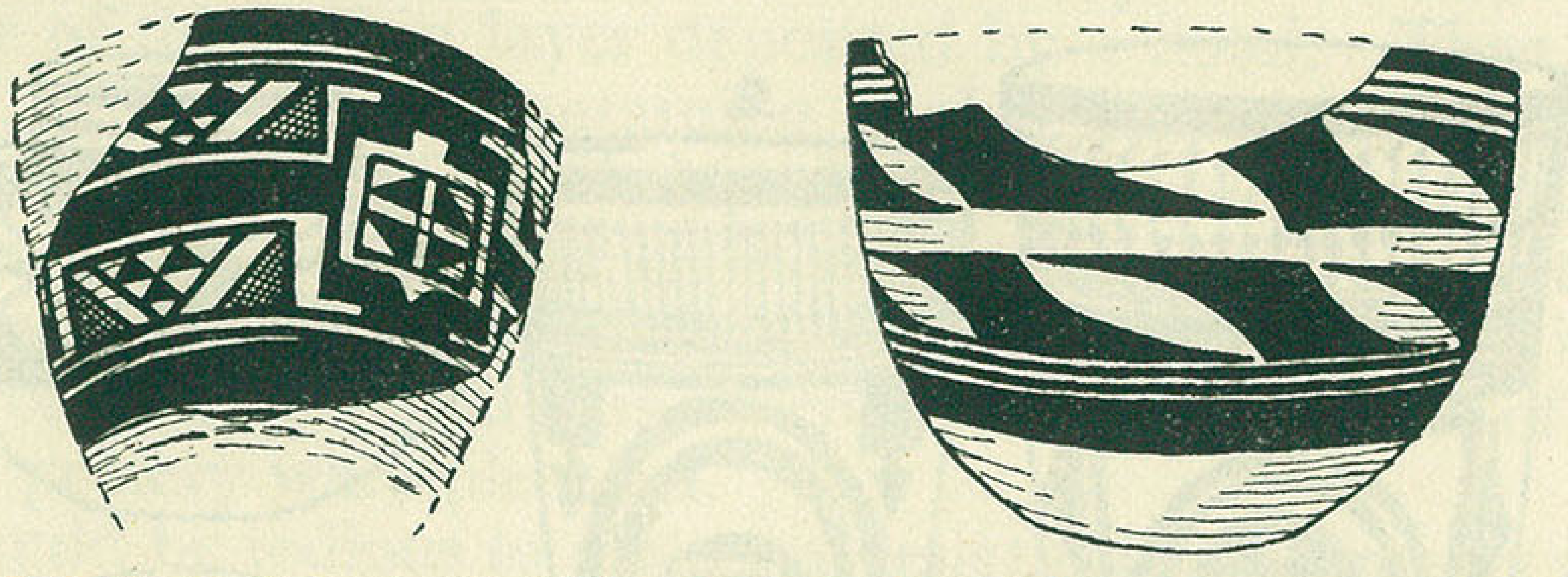
Now this painted pottery has been ably studied by Dr. H. Frankfort, who has suggested that these two types belong to two distinct civilisations. That using the buff-and-black he terms the Highland Civilisation, since it has been found in the lowest layer at Susa (Fig. 28), and came, so he thought, from the plateau of Persia. That he was right in this surmise has recently been proved by Professor Ernst Herzfeld, who has been excavating a number of sites near Teheran, and has found there large quantities of similar pottery (Fig. 29), pictures of which appeared in the *Illustrated London News* in the summer of 1929. The polychrome ware belonged, according to Frankfort, to the

Reproduced from Peake, "The Flood," p. 64, fig. 4, by permission of Messrs. Kegan Paul, Trench, Trübner & Co

FIG. 28.—Pottery from Susa, Period I.

Lowland Civilisation, the origin of which he carries back to North Syria.

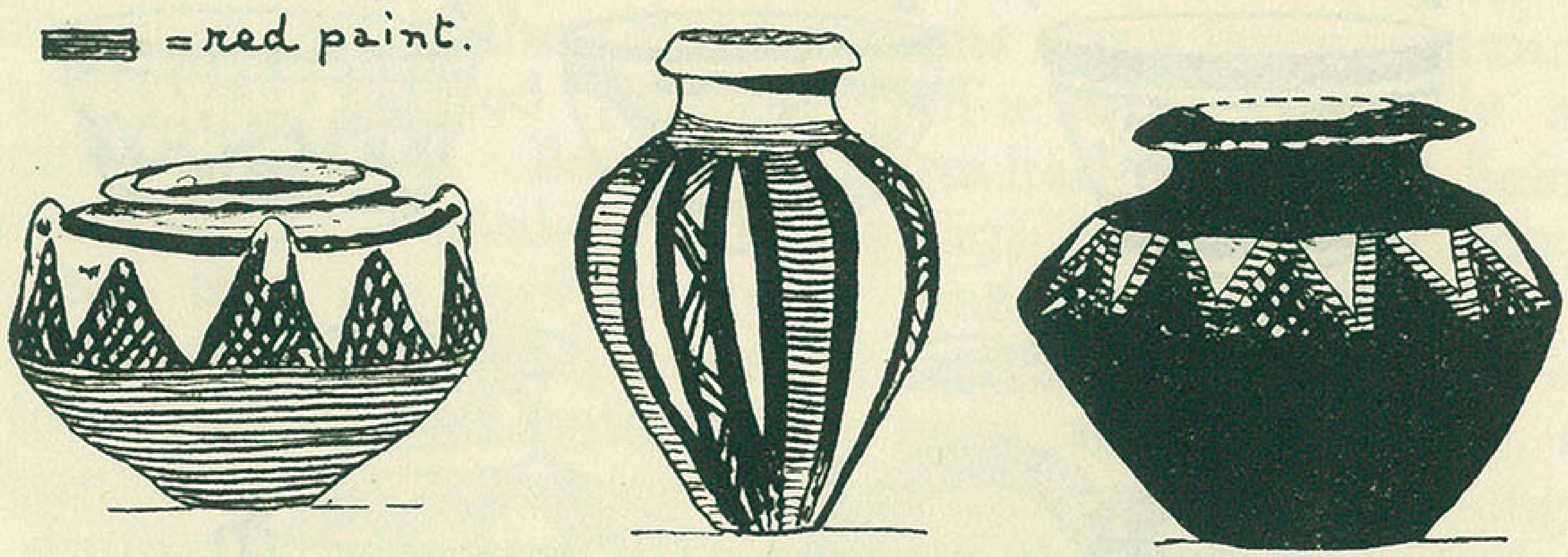
Now, besides that at Susa, a great quantity of the pottery of



Copied by permission from the "Illustrated London News," May 25, 1929, figs. 7 and 11.

FIG. 29.—Pottery from Early Sites near Teheran in Persia.

the Highland Civilisation has been found at Abu Shahrain, the ancient Eridu, the seat of one of the antediluvian monarchies, and at a number of other sites, mostly near the head of the



From a photograph taken by the Oxford and Chicago Expedition to Kish, and kindly lent by Professor S. Langdon

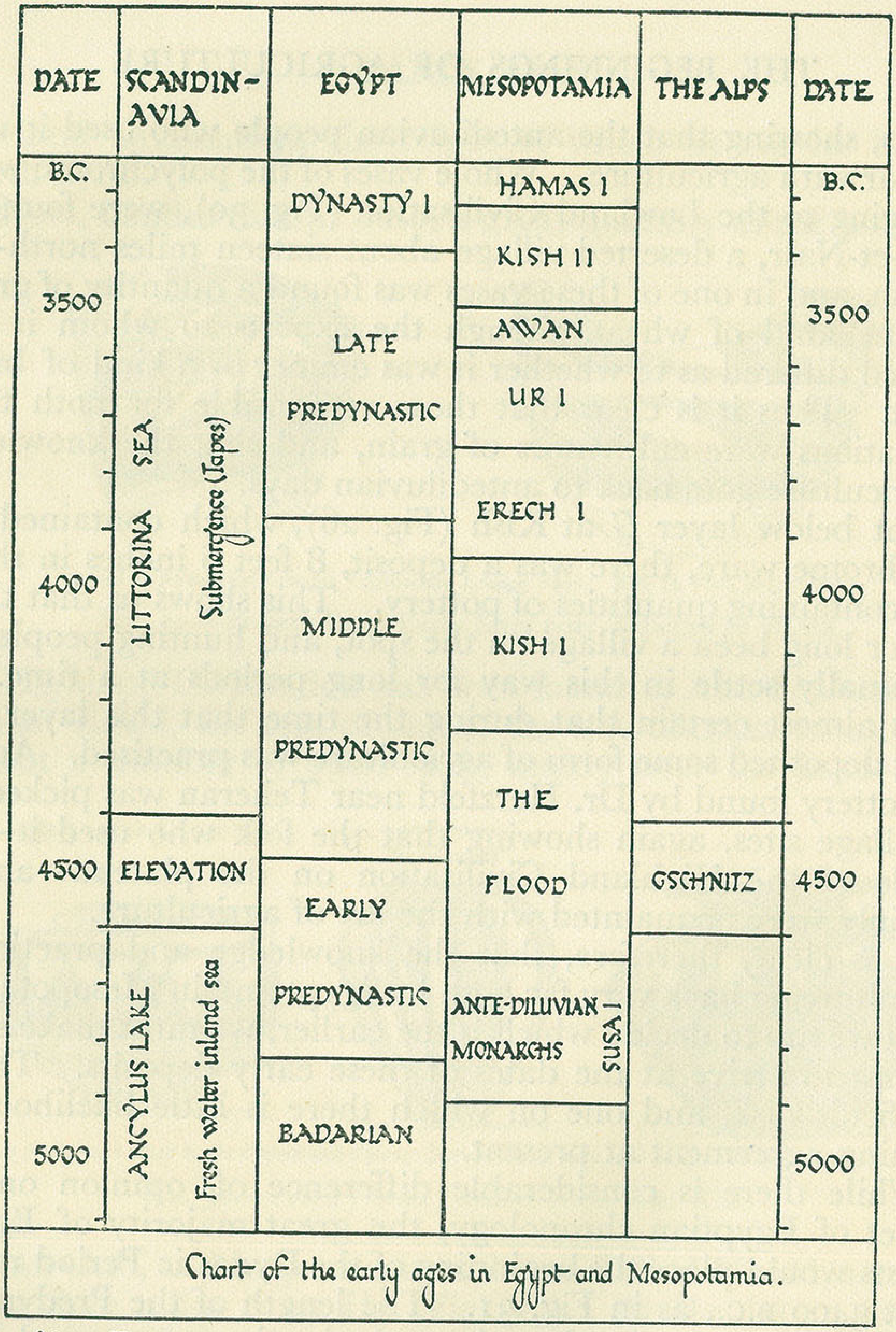
FIG. 30.—Pottery from Jemd-et-Nasr, near Kish.

Persian Gulf, and in great quantities at Tell-al-Ubaïd, a mound about four miles from Ur (Fig. 27). At the latter site this pottery was found in association with hoes and sickles and querns, showing that the antediluvian people who used it were familiar with agriculture. Whole vases of the polychrome ware, belonging to the Lowland Civilisation (Fig. 30), were found at Jemd-et-Nasr, a deserted village about sixteen miles north-east of Kish, and in one of these vases was found a quantity of grain, of some kind of wheat, though the experts to whom it was referred differed as to whether it was emmer or a kind of bread wheat. Thus it is clear that those responsible for both these civilisations were cultivators of grain, and that the knowledge of agriculture goes back to antediluvian days.

But below layer *G* at Kish (Fig. 26), which contained the polychrome ware, there was a deposit, 8 feet 6 inches in thickness, containing quantities of pottery. This shows us that there had for long been a village on the spot, and hunting peoples do not usually settle in this way for long periods at a time. It seems almost certain that during the time that this layer was being deposited some form of agriculture was practised. Again, the pottery found by Dr. Herzfeld near Teheran was picked up on village sites, again showing that the folk who used it—the people of the Highland Civilisation on the plateau—almost certainly were acquainted with the art of agriculture.

It is clear, therefore, that the knowledge and practice of agriculture go back very far both in Egypt and in Mesopotamia, and if we are to decide which is the earlier, we must make some attempt to arrive at the dates of these early deposits. This is a difficult task, and one on which there is little likelihood of reaching agreement at present.

While there is considerable difference of opinion on the subject of Egyptian chronology, the great majority of Egyptologists would place the beginning of the Dynastic Period round about 3400 B.C., as in Fig. 31. The length of the Predynastic Period has been variously estimated, the times suggested lying



Note. The chart reads, in order of time, from the bottom upwards.

Reproduced from Peake and Fleure, "Peasants and Potters," fig. 63, by permission of the Clarendon Press.

FIG. 31.—Chronological Chart.

between 500 and 2000 years; Brunton has recently hazarded that it was 1000 years. On the other hand, two calculations, made independently by different methods, reached a figure of 1500 years. If this were so, the beginning of the Predynastic Period must have been about 4900 B.C. This brings the Badarian Civilisation to round about 5000 B.C., and the Tasian some centuries earlier. This estimate agrees very well with that put forward by Miss Caton-Thompson and Miss Gardner for the Fayûm Civilisation, for on geological grounds they have argued that it flourished between 5500 and 4500 B.C. From this it seems likely that the earliest evidence that we possess of agriculture in Egypt goes back to before 5000, but not farther than 5500 B.C.

Dates in Mesopotamia are, if anything, more uncertain than in Egypt, and equally the subject of controversy. By astronomical means Dr. Fotheringham has fixed the date of the sixth year of Ammi-zaduga, King of Babylon, at 1916 B.C. From this it is possible to calculate back the dates of the early kings of the First Dynasty of Babylon and of the Sumerian kings of Isin.

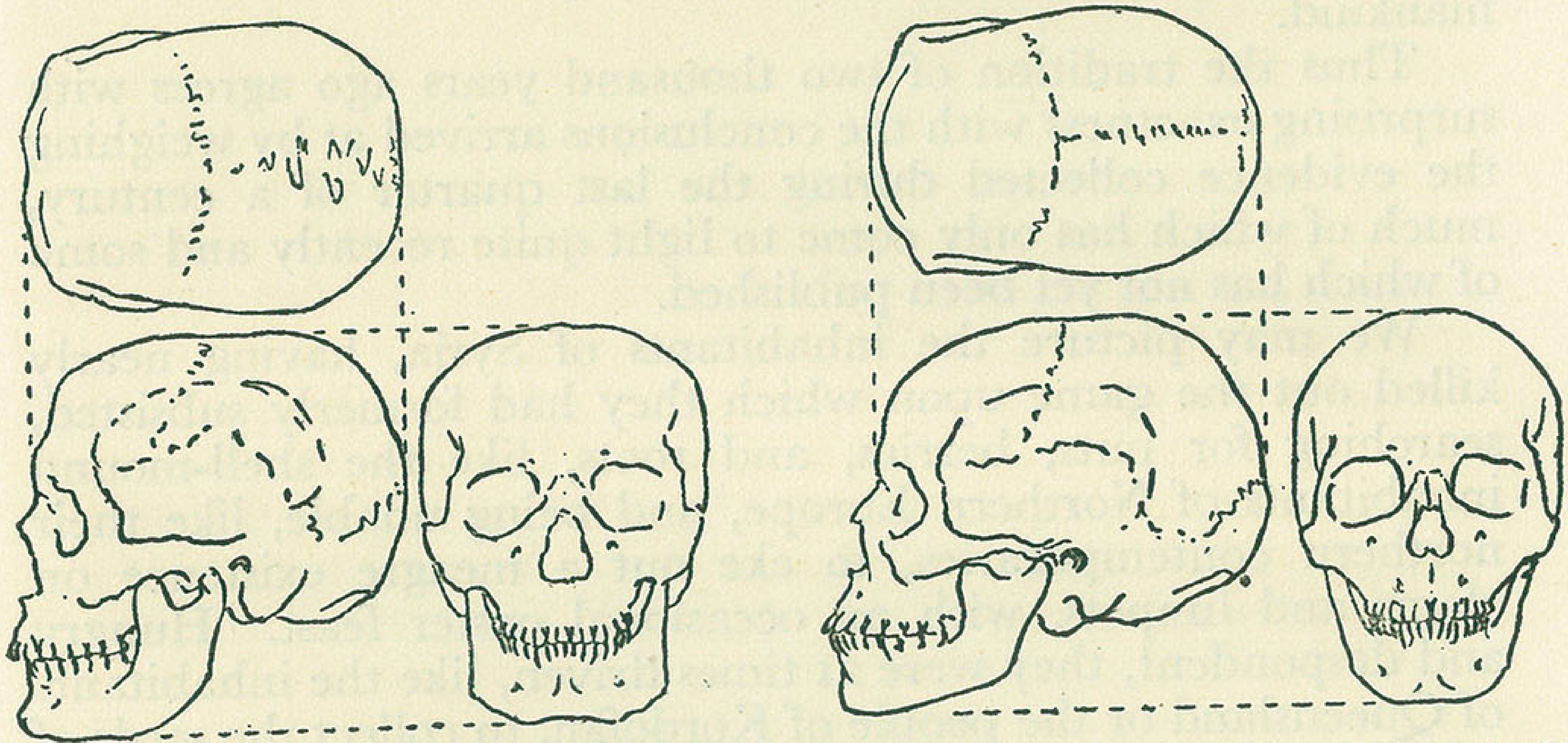
Since we have complete lists of the kings who ruled in Mesopotamia from the Flood almost to the end of the dynasty of Isin, it might be thought that it was an easy matter to date the Deluge. Even the best of these lists, the Weld-Blundell prism, is faulty in places, while in both lists the earlier kings have been allotted reigns of preposterous length, so that Methuselah seems an infant in comparison. Further than this, there are hints that some of the dynasties were partly, if not wholly, contemporary, and it is the fashion at present to assume that two or more dynasties were ruling at the same time.

The question is too complicated to discuss here. In 1927 I ventured to date the rise of the First Dynasty of Kish, the first to rule after the Flood, at 4250 B.C. Langdon has recently argued that the geological evidence suggests that the first flood at Kish, which seems to be the same as that found by Woolley at Ur, took place at 4200 B.C., and a discrepancy of half a century is small when dealing with dates 6000 years ago. But before the Flood two layers were laid down at Kish, one, 1 foot 6 inches in thickness, with the polychrome ware, and another, 8 feet 6 inches thick, containing three types of pottery, but no metal. Thus debris, 10 feet in thickness, had been accumulating on the village site before it was overtaken by the Flood. This must represent a long time, and Langdon is probably moderate in estimating the date of its beginning at 5000 B.C.

Thus we can carry back civilisation, almost certainly associated with the cultivating of grain, both in Egypt and Mesopotamia, to about 5000 B.C., with a possibility of an extra 500 years in Egypt, which cannot positively be denied to Mesopotamia. Honours seem equal, and considering the uncertainty of both series of dates, it would not be wise on these grounds to claim priority for either land.

There is still one other line of approach to the problem—namely, to find whence these people came. In the case of Mesopotamia we have no evidence for the earliest folk, and the lowest layer at Kish has not yet been properly explored. Frankfort, as we have seen, brings the Lowland Civilisation from North Syria, though this suggestion awaits positive proof; while Herzfeld's discoveries confirm his view that the Highland Civilisation came from the Persian plateau.

There remain the Badarians and the Tasians. The skeletons of both these people have been found, and the shapes of their skulls are significant. The Badarian skulls are very long and narrow, and resemble to some extent the heads found among some of the more primitive peoples of India and the surrounding regions. The Tasians, on the other hand, had rather broad and short heads, of a type scarcely ever found in Africa, but which are more at home in the highland regions stretching from Tibet to Central Europe. Moreover, both these people were wont to decorate themselves with gaily coloured shells, such as are found to-day in the Red Sea. El-Badari, and more so Deir-



[*Reproduced by permission from " Antiquity," 1929, p. 467.*

FIG. 32.—Skulls, Badarian to right and Tasian to left.

Tasa, is easily accessible from the Gulf of Suez, and the head-forms and shells suggest that both these people arrived in Egypt from somewhere in South-west Asia.

Thus we cannot with certainty attribute the discovery of agriculture either to the Egyptians or to the dwellers in Mesopotamia, though it seems likely that both obtained the knowledge of this art from some intermediate site. This was the view that obtained among the ancients, and to the archæological evidence that I have adduced I should like to add the testimony of tradition.

Writing some fifty years before the Christian Era, Diodorus Siculus states (I. 14, 1–2; cf. I. 27, 3–4) that Isis, afterwards the great goddess of the Egyptians, discovered wheat or, more correctly, emmer (πυρός), and barley, growing promiscuously about the country together with other plants, and unknown to mankind.

Thus the tradition of two thousand years ago agrees with surprising exactness with the conclusions arrived at by weighing the evidence collected during the last quarter of a century, much of which has only come to light quite recently and some of which has not yet been published.

We may picture the inhabitants of Syria, having nearly killed out the game upon which they had formerly subsisted, searching for nuts, berries, and roots, like the shell-mound inhabitants of Northern Europe, and being unable, like their northern contemporaries, to eke out a meagre existence on clams and limpets, with an occasional oyster feast. Hungry and despondent, they were at times driven, like the inhabitants of Queensland or the people of Kordofan, to collect the seeds of wild grasses, until there arose a woman who was to be their saviour and to lay the foundations of civilisation.

It was, we may well believe, some time between 6000 and 5000 B.C. that this woman collected the seeds of barley and emmer, and scattered them upon a cleared surface on the mountain side, where they were watered by the dew of Hermon that descended upon the mountains of Zion, so that the seed which she had cast upon the hillside she found increased a hundredfold after many days.

This woman was immortalised by the Egyptians as Isis, and as Cybele, Agdistis, and Dindymene by the peoples of Asia

Minor; later by the Greeks as Demeter and by the Romans as Ceres. Her memory has been preserved almost to our own time by our country folk as the Corn Goddess, whose effigy was carried to the barn in the last harvest waggon (Plates VII, XI, XII), in the same way as Diodorus describes the first sheaf and the "stools" of wheat and barley carried round in procession at the feast of Isis in his time.

VI

PRECIOUS METALS: GOLD AND SILVER *

By Professor J. L. Myres, M.A., D.Litt., D.Sc., F.B.A.

THE Discovery of Metals is one of the principal advances towards the control over Nature's resources which characterises civilisation.

By "metals," the Greeks, who gave us the word, meant substances which had to be sought for, in or on the ground; the verb *metallân* meant to "seek"; and *métallon* meant both "metal" and a "mine." In Lettish, a similar verb, *meklét*, means also to "seek," but it seems likely that it is borrowed indirectly from Greek; perhaps from metal seekers, who travel far.† It is likely also that the Greek word, being without other

* By a curious coincidence, a paper was presented, on the same day as this lecture, to the Institute of Metals in London by Dr. T. A. Rickard, A.R.S.M., D.Sc., of Berkeley, California, with the title, "The Early Use of Metals," covering much of the same ground, and dealing also with the history of other metals besides those discussed here. The lecturer desires to express his thanks to Dr. Rickard for the use of an advance copy of his paper, and for much help besides, on matters where his wide practical experience and command of the literature were invaluable. To Dr. Rickard's earlier paper, "Iron in Antiquity," presented to the Iron and Steel Institute in London in September 1929, and printed in its *Journal*, Vol. CXX. (1929), pp. 323–347, reference is made also in the proper places.

† I am indebted for this information to Mr. Roderick MacKenzie, Fellow of St. John's College, Oxford.

Indo-European counterpart, may itself be borrowed from predecessors or neighbours in and around the Ægean, who certainly knew and probably worked metals long before they heard or spoke Greek.

But the realisation that this, that, and the other substance, which we moderns know as metals, form a distinct class of natural substances, with certain physical qualities in common, is a comparatively recent, and not very significant affair. At most the conception of a " metal," as the physicist or the chemist understands the term, registers and summarises the results of many observations and comparisons, and offers a starting point for investigating irregularities in the behaviour of known metals, and for classifying as a new additional metal what is commonly the cause of such anomalies. Popularly, metals are substances usually of high specific gravity (though lithium, potassium, and sodium are lighter than water), high conductivity of heat and electricity; great plasticity, almost complete opacity (though gold in thin films transmits green light, and mercury violet) and a peculiar lustre. When melted by exposure to heat they remain opaque, retain their metallic lustre, and display a high surface tension, so that, like mercury at ordinary temperatures, they draw together into a " prill " or globule. Their vapours interest us less, though the tints of some are surprisingly different from their solid colours; silver vapour, for example, is blue, potassium green, and arsenic orange. The crystalline forms which they take at low temperatures chiefly concern us when they interfere with what is, after all, their most important quality, their combination (in varying degrees) of elasticity and rigidity on the one hand, with plasticity on the other; properties at first sight incompatible, but actually the cause of the remarkable range of utility which has been found for metals in the mechanical arts. Under the general term plasticity are included here the distinct qualities of malleability and ductility, which do not always go together and can be varied by physical means; tin and lead, for instance, may be hammered thin, but not drawn out fine; cast zinc is brittle, but when heated to 100–150° C. it becomes both malleable and ductile, and the foil or wire remains flexible when it is cool, yet at about 200° C. the same zinc becomes so brittle that it may be crushed to powder.

Metals, Modern and Ancient.

Within the last century the number of metals has become increased by chemical research from about a dozen to more than seventy. The turning point in this recent phase of discovery was Sir Humphry Davy's separation of sodium and potassium, both lighter than water, and inflammable in it, by the action of an electric current—itself a recent invention—on potash and soda, which, though soluble in water, we may fairly call their ores. Metals, however, the new substances certainly were, with characteristic lustre, plasticity, and chemical behaviour in presence of oxygen and acids: they rust to " oxides " and form " salts," just like iron or copper.

In the preceding centuries, mere study of minerals, and simpler chemical methods, had already added a few to the " metals " which antiquity had transmitted to mediæval times. Platinum, first found in South America, and believed (as its name shows) to be a variety of silver,* was brought to England by way of Jamaica in 1741 and described as a new metal by Sir William Watson in 1750; in Borneo, later, native gold-seekers were found to be acquainted with platinum, but they discarded it as " frog-gold." Zinc, antimony, and bismuth were all recognised as some sort of metal before 1600.

* *Platina* is a diminutive of *plata*, Spanish for " silver."

Though Erasmus Ebener obtained metallic zinc as early as 1509, it was still confused in 1597 with "a peculiar kind of tin from India"; and even in 1702 Stahl described brass as resulting from the union of a "metal," copper, with what was still known as an "earth"—namely, the mineral calamine. Metallic arsenic was only recognised as related to the well-known arsenic minerals by Brandt in 1733; and bismuth was not clearly distinguished from antimony till after 1700, nor from zinc till the work of Pott, and Geoffrey the younger, in 1753 and 1769.

This leaves us with the very short list of metals recognised in antiquity: gold, silver, copper, iron, lead, tin, mercury. Like platinum in the eighteenth century, mercury was regarded in antiquity first as a "live" or "watery" silver,* and later as either *being*, or at least *including* in very high degree, that which made all metals metallic, and accounted for their plasticity and lustre; a very natural inference from the behaviour of the alloys which it forms with other metals. But the Arabic name *amalgam* for these mercury-alloys warns us of the date at which this notion became current.

Mercury is easily obtained from the conspicuous red sulphide, cinnabar, and was known and prepared in Greece in Theophrastus' time, about 300 B.C. Both cinnabar and the native metal are found in N.W. Asia Minor, and also in Illyria and Transylvania. The last-named area is probably the source of the cinnabar used to decorate pottery as early as the later Stone Age, at Vinča on the Danube. At the lower end of its history, it should perhaps be recalled that it was the ease with which the oxide of mercury can be formed and decomposed with successive increase of temperature, that led to the discovery of oxygen by Priestley, 1774, and Scheele at the end of the eigh-

* "Quick-silver": *hydrargyrum*.

teenth century; one of the "crucial experiments" of modern chemical science. How narrowly the ancient chemists missed this discovery is clear from Geber's account of the relations between mercury and sulphur: both entering, it was believed, into the composition of all metals, and sulphur exhibiting the "contrary force" which in excess obliterated the metallic character of other metals, and converted them back into their ores—which, in fact, were mainly sulphides—and could even counteract the essential metallicity of mercury. It was indeed the awkward circumstance that some metallic ores were *not* sulphides, but oxides, that kept the whole question open till modern times; Brandt's collateral experiments with the oxide and the sulphide of arsenic, about 1730, being the first important step forward towards the discoveries of Priestley and Scheele.

But what is conspicuous in the behaviour of mercury with most metals, including gold—which resisted both the action of sulphur, and also "combustion"—that is to say, that of hot oxygen—was known, however, already in antiquity, to occur, in some degree among other metals; namely, that they could be mingled to form what was known to the Greeks as a "variation" or "changeling" (*alloiôma*), whence we have our word for "alloy"; as the Arabic *amalgam* represents the Greek *málagma*—literally the "softening" of another metal with mercury.

This is a form of behaviour of all metals, not yet completely understood, intermediate in its results between mechanical mixture, or solutions, and chemical combination into a compound with qualities unrepresented in the combining elements. And we shall see, in due course, how much of the early utility of metals resulted from this peculiar behaviour; for all "alloys" differ more or less, in their physical qualities, from the metals they contain: and very small additions of one metal to another are enough to produce very marked changes in colour, melting-point, plasticity, and even specific gravity. Sometimes the causes of these variations were recognised in antiquity; occasionally the process of creating them could be reversed, notably with silver and gold, or lead and silver; more often, the constituents of the alloy were already mixed in an ore, or one of the metals was treated with an "ore" or "earth," the metallic content of which was not recognised; as we have seen happen with brass until the seventeenth century.

This preliminary retrospect of the main phases of later metallurgy is necessary—and I hope also sufficient—to establish a point of view from which to examine stages in the advance of culture and learning, very much earlier and simpler; and to give to those primitive observations and experiments—or at all events to the results of them—significance and reality in relation to what has happened afterwards. In all study of human advancement, we have to make ourselves fellow-workers and fellow-thinkers with our remote predecessors in culture, who were also pioneers in research; and at the same time to apply the knowledge and experience of after-time, and our own time, to recover and interpret "what was really going on," in the furnace, or on the anvil, while the primitive craftsman toiled so laboriously and anxiously, with so many unknowns upsetting his calculations and spoiling his work. That, indeed, is the value of all historical, all archæological, all ethnological studies; they are an exercise in putting ourselves in the other fellow's place, and seeing the world from his point of view; but with fuller appreciation (let us hope) of what his difficulties were; of the inevitableness of many of his mistakes; above all, of the precise point at which he went astray, and of the particular item of knowledge, or bit of equipment, which might have kept him on the road to truth. If the bad workman "blames his tools," the good workman honours the deviser of them.

(a) *The Conception of a "Precious" Metal.*

Of the motives which first led men to observe and value pieces of metal found "native"—that is to say, as natural objects on the surface of the ground, or embedded in soil, gravel, or solid rocks—it is not possible to know anything directly. All we can do is to observe the behaviour of simple peoples, and draw comparisons and inferences.

It has been said that "philosophy begins in wonder"; unusual objects or occurrences attract notice, and excite curiosity. Other primates, and a good many animals and birds, collect brightly coloured or lustrous objects about their habitations, and even play with them, arranging and rearranging these treasures. Sir Arthur Evans tells me that his father observed a family of fox-cubs "playing" with a British gold coin cast up from their earth. Most of us have done the same, in early life, with bright pebbles and shells at the seaside; and we know how attractive such objects are, and how tenaciously we defend our ownership of them. For the collector, at least, they have value, out of all proportion to the labour expended in acquiring them; they are testimony rather to knowledge, judgment, or taste, than to mechanical effort.

It is a further question, why this attention or interest, at once æsthetic and intellectual or scientific, passes over into applied, or decorative art, and use is found for an attractive or interesting object, to enhance the interest or attractiveness of oneself, or one's beloved, or the home, or whatever place or object has acquired (for one reason or another) special value and significance in our lives. The behaviour of children, imitative though it often is, offers suggestive examples of this still almost instinctive impulse. Such significance and use commonly results from some experience or conjecture, often difficult to recover or establish after it has once started the train of thought and action. And one of the most elementary impulses is to enhance on our own account the significance which we apprehend. Polished stone implements are frequently treasured as magical "elf shots"; one such is preserved from antiquity with Mithraic and Isiac symbols engraved on it to intensify its natural potency.*

It is a still further question, how this use of unusual or otherwise attractive objects for personal enhancement is related to the two motives which seem to be most potent, for good or evil, in the behaviour of simple people, which may, I think, be most concisely described as "fear" and "pride." † By "fear," I mean all manifestations of physical, overmastering, irrational, "panic" terror of what is beyond our own control, the limitless indeterminate congeries of things, which baffled even Greek philosophers; the chaos "without form and void" of Hebrew thinkers; on which it is the task and the glory of God, in Hebrew thought, and of man in Greek, to impose definition, analysis, explanation, until for man, as for Jehovah, the world becomes reasonable, and "very good." Against this ever-present, ever-shifting "fear," man clutches at straws, observes coincidences and analogies, accepts casual signs, tokens, and words, as signals from whatever it may be that is behind the sequence of events and is not wholly malevolent; above all, he treasures

* Perrot-Chipiez, *Histoire de l'Art dans l'Antiquité*, Vol. VI. fig. 5: found near Argos in Greece.

† I have dealt with this topic more fully in an essay entitled: "The Beginnings of Science," in *Science and Civilisation*, edited by F. S. Marvin. (Oxford, 1923.)

objects which appear to him significant, which he hopes, rather than expects or discerns, to be important.

For this, in the literal sense of the Latin word, is to have "value"; when we say *ad valorem* we still mean "to the limit of what it can *do* for us." The metaphor is from the one class of events, whereof we know directly both effect and cause—namely, our own exertion of physical strength to give effect to our ideas through our desires; and all things that have "value" exert upon those, for whom they have value, a mental compulsion, not unlike the physical compulsion to which the physicists have applied another good Latin word, originally political, when they speak of electric *potential*.

What man needs and seeks, above all, in these primæval difficulties, seems to be essentially twofold; explanation, intelligible to himself, of what it is that is going on around him; and direction—how to behave, what to do, and what to avoid—in presence of this which is going on in Nature and in his own experience. From the search for an explanation, of a response to curiosity—from man's *need to know*—comes all pure science, no less than all true poetry. From the need of direction come all applied sciences, the response to man's *need to do*, his instinct to disarrange and re-arrange things about him, to control and exploit intractable Nature, and brother-men no less intractable.

For secure scientific reasoning, there are three essential stages: observation, which must be painstaking if it is to be accurate; generalisation, by some supposition, which, if true, will interpret all relevant observations; verification, wherein that supposition is applied to interpret some fresh observation, and is found to explain this, no less than those on which it was originally based. All primitive reasoning, like all modern scientific reasoning, is liable, of course, to errors of fact and to errors of inference or argument. Where it falls short, almost invariably, is that—whereas errors in scientific reasoning are infallibly detected, when it comes to verification by test-case, or crucial instance—primitive reasoning, and much popular argument in our own times, simply do not attempt verification, and consequently mistakes, going undetected, accumulate and breed more and more mistakes. It is this confidence in unverified guesses, suggested often by inaccurate observation, as well as by unsound argument, that I have ventured to characterise as the result and expression of an intellectual "pride" in half knowledge, and such organised and accumulated error is as disastrous in its long consequences as unreasoning "fear" of the unknown.

This has been perhaps rather a long and over-serious preface to the simple question, What do we mean when we speak of "precious" metals? What makes any metal "precious"? What, for instance, makes copper and lead and tin become more and more precious every day in our own time, whereas silver and even gold are certainly far less precious than they were fifty years ago? The answer at first sight is simple: preciousness—that is to say, *value*—depends on the relation between demand and supply. The modern world has "in sight," if not in its pocket, rather more gold and very much more silver than it has current use for, and can win it more economically than even a generation ago. On the other hand, the modern world has far more varied and abundant uses for copper and lead than formerly: new sources of copper are still being discovered and opened up (though not at present quite fast enough); but the supply of lead appears to be limited, and a lead-famine seems to be only a matter of time.

But why are gold and silver, and a few comparative rarities, reckoned as "precious metals," in ordinary speech, whereas copper and lead, for example, are contrasted with them as "useful metals"? Is there not a "use" for silver and for gold? In modern life, as in the classical civilisation of Greece and Rome, gold has two quite different and, at first sight, unrelated utilities; as personal ornament, and as a conventional standard of economic value in other commodities. The second of these is obviously secondary, for it rests on a customary—though, as we have seen, not quite invariable—ratio between supply and demand, in substances which are in other respects convenient for monetary use, through their physical qualities of weight, colour, freedom from corrosion, malleability, and so forth. These, however, they share to some extent with copper; and iron, too, has occasionally been used, as in ancient Sparta, for currency, if not for coined money.

Among personal ornaments, even in quite modern times, we find another distinction (which will turn out to be significant) between objects which may be, but need not be, of gold, such as necklaces, watch-chains, and even watch-cases, and a few objects which *must* be of gold, such as wedding rings and royal crowns. Of these the use is special, ceremonial, symbolic; they bring privileges, duties, responsibilities. "Uneasy lies the head that wears a crown"; and someone once wrote a book "How to be happy though married." If we ask a goldsmith why crowns and wedding-rings are of gold, he may give us the lame answer that they always have been so; and, when pressed, the much better one that "nothing else will do." But why will no other metal serve? And why do many unmarried, and undistinguished, and irresponsible persons habitually wear one ring of gold, however modest the rest of their attire and ornaments? They will probably explain, like the goldsmith, first, that "it is a way people have"; and then, "that nothing else will do"; or perhaps that they wear a gold ring "for luck"; and sometimes it turns out to be a "family ring." But why wear rings at all? Sometimes, however, it is not a ring, but a pendant, and in ancient Rome such a *bulla* was a kind of personal mascot, charm, or phylactery, worn by boys of certain noble families till they came to maturity, and then dedicated in the family sanctuary. In other ranks of Roman society the *bulla* was of leather, not of gold; and favourite animals too wore a *bulla* "for luck." Now we are coming nearer to the heart of the matter. *Some* gold, at all events, is worn "for luck," that is to say, to ensure and enhance the well-being of the wearer.

Now one of the most widespread methods by which men have attempted to modify events, for their own security or advantage, is by rehearsing or simulating the desired result, as when they light bonfires at midwinter to enhance the sun's warmth at its lowest, and start it on another cycle of beneficent spring and summer. Quite as widespread is the use of objects with qualities similar to those desired: red paint, red stones, or red coral, for instance, are used to conserve or enhance the life blood of man or beast, and thereby increase, perhaps even prolong, vitality. Our midwinter holly-berries are probably an example of this; and it is also the oldest known of such observances, if we may so interpret the custom of smothering the bodies of the dead in a quantity of red ochre, which has been traced back from Neolithic times into the Mousterian stage of Palæolithic.*

Quite apart from this assumption that similar causes have similar effects, which is the basis of all those observances which may be grouped under the convenient heading of "sympathetic magic," the mere oddness of a natural object, and especially the perverseness of a malformed specimen of a common

* R. A. S. Macalister, *A Text-book of European Archæology*, Vol. I, p. 299 (Cambridge, 1921).

class, seems to be generally regarded by simple people as due to some exceptional force or potency inherent in the object, and by no means exhausted in producing that effect which called attention to its presence. In the Banks Islands and Northern New Hebrides there are many sacred stones, traditionally " sacred to some spirit from ancient times," and " if a stone is found to have a supernatural power, it is because a spirit (*vui*) has associated itself with it." But " any man may find a stone for himself, the shape of which strikes his fancy " and by trial find whether or not it contains a spirit.*

Among the forms of control over natural processes most ardently and universally desired are the propagation and prolongation of life; the latter, in the natural body, so long as that performs its functions, but when those cease, then by some other means; for the last thing that occurs to any healthy person is that the world can really go on without him. There are also other lives to be considered; animal-lives among pastoral folk, where everything else depends on the maintenance of flocks and herds; plant-lives among cultivators, high and low, for in these societies it is the food-crop that matters. But most of all it is the maintenance of the people themselves, in this life, and frequently also afterwards, according to their beliefs on that subject.

A striking instance of this use of a " life-preserver " is the widespread popularity of amber in primitive Europe, as far as Spain, Italy, Crete, and Asia Minor. For this three several reasons lie near at hand. Flies and other small creatures, once alive, are wonderfully preserved within the substance of this fossil resin. Amber, electrically excited by rubbing, like other resinous substances, attracts small particles of dust and rubbish, and causes lively and apparently animated behaviour in them; it seems to impart life, as well as preserve objects once alive.

* R. H. Codrington, *The Melanesians*, pp. 119, 140, 153 (Oxford, 1891).

And when its rough weathered surface is polished it seems full of light, responsive to sunlight, radiant itself. And we do not have to go very far in the folklore of early peoples to learn how early it was realised that sunlight and sunheat were a first cause of many forms of life on earth, and essential to the well-being of living things.

Similar light-communicating, and therefore (as was believed) life-giving, potency has been widely ascribed to gold. Though not luminous, gold is lustrous, and coloured like the sun; uncorrupted by heat, moisture, ill-usage. Though stone-like in shape and earthly in source, it is soft like living matter, and so heavy in hand that it seems to exert a pressure of its own.

(b) *Gold as Life-Giver and Life-Preserver.*

An early example of these beliefs, and of consequent practices, is in the "fire-altar" ritual of the first phase of Aryan culture in India.* This ritual has as its object the attainment of immortality for the King, by repeating what had been successful in giving immortality to the Father of the Gods. For "the gods are splendour; he enters splendour"; for "he who builds an altar becomes the deity Agni, and Agni (the fire) is indeed the immortal (element)." The sun, the origin of all life, is also "the germ of gold," and fire, its earthly representative, could endow with life things burnt in it. Besides being the messenger of the gods, fire was also the guide of the dead, "the first of the godward-going." Gold, like fire, could give immortality, for "gold doubtless is Agni's seed," as the sun is the "germ of gold," and gold the symbol of the sun. The sacrificer holds gold over water from a well, "and thus it is made like yonder burning sun." Before cremation, gold chips

* Principal passages from Vedic literature are collected by Mary Levin in *Man*, 1930, 32.

were placed on the parts of the corpse most connected with the immortal life of man, "for gold is light, and light is immortality; he thus bestows light and immortality upon him." Then the body was cremated; the gold chips gave it light and immortality; the fire restored its "vital airs"; the dead became reanimated and immortal. The sacrificer himself, too, would have a body of gold in the other world: indeed the only risk was lest he should attain immortality prematurely; and precautions were taken against this.

Similar practices, on a lavish scale, suggest the prevalence of similar beliefs about the life-preserving potency of gold, in the royal burials at Ur and in the tomb of Tutankhamen. In Cyprus, tombs of about Tutankhamen's time contain gold mouth-pieces (like the "gold chips" which enhanced the "vital airs" of old Indian corpses), and gold flies, shells, palm-trees, and other objects probably symbolic, though we do not quite know their message. At Mycenae, in the "shaft-graves" within the "Lion-gate," complete masks and a breast-plate of gold were supplemented with many minor ornaments, decorated with butterfly, octopus, palm-leaf, and elaborate spiral designs; symbolism, here too, probably enhancing the potency of the mere gold. At Hissarlik, considerably earlier, much gold, in simple wire-work and foil, was worn by some of the living, quite in an early phase of bronze-culture; and occasional gold ornaments, for the living probably, and certainly for the dead, are known in Western Europe back to the later Stone Age. In the New World, Mexican and Peruvian tombs illustrate similar use of gold in pre-Columbian times.

Compare, now, with that Indian philosophy of gold, light, and life, three distinct aspects, and survivals, of that widespread system of beliefs. First, we have the notion, popularised among early Greeks in Hesiod's account of the "Golden Age," that in the earliest days not only had gold been commoner, but men had lived longer and more happily on that account. And though Hesiod's "golden breed" were "covered by the earth in due time," they are "spirits by the will of great Zeus, excellent, above-ground, guardians of mortal men, who keep watch over justice and evil deeds, wrapped in mist, passing everywhere upon earth, givers of wealth; and this royal right they had." Like the first to attain to godhead in India, though they did not quite become immortal in the flesh, they retained an incorporeal existence wherein they were in turn wealth-givers, and right-givers; for right is bred of light among Greeks.

Secondly, we need not go further than our own traditional philosophy for the notion that in the latter days not only will a "Golden Age" return, but that the Place of Eternal Happiness is itself "Jerusalem the Golden." "And the building of the wall thereof was jasper: and the city was pure gold, like unto pure glass . . . and the twelve gates were twelve pearls" [another widely-valued "giver of life"]. . . and the street of the city was pure gold, as it were transparent glass." * And it is the luminosity—the light-giving quality—of the gold that is essential here; "her light was like unto a stone most precious." The Heavenly City, that is, more than fulfilled the symbolic promise of the Mosaic Tabernacle and Solomon's Temple "overlaid with the best gold."

Thirdly, in the long story of attempts to supplement natural sources by synthetic processes, the alchemists' search for the "philosophers' stone" or other means to turn base matter into gold, is throughout involved with the twin-quest of the "elixir-of-life," which, like the gold of Vedic ritual, should make men live for ever.

For us, the interest of these researches is historical and two-

* *Revelation* xxi. 18.

fold. They are the precursors and pioneers of our own metallurgy and chemistry, as Babylonian astrology was of Greek astronomy. And they go far to explain the peculiar fascination —the *auri sacra fames*—which gold has exercised on a very large part of mankind, in the New World of pre-Columbian Mexico and Peru, as well as in the ancient cultures of India and China, Babylonia and Egypt.

Once this *auri sacra fames*—this hunger, not so much for gold itself, as for what gold, as was believed, could alone supply, as a " life-preserver," here and hereafter—had entered into the minds of men who had the means to gratify it, a new economic, and therewith a new political impulse, was introduced into human societies: and all the more so, because in utilising the gold that was available, so large a proportion of it was irretrievably put out of use, by being buried with the powerful dead. How vast was this immobilisation of gold, we are only beginning to realise, in Sumerian royal tombs, and the funeral equipment of Tutankhamen; and Tutankhamen's gold is the more instructive, when we consider that he is only one out of scores of really important kings, who may be inferred to have had similar provision made for them.

(c) *Early Sources of Gold.*

Something of the methods, and even of the sources of this search for gold, may be gathered from Egyptian tomb-paintings of tributary peoples bringing gold among other offerings to eighteenth-dynasty kings; but this is the skimming of the cream. Whence were those Keftiu tributaries, those conquered and looted cities of Syria, those Red Sea navigators to the land of Punt, obtaining severally their gold; exploiting ulterior resources by intercourse with more distant countries and peoples?

To some extent, actual finds of worked gold give a clue to distant centres of culture and craftsmanship; the Gebel-Arak dagger, found in a predynastic grave in Egypt, belongs to a cycle of metal-working, rather Armenian and Caucasian than Mesopotamian; a gold-plated statuette, now in Toronto, is described as Sumerian in features and technique; but its date is uncertain, and in style it is not very different from predynastic figures in Egyptian materials.* Rather further afield we are led by the high percentage of tellurium in some Egyptian gold; a metal in association with which there is much gold still worked in the Transylvanian section of the Carpathians. But until the gold objects from Hissarlik, on the Dardanelles, have been analysed, there is obviously a missing link here; and the Nearer East is still very imperfectly explored, even for gold itself.

Only with the growth of Greek seaborne trade, to coastal colonies from the Sea of Azov to the Ebro, and with the organisation of the Persian Empire, do two large distinct sources of gold become conspicuous; India, which poured its tribute into the treasury of Darius, and later of Alexander and his Seleucid and Parthian successors; and Western Siberia, whence the gold came through Sarmatian and Scythian hands to Greek ports on the Black Sea coast. Here the classical myth of the "gold-guarding griffins" coheres with recent folklore about the "claws of great birds" which turn out to be rhinoceros-relics out of glacial gold-gravels; and the "gold-digging ants" of Herodotus and Megasthenes fade into fur-clad Tibetans panning nuggets no bigger than insects.†

Within the nearer world of Greek experience, however, the gold-fields, first of Lydia, then of the Pangaean country between Thrace and Macedon, seem to have satisfied local needs; and

* *Bull. R. Ontario Mus.*, Jan. 1930.

† T. A. Rickard, *University of California Chronicle*, Jan. 1930.

the Lydian gold, exploited in the seventh and sixth centuries by Gyges and his successors down to Crœsus, supplied the material cause for an economic invention hardly less significant than the original conception of gold's life-preserving potency.

Outside the cultures of antiquity, and their European and West-Asiatic outlands, it is rather the purposes for which gold has been sought and used, than its early discovery, that are significant. Obviously gold may have been observed and collected very early; but neolithic gold in French or Spanish sites is only relatively ancient, as American gold is prehistoric if it is pre-Columbian. There are a few regions, like Australia, where gold, though known to the natives, was not worked by them. In Katanga, native metal-workers preferred "red metal," copper, because it could be hardened by hammering into tools and ornaments, though "white metal," gold, being heavier and softer, admittedly made better bullets, of course by cold hammering.* In Guinea, similarly, and in parts of North America, natives were found to prefer copper to gold. Sometimes, too, gold has been known and worked, but without special observance; in Colombia and Brazil, where fish-hooks were hammered out of natural nuggets, the malleability alone was of interest. Occasionally, though gold has been valued, it has been for its appearance only. In Mexico, when the Spaniards melted down the gold ornaments they collected, what surprised the Aztecs was the wanton destruction of good workmanship: for them, apparently, gold was like ivory or soapstone, a superb material for the craftsman. Even among fine goldsmiths, moreover, the very irregular weights of gold ornaments suggest that, as in modern India, these were worked up from the piece or pieces of gold supplied in nuggets or coins; and the massive

* V. L. Cameron, *Across Africa*, 1885, ii, ch. 17, and information from Dr. T. A. Rickard, 1930.

gold cup dedicated at Olympia by the Kypselid family of Corinth, shows large and small flecks of lighter-coloured electrum, where such nuggets have been kneaded together cold.

The melting of gold, and still more the refining of it from such impurities, are not demonstrable from contemporary evidence until the Eighteenth Dynasty.

(d) *Precious Metals as Measures of Value.*

"The art of measuring brings the world into subjection to man"; and in the great River-side Cultures, where the domestication of flowing water for human uses first made possible either extensive or intensive cultivation of grain-crops, in systems of basin-irrigation, measurements of various kinds became indispensable, if society was not to be dissolved by the failure to give "to every man his due." (1) In alluvial, irrigated country, geometry, in the strict sense of land-measurement, took shape in measures of *length* and *area*, to define the cultivation-plots, and recognise their limits after flood time. And allowance must be made, at a quite early stage, for the need of solid-earth measurements, in the construction of embankments and canals; and also of the brick-work of Babylonian *ziggurat*-temples, and the masonry of Egyptian *mastabas* and pyramids. Only recently has the solid-geometry of the pyramid-builders become intelligible through the reconstruction of Herodotus' account of it. (2) For estimate and apportionment of grain-crops and liquid produce, such as oil, wine, and Egyptian beer, measures of *capacity* were needed; and (3) measures of *weight*, for commodities not easily reckoned by the bushel or the gallon; all furnishing facilities for interchange of equivalent quantities. (4) In Babylonia, measures of angular-distance gave to the reckoning of *time*, by observation of sun, moon, and stars, a precision never attained by Egyptian night watchmen nor by the various water-clocks common to North Africa and the Greek world, which needed to be frequently and clumsily re-started.

But with these inventions, the quantitative needs of the River-side Cultures seem to have been met quite early, and it was only at a much later stage, and on the margin of the nascent Greek world, in Western Asia Minor, that the first experiment was made in uniform measurement of economic values, in terms of amounts (practically of unit-weights) of a single commodity exceptionally precious and universally acceptable.

There had, however, been awkward attempts in this direction, in early societies, and some very simple societies have adopted various queer expedients. Modern examples are the coco-nut currency of the Nicobar Islands, the block-tea currency of the Russo-Chinese caravan-routes, the block-salt currency of Abyssinia.* In pastoral society, cattle are the standard, and indeed almost the sole form, of wealth; and the values of weapons, slaves, marriageable women, and other exchangeable goods are reckoned in oxen or cows. In sea-borne trade, the commodities are either bulky foodstuffs and raw materials, measured or counted, or else luxury-objects (beads, metalwork, spices, and drugs) which have individual fancy-values, at the caprice of the customer; though occasionally such objects attain to standard value, recognised over large areas; the African cowrie-shell is a typical instance. Moreover, while the cargo itself is thus bartered on arrival for what it will fetch in commodities, the ship, once manned and provisioned, is self-supported for the period of its voyage, or at most the crew consume part of a cargo of foodstuffs, and conse-

* Examples are collected by Sir R. C. Temple, "The Evolution of Currency" in *Lectures on the Method of Science* (ed. T. B. Strong. Oxford, 1906).

quently no provision for journey-money is necessary. *La veritable monnaie maritime, c'est la marchandise.**

On a land-route, however, the caravan, to save transport, pays its way, trafficking for food as it proceeds, from oasis folk or caravanserai-villagers. It consequently needs some portable, negotiable commodity, accessory to the main cargo, to avoid "breaking-bulk" at each halt. Such commodities are precious stones—blood-stones, pearls, cowrie-shells, and other magical "life-preservers"; fragrant and stimulant essences, incense for fire-rituals, and (above all) gold, which has the necessary qualities in high degree: it is portable, universally desirable, incorruptible, easily and accurately divisible; and, above all, being so nearly uniform in quality, it can be accurately estimated by weight. In early Palestine, it is already "current money with the merchant," though at a payment it has to be weighed out.

Obviously, if there happens to be a natural goldfield near the terminal bazaar-city of a trade-route—still more at the junction of a trunk-route and numerous distributories—whoever controls the goldfield can acquire a great variety of merchandise, and dispose of it again, at little cost to himself. As the Bradford man said, in happier days, "We don't make money, we scoop it oop." For his guests (as bazaar-manager and caravanserai owner) are also his customers both for their return-cargo, and above all for their journey money, without which they cannot even start.

But no less obviously, what is destined to be tendered piecemeal to many distant sellers must be of indisputable quality. The gold-merchant at the terminal bazaar must therefore guarantee what he provides; and he, of all people, best knows, or can ascertain, what gold is good. With his guarantee of quality, stamped on his ingots, or mere nuggets (as in Cali-

* G. Radet, *La Lydie et le Monde Grecque*, p. 156 (Paris, 1893).

fornia during the gold-rush), they will become indeed " current money with the merchant," for if there has been any mistake, he can confront the guarantor with his own signet and trade-mark. The amount, meanwhile, as in Abraham's bargain with the Hittite, is still verified by weighing.

Now this is precisely the invention of *coinage*, ascribed in Greek tradition to Gyges, King of Lydia, in the generation after 700 B.C., whose unshapely gold pieces, rough-cast, or natural ingots, and moreover of quite variable silver-content—for the natural Lydian *electrum* contains sometimes as little as 40 per cent. of gold—bear the lion's head of what seems to have been the royal seal of his house, for it recurs on a long sequence of issues down to the time of Crœsus, his fifth successor (560–545 B.C.). For his capital, Sardis, lay (1) at the western end of the long trunk roads through Asia Minor to Syria and Mesopotamia; (2) at its junction with divergent routes to a long stretch of sea coast set with Greek cities engaged in oversea trade with their motherland and its other regions of colonisation; (3) in the midst of a fertile and then populous region, one of the paradises of the Nearer East; (4) at a point where alluvial gravels of the Pactolus River are rich in gold from the reefs of Mount Tmolus, only a few miles to the south. Such combinations of circumstances are rare, but it needs more than fortunate circumstances to bring about an invention of this kind. Whether it was the Lydian gold-master himself, or the Greek money-lender from Ephesus half discerned in the background of his story, *someone* in or near Sardis literally set his seal on the traditional preciousness of gold, and made it, for all after-time till now, the supreme standard and measure of the values of other things. When Aristotle, however, writing three centuries later, describes the " stamp " or *character* struck upon the " accepted " unit, as a " sign of how much," he is interpreting the gold of Gyges, and even of Crœsus, in the light of the more skilful moneying of his own time. In the beginning, as has been indicated already, what was guaranteed was not quantity but quality. The famous "Lydian stone" made assaying easy, because it was the first "touch-stone"; the Lydian *character* was rather a "sign of how *good*."

It is an obvious question, why, with this new economic function of gold superadded to its magical and ceremonial uses, the search and the supply never fully overtook the demand. On one occasion, indeed, when Philip of Macedon deliberately flooded free Greece with the output of the Pangaean gold-field, the ratio of gold to silver at all events does seem to have sunk temporarily; but even the release of the hoarded treasure of the Persian kings by Alexander does not appear to have upset it seriously. The answer, probably, is given by two considerations mainly. The frequent insecurity of public and private enterprises led to habitual hoarding, such as India and the Further East practise still, and consequently to continual loss by lapse of memory, very ill compensated by the casual "finds" which romances and even histories attest. But far more important, and less compensated, except very rarely, is the perennial drain on the gold-fund of the living, for the supposed convenience of the dead. Gold is rare, in nature; but it has been made relatively much rarer by man's immobilisation of it in his tombs.

(e) *Silver, a Precious Metal, Produced Artificially.*

It is, however, curious that the nearest approach to an anticipation of the Lydian use of gold as currency, though it occurs in the same neighbourhood, is in respect not of gold, but of silver. At Hissarlik, on the Asiatic side of the Dardanelles, the so-called "Treasure of Priam" from the "Second City" in order of stratification and date, includes (along with many objects of bronze, a few of silver, and a fair quantity of gold) six similar ingots of silver, all approximately one-third of the "light Babylonian mina" in weight, or about 173 metric grammes. Though unstamped, and quite unworked, they are so uniform, and their weight is so nearly exact that it seems probable that they were intended as units in exchange; and it is certain that the same "light Babylonian" system of weights determined the monetary standards of a curiously disposed group of cities and native states in adjacent Thrace during classical times, and indirectly also the widespread Euboic and Attic standards west of the Ægean. There is an echo of such early silver-traffic in the Homeric allusion to a "birthplace of silver" on the eastern margin of Priam's political regime, assigned in Greek tradition to the thirteenth or twelfth century B.C.; and much earlier than that (about 2400 B.C.) an extensive Babylonian silver traffic in Cappadocia is demonstrated by contemporary documents.

But this is anticipation only. What is noteworthy is that when the Greek cities of the Ægean adopted widely the Lydian invention of coinage, in the seventh and early sixth centuries B.C., they did so for silver, not for gold.

Now silver, though thenceforward it came to stand only second to gold as a monetary and "precious" metal, has a very different and at first sight quite incongruous history.

Silver, like gold, occurs native in threads or veins; it is so easily reduced from its chloride, that after forest fires it may be found in surface soil, and it has even been thus produced, both accidentally and deliberately, by man. But, unlike gold, silver tarnishes quickly; it is therefore not so easily recognised, except in dry countries where blown sand has repolished it. Such were the sources of the copious silver of Mexico and Peru, cold-wrought into personal ornaments in pre-Columbian times: and in some parts of North America native silver, occurring with native copper, seems to have been regarded simply as a white variety, and was utilised for decorative plating.

In the Ancient East, silver was, for long, rarer than gold; in Egypt, as in China, it was treated as a white variety; but it is not clear whether it was more highly valued. Its later magical association with the moon—as in the mediæval name "lunar caustic" for silver nitrate—may go back to primitive beliefs like that which connected gold with the sun; but there is no early record of it. From the rapid augmentation of Egypt's silver supplies under the eighteenth dynasty period of conquests in Syria, and from the much earlier evidence for Babylonian silver trade in Cappadocia, it seems likely that Asia Minor was for long a principal source, and that this supply was still copious when silver "was nothing accounted of in the days of Solomon." One actual vessel of silver of this period or earlier has been found in Cilicia, and its shape identifies a whole fabric of grey-faced pottery in Cyprus as an imitation of such silver-ware.

Further west, there is occasional silver on early sites in the Greek islands and in Crete; and in the shaft-graves at Mycenæ it begins to be commoner, though much rarer than gold; but at Hissarlik, less remote from the source in Asia Minor, silver is rather more abundant, and the currency bars already noted suggest that it was being regularly traded.

All the more remarkable, then, is the sudden vogue of silver as the money-metal and standard of value in the Greek cities around the Ægean in the seventh and sixth centuries. As most of these local coinages stand in direct or easily recognisable ratio with the gold and silver-gold coinages of Sardis and the Greek cities on the west coast of Asia Minor, there need be no doubt whence the device of moneying was borrowed. But no part of the Greek world has native silver, nor the "cerargyrite" chloride which is so easily reduced, in workable quantities. There is, however, local abundance of argentiferous galena, a silver-lead sulphide, needing skilful reduction and repeated refining, with total loss of the lead originally, though in late Greek times this was partly remedied. And it was the vast mass of this mineral in its home territory that made it possible for Athens to break the financial dependence of the Greek cities on Sardis, and to maintain its own financial supremacy until the ulterior gold-resources of Persia—the "ten thousand archers" who did the Great King's secret service in Greek politics—were supplemented by the new and nearer gold-fields of the "Thrace-ward parts" when these fell out of Athenian and into Macedonian hands.

Here, then, we have the remarkable situation, that a metal of which the origin was known to be artificial, and for which the demand was mainly if not primarily monetary—about which, that is, there was neither mystery nor rarity, for it could be produced at will—was so far assimilated to gold as a "precious metal" that it replaced it for several centuries, and over a very wide area, as the standard measure of values. From the Greek kingdoms of Egypt and Syria—and even of Bactria far to the east—to Italy and Gaul, Carthage and Spain, silver coinage was normal from the age of Alexander to that of Augustus. Gold, indeed, was coined by anyone who had temporary control of this or that goldfield, or of an avenue of gold-importation, as Lysimachus controlled the route to Scythia; but for ordinary mercantile purposes on the larger scale now practicable, gold was not plentiful enough; and the colloquial use of *argyrion* and *argentum* (perpetuated in the French *argent*) testifies to the general use of silver money. And it was perhaps this wholly rational and economic utilisation of artificially prepared silver which most powerfully contributed to rationalise popular notions about gold, leaving this not very useful, and really not very rare metal, in the peculiar economic status among natural substances which it has continued to share with silver until modern times.

VII

USEFUL METALS: COPPER AND IRON

By Professor John L. Myres, M.A., D.Litt., D.Sc., F.B.A.

In dealing with Precious Metals, we have seen how substances of unusual, attractive, and (especially) lustrous appearance came to be valued *partly* on account of physical qualities (colour, lustre, malleability) which could be artificially enhanced by workmanship, *partly* on account of qualities imputed to the metals by inference and analogy with sunlight, life, eternity, etc.; how *eventually*, because the demand created by these beliefs about gold was never overtaken by supply, this " precious metal " acquired a reputation for stability of price; how this qualified it to become a general standard of values, and *consequently* contributed emphatically to sustain its reputation for value, and confirm the stability of its price.

The historical association of silver with gold, and the early importance (already noted) of electrum, has made it desirable to treat this very different metal next, and consequently to anticipate certain points of metallurgy and craftsmanship which belong to later stages of culture. So we have taken for granted skill to reduce silver from its ores; disregarding the facts (1) that this skill is essentially the same as is required for copper and lead; (2) that copious silver only appears in antiquity long after copper was being reduced from its ores, and within the same large region of culture, and also (3) that one of the early sources of silver, Cappadocia, was adjacent to one of the earliest sources of iron-working, at a still later stage.

We may now return to the primitive uses of metals, to deal with a substance, in many ways similar to gold, but destined to very different kinds of exploitation, not as a "precious" but as a "useful" metal.

(a) *Copper as Malleable Stone.*

Native copper is fairly common in many districts, eroded from plutonic rocks and conglomerates derived from them. It is often associated with its own ores, and is itself easily corroded to a green powder or patina which closely resembles the natural carbonates and silicates. Usually, like silver, its surface is tarnished purple or greenish black, but it is easily scoured clean. Moreover, its commonest ore, the sulphide, has a brilliant gold-coloured lustre, and the iridescent "peacock ore" well deserves its name.

Native copper is malleable, like gold, and pliable in the thin natural plates and filaments which are often eroded from their gangue. It is conspicuously weighty, though not so heavy as gold; and consequently attracts attention, once handled. It combines and decombines chemically much more easily than gold, and consequently occurs in much larger nuggets; the record mass, from the Minnesota Mine in Ontanagon district, weighed 420 tons. What has been already noted in regard to gold is therefore even more to be considered here—namely, the very large surface load of nuggets which accumulated on any copper-bearing district, before man despoiled it: this was conspicuous in Katanga and in the wide copper-field west of Lake Superior, where the Algonquin redskins *prenoient par* *morceaux* the natural masses, and welded them cold :* for the high conductivity of copper made fire-setting futile, and the alternative was to pound and pull and twist by main force. The earliest Egyptian objects of copper are all small sheets, strips, wires and beads, such as may be fashioned in this way: we do not yet know the precise source of this copper, but there is no necessity to assume knowledge of copper-smelting to account for them, nor for many other early instances of worked copper. And in general, the distinction should be clearly made between the uses of native metals regarded simply as malleable stones, and the discovery that it was possible to produce a substance that was malleable, from certain kinds of stone that were not.

Though there are many instances of copper worn as ornament by primitive peoples, there is no such glamour of mystical qualities about it, as with gold: at most there is a theory of divine origin for the copper itself, as when the nuggets about Lake Superior were regarded as "presents given by the gods beneath the waters," or as themselves "divinities." Reasons for this commonplace view of copper may be that it tarnishes readily, and that its physical properties may be appreciably altered by contumelious hammering: it has indeed no such "imperishable nature" as gold. Occasionally the attempt has even been made to remedy the defect of corrosion; the Mound-builders of Ohio plated implements and beads with native silver, and with iron; as the Baluba people in Belgian Congo plate their iron axe-helves with copper.

It is, on the other hand, less to its malleability (which it shares with gold) than to its compressibility by hammering, and consequent increase of hardness, that copper owes its eminent

* de Champlain, quoted by T. A. Rickard, *Copper Mining of Lake Superior*, 1905, p. 102.

utility. An edge can therefore not only be worked on a copper bar or slab, and be reworked after use, but the very process of shaping improves its temper, provided the hammering is not excessive; and by repeated heating and annealing, the risks of over-hammering and crystallisation are diminished.

Such hammered implements, worked cold from natural nuggets, are not easily distinguished from those that have been hammered-over after casting. Primitive ingots, however, cast in open moulds, are usually flat on one side, or even concave from shrinkage, whereas hammered nuggets are convex on both sides. But allowance must be made for the primitive use of plump stone celts as models for copper castings, and for hollow moulds such as were found on the Mond-see site in Austria, one of them still enclosing the stone prototype.

Though difficult to fuse in a large mass on account of its high conductivity, copper melts at the quite moderate temperature of 1083° C., and the ability to reach this temperature, even for a short time, enabled early metal-workers to make use not only of the fluidity of the copper itself, but also of a variety of devices for giving it a new shape as it cools; for the metal shrinks sufficiently, after solidifying, to come clear away from the mould, leaving sharp edges and the slightly concave surfaces already mentioned. Closed moulds were in use in Mesopotamia, at Ur and Tell-al-Ubaïd, before 3000 B.C., and at Tell-al-Ubaïd even the *cire-perdue* process, where the model is of wax, and is melted and absorbed by the clay mould in the process, permitting very elaborate forms to be cast in one piece. It also made possible hollow-casting with great economy of material, and in particular the reproduction of shaft-holed axes, which had previously to be perforated by laborious punching or boring.

Fused copper can also be altered in temper, for the presence of copper oxide increases the hardness, and beyond a certain amount leads on to brittleness. This, however, is a peculiarity more embarrassing to the smelter of copper from its ores, than to the mere melter of native metal.

It will be seen from all this that there is no reason to suppose that metallic copper came into general use as the result of chemical accidents or experiments with ores in a hearth fire, and the freedom of early copper objects from traces of sulphur makes it unlikely that their metal was reduced from the sulphides which are the most widely distributed of its ores. Probably there was quite a long period, in other regions besides North America, when the surface supplies of native copper were still sufficient for ornaments and a few special tools, but stone implements remained in common use otherwise. There certainly came, however, somewhere and somewhen, moments when these supplies failed, and people looked about more keenly for traces of metallic copper. Now native copper so commonly occurs associated with its ores, and especially with the sulphides, that it is not at all improbable that these metallic-looking but brittle stones should have been deliberately heated with intent to make them malleable, or even reduced accidentally, as has been observed several times in native campfires in the Katanga copperfield.*

Malachite, the native carbonate of copper, easily reduced, and richer in copper than any of the sulphide ores, was used for face-paint in predynastic Egypt, and it has been suggested that this may have been the accidental source of the earliest Egyptian copper. But it would be practically a fresh discovery, to proceed from malachite to pyrites-smelting; and the absence of sulphur from a piece of copper does not prove it derived from malachite; it may have been native metal, as we have seen.

* Rickard, *l.c.*, 1930, p. 12, n. 47.

(b) *Copper and its Alloys.*

When once the smelting of copper from its sulphides was achieved, a fresh train of discoveries was initiated; because many of these ores are composite minerals, including other metals as well as copper, and also resembling the ores of other metals which contain no copper at all, but occur associated with these copper ores. Of these other metals, tin has turned out to be of exceptional importance, by reason of the peculiarities of the alloys, though antimony and arsenic in small quantities also make copper more workable. Even containing less than 5 per cent. of tin, copper becomes harder and tougher than pure copper when hammered; with more than 5 per cent. it cannot be cold-hammered at all, though it is still malleable at a good red heat (above 480° C.) and becomes very tough if promptly quenched: this is the famous "tempered copper" of Greek literature. With 8 per cent. the alloy becomes brittle when hammered to an edge. Towards 12 per cent. a fresh quality appears; the alloy becomes more fusible, and consequently fills a mould more accurately; the absorption of gases, and consequent blisters and bubbles, so troublesome with pure copper, are checked, and also the shrinkage of the solidified mass; so that castings may be of wonderful accuracy, as ancient art-work testifies.

Tin, however, is not common nor widely distributed, and the supersession of copper, hardened through mere hammering or admixture of copper oxide, by various *bronzes* or tin-alloys, was gradual and partial. In Egypt there was practically no bronze till the Syrian conquests of the Eighteenth Dynasty introduced it copiously from abroad; Cyprus used its own copper unalloyed till about the same time; Hissarlik, however, had bronze commonly in its "Second City" which perished about 2000 B.C., and the Ægean islands quite as early. Whether the source of tin was somewhere in the ill-explored mountain-mass of Armenia and Caucasus, or in South-eastern or East-central Europe, or, on the other hand, far to the north-east in Chorasan, is still quite uncertain. Probably many local smeltings contributed their shares to a widespread fund of experience; and there is certainly a combined tin-and-copper area no further afield than the Taurus Mountains. But in Bohemia alone can the local production of a bronze plenteously rich in tin be demonstrated, and the distribution of the product along well-defined lines of intercourse to the south-east, as well as in other directions. And there is no reason, from the geographical distribution of early bronzes, to regard the reputed *Cassiterides* or Tin Islands as either an early or a very distant tinfield. Both British and Spanish tin was worked in Roman times, but earlier allusions, more or less legendary, are unsupported by material evidence.

It was only in Roman or quite late Greek times, too, that an exceptionally pale or gold-coloured alloy was produced locally in Bithynia and some other districts, by mixing with the copper ore an earthy mineral which (from the composition of many ancient mirrors especially) must usually have been calamine, a common ore of zinc; but, as already noted, the metallic element in this alloy was not determined till modern times. A copper–lead alloy, similarly, being peculiarly pliable, was used in antiquity for bindings, though its dull colour and inferior tenacity restricted its general use.

(c) *The Threefold Discovery of Iron; Meteoric, Wrought, and Cast.*

Though in essentials the history of Man's use of iron presents the same main phases as that of copper, there are special reasons why discovery was more haphazard and invention more fitful than we have seen them to have been for copper.

Iron, like copper, occurs naturally in metallic form, but in ordinary moist air it rusts so rapidly that its metallic quality is disguised until it perishes, except in very large masses. And the ores of iron, unlike the commoner ores of copper, seldom have metallic lustre to attract attention: only pyrites, the sulphide, looks and behaves like copper sulphide until it is reduced, and then it yields no copper, but a rusty clinker which it was long before anyone succeeded in converting into another metal. The oxides, similarly, though some of them can be reduced in a camp-fire, yield merely a rusty spongy residue, which must be pounded and kneaded at a red heat till the slag is squeezed out and the metal is welded into a solid "bloom" without being brought to melting-point at all. Once this laborious process was discovered, however, it was easily repeated, and the knowledge of it may have spread rapidly, for those ores are abundant, and conspicuous by their rusty weathering. It is, moreover, also so simple that it may have been discovered accidentally in more than one distinct region.

This is a kind of problem which frequently confronts the student of man's inventions, and of the cultures they compose. Consequently the inquiry, *how*, *when*, and *where* iron came into general use, has a philosophical significance far beyond its interest as a question of chemistry or archæology.

Native iron, in large enough quantities to be useful, is very rare indeed; but at Ovifak in Greenland a ferruginous basalt has been erupted through coal measures, and reduced in this natural furnace; and in this solitary instance it is known that native iron has been worked by native men.

It is a curious accident that at Melville Bay in the same geographical region as this "telluric" or earth-born iron we have the only directly observed instance of the utilisation of "meteoric" or skyfallen iron, worked, first, like the great copper nuggets of Lake Superior, by patiently pounding and wrenching.

These meteorite-fragments are now in the American Museum of Natural History in New York, the Melville Bay natives obtaining their iron more conveniently from European sailors. Throughout the area of the Mound-builder culture, in the Mississippi basin, iron objects were occasionally found, in the same technique as those of native copper; and much of this iron is shown by its high nickel-content to be of the same meteoric origin as that of Melville Bay. But the rarity of such iron objects in the New World, and the comparative rarity of nickel-iron meteorites in those parts of the Old World which have been sufficiently explored, suggest that Old World meteorites have been used up and that the knowledge of iron in the Old World is more ancient and widespread than in the New. Some forty-four recent instances of the utilisation of meteoric iron have been recorded *; and the high nickel-content of most of the rare early Egyptian iron makes it probable that the source here too was meteoric. A puzzling exception is a fragment of an iron tool wedged among the masonry of the Great Pyramid, which is without nickel, and apparently not native iron either: but the circumstances of its discovery in 1837 were not recorded with sufficient attention to preclude doubt as to the date when it was inserted there.

Apart from five isolated finds, in all, of iron in Egypt from pre-dynastic times to 1350 B.C., the earliest iron objects found there hitherto are the knife, amulet, and model head-rest which were personal treasures of Tutankhamen, buried with him in or about 1352 B.C., and evidently precious. Within the next generation, an iron sickle was buried under a sphinx erected for Horemheb. Certainly not later than these Egyptian finds,

* Zimmer, *Journ. Iron and Steel Inst.*, 1916, XCIV, 306–56. Quoted by Rickard, "The Early Use of the Metals," *Journ. Inst. Metals*, 1930, p. 25; other details in Rickard, "Iron in Antiquity," *Journ. Iron and Steel Inst.*, 1930, CXX, p. 334.

and probably as much as a century earlier, are an iron nail from the Minoan Palace at Cnossus, and an iron finger-ring from the Minoan tomb at Vaphio in Laconia. A solid iron bangle from a Late Minoan tomb in Rhodes may be as early as 1300 B.C.

These western finds are significant in view of the next incident. About 1250, Rameses II wrote to Hattusil II, king of the Hittite realm in Asia Minor, asking for iron; but there was none in store, and only a complimentary dagger was sent. About the same time, in an Egyptian narrative of a journey in Syria, " iron-workers " mend the narrator's chariot at Jaffa; and in a hymn to Rameses II " his legs are as the marvel of heaven " in a list of similes from metals. This phrase *bia-n-pet*, " marvel of heaven," occurs repeatedly in later texts, and there certainly means " iron ": in Egyptian cosmology the firmament was of iron, and the same notion recurs in Greek epic, not later than the ninth or tenth century, and may-be earlier.

Confirmatory evidence is the use of blue colour, instead of the customary red for copper, in representations of weapons in the army of Rameses III, soon after 1200 B.C.; evidently some alternative metal, grey or bluish, was coming into use; and there is an iron halbert of this reign, and soon after a few other iron objects occur. But it was not till the Assyrian conquest of Egypt in 668 B.C. and the subsequent reconstitution of the Nile Valley and Delta as a Mediterranean power, that iron became at all familiar there.

The momentary acquaintance with iron as a product of Asia Minor, which this Egyptian evidence reveals, is in accord with the rather sudden frequency of iron weapons—not ornaments merely, as in the Minoan west—in Palestine after the collapse of Egyptian overlordship about 1200 B.C.; with the similar " iron age " which begins in Cyprus after the contemporary collapse of the Minoan colonies there; and with the appearance of iron weapons in the "reoccupation layer" at Carchemish on the Euphrates about 1150 B.C.

At first sight all this suggests that iron was being popularised around the Levant by the "Sea-Raiders" and "Land-Raiders" who began to be mentioned in Egyptian documents about 1225, and flooded landways and seaways alike as far as the defences of Egypt, in the years around 1190 B.C. And as there are iron swords on several sites in Greece, from Crete to Thessaly, at about this period, of the same general form as the bronze "leaf-shaped" swords of Danubian type, which these invaders carried with them as far as Egypt and Gaza, and also into several districts of Italy, it was suggested a generation ago by the late Sir William Ridgeway that the knowledge of iron itself reached the East Mediterranean from the same quarter whence the Romans, long after, drew their chief supply of steel for the *Noricus ensis* of their legionaries.

But the recognition of Hittite iron-working in Asia Minor, so much earlier, has changed our whole perspective, and explained the persistent efforts of Assyrian kings from A.D. 900 onwards to obtain control of the approaches to Asia Minor through Taurus, and the rich booty of iron captured by them in Damascus, already a great iron-working centre by 850 B.C. Closer examination of the sword-types shows that the earliest iron swords of the Ægean and Cyprus are a compromise between the Danubian "leaf-shaped" weapon and older Mediterranean—perhaps also Anatolian—fashions. Homeric allusions to iron among the loot taken by Achæans from their Trojan enemies, and Greek folk memory of a "discovery of iron" about 1350 B.C. by metal-workers round Mount Ida in the Troad, point to progressive distribution north-westwards, towards the Danube, not away from it; and there is lacking now only the excavation of some single stratified site in Asia Minor itself to clinch all this circumstantial evidence, and demonstrate the moment at which iron came into general use within the region where we have already earliest references to it.

Assyria, like Egypt, had occasional weapons of iron before the metal became popularised eventually; but the scimitar of Raman-nirari, dated about 1300 B.C., is of a foreign, probably Syrian type; and that Assyria had no alternative source of iron in the direction of Media or Babylonia, seems certain, from the archæological series at Asshur, and the apparition of iron still later in Babylonia than in Assyria itself.

This leaves a great gulf between what seems to be a closed system of iron-fabrics dependent on a centre of origin in Asia Minor, and the iron-working cultures of South India and Northern China. But the recent demonstration of Scythian influence on the decorative art of China, quite early in the Chinese iron-industry, but at a period when European Scythians had already acquired knowledge of iron from Asia Minor by way of the Caucasus, correlates Chinese iron-working definitively with this Anatolian system; and intermediate links are being supplied as Trans-Caspia, Siberia, and Mongolia become better known.

Indian iron-working remains ill explored and hard to interpret. The great iron pillar at Delhi, weighing about 26 tons, is forged from small blooms of very pure wrought iron, and the oldest of the inscriptions on it is of A.D. 310. The Dhar pillar, near Indore, was considerably larger, when whole, similarly constructed, and probably of much the same age. But these great monuments presume mature skill; and already in 480 B.C. the Indian contingent in Xerxes' army is described as using iron-tipped arrows.* Even this, however, is under

* Herodotus, vii. 65.

Persian suzerainty, and the Persians were in a full "iron age." Earlier than this, there is at present no means of dating any of the iron-using cultures exhibited on sites and in tombs in several parts of India: nor do the simple furnaces and other appliances show any distinctive original peculiarities.

The suggestion has been made that Egypt, and perhaps Mediterranean lands through Libya, may have become acquainted with iron from some African source. Certainly many parts of Africa, including the Sudan, exhibit the unusual sequence of iron-working after a "stone age," without intermediate acquaintance with copper or bronze, such as characterises the Ancient East and Europe. And these iron-using cultures extend to the extreme south, and were established (at Zimbabwe in Southern Rhodesia, for example) as early as the eighth century, A.D. in practically modern phase. But the general trend of migration and the spread of cultures has been, in accordance with the physiography, from north to south along the equatorial highlands, and from east to west along the northern margin of equatorial forests.

Now if Egypt had had an immemorial iron-industry, it would not have been surprising if there had been derivative iron industries throughout Africa along these avenues of propagation. But as Egypt had not effective mastery of iron till about 650 B.C. at earliest, iron-working in Africa south of Egypt must be either derivative from Egypt after that period, or, if original and independent, must be earlier. But if earlier, it is difficult to account for Egypt's lack of iron as late as 650 B.C. (seeing that the country had been a dependency of an "Ethiopian" regime in the Sudan from about 750 B.C.), or for the apparition of iron on sites in Nubia as part of the culture which was acquired from Egypt during, and (still more) after that Ethiopian protectorate; or for the long-established trade in ivory, ostrich-feathers, ebony, and other southern produce, which *did* reach Egypt even before the Ethiopian invasion. On the other hand, if the Sudan learned iron-working, and indeed metal-working generally, from Egypt, the resemblance is explained between the primitive open-hearth furnace and skin-bellows of modern Kordofan, and the depicted outfit of eighteenth dynasty goldsmiths. There need therefore be no hesitation in ascribing other African iron-industries to Egyptian influence more or less direct, and of no very ancient date, seeing that Egypt itself acquired the art so tardily, and from its Asiatic neighbours.

Only one question in regard to iron-working remains to be answered. Seeing that iron, once discovered, is so easily worked, from ores so widely distributed, and with so manifest superiority over bronze, from the moment, certainly quite early, when it was discovered that it could be converted into steel, and tempered at will—why was not this pre-eminently useful metal soon prepared in the large quantities to which we are accustomed now, instead of remaining restricted in its output, as we now see it to have been for nearly three thousand years after we first have evidence of its use?

In part, the answer is given by the ancient and ever-growing scarcity of fuel in the Near East and Mediterranean lands, and the impossibility of replacing wood charcoal by coke, in regions so nearly devoid of coal measures, or even of the lignites which are now worked locally on a quite modest scale. But even had fuel been available, there were two other obstacles: the types of the furnaces and the quality of their respective products.

All Oriental and Mediterranean iron-furnaces, from India to Catalonia, and those of Atlantic Europe, including Britain, down to the eighteenth century, have been of the primitive "open-hearth" type in which the ore and fuel are piled in and above a hollow in the ground, into which the slags sink, leaving the "blooms" of spongy iron among the ashes, to be hammered into coherent solidity, with frequent reheating. This process was necessarily limited in scale, by the difficulty of feeding the bonfire; of maintaining the necessary blast at such close quarters; above all, of continuing the performance, for after a moderate amount of slag and ash had been accumulated, the fire had to be let out and the whole procedure repeated. The piecemeal construction of the great Indian pillars illustrates conclusively the limitations of this method.

A glimpse of an alternative procedure is perhaps given by the Homeric reference to a "mass self-poured," *solos autochoônos*, such as would result if the temperature in an open-hearth furnace rose high enough (to about 1550° C.) to fuse the spongy iron so that it trickled down with the slag and solidified below it as "cast-iron." But how this unmalleable substance would be manipulated, we do not know.

In several districts of Central Europe, however—in Transylvania, in the Jura, and on the Rhine—another type of furnace occurs, certainly in Roman times, and probably also earlier. It is constructed like a chimney or hollow tower, with draught holes at its base, which may have been supplemented by bellows, and served also to "tap" the contents of the furnace as required. In this chimney-furnace, adapted from a kiln or a common house-fireplace, fuel and ore are poured in at the top; the process therefore is a continuous one; the temperature may be as high as the dimensions and the fuel-supply permit; the iron is melted as well as smelted, and is "run off" with the slags into open moulds outside the holes in the base, which are plugged with clay betweenwhiles. Here are all the essentials of the modern blast-furnace; and provided that there is the skill to convert the "cast-iron" which it yields into malleable "wrought-iron" or into temperable "steel," there is no obstacle to the production of iron in large quantities.

So matters remained in Europe until the eighteenth century. The south and the west had the old open-hearth furnace, and produced wrought-iron on a modest scale. Central Europe had, in addition, the chimney-furnace, but no adequate method of "converting" its cast-iron, and consequently no inducement to large-scale production, the brittleness of cast-iron limiting its utility in construction. Eventually, however, this metallurgical problem was solved. The use of water power in mediæval times greatly increased the strength of the blast. In 1611 an English patent was granted for the use of mineral coal instead of charcoal; in 1735 coke began to replace coal; in 1784 the "puddling-furnace" greatly simplified the decarburisation of cast-iron; and Bessemer's "conversion" process in 1856 made it possible to produce steel in any desired quantities direct from pig-iron. Only when these successive inventions had removed the old limits of amount, was it worth while to turn attention to the varieties of quality which resulted, as with copper, from alloying iron with manganese and other metals, and also from modification of the physical conditions of production; and this phase of discovery still continues.

It would have been easy to multiply details and examples, and to apply the same method to the history of less important metals. But those which have been discussed are not only of incomparably greater economic and cultural interest, but happen also to illustrate all the more significant aspects of this branch of Man's achievement of control over Nature's resources, and of the modes in which anthropologists and archæologists study them.

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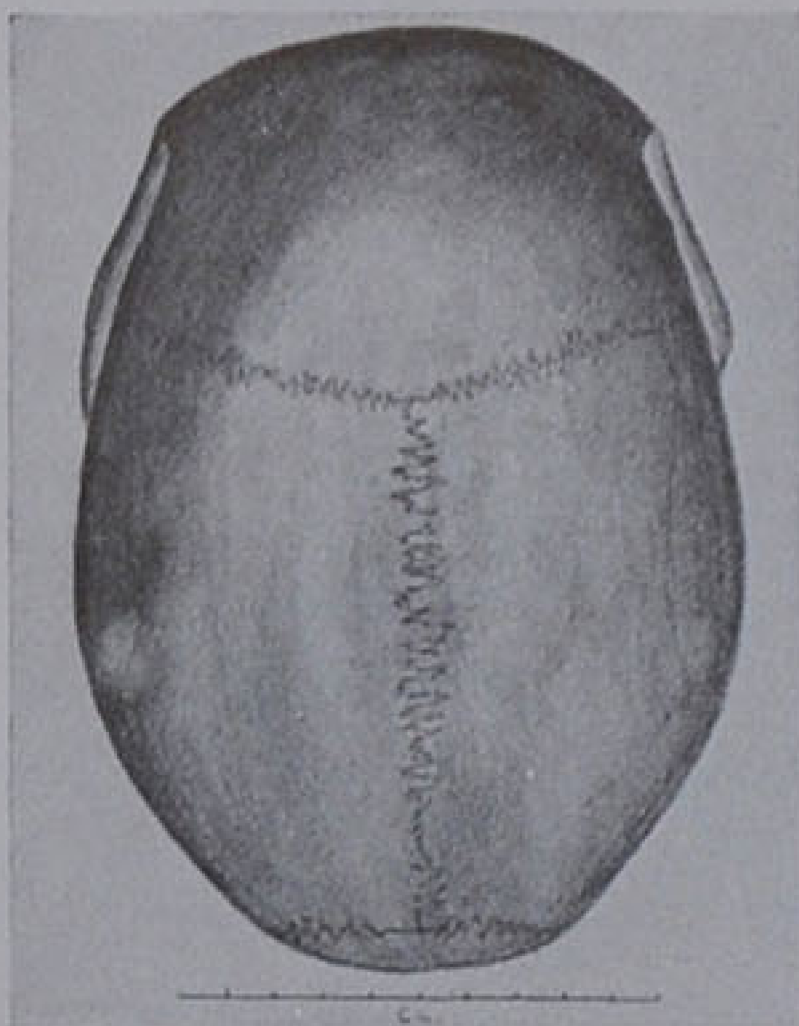
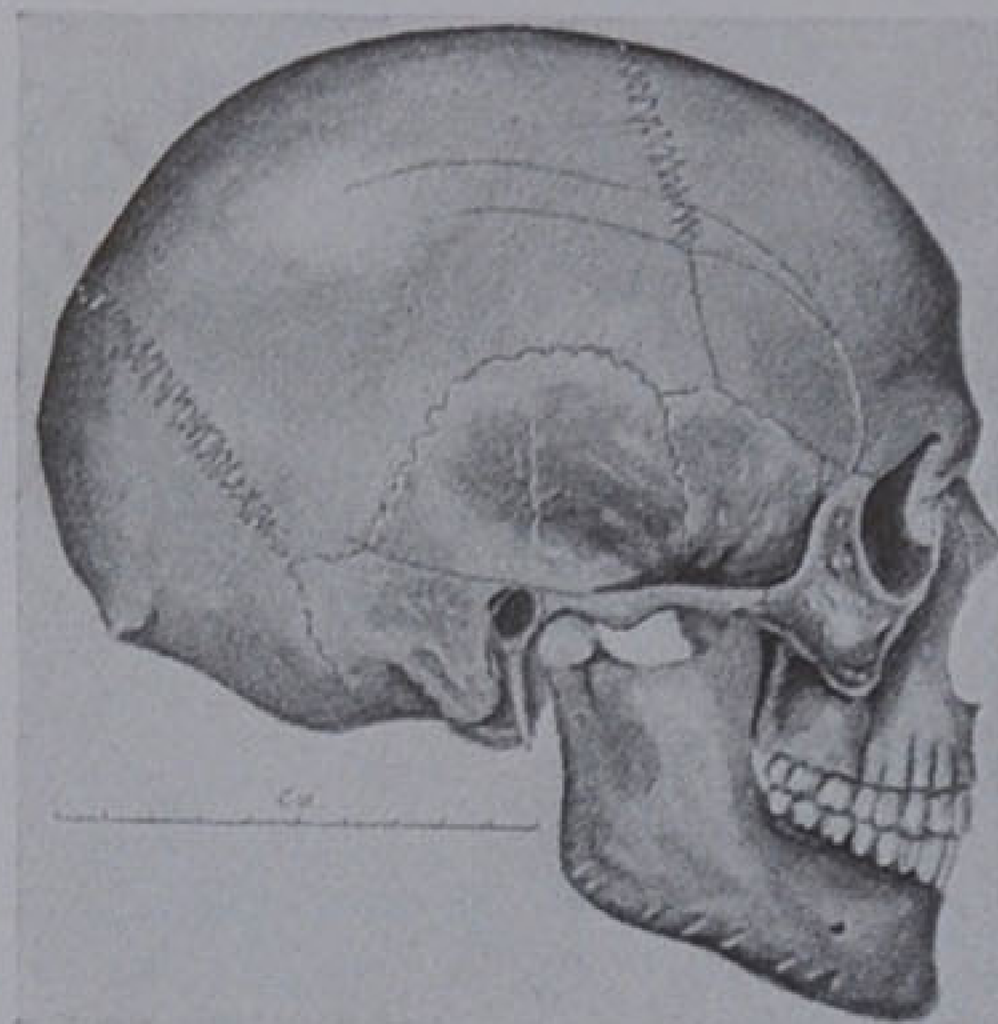
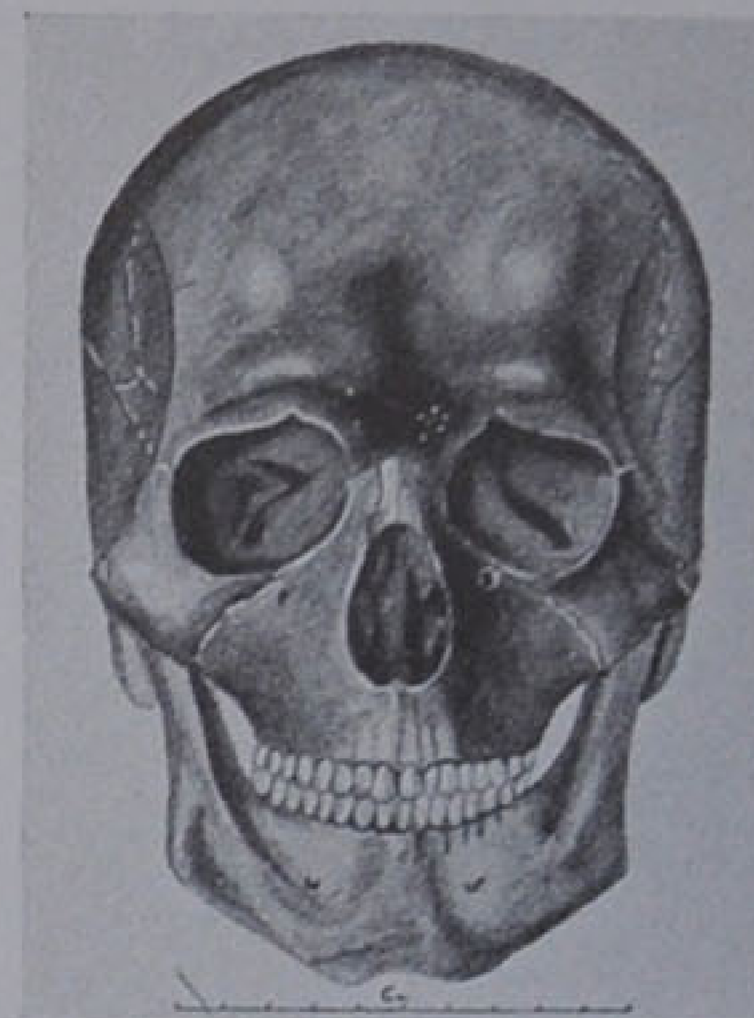
PLATE I.



(*a*) Top.



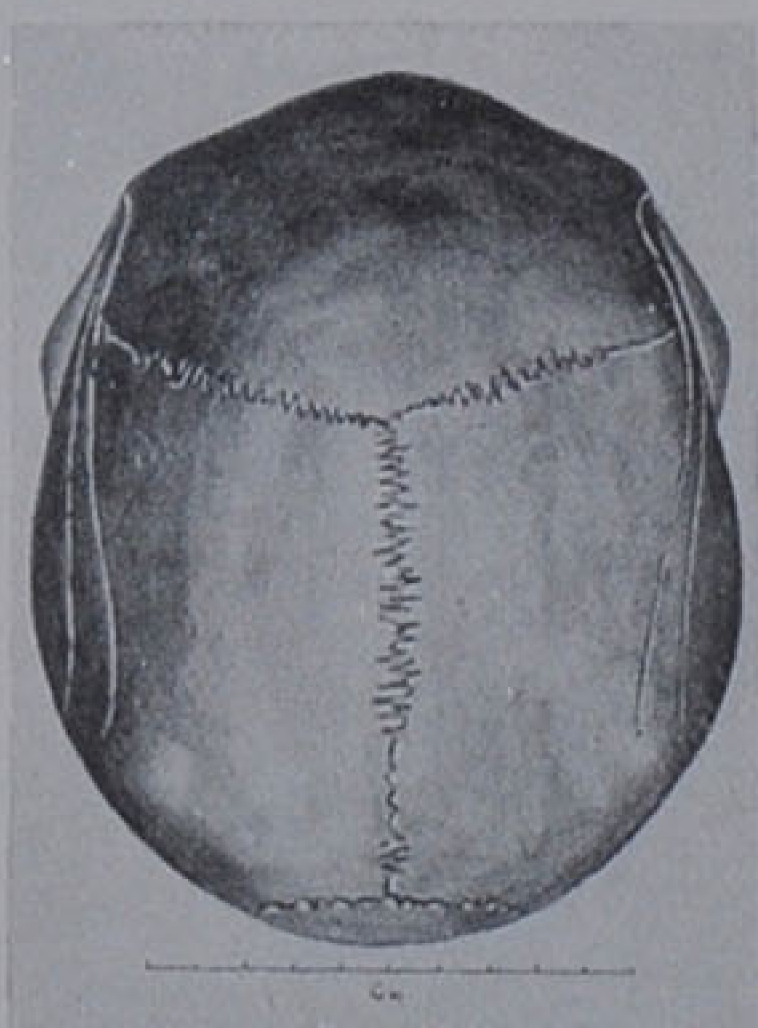
(*b*) Side.



(*c*) Front.

A. Long Barrow Skulls (20).

($\frac{1}{5}$ *natural size*).



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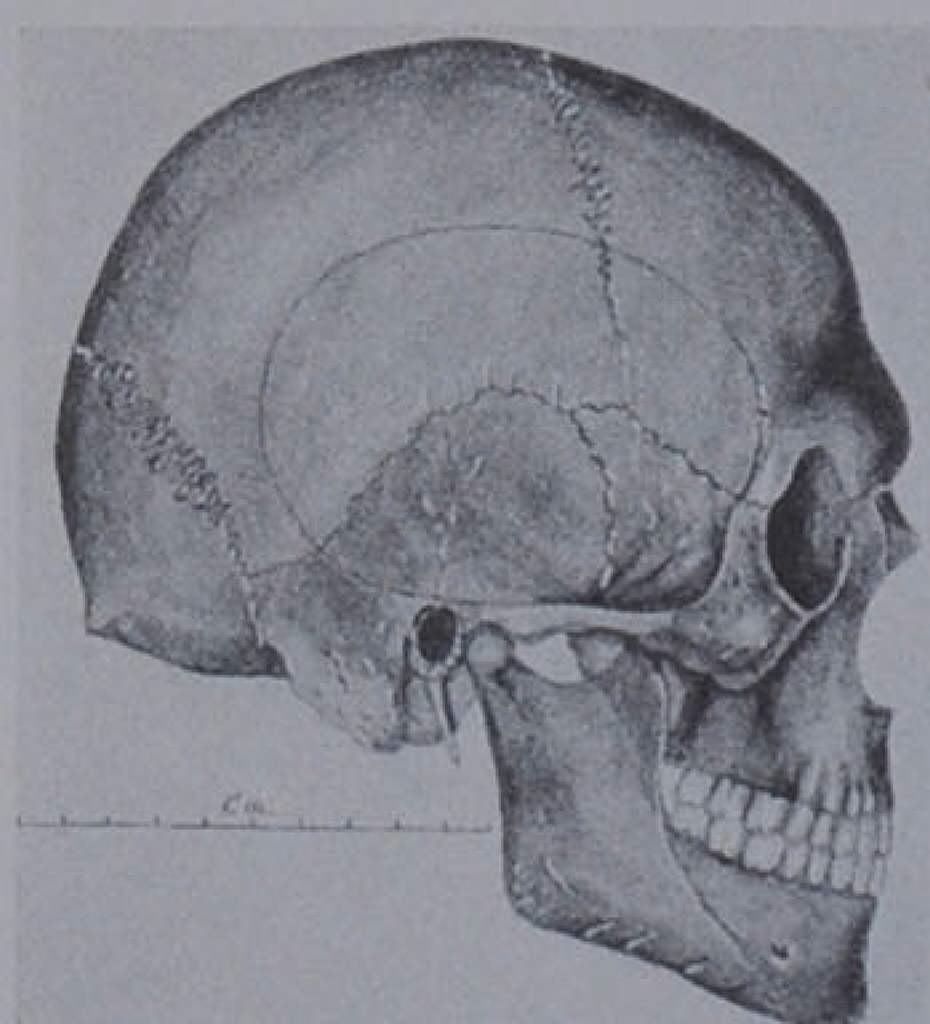
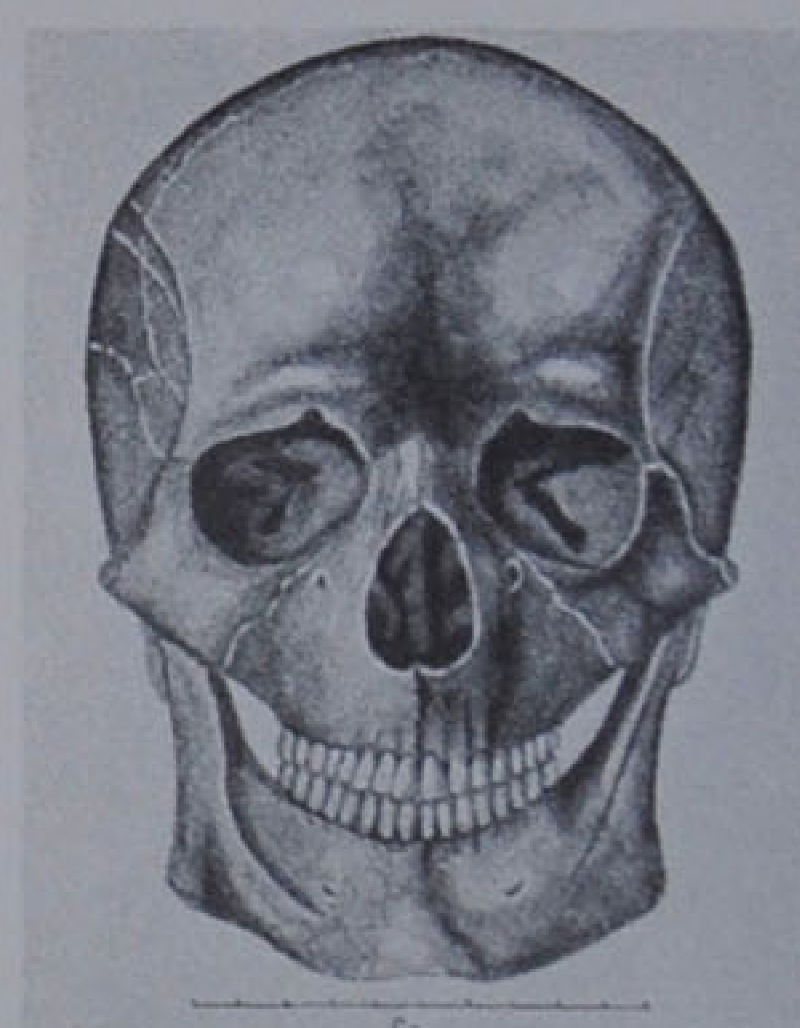


(*e*) Side.

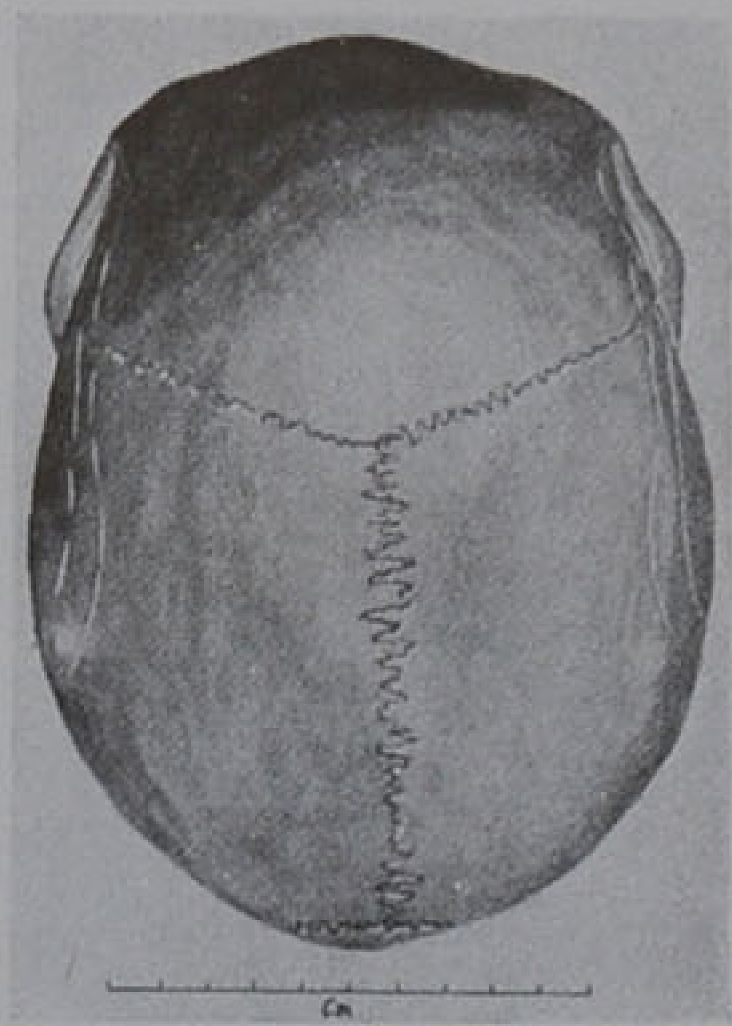


(*f*) Front.

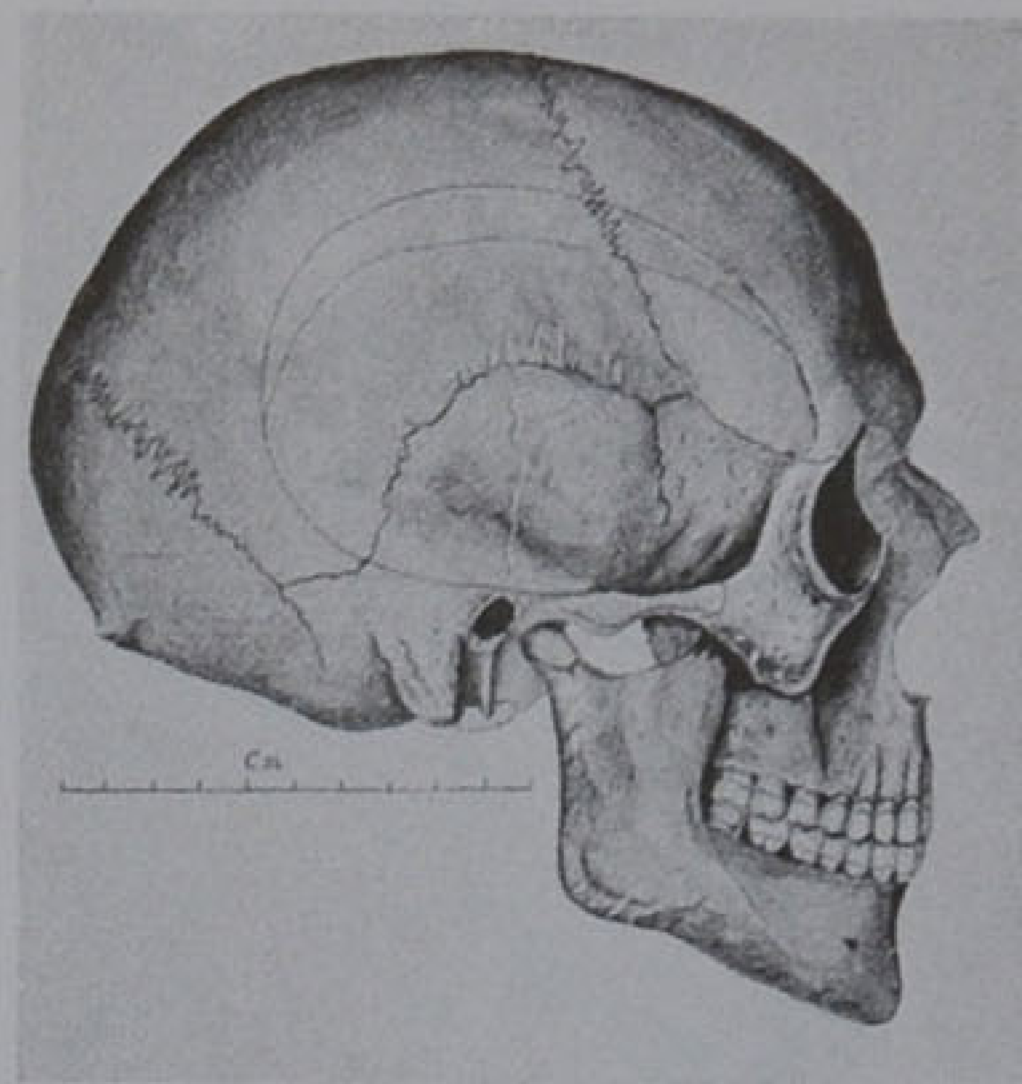
B. Beaker Folk Skulls (7).

($\frac{1}{5}$ *natural size.*)

PLATE II.



(*g*) Top.

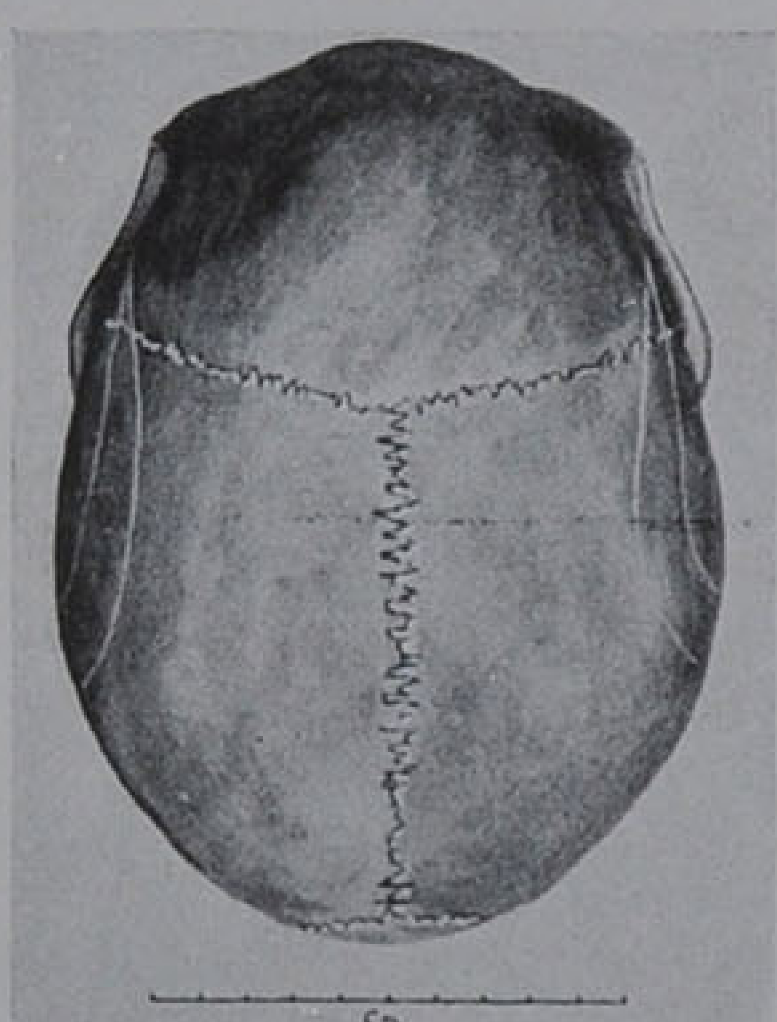


(*h*) Side.

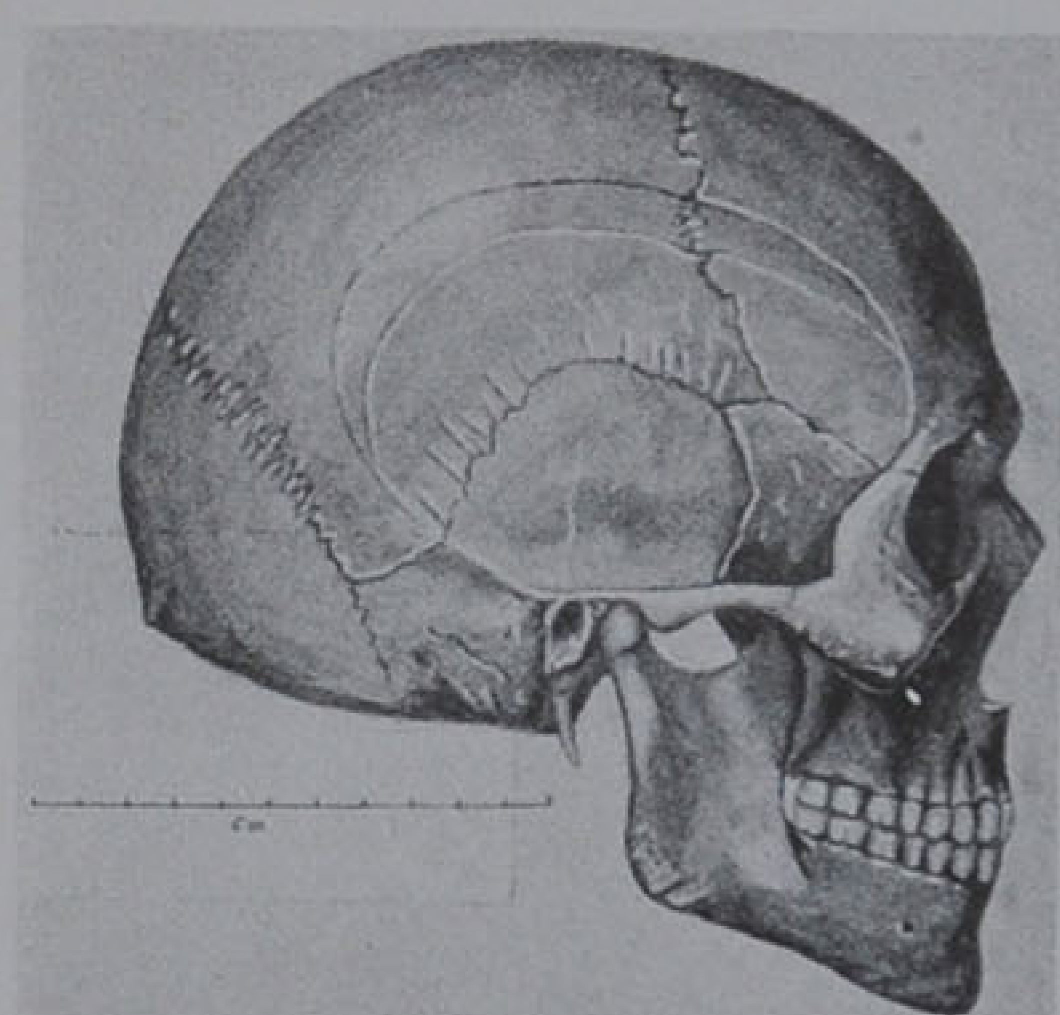
(*i*) Front.

Romano-British Skulls (20).

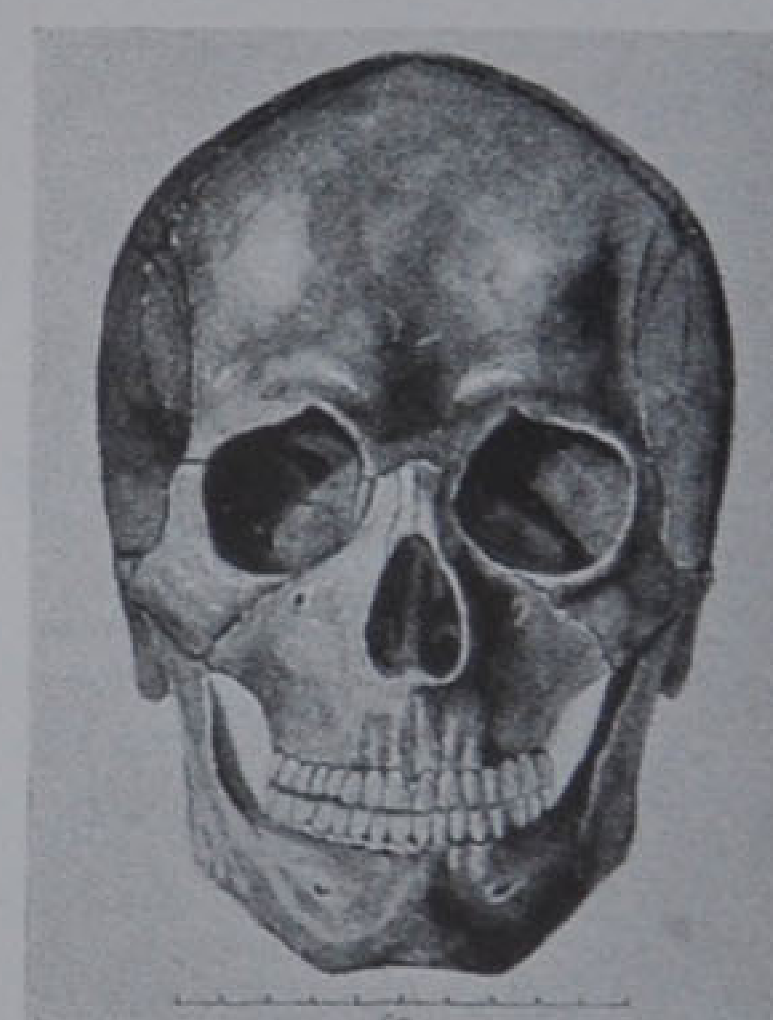
($\frac{1}{5}$ *natural size.*)



(*j*) Top.



(*k*) Side.

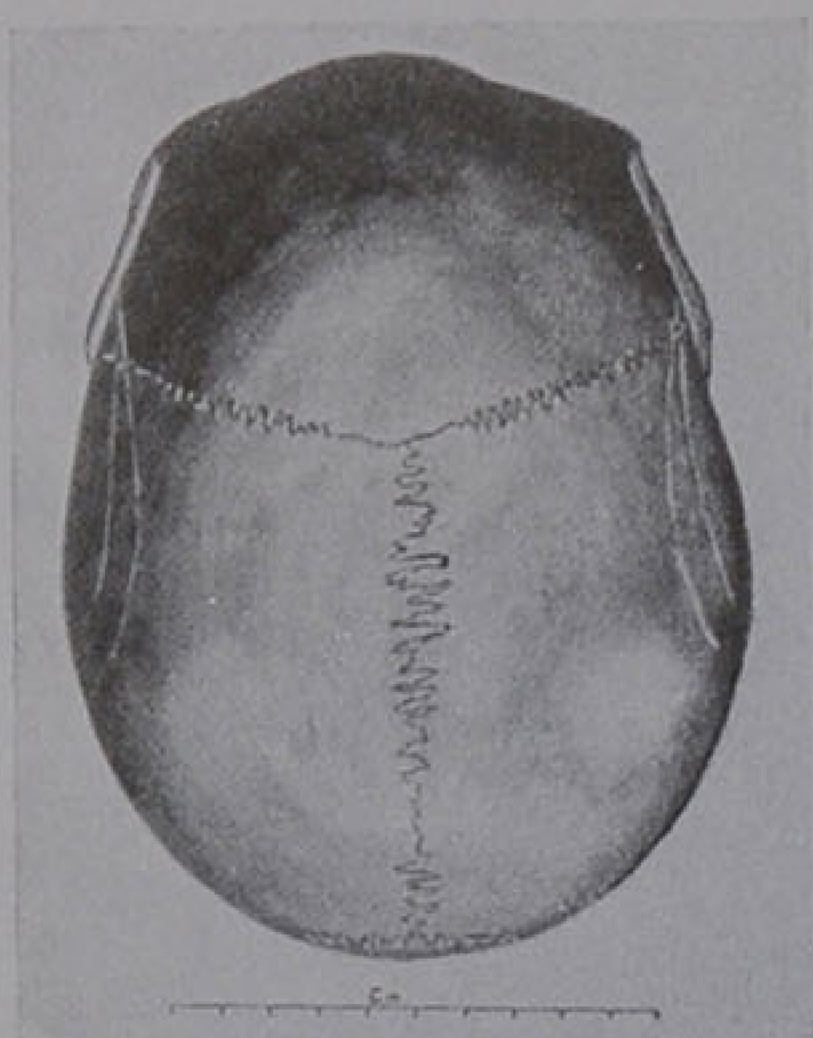


(*l*) Front.

Anglo-Saxon Skulls (48).

($\frac{1}{5}$ *natural size.*)

PLATE III.



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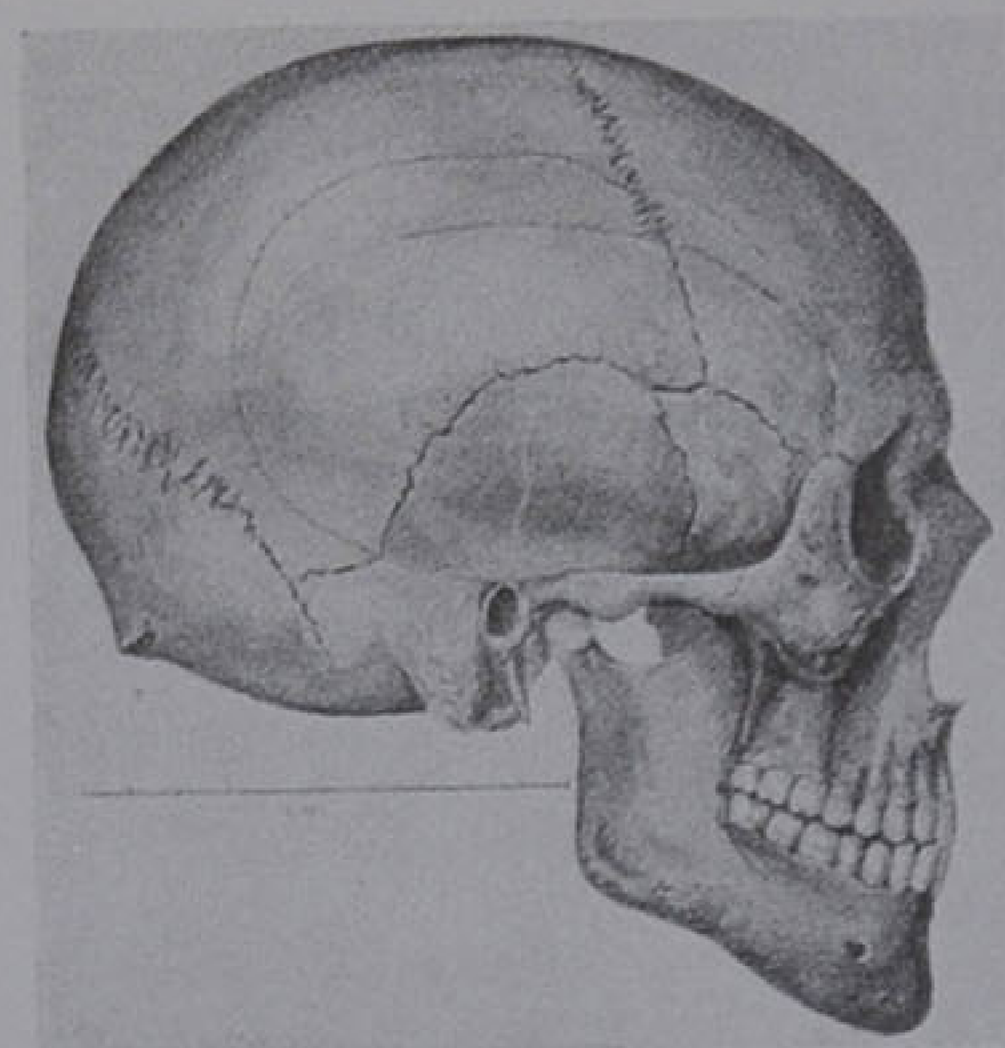
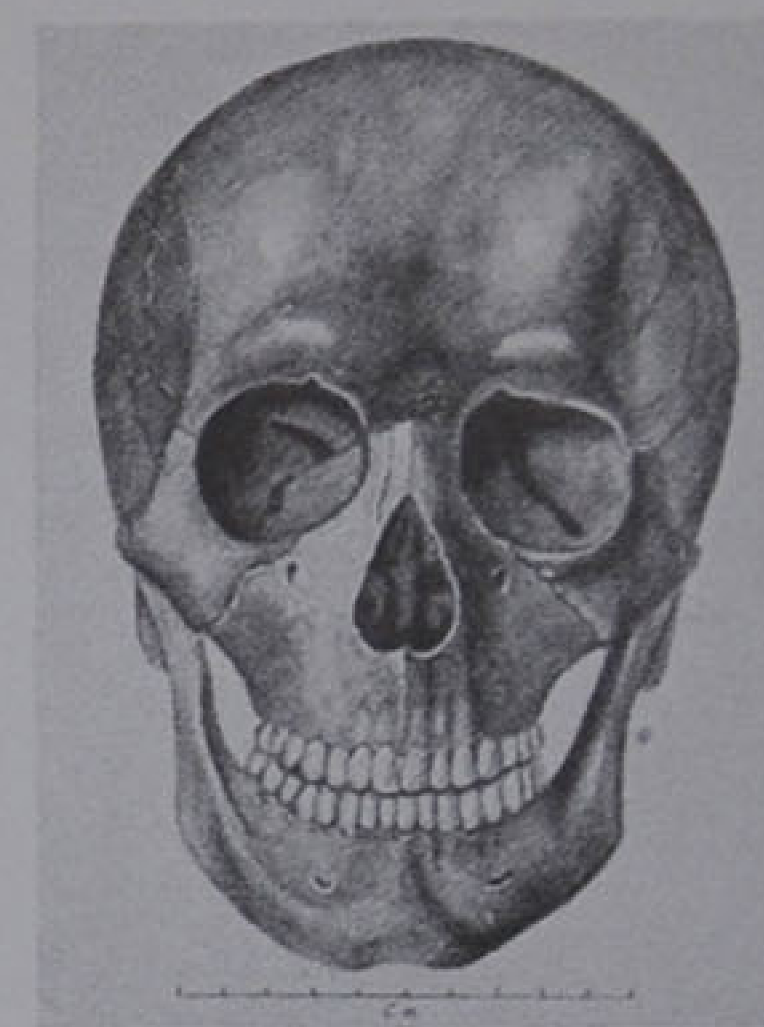


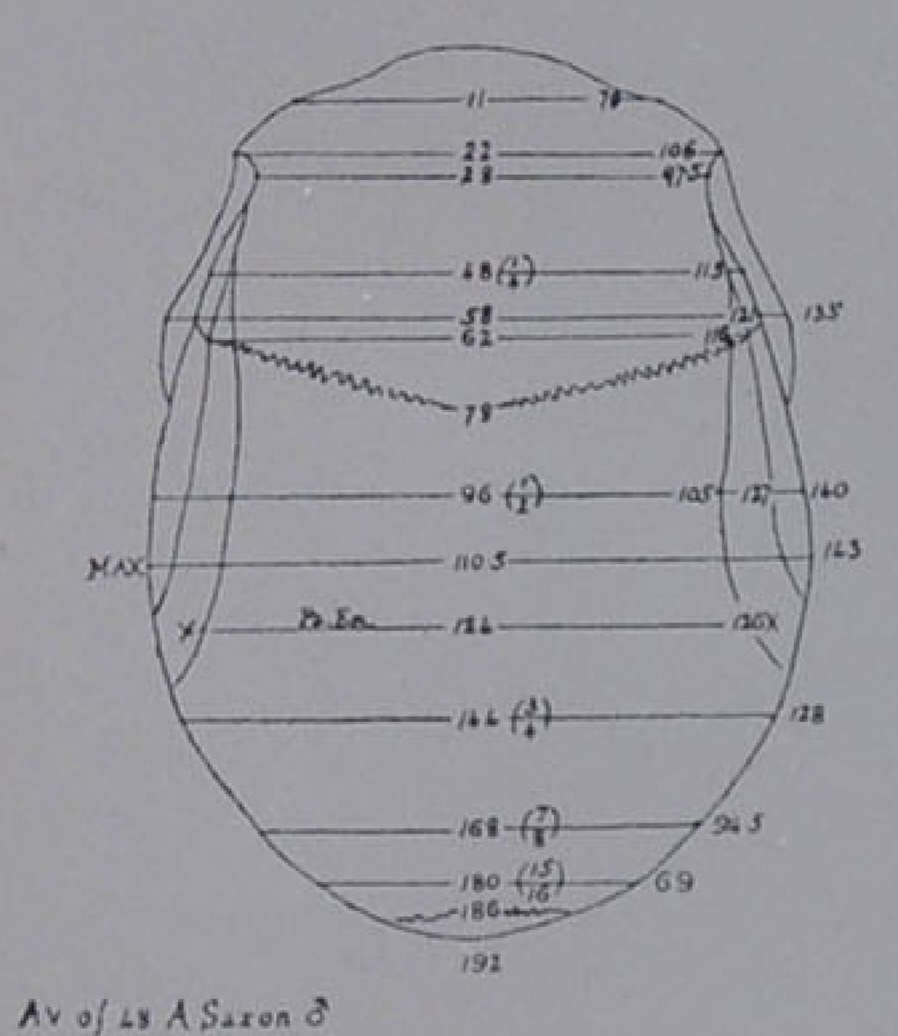
(*n*) Side.



(*o*) Front.

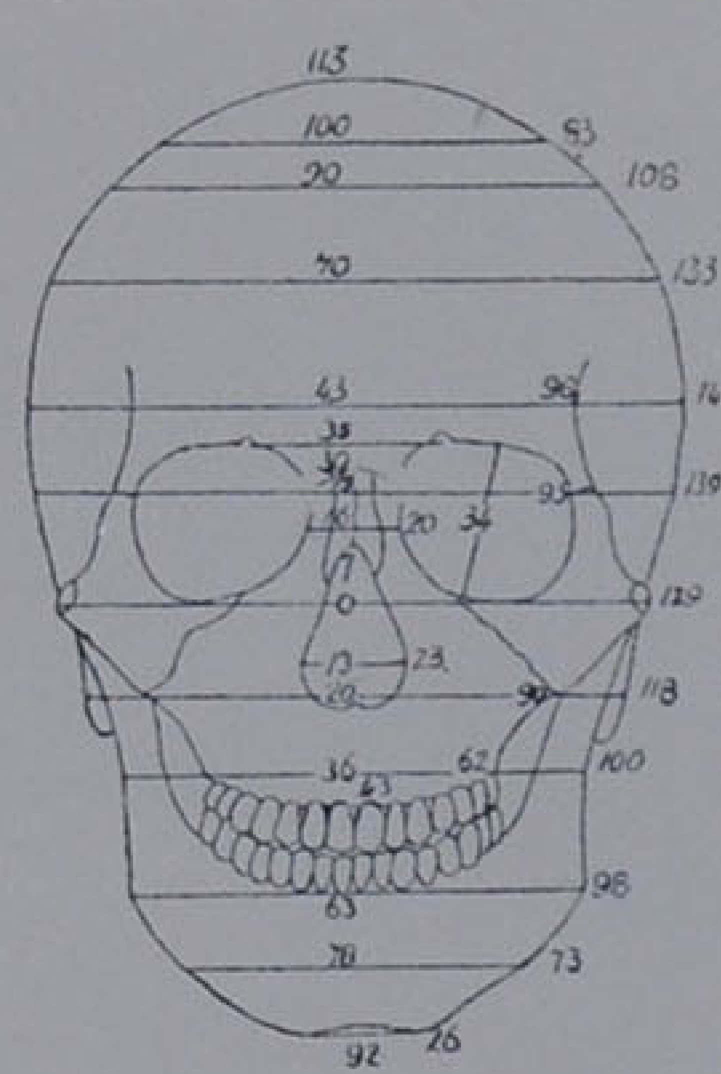
Eighteenth-century Londoners (30).

(⅕ *natural size.*)



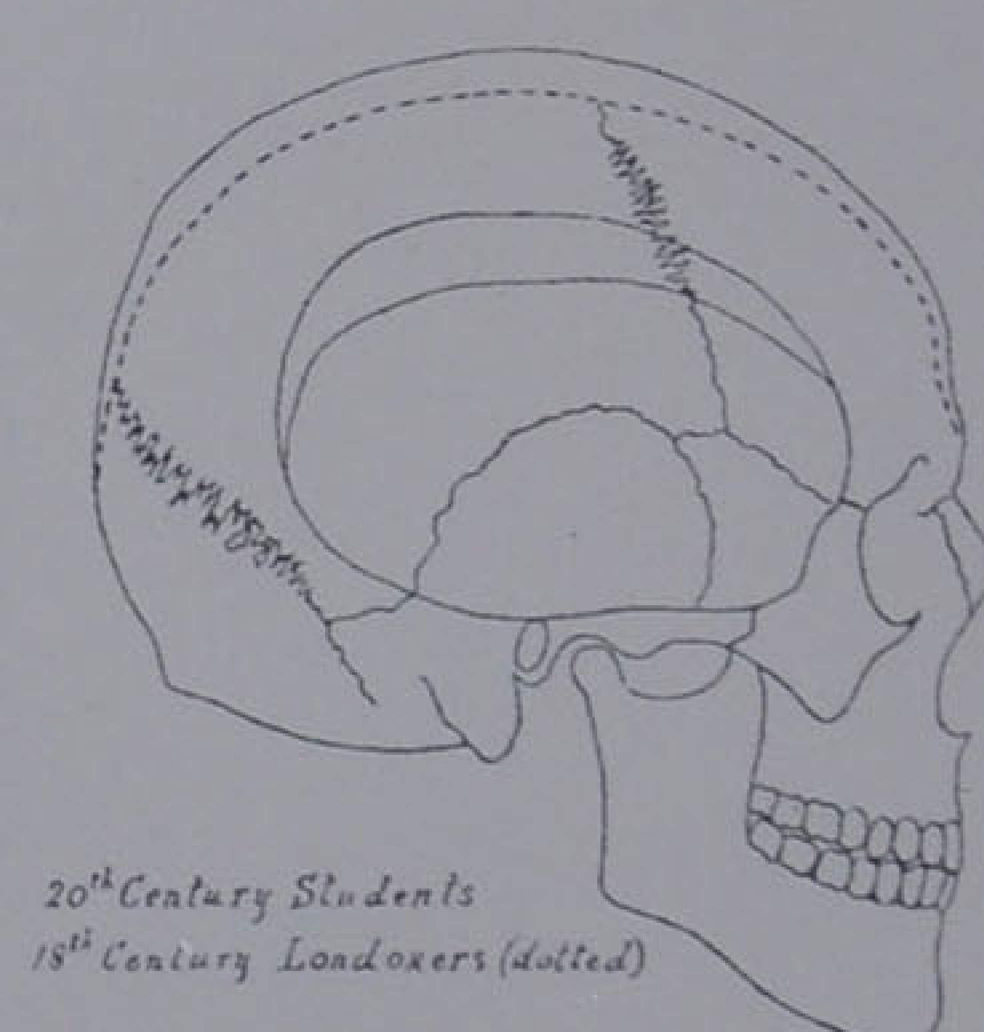
(*p*)

Anglo-Saxon Skulls (48): diagram of measurements.



(*q*)

Long Barrow Skulls (20): diagram of measurements.

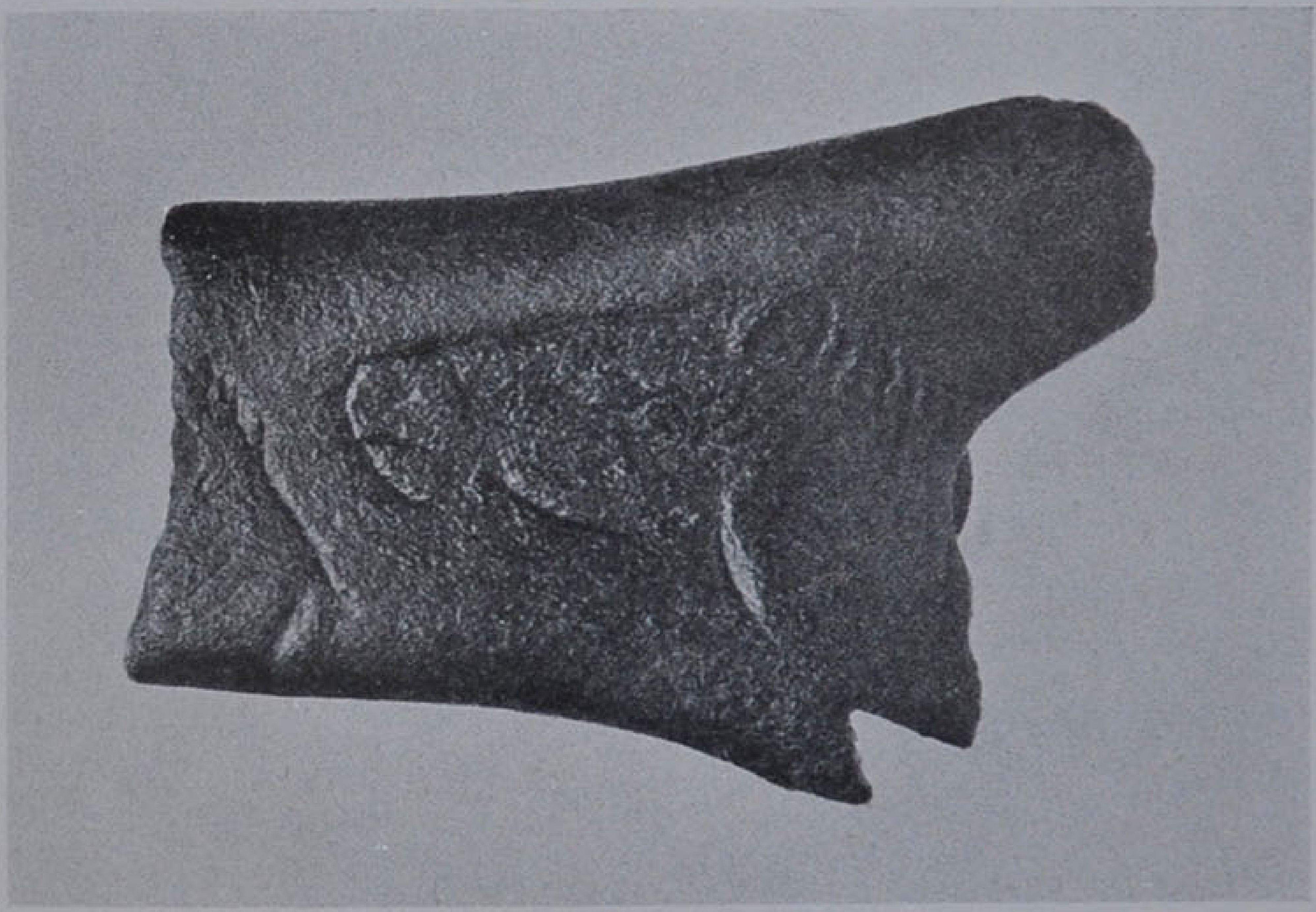


(*r*)

Eighteenth-century Londoners (30): dotted line.
Twentieth-century Students: firm line.

PLATE IV.

A. Reindeer turning its head back: on a flat piece of limestone.



B. Horse-head, on a piece of reindeer-antler.

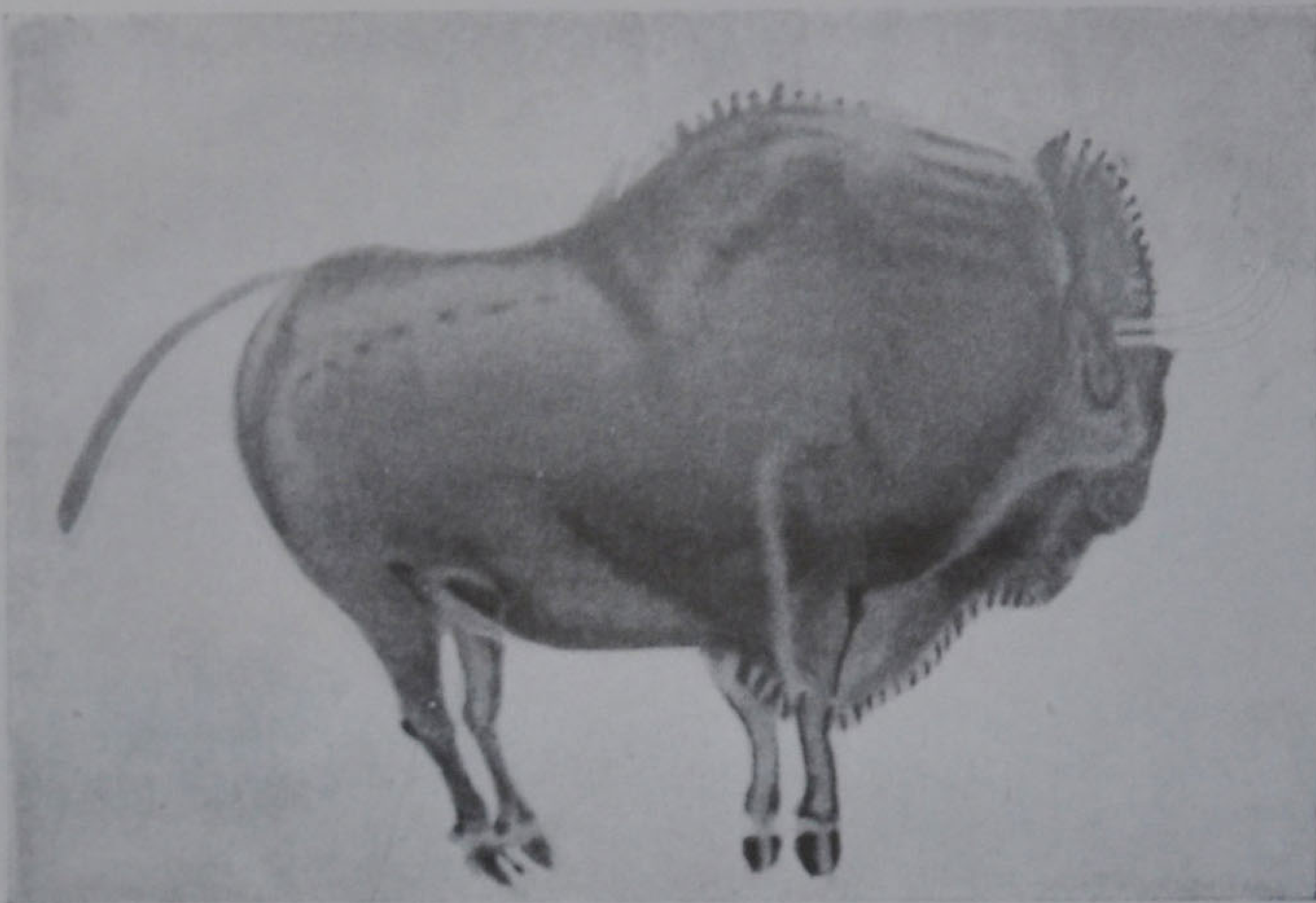
Examples of the Upper Palæolithic "Home" Art, from the cave at Laugerie Basse, Dordogne. In Mr. M. C. Burkitt's collection.

PLATE VA.

Reindeer, in the cave at Font-de-Eaume, Dordogne: here and there, engraving supplements paint.

Example of Upper Palæolithic Polychrome Paintings.

(Reproduced from M. C. Burkitt, "Prehistory," 1911, Plate XVI, by permission of the Cambridge University Press.)



Bison, in the cave at Altamira, Cantabria.

Example of Upper Palæolithic Polychrome Paintings.

(Reproduced from M. C. Burkitt, "Prehistory," 1911, Plate XVI, by permission of the Cambridge University Press.)

PLATE VI.

Paintings of the Third Spanish Groups of the Copper Age in the cave of Las Figuras, Laguna de la Janda, Southern Spain.

(From a photograph by Mr. M. C. Burkitt.)

Einkorn Wheat (*Triticum ægilipoides*).

(*Reproduced from Percival, " The Wheat Plant," Fig.* 117, *by permission of Messrs. G. Duckworth & Co.*)

Emmer Wheat (*Triticum dicoccum*).

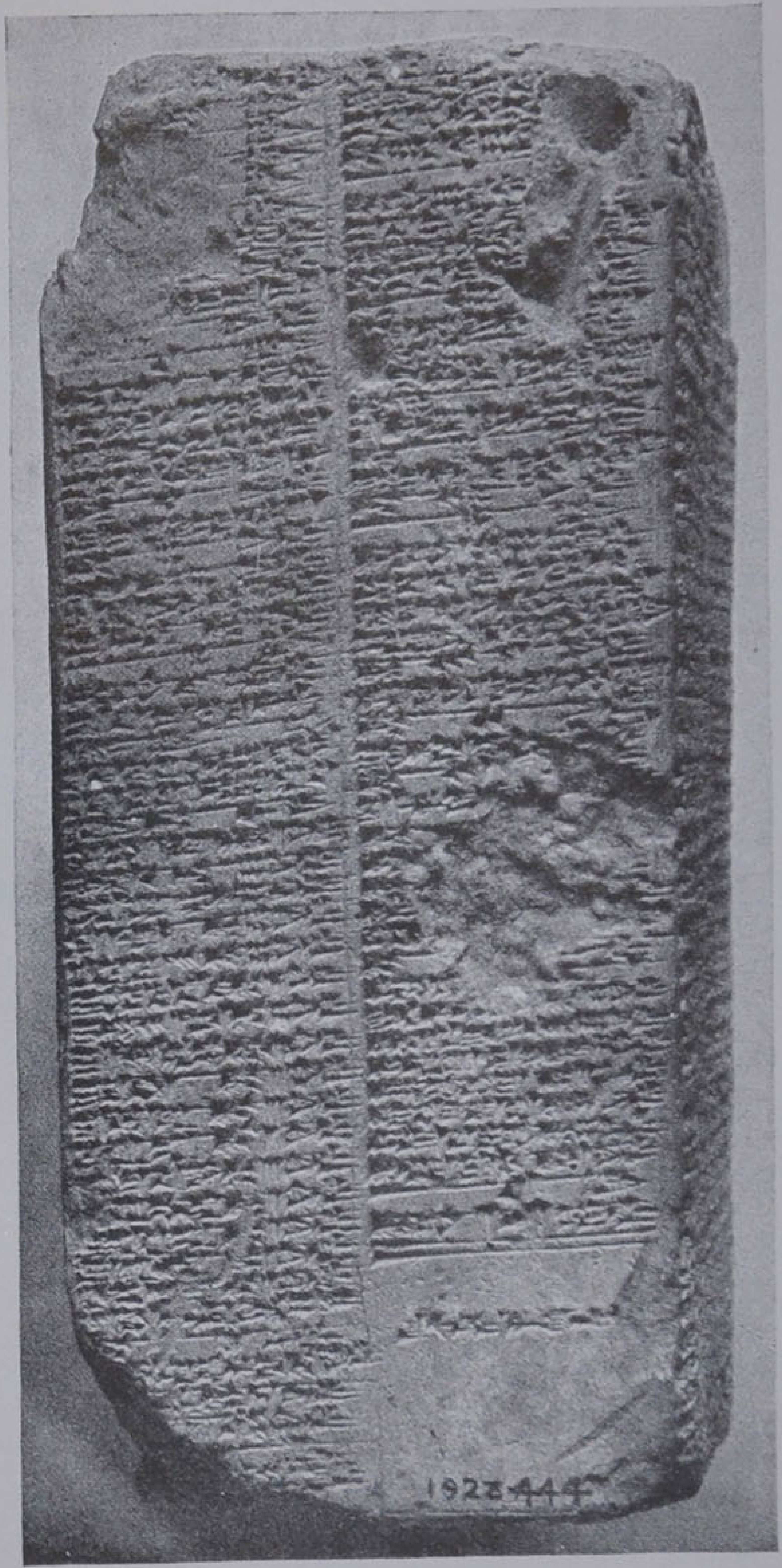
(*Reproduced from Percival, "The Wheat Plant," Fig.* 128, *by permission of Messrs. G. Duckworth & Co.*)

PLATE IX.

Bread Wheat (*Triticum vulgare*).

(Reproduced from Percival, "The Wheat Plant," Fig. 169, by permission of Messrs. G. Duckworth & Co.)

PLATE X.



The Weld–Brundell Prism.

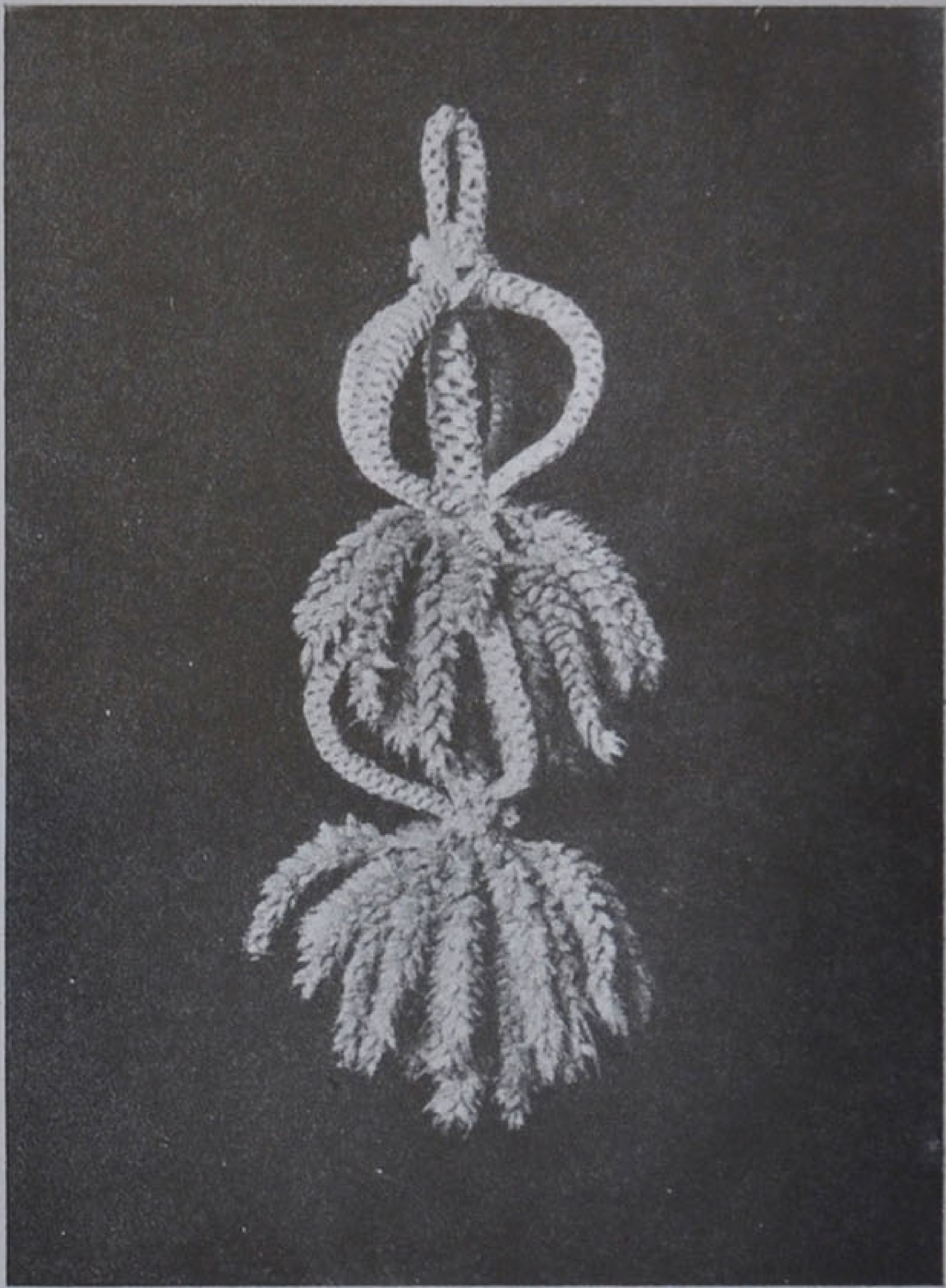
(Reproduced from Peake and Fleure, " Peasants and Potters," Fig. 33, by permission of the Clarendon Press.)

PLATE XI.

Plaited Corn Ornament hanging from Roof-beam in the living-room of a farmhouse at Yockleton, Shropshire.

(Photographed in October 1929 by J. W. Chitty ("Man," 1930, p. 12).)

PLATE XII.



Plaited Corn Ornament from Yockleton, Shropshire, now in National Museum of Wales.

(Photo. Nat. Mus., Wales: reproduced from "Man," 1930, p. 112.)