

## A SHORTER HISTORY OF SCIENCE

### CHAPTER I. *THE ORIGINS*

**Prehistory.** What is Science? The word comes from the Latin *scire*, to learn, to know, and thus should cover the whole of learning or knowledge. But by English custom it is used in a narrower sense to denote an ordered knowledge of nature, excluding such humanistic studies as language, economics and political history.

Science has two streams corresponding to two sources, the first a gradual invention of tools and implements whereby men earn their living more safely and easily, and the second the beliefs they form to explain the wonderful universe around them. The first may perhaps better be called technology, for its problems are too difficult for early theory, and only in later stages does it become applied science; the second, which in historic times grew into a pure search for knowledge, is the main subject of this book.

If we seek for the beginning of science and the matrix in which it arose, we must trace the records of early man as given us by geologists and anthropologists, who study respectively the structure and history of the earth and the physical and social characters of mankind.

It is probable that the crust of the earth solidified some thousand million years ago, 1.6 thousand million, or  $1.6 \times 10^9$  years, is a recent estimate. Geologists recognize six great periods which followed that event: (1) Archaean, the age of igneous rocks formed from molten matter; (2) Primary or Palaeozoic, when life first appeared; (3) Secondary or Mesozoic; (4) Tertiary; (5) Quaternary; (6) Recent. The age of these periods relative to each other is shown by the position of their deposits in the earth's strata, but no certain estimate can be made of their absolute age in years.

One school of anthropologists holds that traces of man's handiwork are first seen in tertiary deposits, and the most recent evidence is held to support this view. The earliest signs of man, perhaps somewhere between one and ten million years ago, a minute fraction of the earth's life, are flints or other hard stones roughly chipped

into tools or weapons. They are found lying on the surface of the earth, in river beds, in excavations made by engineers or dug deliberately to find them, and in caves—one of the most primitive types of dwelling. The oldest stone tools, named eoliths, are difficult to distinguish from natural products, flints chipped accidentally by the action of water or movements in the earth, but the next group or palaeoliths are clearly artificial and of human origin (Fig. 1).

Ignoring the doubtful eoliths, we can divide the stone age into two parts. Palaeolithic man only chipped his implements; he hunted wild animals, but did not tame them or cultivate the soil. Neolithic man belonged to a different and higher race, which seems to have invaded Western Europe, bringing with it domestic animals, some skill in agriculture and in the forming of pottery and of polished implements in flint or hard igneous stone, in bone, horn or ivory. In some parts of the world Neolithic man found out how to smelt copper and harden it with tin, thus passing from the stone to the bronze age, and incidentally making the first discovery in metallurgy. Later on, bronze gave place to iron, probably because of its greater advantage in weapons of war.



FIG. 1. Palaeolithic flint tool

Returning to a consideration of the stone age, we see that the variety and finish of the tools found increase as we examine the higher, and therefore later, deposits. Weapons dropped in war or the chase give us only casual finds, but occasionally we come upon the floor or hearth of a prehistoric dwelling, and add more largely to our collection. Signs of fire, such as burnt flints, show another agent in the hands of man, while the remains of plants and animals indicate by their nature the climate of the time, whether warm, temperate or glacial.

At an early stage in the story, man took to living in caves, a shelter from the weather ready to his hand, and a museum kept for us, containing not only dropped tools and weapons, but also, beginning in Palaeolithic times, pictures drawn on the walls by the inhabitants,

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pictures from which we can gain some knowledge of the life lived by men thousands or millions of years ago, and even an insight into their thoughts and beliefs.

Lower Palaeolithic civilizations, dating from the beginning of the quaternary era, and ending as the last ice age approached, must have covered an immense stretch of time, during which there seems to have been a steady improvement in culture, at all events in the lands which are now England and France.

Middle Palaeolithic times are associated with what is known as Mousterian civilization, so named from the place where it was first discovered—Moustier near Les Eyzies. The race which made it, known as Neanderthal man, again from its place of discovery, was of a low type, generally held not to be in the direct line of human evolution. The cold of Mousterian times drove man more extensively to caves and rock shelters as homes, and so preserved many of his tools, which show that he had learnt to fashion them from flakes chipped off flints, unlike the majority of Lower Palaeolithic tools, which were made from the cores left when flakes were chipped away.

Upper Palaeolithic or Neo-anthropoc man appeared in France after the worst of the last ice age was over, though a continuing mixture of reindeer with stag in the bones and pictures shows that the climate was still cold. The Upper Palaeolithic race was far higher in the scale of humanity than any earlier one, and began to make household objects; there was a definite bone industry and the flaking of flint was greatly improved. We can see such things as eyed needles and double-barbed harpoons carved in bone, and found in Magdalenian, Upper Palaeolithic, deposits. These and other tools and weapons show a marked advance on earlier implements.

Of somewhat the same age are the oldest pictures on the walls of caves. Outlines of men and animals—horses, buffaloes and extinct mammoths—appear. Then, as some indication of beliefs, we have drawings thought to represent devils and sorcerers.

To gain a more definite idea of these beliefs, we may compare them with those of early historical times, as described by Greek and Latin authors, and those still found among primitive people in various parts of our modern world. A huge amount of such evidence has

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been collected by Sir James Frazer in his great book *The Golden Bough*, primarily to explain the rites of Diana Nemorensis, Diana of the Wood, carried on, even in classical days, in the Grove of Nemi in the Alban Hills near Rome, and obviously surviving from earlier, more barbarous, ages. In the Grove of Nemi lived a priest-king who reigned there until a man, stronger or more cunning than he, slew him and held the kingship in his stead.

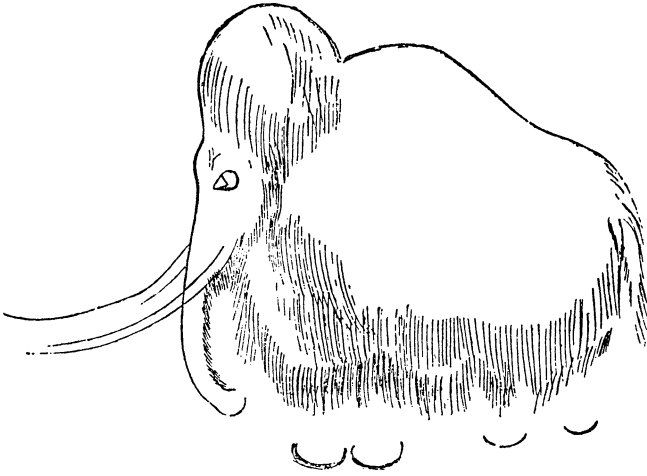


FIG. 2. Cave drawing of a mammoth

In order to explain this tragic custom, Frazer ranges over the world and over long stretches of time. He deals in turn with magic, magical control of nature, nature spirits and gods, human gods, gods of vegetation and fertility, the corn-mother, human sacrifices for the crops, magicians as kings, the periodic killing of kings, especially when crops fail or other catastrophes happen, and the arts as an approach to primitive science. Some anthropologists regard magic as leading directly to religion on one side and to science on the other, but Frazer thinks that magic, religion and science form a sequence in that order. Another anthropologist, Rivers, holds that magic and primitive religion arise together from the vague sense of awe and mystery with which the savage looks at the world.

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Magic assumes that there are rules in nature, rules which, by the right acts, can be used by man to control nature. Thus magic is a spurious system of natural law. Imitative magic rests on the belief that like always produces like. When frogs croak, it rains. The savage feels he can do that too; so, in a drought, he dresses as a frog and croaks to bring the wished-for rain. Countless similar instances of imitation might be given. Contagious magic believes that things once in contact have a permanent sympathetic connexion. The possession of a piece of another man's clothing, and still more of a part of his body—his hair or his nails—puts him in your power; if you burn his hair, he too will shrivel up.

Now these examples take the magician no farther; by coincidence his action may sometimes be followed by the appropriate happening, but more often it fails. Suppose, however, that, by accident, the magician hits on a real relation of cause and effect—for illustration he rubs together two bits of wood and produces the miracle of fire. By that experiment he has learnt a true fact which he can repeat at will, and he has, for that one relation, become a man of science. But in magic, if he fails too often to produce his effect, he may be forsaken or even killed by his disappointed followers, who may perhaps cease to believe in the control of nature by men and turn to propitiate imagined and incalculable spirits of the wild, gods or demons, in order to obtain what they want; thereby they pass to some form of primitive religion. Meanwhile, far out on the other wing, the discovery of fire, the taming of animals, the growing of crops, the gradual improvement in tools, and the development of many other simple arts, lead, by a less romantic but surer road, to another origin of science. Whatever may be the relation between magic, religion and science—and that relation may differ in various times and places—there is certainly a real and intimate connexion between them. Science did not germinate and grow on an open and healthy prairie of ignorance, but in a noisome jungle of magic and superstition, which again and again choked the seedlings of knowledge.

Neolithic man again shows an advance. Structures such as Stonehenge, where a pointer stone marks the position of the rising sun at the solstice, serve not only religious uses but astronomical functions also.

Prehistoric burials often give interesting information. They are found till the end of Neolithic times, cremation only appearing commonly in the bronze age, and then mostly in Central Europe where forests supplied fuel. Well-finished stone implements were often placed in the tombs, showing us the state of contemporary art, and sometimes suggesting a belief that such things would be useful to the dead when they passed over to another world—a belief then in survival.

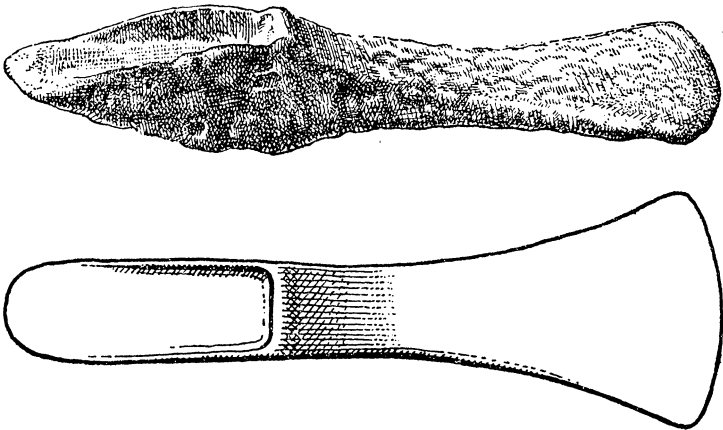


FIG. 3. Palstave of late middle bronze age, found at Hilfield, Dorset

We must not assign to primitive people, whether prehistoric, ancient or modern, too rationalist an outlook. When a savage dreams of his dead father, he does not reason about it, but accepts the dream as real, and his father as, in some sort, alive—not perhaps as much alive as his mother still in this world, but quite clearly surviving his death, though perhaps in an attenuated form as a spirit or ghost. There is no distinction in kind between natural and supernatural, only a vague difference in degree.

With the coming of the bronze age, we pass to a higher culture, made possible by the use of metal. We find axes, daggers and their derivatives spears and swords, and household goods such as lamps. Man has definitely passed from the use of stone as his sole material,

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and when bronze is replaced by iron, we approach and soon enter periods when true history can be pieced together by written records on stone, clay, parchment or papyrus.

**The Dawn of History.** Settled life, with primitive agriculture and industrial arts, seems first to have begun in the basins of great rivers—the Nile, the Euphrates with the Tigris, and the Indus, while analogy would suggest that the early civilization of China too began near its rivers. In contact here and there with these river folk were nomads, pastoral people, wandering with their flocks and herds over grass-clad steppes or deserts with occasional oases. Nomad society was, and is, essentially patriarchal, the social unit being the family, perhaps with slaves, and the government the rule of the father. In normal times, the units kept separate from each other, each in search of food for their beasts. In the Old Testament we have an early and vivid account of the life of nomad people.

And Lot also, which went with Abram, had flocks, and herds, and tents. And the land was not able to bear them, that they might dwell together. . . . And Abram said unto Lot. . . . Is not the whole land before thee? separate thyself, I pray thee, from me: if thou wilt take the left hand, then I will go to the right; or if thou depart to the right hand, then I will go to the left.<sup>1</sup>

With these isolationist views and customs, neither civilization nor science was possible. Co-operation between the family groups only arose for some definite purpose—a hunt of dangerous wild beasts, or war with other tribes. But sometimes, owing to a prolonged drought, or even perhaps to a permanent change in climate, the grass failed, the steppes or oases in the deserts became uninhabitable, and the nomad folk overflowed as an irresistible horde, flooding the lands of the settled peoples as barbarous conquerors. We can trace several such outrushes of Semites from Arabia, of Assyrians from the borders of Persia and of dwellers in the open grass-clad steppes of Asia and Europe.

Now it is clear that we need not look among nomads for much advance in the arts, still less for the beginnings of applied science.

<sup>1</sup> Genesis xiii. 5–9.

But the Old Testament, preserved as the sacred books of the Jews, not only gives in its earlier chapters an account of nomads, but later on deals with the legends of the settled kingdoms in the Near and Middle East—Egypt, Syria, Babylonia and Assyria—a good introduction to the more recent knowledge obtained by the discovery of the buildings, sculptures and tablets, and by the excavations of such relics as royal tombs. This later knowledge is of course fragmentary, depending upon the double chance of the survival of ancient records, and of their discovery and correct interpretation by present-day explorers.

Since the late stone age, the sea-coasts and islands of the Aegean have been chiefly occupied by the Mediterranean race, short in stature with long-shaped head and dark in colouring; to them is due what prehistoric advance in civilization occurred. Farther inland, especially among the mountains, the chief inhabitants were and are of the so-called Alpine race, a stocky people of medium height and colouring, and broad, round-shaped skulls, who pushed into Europe from the east. Thirdly, spreading out from the shores of the Baltic, we find a race which may be called Nordic, tall, fair-haired and, like the Mediterranean people, with long-shaped heads.

**Egypt.** Egypt is divided into two very different parts—the Delta, where the Nile seeks the sea through mud flats of great fertility, and the valley of Upper Egypt, spreading for a few miles broad in the rift through which the river makes its way between the sands of the western desert and the rocky hills of the eastern shore.

On both sides of the Nile rift, and at many points along its length, Palaeolithic implements are found, showing that human occupation began in early geological times. Then came Neolithic man, with his better tools and the great discovery of the potter's art. When soft clay is worked into a designed form and fixed in that form by fire, a new thing has been created. Here is something more than adaptation, as in flint weapons or stone bowls, something which means true invention and a long step towards civilization.

The history of Egypt begins with the first dynasty of kings, somewhere about 3000 years before Christ. Earlier times are repre-



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sented by legends such as that of the divine Horus, Sun of the Day, and his followers. The hieroglyphic script, in which many Egyptian records are written, was first deciphered from the Rosetta stone, discovered by Boussard in 1799 near Rosetta, east of Alexandria. On it is set out a decree of Ptolemy V Epiphanes, in hieroglyphics, demotic script<sup>1</sup> and Greek. Thus those hieroglyphics were interpreted by Champollion and Young, and a beginning made in the study of Egyptian documents, both on incised stone and on paper made from papyrus which, in the dry climate of Egypt, does not perish.

The first clearly historical king was Menes (3188–3141 B.C.), who became sovereign of all Egypt and founded the city of Memphis. Even under his, the first, dynasty, records were kept of the chief events of each year, such as the height of the Nile flood. Documents become plentiful in the time of the fourth dynasty, and the pyramids, orientated astronomically, were built from the fourth to the twelfth dynasty, but the best achievements in practical arts begin to appear under the eighteenth dynasty, somewhere about 1500 to 1350 B.C.

The Egyptians imagined a divine intervention to explain the origin of every craft, art or science; especially were they referred to Thoth, a moon god who measured time in days and years, and established in the temples 'watchers of the night' to record astronomical events.

In arithmetic a decimal system was employed as early as the first dynasty. It had no sign for zero (a much later Indian invention) and no positional notation, also no separate signs for numbers between 1 and 10, so that the unit had to be repeated to the number required. Fractions also were dealt with by units, so that our  $\frac{7}{12}$  was written as  $\frac{1}{3} \frac{1}{4}$  implying addition. These unit fractions persisted long after mixed fractions became general.

<sup>1</sup> A shortened form of hieroglyphics.



FIG. 4. Early Egyptian pottery



FIG. 5. An Egyptian queen driving in her chariot

The official calendar contained 365 days in the year, though the Egyptians seem to have known that the solar year was nearer  $365\frac{1}{4}$ . The former year thus worked back through the seasons, completing a cycle in about 1500 years, a period which appears to have been