ions, however, in no sense lessens the control effect of the external sodium ion concentration.

Entrance of sodium ions into the fibres in potassium-free Ringer solution, and the effect of the concentration of sodium ions on volume control. Immersion of sartorii in potassium-free Ringer solution (122 mol. sodium chloride per litre) for 24 hr. at 3° C. causes a mean increase of sodium ion concentration of 24 m.eq./kgm. of the original weight. Re-immersion for 8–24 hr. in isotonic solutions with potassium chloride substituted for sodium chloride (beginning with 20 m.eq. potassium chloride per litre) results in the line *C* of Fig. 2. This line cuts the ordinate at 0.55. *Re-immersion in the high-potassium Ringer solution stops the entrance of sodium ions but does not reverse it, as shown in the following table:*

Mean sodium of fresh muscle (m.eq./kgm.)	Mean sodium in muscle after 24 hr. in K-free sol. cont. 122 m.eq. NaCl/l. (m.eq./kgm.)	Mean sodium in muscle after re-immersion in K-Ringer with 122 m.eq. NaCl/l.		KCl added to the Ringer fluid (m.eq./l.)
		8 hr.	24 hr.	
23.9	46.9	55.3	50.1	10
	51.5	46.9	48.7	30
	44.8	42.4	39.5	60
	45.8	43.3	50.0	90
	Av. 47.2	47.0	47.1	—

(Each figure is the mean of four or more results.)

All the sodium that has entered the fibres in the potassium-free Ringer comes out again very readily when the re-immersions are conducted in isotonic Ringer fluids with increasing potassium chloride and decreasing sodium chloride. A satisfactory explanation of such facts at present would appear to be that a number of fibres lose their usual permeability, allowing sodium ions to pass through as freely as potassium ions. Into the water of such fibres sodium ions should enter to the extent of approximately 24 m.eq. per litre, plus about 2 m.eq. extra as inter-space allowance, since the external sodium ion concentration is somewhat higher than the plasma value. The increase actually found was $47.2 - 23.9 = 23.3$ m.eq. per kgm.

Such experiments would appear to invalidate the conclusions of Steinbach¹⁶ (who has incorrectly presented my views in a recent paper¹⁷). We have, besides, conducted a very large series of experiments at room temperature and in the cold, copying Steinbach's conditions as closely as possible, but have consistently failed to obtain the reversibility he describes for the entrance of sodium ions into the fibres.

Factors determining the free passage of ions through the muscle fibre membrane. Only some points can be briefly indicated. Lipoid solubility would seem to have little if anything to do with the passage of small ions or of water across the membrane. Thus, the order of passage for water, potassium chloride and urea is as 5 (or more): 1.0: 1.1; but the partition coefficient of urea with respect to fatty oils (and water) may be shown to be about 100 times greater than that for potassium chloride, if we suppose that a real value can be attached to the latter. We may also assume that it is very much greater than that for water itself. All the ions that freely enter the muscle fibres are below a certain size-level. It is therefore strongly suggested that these enter through molecular pores. But, below a certain size-level, large differ-

ences in rates of entrance can occur, and besides the ion size, other factors appear to be called into play, such as ion shape and deformability.

A dehydration hypothesis. It may be pointed out that if we regard the relatively much greater hydration of sodium (related to its ionic potential) as affording an adequate basis for membrane discrimination between it and potassium, an active process of dehydration of sodium could in turn conceivably provide a mechanism for a very slow extrusion. It would perhaps also help to explain some cases emphasized by Krogh⁷, in which sodium ions appear to traverse living membranes faster than potassium ions. (This hypothesis has also been independently suggested to me by Prof. Fearon.)

In the above account the mode of entrance of magnesium into cells has not been dealt with, nor indeed the large number of inorganic trace elements. It is assumed that such can pass through the membrane slowly, not as inorganic ions, but by complex-formation showing lipoid solubility, or entering in some way into the membrane structure.

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BRITISH PREHISTORIC ARCHÆOLOGY: RECENT AIMS, METHODS AND RESULTS*

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THE aims of prehistoric archaeology are, broadly, to give an account of the nature and activities of man where no written history is yet available, defined both in time and space and in character. The definition in time first began to take shape about a hundred years ago; the vital importance of that in space has been recognized principally during the last twenty-five years, when a geographical approach has been seen to be indispensable to inquiries into matters both of time and of the character of prehistoric culture. These inquiries may be made either primarily from the 'historical' point of view, or primarily from the 'anthropological', aiming beyond simple definition in time and space at the fullest possible presentation of prehistoric cultural character. Each point of view has its appropriate methods, and, being essentially complementary, the two are accustomed to converge in the attainment of results; but roughly speaking the 'historical' approach, which is the older established and uses the more purely archaeological

* Summary of a discourse delivered to the Royal Institution on March 22.

methods, has in Britain provided the broad framework of the prehistoric story, while for the improvement and refinement of the framework, and for most of the purposes also of the newer or 'anthropological' approach, a wider range of methods has been called into being, variously involving the collaboration of archaeology with the natural sciences. The present illustration of this will be divided between the pre-Roman Iron Age, the Bronze and New Stone or Neolithic Ages, and the Middle and Old Stone or Mesolithic and Palaeolithic Ages: the broad outline given first, and then a selection of recent developments within it.

Iron Age

The latest pre-Roman immigrants into Britain were the Belgic peoples of the south-east and south, with other arrivals from across the Channel farther west, all in the first century B.C. So far back as the third century B.C. the latter had been preceded by earlier Celtic incomings, less compact, but resulting in several strong patches and a wide further scatter of immigrants, mainly a war-like and art-loving aristocracy ruling over the more solid mass of the Iron Age Celtic population, which already earlier, approximately in the fifth century B.C., had come over to settle over all the south and east, with considerable fringes beyond, and which provided the original and basic culture of the whole period. The archaeological material documenting this sequence is fairly well determined, but its further study is proceeding in a number of directions, often in co-operation with the physical sciences (for example, spectrographic analysis of metals and metallurgical equipment) and with various technological studies. But wider results are being obtained by field research and excavation.

The question of towns and fortifications has attracted much attention. How far can the fortified towns of the Roman period be shown to have had genuine native antecedents? Both at Verulamium by St. Albans and at Colchester, Roman towns have been shown to adjoin the sites of capital settlements of the Belgic peoples; but these appear, particularly in the latter case where the enclosing fortifications spread over many miles, to have covered large tracts of ground in an intermittent and patchwork manner, very unlike the concentrated urban planning of Roman times. This result of modern field-work has to be compared with that of the many trial-excavations conducted in the hill-forts or 'camps' of the British Iron Age, which as a class have their beginnings already in the original phase of settlement. That is, broadly, that these strongholds were quite often only inhabited intermittently, or used as fortified refuges in time of trouble, but that in the later phases of the Age, and above all in the last phases (contemporary with Belgic Verulamium and Colchester), some of them certainly were inhabited intensively enough to deserve the name, if not of towns, then at least of fortified capital villages. The most impressive of these is Maiden Castle in Dorset, where to the sequence of occupation there corresponds the successive enlargement and strengthening of the huge earthworks defending it: at first enclosing the eastern portion of the hill only, they were later extended to enclose the whole. The form of such successions varies at different sites; at Bury Hill near Andover the site of a large and simple earlier fort lay derelict for at least a century before the building of a smaller but stronger one. This result was obtained by test-sections cut where the two sets

of earthworks overlapped; and the minimum duration of the interval was estimated from soil-analysis of the turf-line between them—one example, out of many that could be given, of the co-operation between archaeology and soil-science, from which a wide range of important results may be expected in the future. The history of hill-forts in Britain thus varies much from site to site; and if whole groups of them are investigated and the findings collated for the entire area—as has been done for the Sussex Downs—the composite picture obtained will be of value not only historically, but also as a starting-point for assessing the character of the area's communal life throughout the period.

But for that assessment the evidence of fortified sites must be brought together with that of the homesteads and villages of the open country. The 'villas', familiar as the chief units of rural economy in Roman times, have sometimes, in the south-east, been found to overlie the remains of Belgic habitations, and though their always 'civilized' architecture, with its rectangular ground-plans, was a Roman innovation—a radical change from the round or oval design of most prehistoric dwellings in Britain—yet their character of a substantial single homestead has its roots not only in pre-Roman but in pre-Belgic times. For whereas older methods of excavating and interpreting Iron Age rural sites left it to be supposed that these were usually villages of numerous small dwellings, thought often to be represented by the pits with which such sites are commonly studded, the excavations at Little Woodbury near Salisbury have proved that such pits were storage-pits, and that the site was essentially a large single homestead, datable onwards from the third century B.C. The house has been planned and 'reconstructed' from the post-holes that held its timber uprights, and was a circular building with a roof sloping up to a central four-posted core, and with an outer verandah or aisle running round it under the eaves. Simpler and variant forms of the type are known elsewhere, in the west and north mainly dry-built in stone; some regions and phases of the period, on the other hand, display the alternative type in which the floor is somewhat sunk into the ground and walls and roof are formed in one, of more or less pliant stakes or boughs, embedded around the floor-margin and arched over and woven together above like an inverted basket. The satisfactory excavation of either type needs careful work; but without this, or without clearly visible remains of stone-built structures, it cannot safely be decided whether any given site is a single homestead or a true village, since the Iron Age had both—just as in Roman times there were both 'villas' and villages.

Photography from the air, as has now become well known, is of very great assistance in locating such sites and giving a rough overall plan, whether it reveal them by picking out their contours in the turf, or by showing up the pattern of differential growth and coloration which their remains impart to crops in the overlying soil. It is also of great value when applied to earthworks and other major ancient features of the country; and particularly to the systems of fields tilled in Roman and prehistoric times and traceable from their delimiting scarps and banks, or 'lynchets'. These 'Celtic fields' are commonly small and squarish, implying cultivation by a light or two-ox plough; another sort, longer and more strip-like, has been associated with the heavier plough-teams employed in Britain first by the Belgæ and then on (probably many) Roman 'villa'-farms;

but it appears also earlier and in non-Belgic districts, so that its full history has yet to be made out. All this research into the 'anthropology' and agrarian life and institutions of pre-Roman Britain shows how archaeology can widen its aims and methods to give ever more vivid and precise results. But the importance of the 'historical' framework of course remains; indeed, in any case in southern Britain, the Iron Age pattern of life is now known to have been taking shape already in the last centuries of the Bronze Age.

Bronze and Neolithic Ages

Those last centuries, after 1000 B.C. and running on into the Iron Age some five or more centuries later, were in fact marked by immigrations which appear as forerunners of those of the Iron Age peoples. In the 'transition' between the two Ages, they affected the north more than was formerly suspected; while the central fact of the southern Late Bronze Age was the incoming of people from north-west Europe whose cultural tradition had long been maturing on the Continent independently (in the main) of the insular Middle Bronze Age tradition of Britain. This latter tradition had had a long life, going back centuries beyond 1000 B.C. to the Early Bronze Age, when its constituent elements were formed by another complex of immigrations, acting upon native populations still earlier established. The tradition included some agriculture, but was predominantly pastoral, with cattle as the main primary source of subsistence and wealth. The craft of bronze-working cannot be considered here, but was of a high order, and in the Late Bronze Age expanded its production and commerce greatly; flint and stone working went on beside it; and in pottery, the best-known products are the urns containing the remains of the cremated dead. The native Middle Bronze Age urns, quite unlike those of the Late Bronze Age immigrants, have their closest prototypes in the so-called 'Food-vessel' pottery, which reflects the Early Bronze Age mixture between immigrants and natives. Of the immigrants the most numerous and widespread were the various 'Beaker' peoples, so called from their distinctive drinking-cups, who arrived shortly before and after 1800 B.C.: the natives were the peoples who had carried the culture of the Neolithic Age, from its various beginnings in the centuries before. In addition to the group to be noticed below in connexion with Skara Brae in Orkney, one group of these were mainly hunters, fishers, and herdsmen, and of North-European affinity, while the other series of groups represent the great West-European family of peoples whose original Neolithic economy, an outgrowth from the civilization of the ancient East, brought agriculture and stock-farming for the first time to the British Isles, between about 2500 and 2300 B.C.

The Neolithic flint and stone and other industries and the beginnings of metal-working must here be passed over; but before the Neolithic and Bronze Age peoples' mode of life is considered, their tombs and religious monuments must engage attention, for these are much more conspicuous among their remains than those of the later peoples, no doubt because, at their stage of development, supernatural agencies played a more compelling part in their general conceptions. Of the Bronze Age, the most familiar monuments are the 'round barrows' erected over the graves of the more important dead: common in many districts, their known numbers have been

greatly added to by air-photographic detection of examples flattened by modern ploughing.

Great strides have also recently been made in the technique of their excavation. As well as the mere recovery of the grave-deposit, the modern excavator aims at the study of the entire structure of the barrow, as a complex monument embodying ritual prescriptions which have much to reveal of the people's culture and ideas. The method is to divide the barrow into quadrants, and so to excavate it as to obtain precise information of its various features in all three of their dimensions. The features may include secondary added to primary interments, various forms of grave, and enclosure-rings of various kinds beneath or around the barrow: of piled or earth-fast stones, of embedded timber uprights, or of driven stakes to carry wattled fencing; also a surrounding ditch, and a variety of outward forms given to the barrow-mass itself. The details of these and other features must be elucidated with the help of scientific specialists, for example, for the geology and petrology, for timber remains, charcoal and other burnt matter, and for structural earth- and turf-work; and from all this a body of knowledge is being gradually built up, which will presently make the religious tomb-practices of the Bronze Age matters no longer of speculation but of ascertainment.

For the Neolithic, the tombs of the Western colonists may often be made no less informative. In the main, they are more impressive structurally, whether it be the 'long barrows' of the south and east, of earthwork with features of turf and timber and sometimes stone, or the essentially stone-built 'megalithic' tombs of the west and north, which in the Severn and Cotswold region are in fact long barrows chambered and walled in stone, and elsewhere variously passage- or gallery- or cist-tombs or 'dolmens': all have had devoted to them a care and labour which shows that the form of fertility religion which came westward with this culture from the East was intensely concerned with the supernatural power of the dead to make or mar the welfare of the living, and with the ritual and magic required accordingly at these tombs, in the chambers of which the burials are found not singly, but grouped collectively or in succession together. Examples from the Cotswolds show only some of the many details which meticulous excavation can reveal; and here again, the more scientific archaeology makes its methods, the more effectively it will contribute to human studies, in the anthropology of ancient religious observance.

The same is true of the investigation of the famous stone circles of Britain which, with 'avenues' and other standing-stone monuments, and with the cognate timber circles disclosed by air-photography and excavation, took their rise in the period of the 'Beaker' and other Early Bronze Age invasions, and are thus only partly connected with the ideas of megalithic tomb-building. The work of recent years at Avebury has here been of particular importance; and as regards the timber circles, 'reconstruction' has begun to entertain the notion that some at least of them were roofed, as would befit the climate of these northern latitudes where they were developed. Thus the 'houses' of the unseen powers imagined by prehistoric man may be brought into type-relation with the houses of prehistoric man himself.

Unfortunately, the actual houses of Neolithic and Bronze Age man in Britain have not yet been explored in any great numbers. Generalizations about their

type and character must await the excavations of more examples and will therefore here be passed over, along with any that can be propounded about the rural economy of small-scale tillage and larger-scale cattle-keeping—with which the so-called 'Neolithic camps' seem especially associated—whereby these peoples lived. But the site of Skara Brae in Orkney, the stone hut-villages, clustered in the sand-dunes, of a remote late-Neolithic community, deserves special notice for its wonderful preservation of the interior fittings and furnishings of the houses, which, the islands being virtually treeless but rich in flat-splitting flagstone forming an indestructible substitute for joinery, have been found intact beneath the covering sand, and show how much we are entitled to imagine of the perished equipment of Neolithic or Bronze Age life in normal wood-using localities.

It remains to point out that scientific collaboration in the archaeology of these periods is not confined to the study of materials and structures, but through research into physical environment and climate has contributed greatly to the 'historical' framework. Bronze Age and Neolithic objects found suitably stratified in sedimentary deposits, and most especially in peat, can be dated in terms of the environmental and climatic history determined for the whole deposit sequence by geological, faunistic, and palaeobotanical investigation. In Wales and the west of England, no less than in Ireland, this originally Scandinavian technique has been successfully applied; and the classic English region for its application is the Fens, where a continuous sequence has been worked out extending right through these Ages (with an especially important horizon of clay indicating a transgression of the sea in the period of the 'Beaker' invasions), from the preceding Mesolithic or Middle Stone Age—which the subject thus introduces next for brief attention.

Mesolithic and Palaeolithic Ages

On its geological and faunistic sides, the technique of determining 'natural chronology' is in general principles the same for the Holocene phases covering the Mesolithic as for the Pleistocene covering the Palaeolithic; on the palaeobotanist's side, its essential method is the pollen-analysis of stratified peats and sediments, recording their content of the pollen of different trees and plants progressively from the bottom to the top of the section examined, and so making the history of vegetation reveal that of climate. Where an archaeological object or horizon of human occupation occurs in the section, it can thus be fitted into place, and the web of cross-correlations so made between environmental and archaeological type-sequences enables time-recording to be taken back far beyond the scope of archaeology working unaided from types of implements, or of pottery, dated already in better documented regions. At the same time, this knowledge of environment throws much light upon the conditions in which the people of any given archaeological period subsisted.

These 'combined operations' of archaeology and natural science have illumined all the stages of the north European and British Mesolithic, covering the thousands of years from the end of the geological Pleistocene to the age of the Neolithic colonizations. But pure archaeology has also its part to play: simple hunters and gatherers as they were, the Mesolithic peoples have left distinctive features of their communal culture, not only in their flint and bone-work but sometimes in their dwellings, some of which,

with floors scooped as pits into their favourite sand or gravel soil, have been found and excavated, notably a group near Farnham in Surrey. In East and Central Europe such dwellings have been dated right back to Palaeolithic times, and that may be done one day in Britain too.

At present, our known Palaeolithic occupation sites consist of caves (in the west, and the southern Pennines) and occasional open 'floors' for camping or flint-working, which may, like the much more numerous occurrences of flint artifacts by themselves, be geologically stratified. For the Palaeolithic, indeed, the geologist becomes master of the whole field of chronology, essential for controlling the archaeological classification of the artifacts into industries and cultures. As the geological evidence gradually reveals itself, the story of Palaeolithic man, and its relationship to the slow fluctuation of the Pleistocene climate between its recurrent glacial and temperate phases, is gradually unfolding. The pace of progress depends on the geologists, and it is natural that where interpretation is so difficult, unanimity among them should not be easily forthcoming. This is not to be cozened by archaeological theorizing meanwhile. But continual progress is being made; and indeed for every prehistoric age, archaeology in Britain should be able to look forward to a continual winning of results, as its methods improve and its aims pierce further. It is beginning to reach its maturity, but it has plenty yet to do.

PHYSIOLOGY OF FERTILIZATION

By LORD ROTHSCHILD

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EXPERIMENTS have revealed a surprising and discouraging lack of uniformity in the physiological signs of fertilization in different types of eggs. In sea-urchin eggs, oxygen consumption increases after fertilization¹; in *Cumingia* and *Chaetopterus* eggs, oxygen consumption is stated to decrease after fertilization², though this might be due to acid production masking an increase in oxygen consumption. Acid production during the fertilization reaction, first noted by Ashbel³, has only been reported in sea-urchin eggs, though as Gray first pointed out, the sudden evolution of carbon dioxide which results from the interaction of this acid and the bicarbonate in the sea water may mask the true oxygen consumption if the carbon dioxide absorbent does not act quickly enough. The experimenter may therefore miss the acid production and 'measure' a low oxygen consumption-rate.

Biophysical measurements, involving the resistance, capacitance, and potential across the egg membrane before and after fertilization, have not been sufficiently numerous to merit much attention as yet, though they too have failed to reveal any common denominator in the fertilization reaction.

One of the most characteristic features of the fertilization reaction is the block to polyspermy. Though there are certain exceptions which are discussed later, the rule is that only one spermatozoon fertilizes an egg. Describing this phenomenon, Just says⁴: "Before the actual elevation of the [fertilization] membrane, some cortical change, beginning at the point of sperm entry, sweeps over the egg immunizing it to other sperm; the direct opposite pole of the site of sperm entry is the last point affected".