spectral lines. Is the Doppler effect the only possible interpretation? If the slowing down of light over vast distances is a possibility, shifts towards the red would be expected—indeed, de Sitter's original cosmology suggested this as alternative or complementary.

A letter to *NATURE* of Jan. 16, 1932, from Prof. W. D. MacMillan, suggests that the red shift is due

to loss of energy in the photon in course of time, due either to inherent instability or collisions with other photons. He concludes: "Such an interpretation of the extraordinary shifts that are observed will be more acceptable to many than an interpretation which makes our galaxy a centre from which all others are fleeing with speeds that are proportional to the distances".

Canons of Archæological Theory *

By Dr. DAVID RANDALL-MACIVER

FROM a vast and intricate subject I will select for discussion only two of the principal problems of archæology—namely, the application of a time-scale and the proof of the dissemination of a culture. First, then, as to the time-scale. A series of culture periods has been well established, so that there is a reliable system of what is called 'relative chronology' from the earliest Stone Age down to the time of full documentary history. But it is a very different matter when we attempt to translate these culture periods into centuries and thousands of years. We are wholly dependent for our absolute chronology upon the dates recorded or obtained by immediate inference from ancient writings or traditions. The fragmentary relics of Mesopotamian and Egyptian official chronology furnish a time-scale, liable to much uncertainty in minor details, but trustworthy in all its main lines. As archæological discovery proceeds in the coming years, we may reasonably hope to arrive at a completely graduated scale of chronological dating in actual years for every part of the ancient world after 3500 B.C. But if it is asked what means we have for establishing a chronological as well as a typological scheme behind 3500 or possibly 4000 B.C., I answer unhesitatingly that we have none, and that unless earlier written records or traditions come to light it is probable that we shall never have any.

One very crude method of attempting to avoid this impasse is so illogical that I need spend little time in discussing it. Below the strata in which definitely datable objects are found—whether at Knossos, Ur, Susa, Mohenjodaro, or any other very ancient site—there are generally strata of a certain thickness in which other and obviously earlier forms occur. Now, it is sometimes suggested, even by skilled explorers in their less discreet moments, that the mere thickness of these undated layers may give an indication of the length of time which it took to form them. Yet a very slight amount of reflection, not to speak of actual experience in the field, will show that this reasoning is as childish as it is simple. I have myself seen in Egypt deposits many feet deep which can, nevertheless, be proved, by well-dated objects at the top and bottom, to have been formed within a single century; and I have also seen a concentrated stratum of not more than four feet which contained the products of many centuries closely pressed together.

* From the presidential address to Section H (Anthropology) of the British Association, entitled "The Place of Archæology as a Science, and Some Practical Problems in its Development", delivered at York on Sept. 2.

In a less crude but not very different form, the same error appears in the attempt made by several justly admired writers to establish a chronological scale for the typological series preceding the historical in a country like Egypt. The system of sequence-dating based on typology is now familiar to all students. It was established for Egypt by Sir Flinders Petrie, and for Europe in general by Montelius. As a scheme of relative chronology it sometimes creaks a little, but on the whole it works well and has justified itself, though it may need occasional emendation. But the recurring attempts made by one author after another to translate this relative system into an absolute chronology of years have no logical justification whatsoever, and only encourage self-deception.

The argument is really based on an assumption which can easily be shown to be fallacious. This is the assumption that the rate of progress in civilisation is always uniform. If we know the rate of development in types which took place during the First and Second Dynasties and know also from inscriptions the length of these dynasties, then, it is argued, we have a yard-stick which can be applied to the period preceding the First and Second Dynasties. It is as though a policeman, having timed a speeding motor car over a measured mile, and found that it was going at sixty miles an hour, should appear before the magistrate and state that it was evident the defendant had been proceeding all day at sixty miles an hour.

If, however, we must abandon such illegitimate methods, it is not quite impossible that properly directed ingenuity may find some others which will give a rough scale, less accurate indeed than the chronological, but, nevertheless, valuable. The recent success of Miss Caton-Thompson in settling the very difficult dating of Badarian culture by truly logical methods based on geology is very encouraging; and thirty years ago I myself made a suggestion which I still think has some value. If, I suggested, we could discover the village corresponding to an ancient cemetery, and also ascertain the total number of burials in that cemetery, then we should be able by calculating the presumable death-rate to arrive at a rough estimate of the number of generations. It is evident that several factors in this equation can never be established more than approximately, but it would be worth attempting, if ever a suitable site could be found.

Next we may briefly consider the problem of the dissemination of cultures. This is really the cardina

problem of archæology, irresistibly attractive, and for that very reason offering peculiar temptations to hasty and premature generalisation.

Now, the foundations of this particular study, in so far as they have been well and truly laid at all, have been laid not by archæology but by other sciences, those in fact which deal not with man himself but with the conditions necessary to his very existence. Geology, climatology, palæontology, palæobotany have been the instruments of that great progress in synthetic theory which I have pointed out as the special achievement of the last thirty or forty years. Those who have worked out the details and the stages of the Ice Age and the rainy periods have shown us that various parts of the world were uninhabitable for a long time. It is obvious, for example, that man cannot exist under a snowfield, so that it is useless to look for him north of lat. 50° until the Ice Age is well past.

Conversely, large areas which to the modern view seem impossible homes for man are shown to have been eminently suitable for the life of the palæolithic hunter. The Sahara and the Gobi desert in their present condition cannot maintain the life of man or beast; but the climatologist shows that there was a not very remote period when they were well-watered regions, covered with grass like the South African veldt, and teeming with large game. Thus he explains what otherwise might have remained an ambiguous problem for the archæologist, the finding of human implements of very early types in these apparently uninhabitable tracts.

The botanist next comes forward to tell us that the food plants on which a settled agricultural life depends can only be found in their wild state in certain closely defined areas. He also shows how changes of climate produce various types of afforestation which necessarily limit the movements and activities of a man who possesses only primitive tools.

But when the archæologist proceeds by purely archæological methods to fill in the details on a background of which the outlines are thus immutably drawn by the other sciences, he is confronted with innumerable difficulties of method, and the logic of his procedure is not always well studied. In the first place, we must necessarily rule out many types of reasoning which are so general and inconclusive that they can never carry any conviction. A little serious reflection must show that we necessarily know so little of the mental equipment of early man that it is often impossible to say what actions and habits are natural to all men as highly developed anthropoids, and what are so peculiar as to be specifically human and characteristic of one or another developed type of man.

That man should seek shelter from the elements is so obviously natural, and so like all other animals, that probably no one would argue that the living in caves or the construction of a primitive shelter, analogous to an animal's lair or a bird's nest, must presuppose any identity of race or origin. Or again, may not any animal pile up stones? And if so, at what exact stage does the piling up of stones become such a complex action that it can only be developed in one place? Suppose that a shelter of stones

has to be roofed. Is the laying of slabs, one overlapping the other so as to form a corbel, so intricate a device that it might not be invented in many places simultaneously? It seems a very primitive process, even if it has been developed with great skill in certain countries.

It has sometimes been suggested that the discovery of the uses of burned clay, and consequently of baked pottery, may have been due to the accidental firing of a wattled hut. If so, it is difficult to maintain that the invention of pottery could only happen in one place, unless the use of fire was limited to one little spot on the earth.

These apparently elementary questions go to the root of the whole matter. Whatever answer an archæologist might give, he could not persuade by logical means any opponent who chose to disagree with him. He would be obliged, when driven into a corner, to say, "I am convinced" of this or that, but the conviction would express nothing more than his own temperament and psychology.

To apply logic at all, then, we need to find our material in highly specialised products or habits of man. In short, it is only possible to reason convincingly when manufactures or arts and crafts have reached a high point of intricacy. Let us take examples from flint-working, man's earliest craft. It seems fair to say that the use of natural flints, perhaps even of pre-Chellian or rostrocarinate and other forms which involve the minimum of workmanship, might arise independently among various types of almost simian man. But when it comes to elaborate chipping, and when this chipping produces implements of identical and highly specialised forms, then it is indeed logical to argue that this process and these forms could only have been invented once and only in one region. Chellian flints already seem to me to be so distinctly a product of a highly specialised intelligence, which might have taken a hundred other forms, that it must inevitably be inferred that a single type of man originated these artefacts, even though they are found distributed over an immense area.

Still more it might be supposed that when one more degree of elaboration has been added, by the use of so peculiar a technique as pressing off flakes as well as chipping, the logical inference was still stronger. If, further, this peculiar technique is combined with peculiar shapes, then the case seems to be almost irresistible. To accept this would entail some surprising consequences, linking, for example, the Badarian culture of earliest Egypt with the Solutrean of Europe and perhaps with other even remoter places. Yet it is certainly good reasoning. It is curiously significant, however, of the difficulty of arriving at any certain conclusions that just as we might be ready to accept this theory of the Solutrean, with all its far-reaching consequences, Menghin comes forward with the assertion that the Solutrean style is the natural and inevitable product of the juxtaposition of a core-working and a flake-working industry.

In contrast to the doubts and uncertainties which beset all reasoning based on the manufactures and

products of early man, it is a relief to turn to a field in which unquestionable logical certainty can be achieved. This is when we are able to study man's action in moving and displacing natural products. For when the natural distribution, as known to geologists, of rocks, ores, and other natural products is artificially changed, there can be no doubt that man has been at work. Thus, if a certain kind of flint is peculiar to Grand Pressigny in France and implements of that flint are found in Switzerland, there can be no doubt that Switzerland is trading with Pressigny. Similarly, if gold combined with antimony is known only to occur in Transylvania, it is a just, though a surprising, inference that the sceptre of a very early Egyptian king, living about 3000 B.C., which shows this unique combination of metals, is made of gold from Transylvania. To take a simple example from nearer home: if a number of stones in the circles of Stonehenge are of a type peculiar to Wales, they must have been transferred from Pembrokeshire to Salisbury Plain by man.

Raw materials, then, are better evidence than manufactures, especially in the earlier stages of man's life. When we are dealing with the works of man, logical processes of real value only begin to be applicable as handicrafts become more complicated and as the arts begin to emerge. Between art-styles, if we are sufficiently discriminating, it is possible to institute sound contrasts and comparisons. To take an extreme example, we should no doubt recognise a Greek statue even if it were found in West Africa. The hammer-axes of Troy and the Danube, the polygonal battle-axes so widely spread over southern Russia and northern Europe, the lunulæ of Irish gold, the decorated situlæ of Iron Age Italy, the painted vases of pre-Corinthian style, may stand as examples of highly specialised products which unquestionably denote commerce and reciprocal influence wherever they occur.

We have to be on our guard, however, against many cases in which the style is scarcely developed enough to be a convincing criterion, or in which the style has become so confused owing to cross influences that it gives an ambiguous answer. Most of all does this occur in the sphere of pottery. There is more bad reasoning in regard to pottery than in regard to any other part of our subject.

Especially in such early stages as the Neolithic and the Chalcolithic, there is the same danger of reasoning in too general terms that I have already pointed out in regard to primitive customs and habits. The smaller vessels used during the Neolithic stage are all imitations in clay of receptacles originally made in other materials. Goatskins, leather bags, gourds, and baskets are some of the natural predecessors of pots. It is only to be expected, therefore, that the clay imitations of these will be found far and wide among people who may have had no racial connexion or commercial intercourse of any kind. It is only occasionally that geographical conditions may intervene to prove that there is a real unity of culture underlying the superficial resemblances. There is, however, one happy instance of this. Gourds are indigenous in tropical and semi-tropical countries, but do not grow natu-

ally in Europe. When, therefore, pots derived from gourd-forms are found in Moravia, it is a logical and necessary inference that the people who made them on the Danube came from a gourd-producing country like Asia Minor, or were in close commercial relation with it.

In this connexion, I should like to contrast two examples of reasoning, one of which has led to useful and fruitful results, while the other threatens to plunge us into confusion. All archaeologists are agreed that the beakers which have such a wide distribution over Europe in the Bronze Age are derived from a single source, though they are not unanimous as to the centre of origin. This unification of a single system all over the west and north of Europe, including Great Britain, has greatly assisted the study of the Bronze Age in those regions. But contrast with this the attempts which are being made to unify the schools of painted pottery so as to make a chain from Chalcolithic Sicily to China. The dates are hopelessly incompatible over large sections of this immense area, the civilisations have few if any points in common, and yet we are invited to unify them on the sole basis of paint being used. It is even asserted in so many words that it is improbable that the idea of applying paint to pottery should arise independently in different centres. It might be too dogmatic to say that this is utterly illogical, but it can certainly be said that it is quite unconvincing. The discovery of paint is in itself easy and inevitable, and once this medium is known, it will naturally be used for anything and everything.

This leads me to make, in conclusion, the only suggestion that I think need be made in regard to the training of the young archaeologists of the coming generation. I do not believe that early specialisation in archaeological training would be wholesome—indeed, I think it would probably be rather harmful. As I mentally call over the roll of my most distinguished colleagues, some a little older and some a little younger than myself, I am struck with the remarkable diversity of their background and training. This diversity has probably been a real source of strength. That classical scholars, historians, anthropologists, geologists, lawyers, engineers, artists, and many other types of mind should focus from different angles on the same subjects has led to catholicity and breadth. For it is not so important that an archaeologist should be an expert in one subject as that he should be widely and well educated.

With this premise once granted, I think that much time would be saved, and much efficiency would be added, if the student at the beginning of his archaeological career were to superimpose a year or so of intensive technological training on his more general education. We all know the saying that a man does not really know about an object until he can make it. A technical training in primitive handicrafts such as pottery-making, flint-chipping, weaving, and the hammering, alloying, and casting of metals, would give him an insight which no mere reading or even handling of finished specimens can give.