Evolution in Material Culture.*

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BY the aid of *methods*, often dependent upon extraneous *means*, man employs *materials* for the achievement of *results*, many but by no means all of which persist as artefacts or other *products*.

Substance is the static warp, and method the dynamic woof, of man's material culture, whilst the products may be looked on as the fabrics, though these are not always tangible. Amongst the more obvious of those which are material in their nature are artefacts of all kinds, but it is clear that such products are themselves the means to further ends. These further ends are material in the case of implements, less immediately material in that of houses or canoes, and non-material in the case of shrines or musical instruments, which satisfy demands of social and individual mentality. Here we find our objective point of view overlapping the subjective—our material products require for their explanation some understanding of such aims and ends as lie outside the field of primary material needs. As soon as we get beyond the study of the instinctive quest of food and self-protection, and pass to that of the aims of the human artificer, we realise that aims and ends as well as ways and means are products of evolution. Man did very well before he was a man at all, and no one has given any reason why he ceased to be an ape.

THE DISTORTING MIRROR OF THE PRESENT.

Our attitude towards the problems that arise in the study of origin and development depends very largely upon the extent to which we ascribe to man a power of foresight enabling him to overrun the limits of environmental suggestion. If we assume that his progress has been based upon his opportunist reactions to such suggestion, we secure a vantage point from which to take a retrospective view of human progress. The visibility is not too good, and the details that are fundamental are often but obscurely seen, partly because the field of view is not only restricted by our ignorance but is also overshadowed by our knowledge. We can see too little of the past and too much of the present.

We have to make a big allowance for our own sophistication, when we are trying to explore the origins and growth of discoveries and inventions, and neglect of this precaution is not infrequent. In the case of pottery, for example, it is sometimes maintained that the plasticity of clay is so obtrusive, and its hardening by heat so easily made manifest, as to place the ceramic art amongst those human industries that may have been developed more than once, if not over and over again. The two essential properties of clay are obvious enough, given the conditions for its accidental hardening by fire, and both may have been discovered at various periods. Looking backward it seems evident to us that an early discoverer, look-

ing forward, could have deduced from these two properties of clay the advantages of modelling this plastic stuff into the forms of vessels and baking them to hardness. Some may think that the deduction was an easy one, but the ease is purely retrospective. The potter was not a product of predestination. The conventional theory of the origin of pottery through the plastering of clay on the walls of baskets may or may not be acceptable, but it is in any case a recognition of the need that is felt to bridge the gap between the discoveries of two properties of clay, and the production of an earthenware pot. The discoveries were essential, but it is only in the light of our own knowledge that pottery appears to have been an inevitable result.

To take another example of the hasty reasoning which credits ancient man with anticipatory conceptions that in ourselves are due to knowledge, it is sometimes suggested that there is no improbability in the idea of the multiple origin of the pyramid, since the observation that piles of loose materials readily assumed a conical form must have been frequently made. To this it may be answered that pyramids are not small, are not made of loose materials, and are not conical in form; but this is only a small part of the relevant reply. The affiliation is indeed inconceivable, since the evolution of a pyramid depended not only upon many material factors, but also upon a number of social and religious sequences. Pyramids were not preconceived as being more pleasing to the gods, and more elevating to the human soul, than any other geometrical monstrosity; nor were they built out of mere Euclidean bravado. For such structures, even in their various modifications of material, form, and function, to appear independently in Mesopotamia, Egypt, India, Cambodia, Java, and America, would have called for parallel networks of coincidences rather than parallel chains.

MAN'S COMMON FACULTIES.

The question as to the nature and importance of the common faculties of the human mind—the components of the psychic unity—is one which demands more attention than it has yet received from anthropologists, Bastian notwithstanding. This is especially the case in relation to the subject of independent evolution. For our purposes it would not only be needful to isolate the common faculties, but also to identify those which have a bearing on the progress of discovery and invention. Here we should meet with the primary difficulty of distinguishing between an inborn human faculty and a traditional or inculcated mode of thought—an acquired type of reaction.

Assuming we had progressed so far in the comparative psychology of *Homo sapiens*, we should still be left with the problem of determining which—if any—of the common faculties are directive in their nature. It is not a question of deciding

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which faculties are permissive, enabling man to react in a similar way to similar external stimuli, but of determining which of them give him the power, whoever and wherever he may be, to override deflecting influences. Two environments may be similar, but only when they are the same are they identical, and our broad generalisations as to the cultural effect of surroundings such as deserts, mountains, forests, river-valleys, have a bearing upon the general mode of life they encourage or permit, and therefore upon a portion of the field which is open to the discoverer and inventor, but they ignore the differences in the details of any two environments of one general character; and it is discrepancies in detail that produce divergencies in end results. The human mind is very prone to skid on trifles. Moreover, even on the assumption that two similar natural environments are so nearly identical as to lead to similar reactions, under the guidance of the common faculties of the human mind, there still remains the most important factor of them all—that of the artificial environment, in gross and in detail, which formed the starting-point of two peoples whose artefacts and general culture are compared.

Taking all these difficulties into account, we see that the common faculties of man, if they are to be powerful enough to keep his independent lines of progress parallel, must be of an initiating and controlling character. If they are of such a character, history should reveal a wealth of examples of their power to keep man steadily progressing on his course, in all grades and aspects of his culture. But history has no such tale to tell, since it is merely a story of one provisional expedient following on another.

That there are mental faculties common to all men is undoubted, and it was in part by the exercise of such faculties that man secured advancement. Of the evolution of the human brain we begin to know a little, but we are not able to draw a line of demarcation between the innate and the acquired powers of its cells and tracts. In both mind and body we inherit potentialities which only unfold under certain conditions. For the development of the body we may define what are normal conditions, and they must not depart too widely from natural conditions; but for that of the mind the conditions may be almost wholly artificial. Heredity provides the aptitudes, but the grist is delivered through the sense-organs, and whilst the brain is a natural growth, the mind is a cultural construction. Human thought is compilation—a rehash of the past in the present—and no satisfactory record has ever been made of the mind of a man whose sole knowledge had been acquired without the tuition of his fellow-men.

The brain of Later Palæolithic man appears to have been like our own in all essentials, and a Cro-Magnon born to-day might become a skilled mechanic or an able bishop. But man had no more need to become a mechanic than he had to practise as a theologian, though he drifted into both professions. If the mental faculties that had survival value in the prevailing of our species were

also those that were active in the initiation and pursuit of cultural advance beyond its needs, we are perhaps led to the conclusion that by far the greater part of human culture, material and immaterial alike, is an afterthought of evolution—an embroidering of the fabric. Man was given the means to earn a livelihood, and found himself commanding and inventing luxuries. In producing a new and cunning big-brained animal with hands, Nature overshot her mark, and we are struggling with the consequences.

The essence of my contention—and, of course, not mine alone—is that there are no common faculties of the human mind that are capable of overruling the vagaries of environmental and historical compulsions, and of directing man's progress in discovery and invention, in various times and places, along lines that are parallel. Beginning with the primary discoveries of early man, applied for material purposes, the prevailing outcome of his independent and opportunistic reactions to the results of his own interference with natural materials and phenomena has been divergence and not parallelism.

DISCOVERY AND INVENTION.

It is obvious that discovery lies at the root of all man's material activities, since he must know something of the everyday behaviour of material substances before he can apply or adapt natural objects to his purposes. Discovery may result in the development of activities in which method remains the essential and controlling factor, as in agriculture and the domestication of animals, and we may then call the resulting system of techniques a discovery-complex; or it may initiate and further the development of artefacts, which we may provisionally call inventions. Perhaps few would be disposed to call an agricultural system an invention, and the same applies to techniques of metallurgy or weaving. If these arts are called discovery-complexes, what term may be applied to the products, such as bronze and woven cloth? Iron is an element, extracted from its ores, and man has not reached the stage of inventing elements. Bronze is an alloy of two elements, owing its first production to a series of discoveries, and we can scarcely call it an invention. We may perhaps best get out of the difficulty by using the term discovery-product for all artificially extracted, prepared, and compounded materials which have no significant form imposed upon them, but are merely the raw materials for the future production of shaped artefacts.

The application of the term 'invention' to any and every shaped or constructed artefact can only be justified on the grounds of expediency, and it must be understood that the concession is not meant to embody a definition of invention as distinct from discovery, in the relation of these words to the subjective workings of the human mind, or even to the objective results.

The word 'discovery', in its bearing on material culture, relates only to the subjective appreciation of the properties or reactions of material substances

or bodies, and it does not necessarily carry the implication of an objective exploitation of the knowledge gained. Only when the knowledge is applied to a useful purpose, more or less directly, for the initiation or development of a method or an artefact, does the discovery play a practical part. We may say, therefore, that a discovery is a subjective event which may in many cases be utilised in an objective application, and that it is these applied discoveries alone that are factors in human progress. It is therefore necessary to qualify the word discovery, and speak of an applied discovery, before we can obtain an objective as well as a subjective term. If we attempt to treat the word invention in the same way, and speak of applied invention as the objective aspect of invention, we realise at once that we are doing violence to our conception of the meaning of the word. The word invention, in fact, unlike discovery, is mainly objective in its significance.

APPLIED DISCOVERIES.

It is clear that material progress began with discoveries relating to materials, objects, and phenomena, of natural or chance occurrence, and that the initial value of such discoveries lay in their immediate practical use. It may have been the behaviour of stones he handled that first aroused man's interest in them, but the utility of individual stones as implements was more important to him than the properties which made them useful. His generalising was unconscious, or even instinctive, since animals discover, though man alone invents. The making of discoveries was not the result of a conscious search for means or methods to achieve an end. Upon those which arose out of observation of simple natural phenomena, and of superficial properties of natural materials, were built up knowledge and experience which led man further and further away from his initial steps, until he was making discoveries about materials which owed their character or composition to his development of methods of treatment.

The general conclusion to which we are forced is that there are no absolute criteria by means of which we can decide what part may have been played by independent discoveries in the production of similarities in human culture. We are safe in assuming that simple primary discoveries, such as that of the plasticity of clay, or the malleability of copper and gold, may or must have been made more than once, but we are equally safe in assuming that, with every step beyond the first, an independent repetition of the same sequence becomes more and more unlikely, and also that the more difficult a single discovery and the more difficult its application, the less likely is its fruitful repetition.

INVENTIONS.

The general recognition of the gradual character of the evolution of human artefacts—so obvious even under modern conditions—makes it unnecessary to dwell upon it. There are, however, no accepted definitions of the kinds of developmental changes or modifications, viewed either

objectively or subjectively. If the initial steps in the evolution of simple artefacts are due to discovery alone, as already suggested, we have to decide in what way such steps differ from those which can be called inventive, if difference there is; and also to inquire into the nature of any other factors that may play a part in evolution. Moreover, if we call all artefacts inventions, there is no term left for single inventive steps. If, for example, the outrigger-canoe or the Chinese repeating crossbow is an invention, what distinctive term can we apply to the steps by which it has evolved, assuming these can be identified as due to individual discoveries, or to true inventions, whatever these may be? There is also the possibility—or the certainty—that changes may occur which are due to neither discovery nor invention, but to some slower and more gradual process.

If we begin with implements which were amongst the first to achieve an individuality of their own, those made of stone are for many reasons the most convenient for our purpose. We can scarcely doubt that accident, perhaps often repeated, led to the intentional breaking of stones for the production of edged or pointed implements, which gradually evolved into standardised forms. To summarise a sequence of events that arose out of more than one discovery, we may say that the first artificially shaped stone implement was due to the application of a discovery, and since the artificial shaping was a definite and decisive step, it may be called a *mutation*. Since also it was the first intentional conversion of a particular kind of natural object or material into a kind of artefact, it was a primary mutation. From such a mutation, perhaps occurring more than once, developed the many forms of stone implements with which we are familiar. A mutation of this or any other type is an abrupt and discontinuous step, contrasting with changes which are trivial in character and produce their effect by a process of summation. For these the name of *variations* is appropriate.

In the shaping of the early types everyone agrees that forms such as hand-axes and 'ovates' were not preconceived as models to be aimed at; they must have been the end results of a gradual process of change, in which the shapes emerged through an opportunist selection and imitation of those which were most convenient and effective. This was in effect a process of variation, casual at first but later becoming more selective and adaptive.

Simple stone implements are thus to be traced to a primary mutation, a sudden jump, followed by variation, a gradual process. They were evolved, not invented to serve specific purposes. Similarly, beginning with a primary mutation in each case, the fighting-stick became the club, with its immense variety of form; the digging-stick became the spade, and perhaps the spear, with its derivative the arrow; the pick became the hoe and finally the plough; the hollow reed became the blow-tube. Even before the more evolved implements of these classes had got beyond their one-piece character, however, other factors than variation

sometimes intervened. That is to say, whilst the field of variation is that of form, it is not in exclusive possession of this field.

If a primary mutation was due to one or more discoveries made in relation to the behaviour of natural objects or materials, it is not unreasonable to suppose that similar discoveries concerning artefacts may have led to other mutations. As a hypothetical case, let us consider the origin of the bamboo spear-thrower of New Guinea, which has a socket for the spear, in place of the peg that is present on almost all other spear-throwers. We may suppose that this implement was derived from the ordinary type made of wood, such as is in common use in Australia, and that the first change was that of translation into bamboo. The carved or attached peg for the spear was at first retained, but during the manufacture or use of the appliance it would be easy for the discovery to be made that the bamboo rod readily supplied a natural socket, which would serve in place of the peg for effecting the discharge of the spear. Then followed the intentional construction of spear-throwers with socket instead of peg, and we may call the step—which may or may not be regarded as a progressive step—a free-mutation. If it happened as the result of a discovery, as suggested, it was free from any influences from other implements or mechanisms. It is impossible to be sure that no such outside influence was at work, but the step being decisive and discontinuous, it was at any rate a mutational step and not variational.

We may assume with some degree of probability that free-mutation initiated the provision of the foot-rest on the digging-stick, a grip or handle on the stone knife, the detaching head of the spear to produce the harpoon, the sling-hafting of the flail, and that it was concerned in the origin of other types of hafting. Primary mutation, followed by variations which led to change in form, stimulated by discoveries in relation to method, and often influenced by substitution, led to other discoveries which could be applied for the improvement of the form or construction of artefacts, and these applied discoveries may be called free-mutations. In this way there were produced many implements of a simple character, some having form alone, others showing construction and often mechanism.

So far we have identified no inventive foresight of a kind that would lead directly to the subjective preconception of a new or improved type of implement, differing in any important respect from what had gone before. We know, however, that in our own times the inventor designs his products in advance. This is not to say that at some stage in the evolution of material culture there was a sudden change in the mentality of man. Discovery and imitation lay at the root of all his methods, initiated all his artefacts, and led to the appearance of free-mutations, but when he had established a variety of artefacts that had construction as well as form, he began that process of transfer and adaptation of structural and mechanical characters for which I have suggested the term cross-mutation.

These, like the other mutations already defined, were abrupt and discontinuous changes which could not have arisen gradually by variation, but, unlike other mutations, they owed their origin to a combination of features, or an application of 'principles', which had evolved in independence.

The process corresponds to what Mr. Henry Balfour has laid stress upon as hybridisation. It is a process involving foresight, in predicting the possibility of combination, and ingenuity in effecting it. A cross-mutation is a true invention, a product of the inventive faculty, unaffected by discovery in its first conception, though the inventor nowadays may need to make discoveries in relation to materials and methods before he can test the viability of his inventive forecast. Through it all runs the opportunist thread that may be plainly seen in the historical retrospect. Combinations for inventive purposes can only occur to the mind in an artificial environment in which the two (or more) elements of the combination are at hand, and these may have been evolved in entirely different artefacts or contexts.

Accepting these arguments as valid, an invention proper—as distinct from our loose application of the term to shaped and constructed artefacts in general—may be defined as a single mutational step which owes its origin not to discovery, but to a combining of structures or devices already in existence. The result is objectively a structural combination, which is preceded subjectively by the action of the mind in recognising the advantages and the possibilities of the hybridisation, and in thinking out the method of effecting it.

In a further treatment of the subject of inventions it would have been desirable to discuss such factors as change of function, change in method of use, substitution, and numerical mutation, but sufficient has been said to indicate the analytical method of approach.

If we take into account all the factors involved in the development of artefacts, even in simple cases, independent evolution involves coincidences, few or many. It is also clear that the further the artefact from the primary mutation which began it, that is to say, the longer the series of variational and mutational changes that has been undergone, the bigger the draft on coincidence. Nevertheless, we are still unable to point to definite mutational criteria, and to say that it is impossible that some particular mutation—and especially a primary mutation—should have occurred more than once. But a primary mutation is only a first step. As in the case of discovery-complexes and discovery-products, it is necessary to consider each case on its merits, and endeavour to identify all the links in the evolutionary chain.

The general case against identity or similarity by independent evolution is, however, overwhelming, as is very widely admitted at the present day, but to a large extent it is based on cumulative circumstantial evidence, since there are grave difficulties in finding proofs that leave no loophole for the defence.