Natural Selection and Evolutionary Progress*

By Dr. J. S. Huxley

RATE-GENES AND SELECTION

THE results of selection at one period of the life-cycle may have repercussions on other periods and affect the species as a whole in unexpected ways. Perhaps the best example is that of intra-uterine selection in polytocous mammals, where rapidity of growth must be at a premium. This is likely to be transferred in whole or in part to post-natal life; intra-uterine selection may thus help to account for the progressive increase in size seen in so many mammalian lines during their evolution. At any rate, the converse seems to hold. One of the most characteristic features of man is a slowing down of general rate of development. Without it he could not in all probability have become fully human or biologically dominant. This condition could not have occurred until after man's ancestors ceased to have litters and began to bring forth a single young at a birth.

Haldane, in an interesting paper, discusses these and similar phenomena from the point of view of the time of action of the genes controlling them. A more comprehensive view, however, would include as still more important the genes' *rate* of action.

The concept of rate-genes provides a great simplification of the facts of recapitulation and anti-recapitulation. Whenever the rate of a process is correlated with time of onset and final equilibrium-level, a mutation causing an increase in rate will produce recapitulatory phenomena.

Conversely, a mutation causing a decrease in rate will have anti-recapitulatory effects. It will prolong the previous phase longer in ontogeny; it will not only slow the process down but also stop it at a lower level of completion, and it will remove certain previous adult characters and push them off the life-history. Many of the phenomena of so-called 'racial senescence' in ammonites may be due to phenomena of this type.

As de Beer has pointed out, when cænogenetic changes occur in the embryo or larva, the adult remaining unchanged, neither palæontology nor comparative anatomy would register any phylogenetic advance. But if now neoteny or fœtalization occurs, the old adult characters may be swept off the map and be replaced by characters of a quite novel type. This process he calls *clandestine evolution*. Garstang has suggested that it has operated on a large scale in the ancestry of vertebrates and of the gastropods.

* *Continued from p.* 573.

A clear-cut small-scale example comes from the snail *Cepea*. Its non-banded varieties are produced not because their genes cause the total absence of pigment, but because they slow down pigment-formation and delay its visible onset relatively to general growth, to such an extent that growth is completed before any pigment can be formed.

This is a comparatively unimportant effect; but when major processes are affected such as metamorphosis, sexual maturity, or general rate of growth or development, the results may be far-reaching. Pædogenesis, neoteny and human fœtalization are examples.

The existence of rate-factors has an important bearing upon the problem presented by apparently useless characters. For alterations in the rate of a process will often automatically produce a number of secondary and apparently irrelevant effects. Numerous examples of such 'correlated characters', as Darwin called them, are now known.

RESULTS OF SELECTION, GOOD AND BAD

It is a common fallacy that natural selection must always be for the good of the species or of life in general. In actual fact we find that intra-specific selection frequently leads to results which are mainly or wholly useless to the species as a whole, including 'hypertelic' characters.

In other cases intra-specific selection may even lead to deleterious results. This is especially true with intra-sexual competition, between members of the same sex of the same species. We may, however, go further and proclaim with Haldane that intra-specific selection is on the whole a biological evil.

This conclusion is of far-reaching importance. It disposes of the notion, so assiduously rationalized by militarists and *laisser-faire* economists, that all man needs to do to achieve further progressive evolution is to adopt the most thoroughgoing competition: the more ruthless the competition, the more efficacious the selection, and accordingly the better the result. But we now realize that the results of selection are by no means necessarily 'good', from the point of view either of the species or of the progressive evolution of life. They may be neutral, they may be a dangerous balance of useful and harmful, or they may be definitely deleterious.

EVOLUTIONARY PROGRESS

This question of evolutionary progress remains. It is not true that the use of the word *progress* is a mere anthropocentrism. There *has* been a trend during evolution which can rightly be called progressive and has led to a rise in the level of certain definable properties of organisms. The properties whose rise constitutes biological progress can be defined in the broadest terms as control over the environment and independence of it. More in detail, they consist in size and power, mechanical and chemical efficiency, increased capacity for self-regulation and a more stable internal environment, and more efficient avenues of knowledge and of methods for dealing with knowledge. One-sided progress is better called specialization.

As revealed in the succession of steps that led to new dominant forms, progress has taken diverse forms: at one stage, the combination of cells to form a multicellular individual, at another the evolution of a head; later the development of lungs, still later of warm blood, and finally the enhancement of intelligence by speech.

So much for the fact of progress. What of its mechanism? It will be clear that if natural selection can account for adaptation and for long-range trends of specialization, it can account for biological progress too; for progressive changes have obviously given their owners advantages. There is no more need to postulate an *élan vital* or a guiding purpose to account for evolutionary progress than to account for any other feature of evolution.

One somewhat curious fact emerges from a survey of evolutionary progress. It could apparently have pursued no other course than that which it has historically followed. For example, the final step taken in evolutionary progress to date is that to conceptual thought. We see, however, that this could only have arisen in a monotocous mammal of terrestrial habit, but arboreal for most of its mammalian ancestry. All other known groups of animals are ruled out. Conceptual thought is not merely found exclusively in man: it could not have been evolved on earth except in man. Only along one single line is progress and its future possibility being continued—the line of man.

THE EVOLUTIONARY FUTURE

What of the future? Man is not destined to break up into separate radiating lines. For the first time in evolution, a new major step in biological progress will produce but a single species. We can also set obvious limits to the extension of his range. Thus the main part of any large change in the biologically near future must be sought in the improvement of the brain.

In any case, one important point should be borne in mind. After most of the major progressive steps taken by life in the past, the progressive stock has found itself handicapped by characteristics developed in earlier phases, and has been forced to modify or abandon these to realize the full possibilities of the new phase.

Man's step to conscious thought is perhaps more radical in this respect than any other. By means of this new gift, man has discovered how to grow food instead of hunting it, and to substitute extraneous sources of power for that derived from his own muscles. For the satisfaction of a few instincts he has been able to substitute new and more complex satisfactions, in the realm of morality, pure intellect, æsthetics and creative activity.

The problem immediately poses itself whether man's muscular power and urges to hunting prowess may not often be a handicap to his new mode of control over environment, and whether some of his inherited impulses and his simpler irrational satisfactions may not stand in the way of higher values and fuller enjoyment.

Man seems generally anxious to discover some extraneous purpose to which humanity may conform. Some find such a purpose in evolution. The history of life, they say, manifests guidance on the part of some external power; and the usual deduction is that we can safely trust that same power for further guidance in the future.

I believe this reasoning to be wholly false. Any purpose we find manifested in evolution is only an apparent purpose. If we wish to work towards a purpose for the future of man, we must formulate that purpose ourselves. Purposes in life are made, not found.

The future of man, if it is to be progress and not merely a standstill or a degeneration, must be guided by a deliberate purpose. This human purpose can only be formulated in terms of the new attributes achieved by life in becoming human. Human purpose and the progress based upon it must accordingly be formulated in terms of human values; but it must also take account of human needs and limitations, whether these be of a biological order, such as our mode of reproduction, or of a human order, such as our inevitable subjection to emotional conflict.

Obviously the formulation of an agreed purpose for man as a whole will not be easy. But let us not forget that progress *can* be achieved. After the disillusionment of the early twentieth century it has become as fashionable to deny the existence of progress, as it was fashionable in the optimism of the nineteenth century to proclaim its inevitability. The truth is between the two extremes. Progress is a major fact of past evolution; but it is limited to a few selected stocks. It may continue in the future; but it is not inevitable—man must work and plan if he is to achieve further progress.

Our optimism may well be tempered by reflection on the difficulties to be overcome. None the less, the demonstration of the existence of a general trend which can legitimately be called progress, and the definition of its limitations, is a fundamental contribution to thought; and we zoologists may be proud that it has been made, chiefly from the zoological side, by evolutionary biology.

Production and Technical Application of High Voltages

THE discussion on September 14 in Section A (Mathematical and Physical Sciences) of the British Association, on the production and technical application of high voltages, was one of those selected by the Council of the Association as having a direct bearing on the life of the community. The high-voltage transmission system connecting our major power stations, and the extensive use of X-rays in hospitals, are but two examples of the impact of high-voltage science upon society, and the extent of the applicability of this science is increasing rapidly. In no other science are physics and engineering more interdependent, and it is significant that nuclear physics would have been almost a closed book without the application of high voltages.

High voltages are familiar to us in four forms: low-frequency alternating voltages, unidirectional impulsive voltages, high-frequency alternating voltages and constant voltages. The engineer is for the most part concerned with the first three forms, the normal and the abnormal types of voltage appearing on transmission lines. The lines and the station apparatus of the 132 k.v. 'Grid' in Great Britain are tested up to two or three times normal line voltage with low-frequency alternating voltages, whilst abnormal voltages—such as surges due to lightning or switching operations—up to ten times normal operating voltage may appear on the lines. Thus engineering laboratories equipped to supply 500–1,000 k.v. at power-frequencies, and 1½ million volts from impulse generators, are necessary to test all apparatus for use on high-voltage systems, and to be in the van of immediate requirements. Constant potentials have been mainly used for radiography, X-ray therapy and physical research, and there appears to be an immediate need for voltages of the order of one million for research on nuclear physics and X-ray therapy.

There are many problems confronting the supply authorities of the 'Grid' which arise at the normal transmission voltage of 132 k.v. Among these may be mentioned the effects of corona, atmospheric pollution, gaseous discharge within the voids in so-called solid insulation, and power arc discharges initiated by atmospheric conditions and other causes, as enumerated by Mr. C. W. Marshall of the Central Electricity Board. The manufacturer is equally concerned with these problems and is constantly evolving new designs and new materials for use in high-voltage apparatus better able to withstand these destructive effects. Electrical gradients used in solid dielectrics are far lower than the theoretical permissible gradients referred to by Dr. S. Whitehead, of the British Electrical and Allied Industries Research Association (E.R.A.), on account of the inherent fluctuations in quality of dielectrics, our lack of knowledge of the behaviour of dielectrics over a period of many years when subjected to thermal changes and mechanical forces, and also on account of the dangerously high over-voltages which are known to occur on lines. It has been estimated that these over-voltages are responsible for 75 per cent of all failures of supply systems.

As Mr. R. Davis, of the National Physical Laboratory, pointed out, studies of the behaviour of dielectrics under impulse voltages are still in their infancy, there being so many variables influencing breakdown, such as wave shape and polarity of the applied impulse, electrode shape, and medium of immersion, temperature, and number of applied impulses. Moreover, our knowledge of the nature of surges arriving at terminal stations is all too meagre: information is being obtained by cathode ray oscillographs and lightning current recorders on lines all over the world, but effective measures are not yet available to prevent damage due to lightning. In this connexion it is interesting to note that the E.R.A. has available a 1½ million volt impulse generator (Fig. 1) with which to study the effects of artificially produced surges on lines and cables, this voltage being adequate to spark over the line insulation of the