



A crisis in evolution

by Professor Joshua Lederberg

Director, Kennedy Laboratories for Molecular Medicine,
Stanford University School of Medicine, California

THROUGH its association with medicine, agriculture and conservation, biological science has been concerned in the most constructive of material advances in the human condition. The sudden successes of biology, brought about through systematic confluence with the physical sciences, now demand an understanding of the nature and destiny of man that must be the principal intellectual task of the brave new world.

This assessment takes for granted the filling in of immense detail on the framework of molecular biology. The magnitude of present efforts, and their constant acceleration, make this the only sensible direction. The application of these findings, especially to man himself, looms as a larger problem than quite unpredictable departures in basic theoretical outlook.

In fact, the main theoretical foundations of biology are simply the conception of life as a chemical mechanism, a manifestation of molecular architecture, and the evolutionary elaboration of this mechanism through random variation and natural selection. These skeletal ideas were contributions of a previous generation — Pasteur and Bernard, Darwin, Mendel and Morgan, the patriarchal German organic chemists — and recent biology has contributed nothing so iconoclastic in basic theory to match the finesse of its experimental demonstrations and technical power. If new theoretical principles are to emerge — and who can tell? — they may well arise either from the mathematical study of complex organisation needed to understand brains, computer programmes, and societies, or from the generalisation of terrestrial life, by the observation of planetary life or intelligent communication with other living systems or by the contrived synthesis of new organisms in the laboratory. Until then, the main distinction between physics and biology may continue to be the relative weight of universal axiom and parochial detail.

Prophecy is a just target for irony, but planning for the next twenty to fifty years is a major responsibility of our political and intellectual leaders.

The exigent time scale of the evolutionary crisis still has not captured their attention.

For æons, the evolution of this planet proceeded by random chemistry. After the spark of life was struck, for one, perhaps two billion years, life evolved with ever-increasing complexity, but with few basic changes in quality. Some hundred thousand years ago, a species emerged able to communicate and thus to accumulate tradition, and generate the explosion of history. In that brief interval, our evolution has been principally cultural. Man, the historical animal, practices his civilisation with the same biological instruments as the Neanderthal. Just in the instant era, our culture is achieving knowledge and control of its biological instruments that are capable of purposefully altering them. At the same time we are evolving other instruments (informational machinery, or computers) which share with man the generation of culture. Should our planning, even for the next twenty years, wait till after the event to react to revolutionary changes in human nature?

What is new in these remarks? The success of quantitative methods in plant and animal breeding soon aroused a series of eugenic schemes to counteract the irrelevance — at best — of social criteria and reproductive flux. To varying degrees, these schemes have evoked worse social evils. Furthermore, our limited knowledge of human genetics left one certainty: that any acceptable level of selection could insignificantly alter the gene pool of any large community on the time scale of cultural evolution. The net effect has been the relegation of many biologists' thinking on human evolution to an area of dubious efficacy, and of many others' to the view that there was a comfortably long time during which not to worry about it; meanwhile we could all be more happily preoccupied with the Bomb, with fall-out, with the population explosion, and with pesticides. And rightly, our colleagues have not been deeply impressed with forebodings that molecular biology would soon give us the capa-

bility of directly altering or producing the human gene string.

However, the debate should not be allowed to peter out. It should be our responsibility to assess the future with at least the more plausible predictions of biological capability. This is a tricky and strenuous enterprise, and deserves both more imagination and more critical judgment than has been spent on it so far. In doing so, we should not let customary scientific conservatism blind us from noting how new advances themselves accelerate the pace of technical advance, and how far the orientation of all the Earth's sub-cultures, especially in mutual conflict, towards technical power, accelerates the practical application of scientific findings. The last point should also answer any wistful hopes that science itself might be muted.

The riskiest elements of this essay are specific predictions of the technical problems that are about to be solved to the augmentation of man's powers and his dilemmas. May I enter some suggestions only to illustrate the genus of possibilities; they centre on the modification of development, influencing the character of single organisms, in contrast to the populational impact of eugenic measures. Hence, we may call them "euphenic." The reader should use his own judgment as to the probable implementation of euphenics in the actual world, and its significance for individual man and his culture.

(1) The successful transplantation of vital organs: heart, liver, limbs. The technical barriers will be overcome long before we can reach a moral consensus on the organisation of the market for allocation of precious parts.

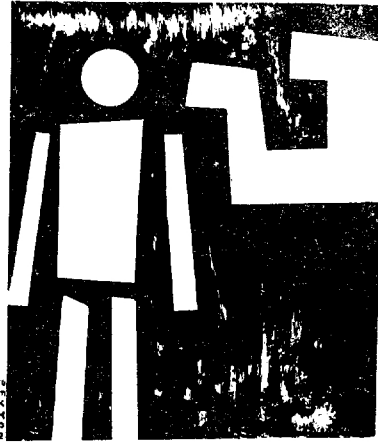
(2) Artificial prosthetic organs. Unfortunately not yet being developed with the necessary vigour to overtake the preceding.

(3) In consequence of these, and probably other advances in, say, protein biochemistry, a sudden increase in the expectation, or prolongability of life. With a wider range of technical resources will come a corresponding expansion of the scale of the useful cost of maintaining a given

personality. Whatever our humanitarian predilections, discrepancies in the availability of these resources must widen.

(4) More optimistically, the modification of the developing human brain through treatment of the foetus or infant. At least some modifications (like those used primitively now in the control of metabolic disease) can be expected to be constructively applied to "normal" children, and might well exceed the present bounds of genetic and developmental variation.

(5) "Clonal" reproduction, through nuclear transplantation. The prototype for this suggestion is the transplantation of a nucleus from an adult tissue cell back into an amphibian egg from which the natural nucleus has been removed, with (sometimes) normal development of this egg. It should be recalled that vegetative reproduction, occasionally concealed under outward trappings of sexuality, is an important feature of the plant world, and a few primitive animals. The experiment has yet to be attempted in a mammal. Apart from its place in the narcissistic perpetuation of a given genotype, the technique would have an enormous



impact on predetermination of sex; on the avoidance of hereditary abnormalities, as well as positive eugenics; on cultural acceleration through education within a clone; and on more far-reaching experiments on the reconstitution of the human genotype.

Perhaps enough has been said, though this is far from the end of the list. I will be accused of demonic advocacy (and have been) for discussing such matters and not pretending that they are indefinitely far off. But they

are inseparable from the advance of medicine, especially as we turn our attention to such urgent challenges as mental retardation, the degeneration of ageing, and mental illness.

The scientific community has little special qualification to impose institutional remedies or moral criteria for the problems of human opportunity. It has the responsibility to teach these problems especially in the university, and to look for imbalances in our technical capability. For example, the grievous social stresses that organ transplantation will engender would be mitigated by the parallel development of artificial organs, or the availability of animal sources. If clonal reproduction becomes possible, or more simply, if present suggestions on the hormonal induction of twinnings are verified, we will wish we knew much more about the biology and psychology of twins.

Meanwhile, a deeper understanding of our present knowledge of human biology must be part of the insight of literary, political, social, economic and moral teaching; it is far too important to be left only to the biologists. In this spirit I can think of no better dedication than to the memory of the prophetic vision and artistic clarity of Aldous Huxley.