Biology and Human Life.¹

By Prof. J. S. HUXLEY.

SCIENCE advances by the search for knowledge for knowledge's sake, but the knowledge spills over into practice as the years advance. Our business is to see how in recent years biological knowledge has been applied to practice, and what new advances may be expected.

The first spectacular applications of modern biology have been in the realm of disease prevention. Pasteur followed up his final demonstration that spontaneous generation does not occur with the discovery of its corollary—to wit, that infectious diseases, such as typhoid, diphtheria, and pneumonia, are caused by living organisms, or, as they are sometimes styled, disease germs.

Hand in hand with this went our knowledge of parasitology. In the first place the life-histories of many of our larger parasites were unravelled, with the result that it has been possible in many cases to break the weak link in the life-chain and to stamp out that particular disease and discomfort. That is true in civilised countries for tapeworm, roundworm, and trichina; and the hookworm and other enemies of the fullness of human life are following in their wake. But later it was found that there was frequently an association between some parasite or other noxious animal and the microscopic agent of some disease. Rats harbour fleas of a particular sort, the fleas harbour the bacilli of plague, and so is plague spread throughout mankind. Ticks spread spotted fever, mosquitoes give malaria and 'yellow jack,' flies may infect our food and our persons in a dozen ways.

So arose what for brevity's sake may be called the germ theory of disease. Any given disease was supposed to be due to a given organism, large or small, animal or plant; if you could exterminate or weaken the germ, you could get rid of the disease. The triumphs of serum therapy—vaccination, and other forms of immunisation—again largely due to Pasteur and later to Ehrlich, showed how the enemy might be circumvented even when it was impossible to annihilate him; and a period of optimism dawned.

The particular brand of optimism based on the germ theory is passing away. The pioneers had forgotten that as it takes two to make a quarrel, so it takes two to make a disease. They had left out of account the human organism.

We now know that the reaction of the organism is as important as the nature of the parasitic 'germ.' We all of us seem to harbour the bacillus of tubercle; but only a small percentage develops tuberculosis. Measles, with us an unpleasant disease of childhood, wiped out whole populations when first introduced among the South Sea Islanders. Why? Because their natural inborn resistance was less than ours. We now know that to every disease germ there are very different grades of inborn resistance; and further, that any of these grades may be increased or lowered by outer circumstances.

While some diseases may therefore be totally eliminated by the extermination of the disease germ itself,

or, more usually, by breaking a link in the chain by which the germ is transmitted, there are others in which, so far as we can see, it will for ever be impossible to destroy the microscopic and elusive bacillus; and if we wish to prevent and not merely to cure, we have to rely on the raising of resistance.

The first method has, however, had its notable triumphs. Malaria, smallpox, yellow fever, bubonic plague, sleeping sickness—there we have a few of the plagues which have been almost expelled from the civilised world and will slowly but surely fade from the uncivilised as well.

As an example of what may be done in the economic field by intelligent control, we have only to look at the past and present of the gipsy moth. Two years ago I was in the United States, and one day went motoring along Cape Cod. Dead trees were standing everywhere in the woods. My host told me that these had been killed by the gipsy moth. Not only that, but for some years there were no leaves on any tree in all that neighbourhood, and the caterpillars came down, when they had stripped the trees, to eat the grass and flowers. On a still day the woods were full of a sinister rustling—the munching of a million jaws, and rattle of the million pellets of undigested food continuously extruded by the destroying army. Hundreds of thousands of dollars a year were spent by the State in spraying and other curative measures, but with only meagre results.

Eventually biology came to the rescue. Entomologists studied the gipsy moth in its original home and discovered just what natural enemies it had there. They imported these enemies—a beetle that devours the eggs, another, larger, which attacks the caterpillars, and a hymenopteran the brood of which, deposited as eggs in the caterpillar, devours the growing animal from the interior. These keep the gipsy moth in check, so that to-day the countryside is green again, and the moth, though not exterminated, is become only a minor annoyance. Without the meticulous knowledge of the ways and life-histories of a thousand and one apparently useless beetles and flies and moths, amassed often just for the sake of knowing, such control could never have been accomplished.

We can do a great deal to ameliorate human suffering by getting rid of tangible enemies to health; but that is not enough. Remove all the living enemies to health in the world, all the germs, all the parasites, all the venomous creatures, and men will not necessarily be healthy. Health is a living, active principle which needs fostering on its own account. Body and mind must be used, the gifts of sun and wind not despised, and food and drink be properly regulated in quality and moderated in amount. It all sounds so simple; but to be simple does not necessarily mean to be easy. At least, however, we are released from the false optimism of the germ theory period, and reminded that healthy living, like all living worth the name, is an art.

With regard to the biology of human population, two problems confront us, the one immediate and

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pressing, the other more complex and less instantly urgent. They are the problems of birth-control and of eugenics. The regulation of the numbers of population, in some form or another, has been practised by the great majority of the human race. As Prof. Carr-Saunders has shown in his remarkable book on the population problem, every savage and primitive people of which we have any knowledge, almost every people of the early civilisations, and many peoples of the civilisations of to-day, deliberately regulate their numbers. Famine and wars are not and never have been sufficient. Either infanticide, or abortion, or various restrictions upon or regulations of marriage, have been practised, with the effect of preventing or slowing the natural increase of population. At present 20 per cent. of the population in Great Britain gives rise to 25 per cent. of the next generation; and the average of this 20 per cent. is neither physically nor mentally so good as that of the other 80 per cent. We are thus confronted with a process which is retrograde in its effects—dysgenic instead of eugenic.

Before we can talk about eugenics, we must prevent this unequal multiplication. There is no prospect whatever of inducing the upper classes to abandon birth-control; our only hope is to equalise the increase throughout society by making birth-control general and starting afresh on the new level. Opponents of birth-control sometimes speak of the sacred right of the child to be born. There is of course no sacred right of a child to be born, but it is remarkable how often the prejudices on such intimately biological matters as birth-control, when not caused by mere ignorance of the facts of Nature, are due to a desire to force natural phenomena into such unnatural categories of the human imagination.

The whole trend of evolution from lower to higher has been towards diminishing the number of offspring, but increasing the parental care, both before and after birth, which is bestowed on them. I think I am right in saying that biologists are almost unanimous in demanding a rational birth-control as one condition of social advance.

Closely linked with this subject, as will at once be seen, is eugenics. A rational birth-control is the necessary prelude to a rational eugenics. We have to make up our minds to a new step in human history: to the conscious control of reproduction. This is being done individually with birth-control; it must be done socially by what we might call mating-control. When we know that men or women are not only the embodiments but also the bearers of hereditary taint and defect, we have no more right to allow them to reproduce than to allow a child with scarlet fever to be visited by all his school friends. We are told that this infringes the sacred rights of the individual and prejudices the idea of personal liberty. Such utterances are but another example of the unfortunate tendency, apparently inherent in the primitive human mind, of demanding and pretending to find absolute sanctions for ideas which are not in any sense absolute.

If we once made up our mind to it, this negative, weeding kind of eugenics could be easily practised. It must be confessed, however, that positive eugenics, or the raising of the upper level, is not so easy. In the first place, though we can be perfectly sure that

the same general principles apply to human inheritance as to inheritance in other animals, we know very little about the details, and cannot solve any of the more difficult problems so long as we cannot control human matings for the purpose; and this, even if it were desirable, is certainly not at present practicable. In the second place, any selection which we could practise, in any state of society at all resembling the present, would produce its results extremely slowly and inefficiently.

In human society as at present organised, mass selection would be the only possible method to adopt. To attempt to reproduce the race wholly from a few thousand, even a few ten thousand, individuals, would for the present be unthinkable. We can do something, but very little, and that little only by running counter to some of the most cherished sentiments of our democratic age. We have got to stop pretending that comfortable mediocrity is our ideal, and that the average man is the god to whom the rest of the world must bring their sacrifices.

Another matter connected with eugenics is the control of sex. Here, in spite of the mystery with which the subject has in the past been surrounded, all now seems plain sailing. The mystery is in its essentials no longer a mystery. We have been able to see in the diversity of plant and animal forms almost every conceivable stage of the evolution of sex; we understand in broad outline its *raison d'être*, its biological function; and we know the mechanism of its determination in higher animals.

Sex is determined, in man as in all other mammals, by the sperm of the male. There are two kinds of sperm, one larger and one smaller; the larger is female-determining, the smaller is male-determining. Artificial fertilisation is perfectly practicable; it was successfully employed in mammals by the Abbé Spallanzani in the eighteenth century. It remains now only to separate the two classes of sperm according to their size, and sex-control would be an accomplished fact. I cannot believe that this separation would present great technical difficulties—certainly none so great as were involved in the construction of an efficient phonograph, or a modern aeroplane. Yet these inventions were perfected in a few decades. I will venture to prophesy that in the matter of sex-control it will be only a few decades before the invention reaches the practical stage.

A democracy of material opportunity freely surrendering itself to the guidance of an aristocracy of thought—that seems to me to sum up pretty closely the biological ideal for society. But we are far from it yet.

There are scores of other ways in which biology can now, or will eventually, affect practical life. The science of genetics, an infant but an infant Hercules, is bound in time to change the practices of stock-breeders; the present pedigree system has its many advantages, but it has its genetic and economic absurdities, in the emphasis on an old aristocratic pride of ancestry *qua* ancestry, irrespective of scientific analysis, and in the fantastic prices given for pedigree prize-winners.

Greater knowledge of physiology will doubtless

enable us to modify the processes of our bodies more in accordance with our wishes—to stimulate our faculties when we need high-tension work, but without evil after-effects; to relax them without the use of harmful soporifics. It seems clear that temperament, even more important than pure intellect in achieving success, is largely an affair of the balance of the various glands of internal secretion—thyroid, pituitary, reproductive, adrenal, and the rest. It may well be that the applied physiology of the future will discover how to modify temperament.

But I must close. Let me emphasise that while pure science will make discoveries so long as she exists,

while technology will apply those discoveries so long as profit is to be made out of their application, it is in the long run the average man and woman who decide *how* that application shall be made. Whether the discoveries of science will in the ultimate event be beneficial, as those of us trust who believe in progress, or whether they are leading the human race to destruction, as many sincere and many far-sighted men assert—that will be decided by the use to which the human race decides to put them. In themselves, apart from their intense personal value to their discoverers, and to others on the plane of pure intellect, they are, like any other tool, neutral.

Developments in the Use of Echo-Sounding Apparatus.

THE use of compressional waves in water for the measurement of the depth of the sea beneath a vessel now lacks the novelty which it possessed some years ago, when practical schemes for using them in navigation were first put forward. Briefly, all such schemes reduce to three essential parts—the source of the compressional impulse, the receiver of the echo from the ocean bed, and the mechanism for recording the time interval between the emission of the original disturbance and the moment of receipt of the echo, or, in some cases, the direction of the returning wave front. Small explosive charges dropped into the water, automatic hammer-blows on diaphragms, and diaphragms which are caused to vibrate electrically are used as sources of compressional disturbances within the audible range and form parts of actual sounding sets which are obtainable commercially. Microphones attached to diaphragms exposed to the sea are in general use for receiving the echo and for transforming the sound energy into electrical power. Various mechanisms, some of which are simple and ingenious, while others appear, from their descriptions in technical papers, to be unduly complicated and too delicate for continued sea-going use, are favoured by different firms who have embarked on the manufacture of echo-sounding gear. A typical echo-sounding apparatus for use in shallow water was described in *NATURE* in an article dealing with the use of the method in navigation.¹

All the systems of sonic echo sounding covered by the remarks in the preceding paragraph involve the creation of an audible disturbance, but there is one system in which the initial disturbance has a frequency which lies above the upper limit of the range of frequencies audible to the normal human ear. The practical form of this apparatus is described in a recent publication issued by the International Hydrographic Bureau,² and the principles of its operation have already been described in these columns,³ where it was observed that this 'supersonic' or 'ultra-sonic' system was of great scientific interest. It is clear that much skill and ingenuity have been expended in the design of the mechanisms embodied in the gear as now manufactured.

For sounding installations from which nothing more is demanded than an accurate measure of the depth of shoaling water beneath a ship, it appears that sonic systems are capable of answering navigational require-

ments, but the merit of the supersonic system lies in its ability to locate comparatively small objects, such as wrecks or rocks, in shallow water. This advantage is gained by the supersonic system because the energy is transmitted through the water in a beam the direction of which can be altered, whereas the sonic impulses are more nearly in the form of spherical waves spreading through the water without marked directionality. The supersonic gear cannot, however, be relied upon to detect projections which are small in comparison with the breadth of the beam, and at great depths therefore this system cannot be expected to show much greater power than the sonic gear to resolve discontinuities in the depth of water, unless either the size of the oscillator, or the frequency of its oscillation, is increased so as to make the beam sharper. There are limits beyond which both of these courses become impracticable.

Judging from published descriptions of the supersonic gear as manufactured by the Société de Condensation et d'Applications Mécaniques, the equipment must be decidedly costly and must require skilled operators and attention in case of defects. For these reasons it is to be expected that the simpler and less costly forms of sonic gear will be more popular and that the use of the supersonic apparatus will for some time be limited to special purposes where the sonic gear fails. On the other hand, disappointments with the echo-sounding gear must be anticipated and be looked upon as certain to come. The final form of every new thing is reached by stages, and it may be years before the defects which are bound to occur in existing echosounders are all eliminated and so great a mass of evidence for the reliability and usefulness of the gear becomes available that the wholesale adoption of this invention is inevitable. It is scarcely necessary to quote examples in which events have followed a course similar to that which may be anticipated in the case of echo sounders, but the gyro-compass and the use of directional wireless in navigation may be mentioned. Both these aids to navigation 'hung fire' for years and the gyro-compass is only now coming into general use, while the application of directional wireless is still somewhat under a cloud, owing to errors in the readings taken, which are partly due to the effect of the ship's structure on the apparatus and partly to imperfectly understood effects such as the apparent coastwise refraction of the electric waves. One cannot blame the experienced navigator, upon whom the onus of a disaster falls, if he is chary about accepting the claims

¹ *NATURE*, March 29, 1924, pp. 463-65.

² Special Publication No. 14 of the International Hydrographic Bureau, Monaco, August 1926.

³ *NATURE*, May 9, 1925, pp. 689-90.