REFLECTIONS OF A BIOLOGIST

ANDREW L. SZEBENYI, S.J.
LeMoyne College, Syracuse, N.Y.

PEOPLE ARE uneasy. Call it future shock or science-fiction syndrome—the experience is that reality merges with fiction, imperceptibly, without clear boundaries. What is fiction today becomes reality tomorrow; and because imagination has hardly any rules or limits, the result is a frightening confusion. It seems there is nothing scientists could not and would not do. Add to this irresponsible "omnipotence" a touch of pessimism, and the anxiety complex is complete.

More recently I came across this uneasiness in a new context. Newspaper reports on scientific issues seem to prepare the public for a fantastic "brave new world" of a biological revolution. They say: "It is possible now..." or "It will soon be possible..." and then they present us with some nightmarish monster of biological novelty. Quite recently I read the following: "Through genetic engineering, scientists will be able within a few years to alter virtually any human trait, creating children with blue eyes, prehensile tails, or startling adaptations for a completely different environment."[1] Most of us would be at least slightly shocked by a statement like this, especially because it is packaged with all the trimmings of reality, since "within a few years" seems to be almost as good as now. In other words, the distinction between the impossible and the real is lost. Scientists can do anything, and in our hypnotic fascination with new discoveries, what we can do we must do, according to the irrational spirit of the technological imperative. No wonder we feel uneasy.

But there are some other facets to our anxiety. In a short article, Willard Gaylin presented quite forcefully the uneasiness of many people about the work of scientists, including the scientists themselves.[2] He stated that "the image of the frightened scientist, guilt ridden over his own creation, ceased to be theoretical with the explosion of the first atomic bomb...some biological scientists now wary and forewarned are trying to consider the ethical, social, and political implications of their research...they are even starting to ask whether some research ought to be done at all...beginning to shake some of the traditional illusions of a science above morality or value-free science." We can detect trends in our society desiring to curtail scientific research, even by force if necessary, to only beneficial knowledge, which cannot be used for destruction.

[1] On dust jacket of David Rorvik, *Brave New Baby* (New York: Doubleday, 1971).
[2] Willard Gaylin, in *New York Times Magazine*, March 5, 1972.

IRRATIONAL ANXIETY

If we take a little time and effort to weed out the irrational and to separate fact from fiction, we will soon come to realize that most of our anxiety is unfounded. We will find that we were anxious about things which do not exist and are not about to become real in any way. We will also realize that it is not the work of scientists that is dangerous; the real menace is in the irrational attitudes of frightened people.

Let us consider, for example, some of the popular misconceptions about genetic engineering. We are worried about biological monsters which irresponsible scientists are about to produce. We are shocked about the idea of test-tube babies or supermarket babies, and we are not about to give up the beauty and mystery of human life and human reproduction. We feel uneasy that these dangerous scientific discoveries may fall into wrong hands and will be misused by people to obtain power, to suppress freedom, and to reduce us to something less than a human being.

Reality is quite different. Designed genetic change, or genetic engineering, means the intentional manipulation of human genes, primarily for therapeutic reasons. It certainly does not mean the genetic reconstruction and mass production of custom-made people. The former is in an experimental stage, the latter is fiction and is not about to happen.

At a symposium on ethical and social problems in human biology, held April 21, 1972, at the State University of New York, Buffalo, Dr. V. E. Headings summarized in three broad categories all the major discoveries in genetics with some bearing on genetic engineering: the selection of offspring, gene therapy, and creating an optimum environment. To the first category belong such efforts as selective or restricted mating, which in the form of genetic counseling is the principal means today to prevent the occurrence of genetic disorders. Artificial insemination belongs to this category, together with selective abortion. The former has been used in man, but mostly in cases of infertility. Selective abortion is regarded by some as a possible means to prevent a large number of inherited disorders and chromosome abnormalities. I would not call the method truly preventive, because in conception the disorder is already given. As far as some new techniques are concerned, fertilization and development outside the uterus and cloning will probably become possible in man. The significance of these methods, from the point of view of genetic engineering, is doubtful.

Methods of direct manipulation of individual genes through techniques like transformation and transduction belong to the second category. Relatively little has been achieved along these lines. There are seemingly insurmountable difficulties, e.g., the incredible complex-

ity of man's genetic make-up. Even if techniques were available, we would not know what to do with them, because our knowledge of the human genetic mechanism in terms of our many polygenic systems and interacting gene complexes, and even in terms of most individual genes, is grossly inadequate. To project a program of control of intelligence, personality, and behavior through the direct manipulation of the genetic material in man shows a total lack of realism.

The third category includes the intentional manipulation of the human genetic material through control of the environment. The principle behind this is the environment dependence of gene expression. Symptoms of many inherited disorders can be alleviated or even eliminated by optimizing the environment. A relatively simple example is phenylketonuria, an inherited metabolic disorder. The major symptoms of the disease are a type of extreme mental defect accompanied by the excretion of abnormally large amounts of phenylalanine and phenylpyruvic acid in the urine. The cause of the illness is a recessive gene which incapacitates an enzyme, phenylalanine hydroxylase, which would normally transform phenylalanine into tyrosine. By eliminating phenylalanine from the diet, the disease will not be expressed. According to Dr. V. E. Headings, "environmental control is a major tool for treating certain genetic disorders...."[3]

Optimizing the performance of human genes through controlled environment does not have to be exclusively therapeutic. It is well conceivable that such conscious effort can be made part of the proper care and education of children. Headings stated that "enrichment of early childhood environment is proving to be effective in eliciting fuller expression of genetic potential."[4]

It should be clear that the principal theme of genetic engineering is medical: it aims at the easement of human suffering with intelligent programs carefully thought out by responsible men. Another major trend in genetic engineering is the better utilization of the genetic material we have through optimizing the environment. To talk about custom-made people, supermarket babies, and irresponsible and evil power-play through genetic control may be intriguing themes for science fiction, but they are not found in biological research laboratories. What is deplorable is that some people in the responsible position of newscasting and reporting present fiction as real. Whether this is done through ignorance or for selfish reasons is irrelevant. What matters is

[3] V. E. Headings, "Optimizing the Performance of Human Genes," Address to the Symposium on Ethical and Social Problems in Human Biology, State University of New York, Buffalo, April 21, 1972.

[4] *Ibid.*

that little by little anxiety increases in people and creates an irrational, antiscientific atmosphere.

Consider, for example, some of the irrational implications of the technological imperative. Scientific research gives us knowledge. If we have knowledge, we can do things. If we can do it, we must do it, irrespective of consequences, even if it destroys us. Scientific research is dangerous, knowledge is to be feared. In other words, the technological imperative not only denies our freedom and treats human reason with contemptuous mistrust; it also points toward a deadly "remedy" by proposing to find security in ignorance.

We are all part of a cultural evolution in which we attempt to exert an ever-increasing control over nature. We are the only beings on earth who can directly counteract the effects of natural selection, who can most efficiently control the environment, who can overcome geographical restrictions to the extent of being able to survive even in such alien surroundings as the hostile extremes of outer space. This cultural evolution is obviously geared toward survival, as indicated by the success of our species. The key of success is our quest for knowledge and the conscious utilization of this knowledge for survival. In this framework I state that any desire to promote ignorance, even in the form of selective ignorance, represents a negative, destructive, antisurvival attitude.

I do not know of any scientific discovery which could be regarded as useless, although at the same time I am not aware of any which could not be misused. Obviously, it is not the discovery but its application that has moral implications. Some people, however, feel that in certain areas of research even the remote possibility of misuse is so grave that it may outweigh all the possible beneficial aspects of knowledge. They feel that in such issues the scientist should be obliged, on moral grounds, to stop research, or at least to postpone the publication of such research.

This mentality is a typical example of irrational anxiety. The controversial research area is genetic engineering, and the anxiety is unfounded. Caution is praiseworthy, but it should not be misplaced. We are all human beings, whether we are scientists, politicians, businessmen, or walk other ways of life. As human beings, we all have certain rights and obligations. To obtain and increase knowledge is a fundamental and natural right of all of us, and to use this knowledge for the common good of man is a fundamental and natural obligation of all men. In view of the ethical duality of applied knowledge, in which our obligation is to aim for better survival, primarily by showing respect for human life, no scientist can be held responsible if his discovery is misused by someone else. Our apprehension is justified, but it is

certainly misplaced if it is directed against knowledge, and not against the cause of calamity, the immoral user of knowledge.

My feelings about scientific research are those of involvement, excitement, elation, and hope. I am convinced that for us knowledge and survival are forever linked. What I fear is ignorance. My basic worry is our ability to counteract natural selection without having sufficient knowledge to see all the implications and consequences of this action. We should realize that natural selection is not simply the Great Eliminator of the unfit; it is also the principal building force which in the interaction of multitudes of environmental variables, traits, and trait determining genotypes, strikes unimaginably complex, opportunistic compromises, with resultant sets of changes and modifications of myriads of evolving living beings, while maintaining life on earth in a steady state of balance. Natural selection is the adaptive relationship of living organisms to themselves and to their environment. I am at a loss for words, considering how little we understand the possible long-range effects of conscious interventions when we counteract some of the immediate effects of natural selection. Nevertheless, to achieve autonomy seems to be a fundamental trend that characterizes our cultural evolution, and in this struggle for self-determining independence there is high premium set upon knowledge, and drastic penalty upon ignorance. The severest form of penalty is extinction.

PROBLEM OF SURVIVAL

Let us consider, in a few examples, how well we handle problems of survival. In the most everyday fashion we counteract the immediate effects of natural selection through medical practice. The result is a steady decrease of the mortality rate. Arthur S. Boughey has stated that "the dramatic and universal reduction in mortality rates throughout the world in the 1950s is the most significant individual causal factor of the present population explosion."[5] There are countries where population increase is out of control, without any known ways to prevent the impending disaster of famine, sickness, and other untold human suffering. We do not want this to happen to us. Neither can we give up the benefits of medicine. This would not be humane. So, instead, we make abortion legal and kill off our children. This "solution" can hardly be called an intelligent one. It is immoral, because it does not respect human life. It is illogical, because the problem is not the birth rate of children but the death rate of adults. And it is also wasteful: the aborted children should never have been conceived.

Other possible solutions, at least in a long-range plan, would come

[5] Arthur S. Boughey, *Man and the Environment* (New York: Macmillan, 1971) p. 243.

from considering how to distribute resources more evenly and how to utilize them more efficiently. We should explore the possibilities of synthetic food and lower our trophic position. We should consider the capacity of atomic energy, and ultimately that of solar energy, to support human life. We should formulate some clear ideas about the optimum number of people who can be maintained on earth indefinitely, in a balanced ecological system, and according to a reasonable standard of living. Then, and only then, will population control acquire reasonable and proper moral dimensions. In these matters I do fear ignorance.

Apart from population increase, the advances in medicine have created other severe problems. More and more people who in the past would have died before reaching reproductive age because of bad genetic make-up, do have children and thus carry the harmful genes into the gene pool of the next generation. Some individuals have ardently propounded various programs of eugenic control consisting in the voluntary or compulsory sterilization of affected persons. From a eugenic point of view, the abortion of fetuses with inherited disorders is a most severe form of sterilization.

A little thinking will make us realize that sterilization of the genetically unfit requires a tremendous, long-sustained effort with very little results in most cases. In terms of human life, allowing 30 years for one generation, it would take 50 generations, i.e., 1500 years, to reduce the frequency of a harmful recessive gene from 0.02 to 0.01, provided every affected individual in every generation is sterilized before reaching reproductive age. If the sterilization program is on a voluntary basis, or if the initial gene frequency is less than 0.02, or if more than one pair of genes are involved in the production of the disorder, the process would be even slower. Following similar considerations, C. C. Li concludes that "the elimination of a recessive defect by sterilization, in terms of human life has little to offer in a practical eugenic program."[6] The sterilization of all the carriers of a dominant deleterious gene would be effective in one generation. "However," as Li points out, "if the dominant gene is rare, a substantial proportion of the affected individuals are the results of new mutations, and therefore, population-wise, failure of affected persons to reproduce would make relatively little difference in the incidence of the trait in the next generation."[7] These considerations show that the results of even the most rigorous sterilization measures are far short of what is expected by some eugenicists.

A seemingly more audacious "solution" would be an attempt to limit

[6] C. C. Li, *Population Genetics* (Chicago: Univ. of Chicago Press, 1968) p. 253.
[7] *Ibid.*

the reproductive potential of the human race to those individuals which after a thorough investigation were found to be the "best." The idea is a good one, provided we have a good understanding of what the "best" is; the execution, however, contains the fallacy of a tremendous amount of unnecessary labor. All we have to do is sit back and let nature strike a balance. Natural selection means that each genotype is weighted through differential survival in favor of the actual best in a given set of environmental conditions. If we were to disagree with nature and would understand by the "best," let us say, the geniuses of our time, the proposition would contain a special twist. Geniuses are relatively rare—which means that our selection for parents of the next generation would come from somewhere near the tail end of human distribution. In a normal distribution, approximately 68% of the total population is within one standard deviation away from the mean. The reason for such clustering around the mean should be understood in terms of success of the average over the extremes. This simply means that people with average intelligence have an over-all better survival rate than geniuses under our given environmental conditions. If we were able to take all traits into consideration and could weight each genotype more favorably the closer they approach the over-all best, we probably would end up with the same differential survival rates as we actually have without going through all this labor.

In addition, the artificial selection of certain limited types of individuals would considerably decrease our genetic variance. In evolutionary terms, reduction of genetic variance below a critical value leads to inevitable extinction. That is why the natural genetic variance of populations is protected by so many and sometimes quite extraordinary means.

I am not predicting monsters. The biological revolution carries with it the hallmark of success. Instead of the nightmarish aberrations of ignorance or fiction, it is characterized by reason and a sense of responsibility, taming nature from a hostile world into an ally through research and knowledge. I do not know where our future is going to lead us, but I am more than hopeful because I know so many who fight ignorance and live for knowledge.