The Ethics of Research on Recombinant DNA

Presented
at
Sixth International Conference on the Unity of the Sciences
November 25, 1977
San Francisco, California

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Introduction

Ethical considerations are difficult to articulate in a world that is as complex and rapidly changing as ours. Standards of conduct, morals, and value judgements that formerly changed from generation to generation now seem to change from year to year.

At any given time we do not all agree on what is generally good or bad for society. Moral and ethical positions can be taken, but they are difficult to defend. The scientific community has, in the past, enjoyed the confidence of the people; it no longer does.

There are too many examples in which scientific research has outrun the scientist's wisdom; the disposal of nuclear waste, the use of insecticides everywhere, the development and use of pills which have unwelcome and dangerous side effects have all diminished public confidence in the authority of science and scientists.

Our thesis is starkly simple. Scientists, in involving themselves with recombinant DNA research, are blind gods tinkering with a delicate mechanism that they do not understand; yet DNA research is research that must be carried out.

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Problem

The ability to manipulate and modify the genetic material of a living organism has produced the rudimentary knowledge that could conceivably alter the course of organic evolution. This is not a hysterical proclamation. The immediate causes of concern have been the possible risks involved in the techniques used in different laboratories and the extensive use of Escherichia coli, a common bacterial inhabitant of the human intestines, for research purposes.[1,2] The great fear is that this organism, in a dangerously altered form, may escape from the science laboratories and infect the populace, causing mass epidemics.

Most of the experimentation in genetic engineering, however, has occurred with attenuated E. coli, and safeguards are being instituted to insure against accidental escape. These are diminishing the fear of creating immediate disastrous epidemics.

As more knowledge becomes available and a deeper understanding of connotations implicit in DNA research emerges, many people are no longer putting emphasis on the possible danger of E. coli experimentation per se and are beginning to seriously contemplate the possible use of genetic engineering on other organisms.

The very essence of scientific inquiry is the pursuit of knowledge. It is the nature of the scientist to wish to pursue a problem to its logical conclusion. It is difficult to imagine a scientist resisting the desire to experiment with primitive (procaryotic) cells other than E. coli, to check data, to compare, to investigate in the attempt to push knowledge further; and this is the great danger. When all the information has been gathered on these organisms the natural course of events compels experimentation with evolutionarily advanced (eucaryotic) cells.

Recombinant DNA research is intellectually exciting. It appears impossible to stop research in this area. The number of experimental projects involving recombinant DNA is large and growing larger. A recent report lists the National Institutes of Health as supporting 123 projects and the National Science Foundation as supporting 52, while the Veterans Administration supports at least 8.[3] There are more than 180 laboratories involved in this research with combined budgets of more than 2 million dollars.[4] The number of projects supported by private sources and in foreign countries can only be guessed.

An outright ban on recombinant DNA research is not likely; we cannot halt scientific inquiry, nor can we pretend the discovery of DNA never occurred. Fears concerning genetic manipulation and the incipient tide of experimentation were summarized in 1971 when Nagle said, "...biology has opened a Pandora's Box of possibilities for man to manipulate and control his own development and the future evolution of his species."[5]

In an unprecendented move, scientists, usually thought of as having low levels of social awareness, came together after a self-imposed moratorium on genetic engineering experimentation in 1975 and agreed to set up safety precautions for the prevention of biohazards.[6]

Concerns of the scientists signaled concern and anxiety by the public. The public became indignant. Exaggerated claims in highly emotional tones resulted from the well-meaning scientific community's effort. Callahan has said "...the public gets interested in scientific decision-making when potential social and ethical issues are called to their attention by scientists."[7] Pressure mounted for instant action in the form of immediate controls on recombinant DNA research. In response to the scientific community's concern and to public outcries, NIH has formulated guidelines specifying levels of physical and biological containment which must be adhered to by institutions and investigators receiving governmental support for recombinant DNA research.[8] Though not everyone is totally happy with them, the NIH guidelines appear adequate to protect the immediate environment.

There are three general areas of unrest, however: (1) Some scientists feel that the NIH guidelines are relatively weak, a problem which should be overcome by states and localities developing more stringent guidelines; (2) NIH has control only of government supported work, and, therefore, these guidelines should be made into federal laws so that privately funded research and industrial research would also have to adhere to the protective guidelines;[9,10] (3) NIH has strong influence only in the United States and cannot force its wishes upon research by foreign governments.

Many investigators do not, today, think that recombinant DNA research is as potentially dangerous as most scientists earlier feared. The initial voices were raised out of fear of the unknown and concerns of imminent catastrophe. These fears are being calmed. Social policies are being formulated, and forums are being proposed for exchange of information between scientists, the public and governmental agencies. Consciousness has been elevated, and many voices are being raised around the issue of recombinant DNA. Conferences and debates have been held in California, Massachusetts, Michigan, New York, Wisconsin, and Indiana, and more are being planned. The deliberations are necessary and must be encouraged.

The proponents and opponents of this research tend to make extreme claims as to the good or evil of DNA technology. Most scientists agree that recombinant DNA is one of the most important scientific breakthroughs of modern history, but they vehemently disagree as to whether the potential benefits of even the most restricted experimentation outweigh the grave potential dangers to human life and the environment.[4]

Proponents

Those scientists who are eager to go forward with the research claim that DNA technology is basically good. Results of the research, it is said, can help eliminate world hunger by increasing protein yield in food crops. This can be achieved by the incorporation of nitrogen-fixing capacities which would allow plants to obtain nitrogen from the atmosphere rather than from fertilizers.[6] Human suffering can be alleviated because of an increase in the availability, at a reduced cost, of pharmaceuticals such as insulin, vitamins, hormones and antibodies.[10] DNA technology is a means to discover a cure for cancer and to reduce man's vulnerability to virus infection. Gene deficiencies that cause phenylketonuria, cystic fibrosis, sickle-cell anemia and Tay-Sachs disease can be altered, thereby reducing and eventually ridding mankind of genetic aberrations. In addition, proponents of DNA research argue that this technology can be a source of pollution-free energy.[11,12,13]

Opponents

Those who believe the research is dangerous cite the possibilities of the escape into the environment of pathogenic organisms which could cause epidemics and the possibility (if not probability) of the unwitting development of agents which could disrupt the ecological balance or which could be used by terrorists.[10] The exploitation and misuse of recombinant organisms by industry also poses a threat; profit motives often overshadow ethical considerations. Further, opponents of DNA research regard tampering with the forces of creation and evolution as morally irresponsible. The possibilities of cloning humans, controlling behavior and misusing eugenics have been cited as negative applications of DNA technology. Another concern is that "shotgun" experiments which will be carried out may produce novel organisms containing unspecified genes which could harm man, plants, and animals.[14] The genetic barrier between organisms (especially pro- and eucaryotes) will be breached, causing dire evolutionary consequences.[2]

Science is neither necessarily good nor inherently evil. Naïveté, however, can often characterize the immediate implications of basic research. The annals of science are rife with accounts of scientific investigations which produced discoveries that could have made the world a better place to live but which were eventually used for destructive purposes. Technology has often surpassed man's ability to cope logically with it. The awesome applications of Nobel's and Einstein's works are classic examples and are often cited as gross illustrations of what can go wrong with scientific discoveries. On a smaller scale, but nonetheless atrocious, Galston reported a poignant example of the adverse use of one of his discoveries. A substance which increased flowering in soy beans was used in a modified concentration as a defoliant on trees and food crops in Viet Nam.[15] This occurred many years after the discovery and without Galston's knowledge.

Biological advances, even more than advances in physics and chemistry, get to the very soul of the possibility of altering our lives.

A vocal critic of DNA technology has said, "The twentieth century has seen a cascade of magnificent scientific discoveries. Two [of them]...have extended our powers far beyond prior human scale and experience. In the nucleus of the atom we have penetrated to the core of matter and energy. In the nucleic acids of the cell we have penetrated to the core of life."[2] The new

DNA technology could permit an understanding of life in a way never before achieved.

It is not enough that scientists have sensitivities to the moral and ethical intricacies involved in recombinant DNA research; each move forward must be careful and deliberate. Scientists "...may have to defend vigorously the value of objective and verifiable knowledge, especially when it comes into conflict with political, theological, or sociological dogmas." [13]

Moral responsibility should incorporate long-range goals as well as short-range goals. We are actively addressing immediately foreseeable problems. Checks and balances are being instituted, and safeguards are being inaugurated. Scientists would be remiss, however, in considering only limited accountability and responsibility. We have not done a good job with controlling and directing the use of many prior scientific discoveries. A cursory reminder of environmental atrocities should make us aware of this fact. We now know that future generations will inherit an earth that is less suited for habitation than it was when we inhabited it. Rapid uncontrolled technological growth has caused severe ecological damage, used up an enormous amount of nonrenewable resources and has allowed medical advances to increase the life-span of man, thereby contributing to the increased population of the world. In our short-sighted pursuit of the "good life," we have diminished the long-range "quality of life."

Results of Short-Sightedness

WATER

Science gave us chemical agents which immediately produced better crop yields and healthier, greener lawns. More than 30 million acres of

U.S. farm lands, forests, and lawns and gardens have been sprayed with pesticides and fertilizers. The long-range results? Dead birds, dead fish and weakened animal life, all caused by pollution that can be attributed to the run-off of chemicals from the land into our waterways. In addition, industry, applying scientific discoveries, has dumped over 50 million pounds of sulfite and other chemical contaminants into waterways, further decreasing marine life and making water unfit for drinking or swimming.

AIR

The air is damaged by carbon monoxide, oxides of nitrogen and sulfur, lead, asbestos, hydrocarbons, and other particulates to the tune of 250,000 tons per day emitted from motor vehicles, 70,000 tons per day from power plants, 25,000 tons from space heating, 16,000 tons per day from refuse disposal, and 72,000 tons per day from other industries. Much of this pollution is the result of fossil fuel usage. Is it any wonder we are in the midst of an energy crisis?

PEOPLE

The human population is exploding, and sooner or later its unrestricted growth will have to be controlled if our species is to maintain its cultural standards or at least to maintain life.

It took over a million years to reach 5 million people (or manlike people) on this planet and less than two thousand years to reach four billion. We are now doubling our population at least every 35 years, and the projected world population could reach the eight billion figure by the year 2000 A.D.; this means four billion more people on earth in just 23 years.

LAND

Consider that each family of four requires the equivalent of a plot of grass or shrubland 50' X 50' in order to liberate by photosynthesis the oxygen necessary to meet their "inhaling" needs. Much of the 58,401,000 miles of land in the world is desert, arid, or covered by construction. At that population growth rate, the necessary 50' X 50' green plots will soon be unavailable.

And with each doubling of the world's population comes a doubling of the need for public services--schools, colleges, hospitals, doctors, nurses, roads--and a doubling of the need for funds to support them.[16] The implications are clear.

These are examples of situations we are in because of misuse (or ill use) of scientific breakthroughs. The immediate implications of the various technologies appeared very positive when they were instituted. They provided elements which contributed to the "good life." The ultimate effect has been pollution of the environment and a diminishing of the quality of life.

Application of scientific knowledge has contributed to increasing the number of people in the world. Use of antibiotics and better health care delivery systems have increased the life span of people. People are also taller, healthier and live longer productive lives, directly or indirectly because of scientific innovations. Morally good? Few would argue against the rightness of applying science in this fashion. If, however, we were to evaluate unemotionally the problem of pollution--including people pollution--we may conclude that we have been seriously lax in our moral responsibility to future generations. We have accepted scientific and technological innovations with gluttony. Our acceptance of these has created problems that require creativity and timely innovation to repair the environment. Too often we have become aware that a problem exists only as it gets out of hand.

With DNA technology we have the opportunity to consider its effect on our present lives, and we can contemplate its use in the future. Should not we pause to consider our obligations to future generations? Should not we consider possibilities of using this new technology in making the world better for future generations?

One Possible Solution

It is obvious that the world population will increase, and environmental problems will grow. The further we are able to look into the future the more serious this problem becomes. Can the new DNA technology contribute to a solution? Conceivably, yes. The possibilities and ramifications of the application of DNA technology are many. Let us explore a rather far-fetched example of the possible use of this technology in solving an ecological problem.

If it became possible to predictably manipulate the gene complement of embryos so that progeny of future generations would be two (2) feet tall instead of six (6) feet tall, would not this constitute a moral good? If men were two feet tall and proportionally built rather than six feet in height--what a difference this would make in solving the overall pollution problem. Imagine how much smaller in size automobiles would be, with a resulting diminution in the level of pollution contaminating the atmosphere. In the same way, homes, pop bottles, beer cans and newspapers, because of their smaller sizes, would not be serious sources of pollution. The same would hold true for the use of pesticides, fertilizers, X-rays, etc.[17] If further manipulation could allow our little men to photosynthesize, there would be no need for food crops. Would this be scientifically undesirable? Morally sinful?

It has been said that recombinant DNA technology is "...the first step toward the manipulation of the genetic equipment of man."[2] Is that necessarily evil? Does not it depend upon one's sense of morality? What might be looked upon with fear and repugnance today may be a welcomed part of life in the future.

DNA technology is a powerful tool and represents a major breakthrough in research. The search for new knowledge carries a certain amount of risk, and, therefore, all the care in the world must be exercised by scientists who do work in this area.[4]

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