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Recombinant DNA Debate

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The Recombinant DNA Debate

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There is a changing attitude of society towards science as a result of the recombinant DNA debate. Biologists and biochemists have developed the technology to induce one organism to produce substances that are characteristic of another, completely different, organism. Now a piece of chromosome carrying the genetic information of one species can be inserted into a chromosome carrying the genetic information of another species. Chromosomes have been found to consist of huge molecules of deoxyribonucleic acid (DNA).[1] The technology by which a segment of DNA is transferred from the cells of one species to that of another is referred to as "recombinant DNA."

This article examines the technique of recombining DNA and possible benefits and dangers of this technique. The alleged dangers of carrying out research with recombinant DNA have led many people to ask if there are, or ought to be, limits to scientific investigation and if the role of science in society should be re-examined. The conclusion raises still another question, namely, whether scientists are capable of being objective in their work.

Recombinant DNA Technology

The DNA molecule, by virtue of the sequence of its subunits, specifies the proteins that a cell manufactures. The

proteins produced by a cell give each cell type its unique character. Thus, when a segment of DNA can be introduced into another cell and can be induced to govern protein synthesis as it did for its "original owner," the new host cell takes on some characteristics of the donor cell by producing proteins that are characteristic for that donor. The significance of this may have been masked by the scientific jargon that has just been used. But imagine bacteria producing human insulin, or a mouse producing enzymes found only in the rat intestine! Let us look at the technique more closely.

In recombinant DNA work as it is usually carried out, the recipient cell is *Escherichia coli* (*E. coli*), a bacterium. The DNA that the investigator attempts to incorporate can come from many sources: other bacteria, plants, animals, even man. Production of "human" insulin by *E. coli* has recently been reported.

For the work of recombinant DNA, segments. *E. coli* possesses, in addition to its large, circular chromosome, small circular pieces of DNA called plasmids. As shown in Figure 1, restriction endonuclease can be employed to open these plasmids.[2] The segment of DNA to be introduced into *E. coli* is allowed to join with these plasmids at the point of the break. Another enzyme, DNA ligase, can then be used to repair the breaks in the plasmids. These plasmids, with their newly introduced DNA segments, are re-incorporated into *E. coli* bacteria. And, if everything has been done correctly, these bacteria will now synthesize proteins specified by the newly incorporated DNA. For a more complete description of these procedures, several very readable accounts are available.[3]

Besides the synthesis of human insulin by *E. coli,* somatostatin, a simple human hormone, has been produced. By culturing large quantities of bacteria with recombinant DNA, insulin, or any other substance specified by the insert-

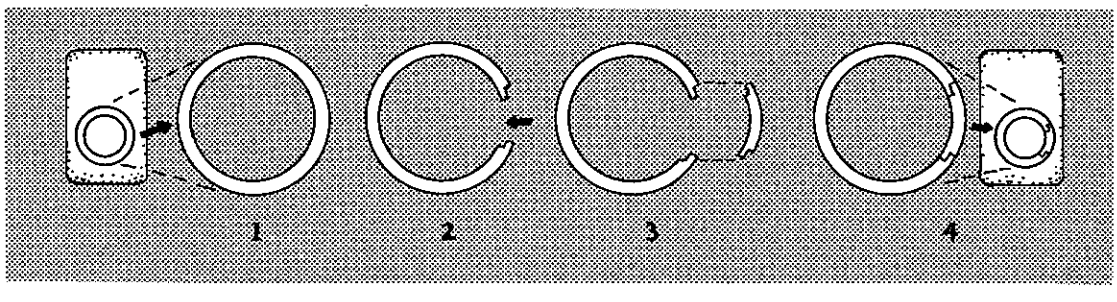

Figure I. Plasmids are removed from *E. coli* cells (1) and are opened with the aid of an enzyme (arrow, 2). A piece of DNA from another species is allowed to join the plasmid at the point of the break (3). Another enzyme is used to repair the plasmid. The plasmid with its inserted DNA is re-introduced to an *E. coli* cell (4). For further details see text.

enzymes which are highly specific in their action have been discovered, isolated, and are now available. One of these enzymes, restriction endonuclease, can be used to split DNA molecules into carefully controlled ed gene, can be synthexized in large quantities, in much the same way as bacteria are now used to produce commercial qualities of antibiotics. Other protein molecules, such as growth hormone or blood-clotting factors, could

conceivably be produced in the same way. Other possible products of recombinant DNA research are bacteria that can fix nitrogen in the roots of nonleguminous plants, bacteria that can digest cellulose in the human intestine, and bacteria that can be used to clean up oil spills.

However, the possibility of dangers has also been suggested. *E. coli* is a normal inhabitant of the human digestive tract. A strain of *E. coli*, produced with recombinant DNA methodology by design or by accident, which would produce dangerous toxins — not uncommon in other bacteria — or which had acquired dangerous new pathogenic habits, could conceivably do much harm to the human population. Furthermore, pathogenic bacteria might acquire a resistance to antibiotics which would make them more difficult to control. The possibility of inserting a cancer-causing gene into bacteria has also been raised. Such possible hazards have raised questions about science in the minds of many people.

The Controversy

A good place to begin the story of the public controversy about recombinant DNA research is the Gordon Research Conference on Nucleic Acids, held June 11-15, 1973, in New Hampshire. Several investigators had begun to have doubts about the safety of recombinant DNA research; these doubts surfaced at this conference.[4] The conferees decided to request the National Academy of Science to study the implications of recombinant DNA research. And, in a move that indicates the politicized atmosphere surrounding the topic, the conferees decided to make their letter public in *Science*.[5] Subsequently, *Science* also published a letter signed by eleven distinguished scientists, asking for a moratorium on recombinant DNA research until guidelines could be established to guarantee the safety of such research.[6]

The two letters in *Science* focused attention on the recombinant DNA debate. Newspaper articles, some informative, some with hair-raising scenarios for catastrophes, kept the issue in the public eye. The Asilomar Conference, held in February, 1975, on the Monterey Penninsula in California, was convened specifically to formulate recommendations for procedures to guard the safety of recombinant DNA research. The National Institute of Health (NIH) immediately took these recommendations under study and arrived at guidelines that are somewhat stricter than the Asilomar recommendations. After much interim discussion of various drafts, guidelines were adopted on June 23, 1976.[7] From the time of the second letter in July, 1974, until the NIH guidelines were announced, no recombinant DNA research was carried out in the United States.[8] Surprisingly, the dictum for science, "What can be done will be done," did not hold true during this period.

The NIH guidelines describe two kinds of containment procedures to ensure safety of the research.[9] The requirements for the first of these, physical containment, are described for four different risk levels. These range from P1, for recombinant work involving *E. coli* and organisms that are known to exchange genes with *E. coli* in nature, requiring the safeguards of commonly accepted laboratory procedures, to P4, for recombinant work involving *E. coli* and primate tissues or animal viruses, requiring carefully dilineated physical containment, such as limited access to laboratory areas, isolation from other laboratories, and other stringent laboratory procedures. The second type of containment, biological containment, is described at three levels, EK1 to EK3.

It depends on special strains of *E. coli* that cannot live outside the laboratory. Work on developing strains more severely "crippled" by mutation is still in progress, but strains for biological containment level EK2 are now available. The guidelines ban certain experiments altogether, such as those with extremely pathogenic organisms. "Shotgun experiments," in which the entire DNA complement of an organism is broken into fragments, and systematically incorporated into *E.coli*, are also regarded as being hazardous and are therefore proscribed by the guidelines.

All federally supported work at universities and national laboratories is governed by the NIH guidelines.[10] Industrial research by pharmaceutical and other companies is less tightly regulated because it is financed by private funds. While there is probably voluntary compliance,[11] this nevertheless is a segment of the research which is not covered by NIH regulations. Senator Edward M. Kennedy has held hearings with the aim of formulating federal legislation governing recombinant DNA research; now that the furor over this topic is waning, it is commonly thought that the legislation will not be enacted.[12]

The public controversy extends to state and local governments. Several states, including New York, are considering legislation governing DNA research.[13] At the local level, the most publicized brouhaha occurred in Cambridge, Massachusetts, the location of both Harvard University and the Massachusetts Institute of Technology. The Cambridge Experimentation Review Board was appointed by City Council on August 6, 1976, to consider whether P3 level DNA research should be allowed to be conducted within the city.[14] The review board, which consisted entirely of "lay" citizens, submitted a unanimous recommendation on February 7, 1977, to allow the research in question, with certain additional stipulations over and above the NIH guidelines. Many scientists at the two institutions were not accustomed to being held accountable to the public for their research in this manner.

Science and Society

The debate we have described, along with other controversies in science, has raised the question of whether there should be constraints on investigative laboratory work.[15] Many believe there should be, but their reasons for constraint vary. Some suggest that DNA research tampers with processes that should not be tampered with. Others would like to have the research stopped because they feel that technology is becoming too powerful in our society. Most question the research because they are afraid it is not safe. For this reason, many scientists suggest that science should be responsible to society. They accept intervention of authorities for reasons of safety, and, in the case of recombinant DNA research, to prevent the escape of harmful bacteria — new pathogens or organisms with new toxins or new antibiotic resistances. However, the niche that science has carved out for itself in our society is not questioned. Even June Goodfield, a perceptive and philosophically astute writer, does not push through to the root of the problem in her discussion of DNA research.[16] The request for science to be responsible to society does not go far enough.

The crucial problem is that science is usually represented as being entirely autonomous, a law unto itself. The philosophy behind this phenomenon will not be discussed here. However, since the time philosophers started to think about epistemological questions,

this has been a major topic of debate. Even today this is reflected by the fact that peer review is considered by most scientists to be the only way to handle problems of publishing, of university appointments, and of research funding. It is not a slip of the tongue or pen in the recombinant DNA debate to hear suggested that "science is responsible to society" instead of "science is responsible to the *rest* of society."

It is of the utmost importance that we come to recognize once again that scientists are influenced by ideas, commitments, and problems within society. The shift of emphasis in biology from molecular to environmental biology certainly lends credence to this notion. Groups such as "Science for the People" have realized that this influence exists in the recombinant DNA debate. Although such groups often argue from the standpoint of safety, they show through many statements that they question, correctly, the objectivity of science and scientific investigators.[17] When we acknowledge this, we can begin to explore what differences ideas have made, even in such supposedly neutral areas as mathematics.[18] We can then also explore what differences our Christian commitment should make in the area of science. Where this exploration can take us will become clear only when we engage in Christian scholarship together.

If scientists are influenced by ideas, in other words, if they are incapable of being objective in the things they do, why is it that we don't hear more about subjective elements in science, about changing opinions, about the role of society's ideas in shaping scientific theory? T.S. Kuhn suggests that one reason we don't is that when theories, and even what is accepted as fact, change, the textbooks also change or are re-written. He says "Textbooks thus begin by truncating the scientist's sense of his discipline's history and then begin to supply a substitute for what they have eliminated." Knowing only a little scientific history, and that learned in a haphazard manner, "both students and professionals come to feel like participants in a long-standing historical tradition," a tradition that, in fact, never existed.[19] There is a persistent trend to make the history of science look linear or cumulative. But, concludes Kuhn,"that is not the way a science develops."[20] Thus, the history of the various sciences shows that scientists individually and collectively often change their minds on matters large and small in response to ideas that emerge from society at large.

In Conclusion

If ideas in society guide scientific endeavors and play a role in the scientific enterprise, then we can legitimately ask how our Christian commitment can guide us in our attempts to understand the living world. It is regrettable that the topic of creation has led to more acrimony than comfort among Christians. To illustrate that the concept of creation can make a concrete contribution in our theorizing, consider these three points:

1. Creation can mean integrality and wholeness, for when we are not bound by faith or philosophy to one cause, for example, a chemical cause for every biological phenomenon, there is room to study the whole range of biological phenomena. Thus, there can be room for the study of the Krebs cycle *and* animal behavior, DNA *and* animal classification. This approach can do away with the problem of reductionism as it was described in an earlier article.[21] All phenomena can be studied and described.

2. The message of creation indicates that God is faithful to His creation. Investigative work can be done happily and in trust. Often the debate about biological topics has been characterized by a love-hate relationship so that science and scientists are viewed with distrust until an item is found in the scientific literature which can be quoted to prove or disprove a theory that has been of concern to some or all Christians.

3. God created and upholds. This constancy and faithfulness is reflected in that we can describe and investigate. The "laws of nature" are manifestations of His upholding care. However, we should not identify these laws and our formulations. Our laws and theories reflect, fallibly, God's creational laws, His upholding care. That leaves room for constancy of phenomena and the changing of scientific theories through time, in response to ideas in society. Thus, in our theorizing, the creating Word which originates, upholds, and structures all of reality has a central place.

These three points serve to indicate that Christian commitment can have repercussions in the scientific enterprise. Now that the place of science in society is being examined, there is an opportunity to indicate that ideas, including Christian ideas, play a role in the formulation of theories.

Notes

[1]For a discussion of the role of DNA, see Harry Cook, "Life: A Physical Phenomenon?" *Pro Rege*, 6, No. 3 (1978), pp. 15-20.

[2]I thank Norman Matheis for drawing the figure.

[3]Clifford Grobstein, "The Recombinant-DNA Debate," *Scientific American*, 237, No. 1 (1977), pp. 22-33: June Goodfield, *Playing God* (New York: Random House, 1977).

[4]For a discussion of these and subsequent events see: William Bennett and Joel Gurin, "Science That Frightens Scientists, The great debate over DNA," *Atlantic*, Feb. 1977, pp. 43-62; Goodfield, pp. 12-30.

[5]M. Singer and D. Soll, Letter, *Science*, 21 Sept. 1973, p. 1114.

[6]P. Berg *et al*, Letter, *Science*, 24 July 1974, p. 303; often referred to as the "Berg letter."

[7]*Federal Register*, 7 July 1976, pp. 41-131.

[8]For a discussion of guidelines in Canada, see: *University Affairs*, Oct. 1977, pp. 2-5; in Great Britain, see: Goodfield.

[9]Grobstein, pp. 31-33; Richard P. Novick, "Present Controls Are Just a Start," *Bulletin of the Atomic Scientists*, May 1977, pp. 16-22.

[10]"Recombinant DNA Research, A debate on the benefits and risks," Editorial, *Chemical & Engineering News*, 30 May 1977, p. 26.

[11]Jeffrey L. Fox, "Revisions to DNA research guidelines debated," *Chemical & Engineering News*, 9 Jan. 1978, p. 25-32.

[12]"Recombinant DNA Debate Three Years On," Editorial, *Nature*, 21 July 1977; "DNA Research: No Federal Regulation Now," *Chemical & Engineering News*, 21 Nov. 1977, p. 22; Barbara J. Culliton, "Recombinant DNA Bills Derailed: Congress Still Trying to Pass a Law," *Science*, 20 Jan. 1978, pp. 274-277; Janice Long and Chris Murray, "96th Congress Expected to be More Conservative, Thriftier," *Chemical & Engineering News*, 8 Jan. 1979, pp. 14-18.

[13]"A New York State DNA Bill," *Bulletin of the Atomic Scientists*, May 1977, p. 21.

[14]"The Cambridge Experimentation Review Board," *Bulletin of the Atomic Scientists*, May 1977, pp. 23-27; Sheldon Krimsky, "Public Must Regulate Recombinant Research," *Chemical & Engineering News*, 30 May 1977, pp. 36-39; Goodfield, pp. 213-218.

[15]The entire Spring, 1978, issue of *Daedalus* is devoted to articles dealing with the theme "Limits of Scientific Inquiry."

[16]Goodfield seems awed by the brilliant scientists she met as she prepared for the writing of her book, and this may have prevented her from adequately dealing with the topic.

[17]Ted Howard and Jeremy Rifkin, *Who Should Play God?* (New York, Dell Publishing Co., 1977); see also the contributions of representatives of Science for the People and similar groups to the debate published in: *Research with Recombinant DNA, an Academy Forum*, March 7-9, 1977, (Washington, D.C., National Academy of Sciences, 1977).

[18]See, for example, the recent article of W. Alberda, "Existence in Mathematics," *Pro Rege*, 7, No. 3 (1979), pp. 11-15.

[19]Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago, University of Chicago Press, 1962), p. 137.

[20]Kuhn, p. 139.

[21]Cook, p. 19.