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"Current Comments"

Genetic Engineering-- Too Dangerous to Continue or Too Important to Discontinue?

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Genetic engineering now makes it possible to fragment DNA into millions of tiny circular bits called plasmids. In the laboratory, these plasmids can be implanted in bacteria. After the initial "splice," bacteria which survive the procedure may produce new bacterial strains. These may be beneficial to humans, innocuous—or harmful.

The techniques of gene implantation and DNA splicing make possible a vast range of fascinating and potentially useful medical research projects. Unfortunately, tampering with bacterial DNA just *might* result in the creation of new diseases. It is ironic that the most insidious existing pathogens—the ones which cause the most suffering and death to humans—are precisely the ones we most urgently need to study. Genetic manipulation of these organisms might lead to control or cure. However, such experiments could lead to new and more vicious pathogens. Any failure of laboratory procedure to contain them could prove catastrophic.

For this reason, the Committee on Recombinant DNA Molecules of the National Academy of Sciences last year asked for voluntary restraint on some experiments pending a more careful review of the issues.[1] In January of this year the British Working Party on the Experimental Manipulation of the Genetic Composition of Micro-Organisms concluded that hazardous genetic experiments "could, and should, be conducted with all the precautions used when handling very dangerous pathogens; and indeed should not be done at all unless the potential benefits are very evident."[2] Shortly thereafter, at Asilomar, California, 140 scientists from 16 nations proposed new guidelines for such research.[3]

These developments have received extensive media coverage. With so much written and said about so complicated and terrifying an issue, it is not surprising that over-simplification, distortion, prejudice and myth have become widely disseminated.

In fact, I would not be surprised if some people began believing that the scientists involved in genetic engineering research (1) are playing childish games, (2) are merely curious, (3) are mad, (4) have all the foresight and judgment of eager adolescents, (5) are misguided ecologists bent on restoring Earth's plants and animals by ridding the planet of man, (6) are searching for an antidote to over-population, (7) want to help the oppressed everywhere by afflicting the capitalist (or communist) pigs with disease, or (8) are egomaniacs aiming to create a race of (a) zombies, (b) slaves, (c) supermen, (d) beautiful young women, or (e) duplicates of themselves.

In order to carry on a rational debate, it is essential that the public be informed not only of the harm which continued experimentation might cause, but also of the very real benefits which DNA-splicing may make possible.

So far, our knowledge of DNA—for example, of its bihelical structure—has had

very little effect on the practice of medicine. But in the near future the understanding of molecular biology will be instrumental in radically changing medical technology. Just a few of the potential applications of DNA-splicing to diagnostic and therapeutic medicine include: defense against infectious diseases; control or cure of cancer; defense against allergic disease; blocking antibodies to facilitate transplantation of tissues and organs; improvement of antibiotic microbes; production of an unlimited variety of human proteins and high-quality protein supplements; and manufacture of industrial chemicals. Merely one of these potential applications, biosynthetic human proteins, may result in more powerful modes of prevention and cure for such diseases as influenza, hepatitis, smallpox, encephalitis, rubella, herpes, rabies, trypanosomiasis, malaria, schistosomiasis, tuberculosis, and leprosy.

In addition, DNA-splicing could revolutionize agriculture. As the editors of the *British Medical Journal* recently pointed out,[4] "If genes which code for nitrogen fixation could be introduced and made to function in non-leguminous crops such as cereals, the benefits would be immense to a world which is short of food partly because of the high cost of artificial manures and the expenditure of energy in making them."

Another possible application of genetic engineering would involve contraception--an increasingly important medical and social problem. Passive antibody therapy directed against human sperm might immobilize it, effectively blocking fertilization with a minimum of side-effects.

Those who are truly concerned about the long-range public welfare must consider not only the largely speculative hazards of genetic manipulation, but also the potential costs of impeding this research.

Similar cost-benefit questions can be asked about almost any activity. For example, domestic cats are suspected of harboring toxoplasmosis and possibly leukemia.[5] Should it be unlawful to keep cats?

Artificial pollination is used for crop development in order to raise the quality and lower the cost of food, but it *might* produce a monstrous weed that ruins subsequent wheat crops. Should it be outlawed?

Periodic failures of our quarantine procedures result in the occassional importation of exotic diseases. Should we forbid international travel?

There is a real possibility, as Joshua Lederberg has pointed out, that what are now research "guidelines" for DNA-splicing will crystalize into legislation.[5] This raises the question of the feasibility of enforcement. Can a prohibition on research be enforced? The person with influenza who insists on going to work is obviously endangering his coworkers, but has Congress seen fit to legislate against such action? Even if it was unlawful, could such a law really be enforced?

In fact, the law is not the sole device by which society enforces its will; it is usually a troublesome and ineffective last resort. In a matter such as regulation of research, the power of the purse—controlling spending for "undesirable" research—may prove far easier and more effective than legal sanctions.

At present, the techniques of DNA-splicing are not applicable to the genetic engineering of human beings. Aldous Huxley's *Brave New World*, with its rigidly caste-separated society of Alpha-pulses, Alphas, and Betas, is not yet possible. However, the technology of genetic manipulation itself is simple enough to be practiced in almost any well-equipped laboratory. Thus, what is simple and convenient to the responsible researcher can become extremely dangerous in the hands of those with less mature professional judgment, or those without the skill to contain bacterial cultures in the laboratory.

The situation is changing rapidly, but before answers can be agreed on, the right questions must be asked. Because of the vast implications of this controversy—for the public as well as for scientists of all disciplines—I will try to contribute to the formulation of the proper questions in two ways.

First, this editorial is followed by a selected bibliography on genetic manipulation. It lists important articles from the popular press as well as the scientific literature. For example, the Godber Report of the Working Party on the Laboratory Use of Dangerous Pathogens contains an excellent code of practice for laboratories involved in experimentation with dangerous pathogens,[6] and the Lederberg article cited above[5] is a fascinating, concise, and authoritative summary of the controversy.

Second, beginning immediately *Current Contents®* will devote space to printing responsible comment on the issue of genetic manipulation. We invite your knowledge, your opinions, and your reactions. Correspondence should be signed, addressed to me, and accompanied by a return address and phone number. This new section of *Current Contents*, devoted to debate and rebuttal of contemporary issues facing the scientific community, will be called *Current Controversy*.

1. **Berg P, Baltimore D, Boyer H W, Cohen S N, Davis R W, Hogness D S, Nathans D, Roblin R, Watson J D, Weissman S & Zinder N D.** Potential biohazards of recombinant DNA molecules. *Science* 185(4148):303, 26 July 1974.--This letter appeared almost in full as: NAS ban on plasmid engineering. *Nature* 250(5463):175, 19 July 1974.
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3. **Berg P, Baltimore D, Brenner S, Roblin R O III & Singer M F.** Asilomar conference on recombinant DNA molecules. *Science* 188(4192):991-94, 6 June 1975.--See the bibliography which follows for other reports on the Asilomar conference.
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Selected Bibliography on Genetic Manipulation and the Controversy Surrounding It

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