BIOETHICS AND BIOTECHNOLOGY

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Summary

Modern biotechnology raises most of the issues facing science and technology today. These include rapid research and development, major potential for improving the human condition, misunderstanding and fear on the part of the public, and conflicts of interests as the nature and funding of research changes.

Biotechnology's potential for good must be seen in light of its potential for harm. Society's ingenuity in undertaking robust ethical analysis of the many issues raised and developing guidelines, however, lags far behind the ingenuity of scientists and investors in moving the field forward and developing new and powerful technologies and products.

This chapter surveys the field of biotechnology, puts bioethics in perspective, and highlights the ethical, legal and societal implications of several key technologies. It also summarizes some important recent ethical guidelines.

1. Introduction

Both bioethics and biotechnology have ancient and modern guises. In the west, bioethics goes back some 2500 years, to the time of Hippocrates. Elsewhere, bioethical traditions go back even further. Biotechnology, on the other hand, is as old as human civilization (Table 1). Both, however, have distinctly recognizable modern manifestations, beginning roughly in the 1960s. This chapter introduces the major issues in today's bioethics and biotechnology and, in the process, highlights how the two have, to some extent, influenced each other's development in the past half century.

4000 BC	Dairy farming by Egyptians, who also use yeast for bread and wine.
3000 BC	Peruvians select breed potatoes.
2000 BC	Egyptians, Sumerians and Chinese develop fermentation, brewing and cheese-making.
500 BC	People in the Mediterranean develop marinating and Europeans flavour and preserve food.
1500 AD	Sauerkraut and yogurt from acidic cooking – examples of using bacteria for human needs. Aztecs make cakes from Spirulina algae

1861	Louis Pasteur develops technique of pasteurization
1879	William Beal develops first experimental hybrid corn

Table 1: History of Classical Biotechnology

The word "biotechnology" derives from three ancient Greek words: “bios”, meaning “life”; “teuchos”, meaning “tool”; and “logos”, meaning ”study of” or ”word” or ”essence”. Thus, extracted etymologically, it becomes “the study of tools from living things”.

The term "biotechnology" can be traced to 1917, when it was used to refer to a large-scale production of materials from microbes grown in vats. During the First World War, it referred to the use of industrial fermentations to produce industrial feedstock such as acetone, which was used to make cordite, an explosive. Today, biotechnology refers to several different technologies. These range from selection and breeding, chromosome analysis (such as used to diagnose Down’s Syndrome), tissue culture for growing tissues or cells in glass jars (used in plant propagation and in producing drugs such as penicillin and monoclonal antibodies), and DNA analysis (for example, DNA fingerprinting, or massive DNA sequencing efforts such as the Human Genome Project). Many people have now come to understand biotechnology as referring mainly to techniques such as recombinant DNA and genetic engineering.

2. Biotechnology will Play a Bigger Role in our Lives

There is little doubt that biotechnology will play a bigger role in our lives in this century. It is already a market worth approximately US$50 billion. The important uses of modern biotechnology can be summarized by the five F’s:

- *Food:* About half the soybeans and one-third of the corn grown in the United States in 1999 contained foreign genes.
- *Fuel*: Different types of fuel can be made using biotechnology techniques; for example, yeasts ferment corn starch to yield ethanol; bacteria decompose sludge, manure or landfill wastes to produce methane; and firewood heats homes.
- *Feedstock*: Instead of petroleum, bio-renewable materials such as starch from corn or whey from cheese-making can be used to make plastics.
- *Fiber*: A new example of industrial biotechnology for fiber is biopulping -- using a fungus to convert wood chips to paper pulp while reducing energy use and pollutants. Other fibers from plants and animals include cotton, wool, silk, linen, leather, umber and paper.
- *Pharmaceuticals:* Vaccines, antibiotics and other therapeutic agents produced by microbes, plants or animals fall under this category. Newer pharmaceuticals will increasingly come to depend on modern biotechnology techniques.

2.1. The Genetics Revolution and Human Health

Until quite recently, our knowledge of diseases at a molecular level has been quite limited. However, exploding knowledge in genetics over the past decade has begun to change the picture. Interestingly, what is emerging is that while our genes may have loaded the gun, environmental factors pull the trigger. Genetics research today holds the tantalizing prospect of promoting health and preventing disability, economic wastage and early preventable death. Genetic knowledge can be used to prevent conception, and to screen, diagnose, treat and prevent the manifestations of disease in those who have genetic susceptibility.

This revolution, fuelled by developments in information technology, will have a profound impact on humanity in this new century. It will challenge our understanding of ourselves, and of the aetiology, manifestation, progression, and management of physical and mental diseases. The new era will witness a profound change in traditional health-care delivery and public health, and in the pharmaceutical and agricultural industries.

The revolution will also change the traditional boundaries between medical disciplines. It will force us to reassess the contribution of environmental factors – including chemical, infectious, physical, social, psychological, and nutritional factors – to public and individual health. It will give us new tools to manipulate these environmental factors in relation to individual genetic endowment, thereby personalizing prevention and therapy in a way not previously possible. This will include the management not only of acute diseases, but also of chronic diseases such as Alzheimer's disease, cancer and diseases of the cardiovascular system.

2.2. Developing Ethical Guidelines for Biotechnology: Important Modern Issues to Consider

The rapid pace of research and development in agricultural biotechnology, in unraveling the human genome, in cloning and stem cell technology, and in organ transplantation, has made it crucial to study the potential impact of these technologies on society and to attempt to develop ethical guiding principles.

In light of the potential social dislocations that might arise from the genetics revolution, organizations have developed ethical guidelines for biotechnology. These guidelines attempt to capture a consensus view of values in society, and trace the implications of these values for human action. In this chapter, we will describe the conclusions of many such guidelines from organizations such as the World Health Organization, the Human Genome Organization, the UK Nuffield Council on Bioethics, and the US President's National Bioethics Advisory Commission, among others.

There is, of course, also a need for ethical guidelines for patient-physician relationships. These, however, have been in existence since at least the time of Hippocrates, and have modern manifestations in guidelines from professional societies, such as the American Medical Association and the United Kingdom General Medical Council. In the field of research on human subjects, the Nuremberg Code was promulgated following Nazi atrocities, which included unethical research on human subjects. Modern iterations of such codes can be found in the Helsinki Declaration and codes developed by the Council of International Organizations of Medical Sciences (CIOMS), among others.

2.2.1. Involvement of Industry

It has become a common lament that biotechnology is moving so rapidly that bioethics is forever playing catch-up. Not only has the pace of discovery hastened and the period from discovery to application shortened, but also the biotechnology industry has removed traditional players from the forefront and brought in new and powerful forces of influence. The choice of what to study and develop was once a prerogative of academics in universities. Today that prerogative has migrated to venture capitalists and, increasingly, to industry. Industries now produce more and, in many cases, better basic and applied research than do many universities.

For researchers in the past, the rewards of research were honor, fame, academic promotion, a role in increasing the pool of human knowledge, and occasionally the development of a groundbreaking product. The scene is changing rapidly: research, even within universities, is now often funded by industry. The desired end is to own intellectual property and its financial reward. With this shift in motivation, movement of gifted researchers to industry is easy and happens early in their careers. Universities are becoming increasingly entrepreneurial, setting up their own intellectual property offices. There is also a developing trend whereby industry researchers are moving back to high-powered research universities into leadership positions, and the boundaries between university and industry are being blurred. In the United States particularly, this trend has coincided with the longest period of sustained economic growth in U.S. history, making it difficult to discern the long-term consequences of such a major re-definition of the roles of public institutions. There is some evidence that industrial funding of university research is detrimental in terms of delaying publication of important results and favoring applied research at the expense of basic research, but that evidence is not compelling at present.

These changes, while they may have an immediately beneficial effect on the economy and in generating discoveries and intellectual property, do have the potential for conflicts of interest. Researchers caring for patients may have a stake in the products or technologies being tested. Many academics own shares in biotechnology companies or sit on their boards. The same applies to those entrusted with developing science policy.
Some people fear that patients' rights and interests may be sacrificed in the rush to obtain intellectual property. Blood samples taken for one test may be subsequently used to obtain DNA for other purposes not consented to by the patient. Pharmaceutical companies are rapidly accumulating genetic data and DNA specimens to study the genetic basis for individual patient responses to drugs, both old and new. Researchers hype the potential of their discoveries so as to inflate share valuations of companies in which they have stakes.

The result is a public overloaded with information and dependent on experts who might have conflicts of interest. In part, public trust can be addressed through appropriate policies and procedures on conflicts of interest in public institutions such as universities. However, at a societal level, the issue of public trust in biotechnology also needs to be addressed directly.

2.2.2. Public Trust of Biotechnology: Engaging the Public

A number of recent events have pitted members of the public and some special interest groups against major biotechnology companies. This is especially so with regards to genetically modified (GM) food products. In Europe, this emerged against a background of "mad cow disease" where the public felt let down by regulators who had failed to identify the connection between variant Creutzfeld Jacob disease and the consumption of beef. GM foods were decried by prominent people like Prince Charles and banned from being served in the British Houses of Parliament. Demonstrations against farmers growing experimental fields and supermarkets carrying GM foods have been common in the west, and have fuelled the controversy.

In the United States, it seemed that regulators were convinced early on of the safety of GM crops, and allowed their introduction and export without labeling, arguing that such genetic modifications were similar to selective breeding in the "natural" way. Biotechnology companies did little to consult with or educate the public either in the US or in Europe. The ensuing backlash has had the effect of lowering share values of agricultural biotechnology companies; supermarkets are refusing to stock GM foods, and many regulators are insisting that such foods be labeled.

Partly as a result of this experience, an interesting trend in is now emerging: the need to involve the public in policy decisions. This important development reflects a variety of changes that are shaping bioethics today:

- The rapid pace of development in science and technology: ethical guidelines cannot be developed quickly enough to keep up;
- The lack of public trust in scientists, corporations and regulators, partly due to the failure to safeguard the public against infected blood and, more recently, against "mad cow" disease in Europe;
- The poor ability of institutions to educate the public on complex scientific issues without obfuscating or patronizing the public;
- Increasing democratization and demands for accountability and transparency;
- Weakening of political control;
- Rapid increase in availability of information, especially through the Internet;
- Development of technology for which there is little precedent in its own terms and in terms of its ethical use;
- The lack of coherence within the bioethical establishment itself in terms of having strong foundational values accepted by all;
- The technical complexity of the issues;
- The appearance of technology that is seen as "unnatural" or brought about by "playing God";
- Globalization of economies, in which policy decisions in one country have implications for many other countries;
- Vocal, well-organized, protest groups;
- An increasing public recognition of the impact of our actions on the environment;
- An enhanced appreciation of humankind existing with other creatures in one "biosphere".

These factors have resulted in two primary outcomes: a public that has become empowered to demand consultation, and policymakers who are reluctant to make risky decisions – including those that may have been acceptable in the past –without public consultation.

For bureaucrats, seeking to involve the public has been a way of coping with their diminished credibility. Thus far, it has rarely been more than paying lip service, and as a result no effective methods of real consultation have emerged. In Switzerland, for example, the 1998 referendum was valuable in educating the public on the issues related to biotechnology, but the outcome in favor of biotechnology was believed to have been influenced more by fears that major Swiss biotechnology companies would move abroad than by any meaningful calculation of the risks and benefits of biotechnology. As isolated events, these population-based polls are unlikely to become an effective method of public consultation. Numerous innovative methods of public engagement stop short of national referenda. These include theatrical productions, philosophy cafes, consensus conferences, deliberative polling, citizens' juries, citizens' advisory committees, global panels of public opinion leaders, and internet based real time public opinion surveys. The need to engage the public on xenotrasplantation, for instance, has led to a web-based WHO electronic discussion group. Canada is about to launch a large-scale public engagement exercise spearheaded by Health Canada's regulatory body before it decides its xenotransplant policy.

In addition to public consultation, there is a need for dialogue among different constituencies. Academics, industries, the public, the media and applied ethicists must collectively identify issues, plan an agenda for vigorous in-depth studies of those issues, engage in transparent discussion of the results of the research in a truth-seeking, non-confrontational way, and reach consensus in the development of guidelines.

If this is done well, the guidelines will be clear, understood by all and, more importantly, supported by all stakeholders. The current confrontational methods have not served the public well. Attempts by industry public relations officers to provide more and more information to a distrusting public have also been ineffective. In this context, bioethicists can have an important function: to bring their specialized knowledge and analytical skills to clarify and facilitate, rather than simplistically to preach or propound on what is right or wrong in their opinion.

An interesting recent phenomenon, likely to become more common as biotechnology issues become more complex, is that bioethicists are being held legally responsible for their advice. The parents of a teenager who died as a result of a gene therapy experiment have recently sued a prominent bioethicist from a well-known US university. The bioethicist had advised the scientist-clinicians who performed the procedure.

2.2.3. Increasing Complexity of Issues Necessitates a Global Dialogue

With the introduction of powerful new biotechnologies, including what is foreseen from the Human Genome Project and from agricultural biotechnology, we will be challenged as never before to assess risks and benefits without complete information or knowledge. The phenomenal growth, understanding and manipulation of human, animal and plant genetics will likely become the overriding bioethical concerns of the early part of this new millennium. Ronald Dworkin has observed that "genetic science threatens to dislocate the boundary between chance and choice, which is the spine of our morality."

Now that the first draft of the mapping and sequencing of the human genome has been completed, the next phase of this enormous scientific enterprise will focus on functional genomics. Proteomics, stem cell technology and tissue engineering will become exciting areas of research; as these technologies come closer to patient care, public concern will heighten and the number of bioethical issues for study will increase dramatically.

The two most important challenges today may well be to increase public knowledge of biotechnology and to make the dialogue between stakeholders more inclusive. Those most in need of the new technologies should have input in the decisions about whether or not to introduce them. This is particularly important for those technologies that might impact millions of people worldwide, rather than a few individuals. The West, particularly Europe, has recently witnessed a public outcry against GM foods. Laudable as these concerns may be, the hungry have not had a voice in shaping this important debate. Most of the outcry has been in developed countries, which on the whole probably have no great need of the new food technologies such as “golden rice”, genetically engineered to contain pro-vitamin A, which is likely to help large numbers of people in developing countries whose eyesight and nutritional status is endangered by lack of Vitamin A. Similarly, rice enriched with iron could solve one of the biggest nutritional problems in the developing world. Consider, as an example, the following comment from someone familiar with the problems of the poorer countries:

“If I have to sacrifice larvae of the monarch butterfly in order to save children from blindness or women from anemia, I would regret the sacrifice and do as much as I can to minimize the damage, but in the end I would not hesitate to do it. Why do I mention this example? Because the Federal Institute of Technology in Zurich informed the world in March 1999 of a sensational achievement. It became possible to genetically modify rice so that it contains vitamin A and iron. This is, of course, of immense benefit to 250 million poor, malnourished people who are forced to subsist on rice.”

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Biographical Sketches

Dr. Daar is professor of surgery, Sultan Qaboos University, Sultanate of Oman, and Hunterian Professor of the Royal College of Surgeons of England. After graduating from medical school in London, he undertook postgraduate studies at Oxford University, where he obtained a doctorate degree in immunology/immuno-genetics and trained in surgery, medicine and organ transplantation. He went to the Middle East to help establish medical schools in the United Arab Emirates and Oman. Work in transplantation led to an interest in ethics. He was a member of the World Health Organization Task Force on Organ Transplantation, chaired the WHO Consultation on Xenotransplantation in 1997 and is on the ethics committee of the International Transplantation Society and of the Human Genome Organization. He is a fellow of the New York Academy of Sciences. Dr. Daar has published a book on tumor markers and another on x-rays of the abdomen; and has published over 200 papers and chapters on surgery, transplantation, immunology, and bioethics. He is on the Editorial Board of the journal *Bioethics.*

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