Health and Biotechnology

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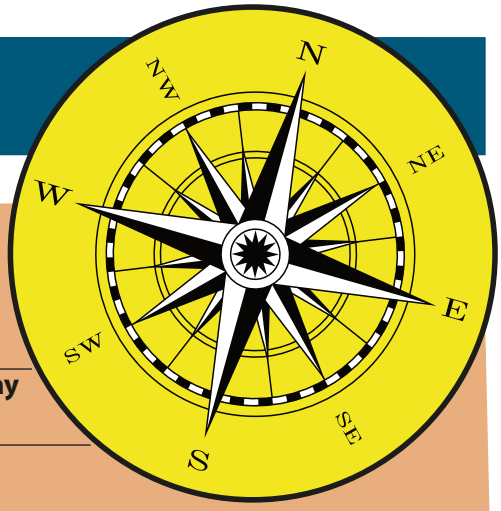
Introduction

Biotechnology is actually an ancient example of humanity using tools, ingenuity, craft, and naturally occurring organisms to make changes to things. It includes processes like using the fermentation process to turn certain fruit juices into wine or hops and malted barley into beer, or the process of turning mammalian milk into curd, yogurt, or cheeses. Humans were using biotechnology long before it was recognized as a scientific practice.

These days the term *biotech* brings up a host of new options to consider. We now think of the genetic alteration of foods, such as altering cereal grains to make their growth resistant to diseases and insects, controlling functions of the cell in order to get bacteria to mass-produce antibiotics, and inserting a specific gene into an organism's DNA in order to get specific products for human use. In addition, many see biotech one day being used to feed the growing population of Earth more efficiently, or to develop "nutriceuticals" that will improve human nutrition in the foods we consume.

In contrast to these hopeful promises, many people worry about the biotech industry because they find it difficult to trust a scientific pursuit that is difficult to understand and seems to be full of very technical unknowns. People are often quick to reject the idea of "tampering" with nature. Even before Mary Shelley penned *Frankenstein, or the Modern Prometheus*, humanity has considered and reconsidered its ability to show foresight in its quest to understand, control, and then alter natural systems. The field of biotechnology is a wide one, but most Canadians will connect with its applications in agriculture, pharmaceutical production, and the emerging group of products we call nutriceuticals.



Exploring the Issues

What are some of the complex issues being dealt with today in the field of biotechnology?

- Science, technology, and human health
- Economic implications of health care
- Controversial genetic research (embryonic and stem cell research, animal testing, patenting DNA, genetic intervention and modification, preservation of genetic material, genetic information privacy)
- Longevity and life preservation measures
- Controversial interventions (euthanasia, abortion)
- Medical interventions (plastic surgery, in vitro fertilization)
- Epidemic and pandemic prevention and response
- Disease control (AIDS, virus control, immunization)
- Birth control and maternal and child care
- Pharmaceutical industry (Big Pharma, marketing, testing, control)
- Food and drug management and testing
- Alternative health practices, safety, control and marketing, etc.

Biotechnology and its Relationship to Sustainability:

Since biotechnology seeks to improve the human condition by harnessing living mechanisms, its applications to the principles of sustainability probably provide the best place to debate what we are doing, why we are doing it, what the future may hold, and a variety of other perspectives. Since biotech practices are already common worldwide—and this has been so for centuries—it does not make a lot of sense to simply state that the practices are wrong, immoral, unethical, or dangerous. This does not mean that humanity should be fully accepting of any and all biotech practices without openly debating the costs, implications, and potential effects of introducing our own desires on natural systems.

Essential Questions

As there are a multitude of perspectives in the field of biotechnology, we will want to encourage critical inquiry, investigation, historical thinking, and thoughtful discussions. Some of the questions below can guide inquiry into biotechnology issues.

Essential Questions Related to Media Issues

- How is biotechnology used in the agriculture and foods industries?
- How can we be sure that biotechnology practices are safe?
- Are genetically modified organisms an example of "parallel evolution" of species? What might the implications be?
- How might the Human Genome Project's results affect things such as reproductive technologies in animals? ...in human populations?
- Who regulates the biotech industry in Canada? ...internationally?
- Biotechnology tends to focus its knowledge and product claims on increasing the efficiency of nutritious food production, pharmaceuticals, and the industrial-scale production of "needed" compounds. Who makes the determination of what is deemed "beneficial" to humanity?
- What are the implications of a largely *anthropocentric view* of the world's needs that can be serviced by biotechnological means?

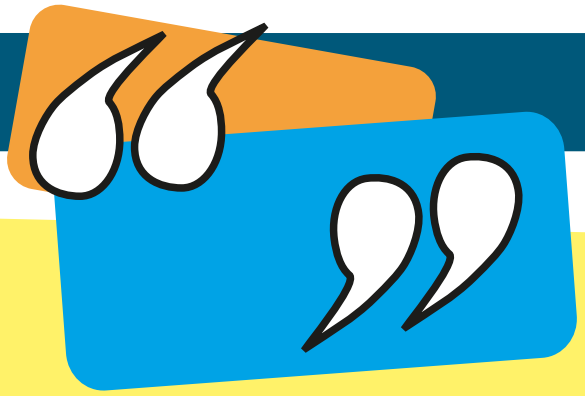
Current Issues in Biotechnology

- Genetic modification of organisms to suit human needs
- Biological systems as "factories" that mass-produce certain compounds
- Cloning of animals for desired traits
- Gene patents: The genome as property (intellectual property rights)
- The role of governments and the people in biotechnology regulation
- Ethical issues surrounding genetic manipulation of organisms

Did you know this about biotechnology?

- At the end of the First World War, there were food and resource shortages and people were searching for an industrial solution to the problem. Karl Ereky coined the term *biotechnology* in Hungary in 1919 to describe a technology based on converting raw materials into useful products. He built a slaughterhouse for a thousand pigs and also a fattening farm with space for 50,000 pigs, allowing him to raise over 100,000 pigs a year. The enterprise was enormous, becoming one of the largest and most profitable meat and fat operations in the world. In a book entitled *Biotechnologie*, Ereky stated his belief that biotechnology could solve societal crises such as food and energy shortages. For Ereky, the term biotechnologie described the process of turning raw materials into socially useful products.
- This new catchword spread quickly after the First World War, as the term biotechnology entered German dictionaries and was taken up abroad by private businesses as far away as the United States. In Chicago, for example, the prohibition of the open sale of alcoholic beverages at the end of the First World War encouraged biological industries to create opportunities for new fermentation products—in particular, a market for non-alcoholic drinks. Emil Siebel, the son of the founder of the Zymotechnic Institute, broke away from his father's company to establish his own company called the Bureau of Biotechnology, which specifically offered expertise in fermented non-alcoholic drinks. (Wikipedia)
- The following word collage contains a number of terms that come from the biotech lexicon. Students may want to select from among these, conduct a bit of research into the term, and expand on the collage.


Nanomedicine
Gene
Misc
Blogs
Proteomics
Biotechnology
Therapy
Ecology
Energy
Agriculture
Methodologies
News
Therapeutics
Food
Rights
Drugs
Property
Meetings
Microbiology
Science
Patents
Bioinformatics
Diagnostics
Biotech
Vaccines
Genomics
Hubs
Information
Intellectual
Environment
Stem
Facilities
know
Cells
Corporate
Events
Industrial



Thought-Provoking Quotations

"The cloning of humans is on most of the lists of things to worry about from science, along with behaviour control, genetic engineering, transplanted heads, computer poetry, and the unrestrained growth of plastic flowers."

– Lewis Thomas

"Biotechnology is creating a new industrial revolution based on biology instead of petroleum. As biotech processes replace old rust-belt technologies, they are enabling a transformation from a petroleum-based economy to a biologically based economy."

– Brent Erickson (Gupta et al., xiv)

"Biotech crops are not a solution to solve hunger in Africa or elsewhere."

– Nnimmo Bassey (Mail & Guardian)

"The first century of the new Millennium will belong…to biotechnology, which will bring unprecedented advances in human and animal health, agriculture and food production, manufacturing, and sustainable environmental management."

– Ben Ngubane (Pendarvis et al.)

"We have the means right now to live long enough to live forever. Existing knowledge can be aggressively applied to dramatically slow down aging processes so we can still be in vital health when the more radical life-extending therapies from biotechnology and nanotechnology become available. But most baby boomers won't make it because they are unaware of the accelerating aging process in their bodies and the opportunity to intervene."

– Ray Kurzweil

"A disquieting era of genetic manipulation is coming, one that may revolutionize human capacities, and notions of health. If we treat moral scruples impatiently, as inherently retrograde in a scientifically advancing civilization, we will not be in good moral condition when, soon, our very humanity depends on our being in condition."

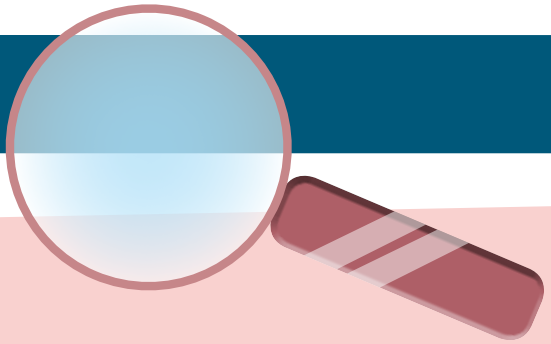
– George Will

"The advance of genetic engineering makes it quite conceivable that we will begin to design our own evolutionary progress."

– Isaac Asimov (Hodge)

"You cannot go on 'explaining away' forever: you will find that you have explained explanation itself away. You cannot go on 'seeing through' things forever. The whole point of seeing through something is to see something through it."

– C.S. Lewis



Glossary

Bio-based products:
Fuels, chemicals, building materials, or electric power or heat produced from biological material(s). The term may include any energy, commercial, or industrial products, other than food or feed, that use biological products or renewable domestic agricultural (plant, animal, and marine) or forestry materials. (USDS)

Biological boundaries:
A concept that differentiates one organism from another and suggests that organisms cannot or should not exchange genetic material. An alternative concept is that genes are defined not by the organism from which they came, but by their function. As scientists have identified genes in seemingly non-related organisms such as plants and humans, they have found identical genes in each. (USDS)

Biopharming:
The production of biopharmaceuticals in plants or domestic animals.

Biotechnology:
A set of biological techniques developed through basic research and now applied to research and product development. Biotechnology refers to the use of recombinant DNA, cell fusion, and new bio-processing techniques. (USDS)

Biotechnology-derived:
The use of molecular biology and/or recombinant DNA technology, or in vitro gene transfer, to develop products or to impart specific capabilities in plants or other living organisms. (USDS)

Bovine spongiform encephalopathy (BSE):
A disease of cattle, related to scrapie of sheep, also known as "mad cow disease." It is hypothesized to be caused by a prion, or small protein, which alters the structure of a normal brain protein, resulting in destruction of brain neural tissue.

Bt corn:
A corn plant that has been developed though biotechnology so that the plant tissues express a protein derived from a bacterium, Bacillus thuringiensis, which is toxic to some insects but non-toxic to humans and other mammals. (USDS)

Cell:
The lowest organizational level of life thought to be possible. Most organisms consist of more than one cell, which becomes specialized into particular functions to enable the whole organism to function properly. Cells contain DNA and many other elements to enable the cell to function. (USDS)

Chromosomes:
The self-replicating genetic structure of cells containing the cellular DNA. Humans have 23 pairs of chromosomes. (USDS)

Creutzfeldt-Jakob Disease (CJD):
A disease of humans hypothesized to be caused by a prion, or a small protein, which alters the structure of a normal brain protein, resulting in destruction of brain neural tissue. The most common form is thought to have genetic origins. There is strong epidemiologic and laboratory evidence for a causal association between new variant CJD and BSE.

Cultivar:
Synonymous with variety; the international equivalent of variety. (USDS)

Double helix:
The twisted-ladder shape that two linear strands of DNA assume when complementary nucleotides on opposing strands bond together. (USDS)

DNA (deoxyribonucleic acid):
The genetic material of all cells and many viruses. DNA is a double-stranded molecule that encodes genetic information. It is held together by weak bonds between base pairs of nucleotides. The four nucleotides in DNA contain the bases adenine (A), guanine (G), cytosine (C), and thymine (T). In nature, base pairs form only between A and T and between G and C; thus, the base sequence of each single strand can be deduced from that of its partner. (USDS)

Embryonic stem (ES) cells:
Cell lines derived from early embryos that have the potential to differentiate into all types of somatic cells as well as to form germ line cells, and hence whole animals, when injected into early embryos.

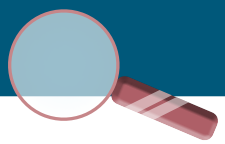
Enucleated oocyte (cytoplast):
An egg cell from which the nucleus has been removed mechanically.

Eukaryote:
Organism whose cells have (1) chromosomes with nucleosomal structure and are separated from the cytoplasm by a two-membrane nuclear envelope, and (2) compartmentalization of functions in distinct cytoplasmic organelles. Contrast prokaryotes (bacteria and cyanobacteria). (USDS)

Feral:
Refers to an individual or population that has returned to the wild after a history of domestication.

Fibroblast:
A type of relatively undifferentiated cell found in many parts of the body that is involved primarily in healing wounds. Fibroblasts are relatively easy to grow in cell culture and often are used for this purpose.

Gene:
The fundamental physical and functional unit of heredity. A gene is an ordered sequence of nucleotides located in a particular position on a particular chromosome that encodes a specific functional product (such as a protein or RNA molecule). (USDS)



Gene gun:
A device invented at Cornell University that allows genetic material to be introduced into a new organism. The genetic material from the donor is "shot" into cells of the recipient, and the material is incorporated into its DNA. (USDS)

Gene splicing:
The isolation of a gene from one organism and then the introduction of that gene into another organism using techniques of biotechnology. (USDS)

Genetic engineering:
The technique of removing, modifying, or adding genes to a DNA molecule to change the information it contains. By changing this information, genetic engineering changes the type or amount of proteins an organism is capable of producing, thus enabling it to make new substances or perform new functions. (USDS)

Genetically modified organism (GMO):
Often, the label GMO and the term transgenic are used to refer to organisms that have acquired novel genes from other organisms by laboratory "gene transfer" methods. (USDS)

Genetics:
The study of the patterns of inheritance of specific traits. (USDS)

Genome:
All the genetic material in the chromosomes of a particular organism; its size is generally given as its total number of base pairs. (USDS)

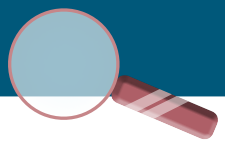
Genomics:
The mapping and sequencing of all the genetic material in the DNA of a particular organism, as well as the use of information derived from genome sequence data to further elucidate what genes do, how they are controlled, and how they work together.

Genotype:
The genetic identity of an individual. Genotype often is evident by outward characteristics. (USDS)

Herbicide-tolerant crop:
Crop plants that have been developed to survive application(s) of one or more commercially available herbicides by the incorporation of certain gene(s) via biotechnology methods such as genetic engineering or traditional breeding methods (such as natural, chemical, or radiation mutation). (USDS)

Hybrid:
Seed or plants produced as the result of controlled cross-pollination as opposed to seed produced as the result of natural pollination. Hybrid seeds are selected to have higher quality traits (for example, yield or pest tolerance). (USDS)

Labelling of Foods:
The process of developing a list of ingredients that are contained in foods. Labels imply that the list of ingredients can be verified. The federal Department of Consumer and Corporate Affairs has jurisdiction over what is stated on food labels in Canada. (USDS)



Microinjection:
The introduction of DNA into the nucleus of an oocyte, embryo, or other cell by injection through a very fine needle. (NRC)

Molecular biology:
A general term referring to the study of the structure and function of proteins and nucleic acids in biological systems.

Mutation:
Any inheritable change in DNA sequence. (USDS)

Mutation breeding:
Commonly used practices in plant breeding and other areas in which chemicals or radiation are applied to whole organisms (for example, plants or cells) so that changes in the organism's DNA will occur. Such changes are then evaluated for their beneficial effects, such as disease resistance.

Nuclear reprogramming:
Restoration of the correct embryonic pattern of gene expression in a nucleus derived from a somatic cell and introduced into an oocyte.

Organic agriculture:
A concept and practice of agricultural production that focuses on production without the use of synthetic pesticides.

Pesticide resistance:
A genetic change in response to selection by a pesticide, resulting in the development of strains capable of surviving a dose lethal to most individuals in a normal population. Resistance may develop in insects, weeds, or pathogens.

Prion-related protein (PrP):
A normal protein, expressed in the nervous system of animals, whose structure when altered (by interaction with altered copies of itself) is the cause of scrapie in sheep, BSE in cattle, and Creutzfeldt-Jakob disease in humans.

Protein:
A large molecule composed of one or more chains of amino acids in a specific order. The order is determined by the base sequence of nucleotides in the gene that codes for the protein. Proteins are required for the structure, function, and regulation of the body's cells, tissues, and organs, and each protein has unique functions. Examples are hormones, enzymes, and antibodies.

Recombinant DNA technology:
A procedure used to join together DNA segments in a cell-free system (an environment outside a cell or organism). Under appropriate conditions, a recombinant DNA molecule can enter a cell and replicate there, either autonomously or after it has become integrated into a cellular chromosome. (NRC)

Selective breeding:
Making deliberate crosses or matings of organisms so the offspring will have a desired characteristic derived from one of the parents.

Tissue culture:
A process of growing a plant in a laboratory from cells rather than seeds. This technique is used in traditional plant breeding as well as when using agricultural biotechnology techniques.

Transgenic:
Containing genes altered by the insertion of DNA from an unrelated organism. Taking genes from one species and inserting them into another species to get that trait expressed in the offspring.

Vector:
A type of DNA, such as a plasmid or phage, that is self-replicating and that can be used to transfer DNA segments among host cells. Also, it is an insect or other organism that provides a means of dispersal for a disease or parasite. (NRC)

Xenotransplantation:
Transplantation of cells, tissues, or organs from one species to another. (NRC)

Zygote:
A fertilized oocyte (egg cell). (NRC)

Glossary definitions were adapted from the following resources (as cited) under the terms for a work of the United States government, as defined by the United States copyright law, under section 105 of the *Copyright Act*.

U.S. Department of State (USDS). *Economic Perspectives: An Economic Journal of the U.S. Department of State* 8.3 (September 2003): 36–38.

National Research Council (U.S.) Committee on Identifying and Assessing Unintended Effects of Genetically Engineered Foods on Human Health (NRC). *Safety of Genetically Engineered Foods: Approaches to Assessing Unintended Health Effects*. Washington, DC: National Academies Press, 2004. Available online at https://www.ncbi.nlm.nih.gov/books/NBK215779/

Resources

Print

Biotechnology for Beginners

Renneberg, Reinhard. *Biotechnology for Beginners*. Arnold L. Demain (ed.). Burlington, MA: Academic Press, 2006.

This book will appeal to readers without a scientific background but who are interested in an entertaining and informative introduction to the key aspects of biotechnology. It discusses the opportunities and risks of individual technologies and provides historical data in easy-to-reference boxes, highlighting key topics. *Biotechnology for Beginners* covers all major aspects of the field, from food biotechnology to enzymes, genetic engineering, viruses, antibodies, and vaccines, to environmental biotechnology, transgenic animals, analytical biotechnology, and the human genome. It also includes articles from influential scientists such as Alan Guttmacher, Carl Djerassi, Frances S. Ligler, Jared Diamond, Susan Greenfield. Each chapter concludes with a summary, annotated references, links to useful websites, and appealing review questions.

Introduction to Biotechnology

Pathak, Ravi. *Introduction to Biotechnology*. New Delhi, IN: Atlantic Publishers, 2006.

This book describes in detail the processes and methods used to manipulate living organisms, or the substances and products from these organisms, for medical, agricultural, and industrial purposes. It acquaints the reader with genetic engineering, bioinformatics, animal and plant biotechnology, environmental biotechnology, bio-ethics, and bio-safety.

Introduction to Biotechnology: An Agricultural Revolution

Herren, Ray V. *Introduction to Biotechnology: An Agricultural Revolution*. Clifton Park, NY: Delmar Cengage Learning, 2012.

This book provides a basic understanding of the concepts that contribute to agriculture's biotechnology revolution. Each chapter of this comprehensive text includes topics such as cell functions, genetics and genetic engineering, the uses of biotechnology, and biotech careers. Also included is a thorough examination of the controversy and concerns over the use of genetic engineering, genetically modified organisms, and cloning, as well as their potential dangers to humans and the environment. This information enables the reader to engage and utilize the text's science-based content in classroom discussions and research activities.

Science and Religion: Understanding the Issues

Morvillo, Nancy. *Science and Religion: Understanding the Issues*. New York, NY: Wiley-Blackwell, 2010.

From the heliocentric controversy and evolution, to debates on biotechnology and the environment, this book offers a balanced introduction to the key issues in science and religion. This book spans the interface between science and religion, and includes illustrations of scientific concepts throughout. It explores key historical issues, including the heliocentric controversy and evolution, but also covers topics of current importance such as biotechnology and environmental issues. It is structured in to sections covering cosmology, evolution, and ethics in a scientific age.

Articles

Towards a global code of ethics for modern foods and agricultural biotechnology

Gesche, Astrid H., Alexander Haslberger, and RoseEmma Mamaa Entsua-Mensah. "Towards a global code of ethics for modern foods and agricultural biotechnology" (2004). In *Science, Ethics and Technology: Conference Proceedings*. J. de Tavernier and S. Aerts (eds.). Leuven, Belgium: EURSAFFE 2004, 5th Congress of the European Society for Agricultural and Foods Ethics. Catholic University of Leuven, pp. 125–128. See http://eprints.qut.edu.au/6569/

Online

Global Issues: Social, Political, Economic and Environmental Issues that Affect Us All.

www.globalissues.org/issue

Here you will find food and agriculture issues such as genetically-modified foods)

Council for Biotechnology Information.

www.whybiotech.com/?p=1636 (A generally very pro-biotech feed, with a concentration on issues related to agriculture and sustainability)

About.com Biology

http://biology.about.com/library/bldyknowbiotech.htm

This site provides background on dozens of current trends and areas of research that are driving the biotech enterprise right now.

Biology Online:

www.biology- online.org/kb/biology_articles/biotechnology.html

BIOTECanada:

Self-described as "Canada's voice for biotechnology"

www.biotech.ca/en/default.aspx

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