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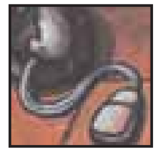

Web Review

Entering the Genomic Era: Websites for the Biotech Century

Mike Moralis

Society is rapidly moving into the post-genomic era, yet many people remain unaware of the fact that they had entered the genomic era, the prelude to the so-called biotech century. Biotechnology encompasses the convergence of several fields, from genetics and molecular biology to information technology. This has profound implications for the future, particularly for agriculture and the life sciences. Functional genomics and proteomics, two terms that fall under the umbrella of biotechnology, are described by politicians as economic engines for the 21st Century.

Proteomics is a term coined in 1995 by Marc Wilkins, then a post-doctoral student in Australia, to describe an organism's total protein complement. The term is derived from "proteome," which refers to the protein complement expressed by a genome. As Wilkins explains, an organism's genome is essentially static and well-defined, while the proteome "changes continually in response to internal and external events."

Armed with knowledge about genes and proteins, scientists can synthetically produce vaccines, hormones and other substances. Relatively new techniques for manipulating genetic material – cutting and splicing DNA, cloning genetic material – have become the foundation for the biotechnology revolution, buttressed by databanks and libraries of genetic information under the label of bioinformatics.

New technologies such as DNA chips, which can "read" genetic material grown on a silicon chip, can confirm the presence of genetic traits that increase a person's health risks, or the presence of disease. This technology is already transforming the laboratory testing industry. And, disease treatment seems likely to shift to from the shotgun approach of contemporary pharmaceuticals to targeted genetic therapy based on the knowledge of an individual's genetic makeup.

The process of drug discovery and development is also being transformed. Researchers are rushing to clone animals, from transgenic mice with human genes for lab research, to Dolly the sheep. In January of this year, researchers in Oregon announced that they had cloned a rhesus monkey, using a different technique from the one used to create Dolly. This opens the door for lines of genetically-engineered primates for research purposes. Cloned, transgenic animals may soon be bred to produce pharmaceutical products, or organs that can be transplanted into humans.

In December 1999, an international team of researchers announced that they had achieved a milestone by sequencing the entire genetic code of human chromosome 22, making it the first of 23 human chromosome pairs to be fully mapped. The chromosome is associated with the immune system, congenital heart disease, schizophrenia, birth defects and several kinds of cancer.

Biotechnology is rapidly transforming both agriculture and medicine. Despite rising concern on the part of the public, genetically modified crops have been designed to have increased yields, resist pests, withstand shipping and transportation, and have enhanced flavour. At the same time, genetic engineering has already produced pharmaceutical products including human insulin, interferon, cancer drugs, antibiotics and vaccines. The debate about more sophisticated medical applications like cloning humans has barely begun.

1. The Human Genome Organization

www.gene.ucl.ac.uk/hugo/

The Human Genome Organization (HUGO), created in the late 1980s, was conceived as an international coordinating body for the Human Genome Project. It is incorporated in Switzerland, and consists of more than 1,000 members, mainly scientists and researchers working on the Human Genome Project in over 50 countries. As a result, the HUGO web site covers a combination of organizational concerns (committees and meetings) and technical information, such as a list of "Individual Human Chromosome Mapping Workshop Report Citations," as published in the journal *Cytogenetics and Cell Genetics.*

2. National Center for Biotechnology Information
www.ncbi.nlm.nih.gov

The National Center for Biotechnology Information (NCBI) was established in 1988 in the United States to serve as a national resource for information about molecular biology.

3. National Human Genome Research Institute
www.nhgri.nih.gov

The National Human Genome Research Institute (NHGRI) was created in 1989, and was originally known as the National Center for Human Genome Research. It is one of the 24 organizations that make up the National Institutes of Health (NIH). The site includes a comprehensive glossary of terminology related to genetics.

4. BioSpace.com
www.biospace.com

BioSpace.com is a life sciences hub site launched in 1995. Since then, it has earned acclaim and awards, particularly in the past year. The site compiles breaking news from more than 375 different sources on an ongoing basis. It also includes a virtual career centre, and offers a business-to-business e-commerce solution listing more than one million products. The e-commerce solution prompted the National Institutes of Health to join BioSpace.com in a strategic alliance to integrate procurement card-based purchasing and electronic settlement between purchasers and providers.

5. Canadian Genetic Diseases Network
www.cgdn.generes.ca

The Canadian Genetic Diseases Network (CGDN) is a nation-wide consortium of leading human genetics researchers, funded through the federal Networks of Centres for Excellence (NCE) program. The site includes a map of 15 "core technology facilities" across the country that make up the network, as well as research projects listed by city, by researcher and by field of investigation. In a limited way, it also covers some early-stage attempts to commercialize research conducted under the auspices of the network. The resource directory includes a list of researchers willing to act as guest speakers on genetic disease research. The web site includes a list of suggested reading material that should be updated; in fact the site's major flaw is its unfulfilled potential. Despite that, it captures some of the world-class achievements of Canadian researchers during the 1990s.

6. Canadian Biotechnology Strategy
www.strategis.ic.gc.ca/SSG/bh00127e .html

The Canadian Biotechnology Strategy is an outgrowth of the federal government's 1983 National Biotechnology Strategy. A renewal strategy, involving several departments of the federal government including Health Canada, Industry Canada and Agriculture and Agri-Food Canada, was approved and announced in the summer of 1998. Its vision is to "enhance the quality of life of Canadians in terms of health, safety, the environment and social and economic development by positioning Canada as a responsible world leader in biotechnology." Information about the strategy, including the Sixth Report of the National Biotechnology Advisory Committee, entitled *Leading in the Next Millennium*, and subsequent public consultations can be found on Industry Canada's Strategis web site: http://strategis.ic.gc.ca /SSG/bh00127e.html.

7. Canadian Biotechnology Advisory Council
http://cbac.gc.ca.

In September, 1999 the federal government announced the creation of the Canadian Biotechnology Advisory Committee (CBAC), an independent arms' length advisory group chaired by Dr. Arnold Naimark. The CBAC held its inaugural meeting in October, and established three standing sub-committees. One will monitor scientific developments related to biotechnology; the second will focus on social, legal and ethical dimensions of biotechnology; and the third will develop strategies to engage the public in "meaningful

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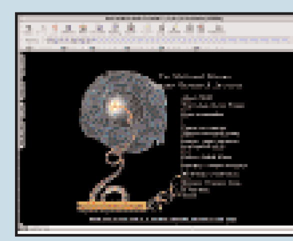

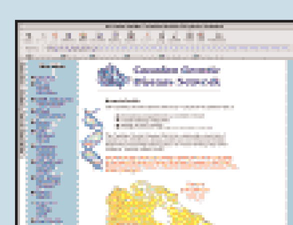

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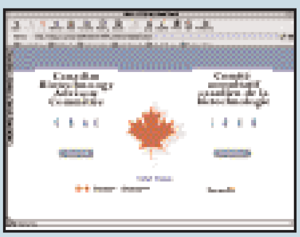

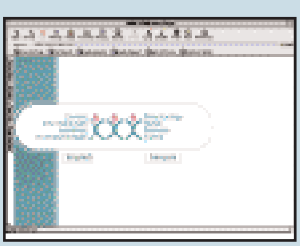

discussion of advances in biotechnology." The CBAC has its own web site: http://cbac.gc.ca.

8. BIOTECanada
www.biotech.ca

BIOTECanada is a fee-based association that strives to represent the "full breadth of the Canadian biotechnology community" with a unified voice addressing advocacy, human resources and communications, as well as providing services to more than 100 members. It works in partnership with regional biotechnology organizations, The organization offers services such as subscriptions to a newsletter, *Vector*, available by fax or e-mail, and a range of other publications including a report, entitled *Canadian Biotechnology '98: Success From Excellence*, based on a survey conducted by Statistics Canada in conjunction with Industry Canada, Agriculture and Agri-Food Canada, Ernst & Young, KPMG and Contact Canada. The executive summary is available on-line. BIOTECanada will also provide information and consulting on a fee-for-service basis. The web site includes a members-only area, as well as extensive links to its members and other biotechnology-related organizations.

9. Biotechnology Human Resource Council
www.bhrc.ca

The Biotechnology Human Resource Council is a partnership established in 1997 between government and industry, through Human Resources Development Canada (HRDC), BIOTECanada, and the biotechnology industry as a whole.

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Understanding the Technology

A genome consists of the total genetic information that makes up an organism. The human genome has an estimated 100,000 to 150,000 genes, which consist of DNA arranged in the classic double helix structure discovered in 1953 by James Watson and Francis Crick. The mirror-image strands are sometimes termed coding and non-coding, or sense and anti-sense strands.

Each cell in an organism consists of a membrane that holds protein surrounding a nucleus containing DNA (deoxyribonucleic acid), which contains the organism's entire genetic blueprint. Human DNA, sometimes called the "book of life," consists of a series of 46 chromosomes..

DNA consists of chemical building blocks: sugar and phosphate, which make up the edges or rails of the helix, and an alphabet with four components: guanine, cytosine, thymine and adenine, organized in pairs – called base pairs – along the spiral of the helix. The base pairs are arranged or encoded in different sequences of varying lengths that make up specific genes.

A gene has a specific location on a chromosome, so genomics consists of sequencing or mapping chromosomes. The plan to map the entire human genetic structure, launched in the late 1980s, is called the Human Genome Project. Functional genomics involves identifying the relationship between gene sequences and cell function.

Scientists in more than 50 countries are collaborating on the project which should be completed within the next five years.