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ABSTRACT

This ERIC Digest identifies how the human genome project fits into the "National Science Education Standards" and lists Human Genome Project Web sites found on the World Wide Web. It is a resource companion to "Learning about the Human Genome. Part 1: Challenge to Science Educators" (Haury 2001). The Web resources and instructional materials can assist educators in meeting the challenges discussed in Part 1 and can serve as starting places in developing school instruction and public outreach programs. (YDS)

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ERIC Digest

Learning about the Human Genome Part 2: Resources for Science Educators

by

David L. Haury

U.S. DEPARTMENT OF EDUCATION
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Learning About the Human Genome

Part 2: Resources for Science Educators

David L. Haury

December 2001

DIGEST
EDO-SE-01-05

Clearinghouse for Science, Mathematics, and Environmental Education

This is a resource companion to *Learning About the Human Genome, Part 1: Challenge to Science Educators* (Haury, 2001). The resources identified below are provided to assist educators in meeting the challenges discussed in Part 1. An indication of the potential linkages between the HGP and the National Science Education Standards is included, along with Web resources and instructional materials that can serve as starting places in developing school instruction and public outreach programs

Linkages to the *National Science Education Standards*

Study of the HGP provides a unique opportunity to address many core science education standards in an integrated manner. The HGP itself depends on the integration of science, mathematics, computing, and other technologies, and the resulting knowledge relates to many of the unifying concepts and content areas of the national standards. The following broad areas of the *National Standards* seem particularly relevant in learning about the HGP:

- Each of the following concepts are integral to the activities and findings of the HGP

  K-12 Unifying concepts:
  Systems, order, and organization
  Evidence, models, and explanation
  Constancy, change, and measurement
  Evolution and equilibrium
  Form and function

- Involving students in HGP-related investigations will extend the traditional concept of inquiry to include the computational sciences and an understanding of the techniques and reasoning patterns associated with constructing genetic maps

  Science as Inquiry
  Abilities necessary to do scientific inquiry
  Understandings about scientific inquiry

- Many aspects of life science relate to the HGP, but concepts in the following areas seem most relevant:

  Life Science
  The cell
  Molecular basis of heredity
  Biological evolution

- One of the key opportunities in teaching and learning about the HGP is that it provides a rich context for studying problem solving and the relationships among the sciences and many technologies. As fields of biotechnology develop and assume more importance to our daily lives, it will become increasingly important to help students understand the connections between science and technology.

  Science and Technology
  Abilities of technological design
  Understandings about science and technology

- The findings of the HGP directly relate to personal and community health

  Science in Personal and Social Perspectives
  Personal and community health

- Study of the HGP provides a unique opportunity to examine a rapidly developing field of knowledge that is expanding our concept of scientific enterprise. As a human endeavor, the HGP also presents to society many decisions having serious ethical dimensions.

  History and Nature of Science
  Science as a human endeavor
  Nature of scientific knowledge
  Historical perspectives

HGP on the Web

Human Genome Project Information
http://www.ornl.gov/hgmis/
This is a gateway to a large array of resources related to the HGP. Following are pages of particular relevance to educators:

- Human Chromosome Launchpad
  http://www.ornl.gov/hgmis/launchpad/
- Human Genome Sequence Access Sites
  http://www.ornl.gov/hgmis/project/journals/sequencesites.html
- Learning About the Human Genome Project and Genetics Through the World Wide Web
  http://www.ornl.gov/hgmis/publicat/urllist.html
- Genomics and Its Impact on Medicine and Society: A 2001 Primer
  http://www.ornl.gov/hgmis/publicat/primer2001/index.html
- Genetics and Human Genome Project Images
  http://www.ornl.gov/hgmis/education/images.html

Functional Genomics (*Science*)
http://www.sciencemag.org/feature/plus/sfg/
News, articles, education section, many resources and links

A guide to online glossaries and dictionaries related to genomics and genetics
http://www.sciencemag.org/feature/plus/sfg/education/glossaries.shtml

Genome News Network
http://gnn.tigr.org/main.shtml
This online news magazine provides informed coverage of important developments in genomic research around the world. Added resources include the following primers: "What is a genome?" "Assembling the genome," and "Sequencing the genome."

Genetics and Ethics
http://www.ethics.ubc.ca/brynw/
A clearing house for information on the social, ethical and policy issues associated with genetic knowledge and technology; a wide range of views and perspectives is presented.

Cracking the Code of Life (NOVA Online)
http://www.pbs.org/wgbh/nova/genome/
The companion Web site to a 2-hour television special that chronicles the race to sequence the human genome. A wide

range of resources is provided, including a webcast of the original show.

The New Genetics: A Resource for Students and Teachers

http://www4.umdnj.edu/camlbweb/teachgen.html

Links to a wide variety of genetics education resources.

DNA Learning Center (Cold Spring Harbor Laboratory)

http://vector.cshl.org/

This website has numerous educational tools including *DNA From the Beginning*, an animated primer on the basics of DNA, genes, and heredity. Other resources include a multimedia guide to genetic disorders, a biology animation library, DNA-related databases and search tools designed for educational use, restriction maps and nucleotide sequences for a set of plasmids, and other resources for teaching and learning about DNA.

Exploring Our Molecular Selves Online Multimedia Educational Kit (National Human Genome Research Institute)

http://www.nhgri.nih.gov/educationkit/

The following high school level modules are available for downloading:

Milestones in Genetics: An interactive timeline presenting more than 90 key events in the history of genetics

Genes, Variation, and Human History: Two interactive classroom activities allow students to study the similarities and differences among individuals and among populations

How to Sequence a Genome: An animated, narrated presentation of the essential steps in sequencing an organism's genome

Ethical, Legal, and Social Implications: Seven case studies are presented with discussion questions

Exploring Our Molecular Selves: A 3D computer-animated video illustrating the basic components and principles of molecular biology.

Instructional Materials

BSCS has produced several comprehensive and modular programs in biology at all levels (http://www.bscs.org/cp.html). Following are selected inquiry-oriented modules relating to genetics and the HGP that are available online or in printed form upon request.

The Human Genome Project: Biology, Computers, and Privacy (1996)

http://www.bscs.org/cp_hs_mod_hgp.html

This high school module focuses on information technology as it relates to the HGP, and it provides teachers with background information on the construction and use of genetic databases. The seven activities involve students directly in the manipulation of hypothetical genomic data and consideration of concerns about the possible misuse of generalized and personal genomic data in healthcare, employment, and insurance.

Mapping and Sequencing the Human Genome: Science, Ethics, and Public Policy (1997)

http://www.bscs.org/cp_hs_mod_mhg.html

This high school module describes the history, organization, and funding of the HGP and provides teachers background information about the science and technology used in the HGP as well as the project's ethical and public policy dimensions. Four classroom activities give students experience working with a database of DNA sequences, analyzing the genetic contribution to human traits, assessing who should have access to genetic data, and using knowledge about our genetics to establish public policy.

The Puzzle of Inheritance: Genetics and the Methods of Science (1997)

http://www.bscs.org/cp_hs_mod_tpi.html

This high school module provides teachers with information about nontraditional inheritance , including genomic imprinting, genetic anticipation, mitochondrial inheritance, and uniparental disomy. The five activities go beyond the implications for personal, family, and public health to examine how these genetic mechanisms reinforce or challenge current thinking in biology, and how they illustrate the nature of science.

Genes, Environment, and Human Behavior (2000)

http://www.bscs.org/cp_hs_mod_gehb.html

This high school module explores how scientists investigate the genetics of human behavior, and includes background information on the methods and assumptions of behavioral genetics. Five classroom activities introduce students to the complex interactions of genetic, developmental, and environmental phenomena on human behaviors.

Bringing RNA Into View: RNA and its Roles in Biology (2000)
http://www.bscs.org/cp_co_mod_rna.html

This college module highlights the growing importance of RNA in research on biological catalysis, molecular self-replication and evolution, and health and disease. Background material is provided for the instructor, and five activities are included for undergraduate classes in general biology, cellular and molecular biology, or evolution.

Other Resources

Human Genetic Variation (1999)
NIH Curriculum Supplement (grades 9-12)

http://science-education.nih.gov/customers.nsf/HSGenetic

This module introduces students to the basics of human genetics, its potential to improve human health, and its application towards understanding human evolution. Five inquiry-oriented activities are correlated to the National Science Education Standards, and to several standard biology textbooks. The activities are also designed for use with the highly regarded 5E instructional model. Exploring the Human Genome

Your World/Our World, Volume 5, Issue 2

http://www.bio.org/library/yourworld/v5iss2.htm

Your World/Our World is a magazine of biotechnology fundamentals and applications in healthcare, agriculture, the environment, and industry, written for students in grades 7 through 10. This special issue includes articles on the Human Genome Project; Structure and Function of DNA; Genes, Proteins, and Genetic Disease; and others.

Reference

Haury, D. L. (2001). *Learning About the Human Genome, Part 1: Challenge to Science Educators* (ERIC Digest EDO-SE-04-01). Columbus, OH: ERIC Clearinghouse for Science, Mathematics, and Environmental Education.

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