

passive treatment of scientific processes into an active experience that helps students develop an understanding and appreciation of the nature and methods of science. The module is being field tested in classrooms across the country. Evaluation data from the field test will guide final revision of the module prior to distribution.

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The Human Genome Project: Biology, Computers, and Privacy: Development of Educational Materials for High School Biology

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One of the challenges faced by the Human Genome Project (HGP) is to handle effectively the enormous quantities and types of data that emerge as a result of progress in the project. The informatics aspect of the HGP offers an excellent example of the interdependence of science and technology. In addition, the electronic storage of genomic information raises important questions of ethics and public policy, many revolving around privacy.

The Biological Sciences Curriculum Study (BSCS) addresses the scientific, technological, ethical, and policy aspects of genome informatics in the instructional program titled *The Human Genome Project: Biology, Computers, and Privacy*. The program, intended for use in high school and college biology, consists of software and a 150-page print module. The software includes two model databases: a research database housing anonymous data (map data, sequence data, and biological/clinical information) and a registry that attaches names of 52 fictitious individuals (three kindreds) to genomic data. Students manipulate the database software as they work through seven classroom inquiries described in the print material. Also included is 50 pages of background material for teachers.

An introductory activity lets students become familiar with the software and dramatically demonstrates the advantages of technology in analysis of sequence data. In activities 1 and 2, students use the database to construct pedigrees and make initial choices about privacy with regard to genetic tests for their fictitious person. Activity 3 expands genetic anticipation, and in activities 4 and 5, students deal in depth with decision-making, ethics, and public policy, revisiting their earlier decision about testing and data accessibility. A final extension activity shows how comparisons with genomic data can be used to test hypotheses about the biological relationships between individual humans and

about the evolutionary significance of DNA sequence similarities between different species.

External reviews and evaluation data from a field test involving 1,000 students in schools across the United States were used to guide final revision of the materials. BSCS will distribute the module free of charge to more than 10,000 high school and college biology teachers.

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Involvement of High School Students in Sequencing the Human Genome

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For the past two years, we have been developing a program that involves high school students in the excitement of genetic research by enabling them to participate in sequencing the human genome. This program provides high school teachers with the proper training, equipment, and support to lead their students through the exercise of sequencing small portions of DNA. The participating classrooms carry out two experimental modules, DNA synthesis (an introduction to DNA replication and the techniques used to study it) and DNA sequencing. Both of these experiments consist of three parts—synthesizing DNA fragments using Sequenase and a biotinlabeled primer, bench top electrophoresis using denaturing polyacrylamide gels, and colorimetric DNA detection that is specific for the biotinylated primer. Students analyze their sequencing data and enter it into a DNA assembly program. This year, in collaboration with Eric Lynch and Mary-Claire King from the Department of Genetics at the University of Washington, the students will be sequencing a region of chromosome 5q that may be involved in a form of hereditary deafness.

Students also consider the ethical, legal and social issues (ELSI) of genome research in a unit that explores the topic of presymptomatic testing for Huntington's disease (HD). This module was developed by Sharon Durfy and Robert Hansen from the Department of Medical History and Ethics at the University of Washington. It provides a scenario about a family that carries the HD allele, descriptions of the clinical and genetic aspects of the disorder, an exercise in drawing pedigrees and an autoradiograph showing the PCR assay used to detect HD. Students use an ethical decision-making model to decide whether, as a character from the scenario, they would be tested presymptomatically for the HD allele. Through this experience, they develop the skills to define ethical issues, ask and research the relevant questions about a particular topic and make justifiable ethical decisions.