BIOLOGY

The BioQUEST Curriculum and Learning Tools Development Project

John R. Jungck, James H. Stewart
Beloit College
Beloit, WI 53511
(608) 363-2012; e-mail: jungck@beloit.edu

DUE-9354813
FY 1994 $ 235,221
FY 1995 $ 161,719
Biology

This project provides the essential philosophies, tools, resources, support, and sharing networks that enable postsecondary biology faculty to examine, critique, and change their biology curricula. A variety of mechanisms is being employed, including the publication of a book and the hosting of three learning tools development workshops. The book is a multi-authored, collaborative work based on the BioQUEST 3Ps philosophy, with specific examples highlighting use of materials in the BioQUEST Library, use of the 3Ps in wet laboratories and field work and situations where computers are not necessary, and discussions of the specific issues related to development and implementation of open-ended, research experiences for students. The project also supports curricular reform and learning tools development through three summer workshops in three major areas of biology. Materials and information are being disseminated through the book, *BioQUEST Notes*, the BioQUEST Library, the Introducing BioQUEST Hypercard stacks, and at conference presentations and workshops. Materials are being field tested as part of the three-stage review process for publication in the BioQUEST Library and will be distributed through other publications such as journal articles and laboratory books, electronic networks, and the monthly consortium status reports.

Computer-Integrated Introductory Biology Lab

Steven W. Strand, Elma Gonzalez
University of California, Los Angeles
Los Angeles, CA 90095-1606
(310) 825-4321

DUE-9455447
FY 1995 $ 415,601
Biology

The Computer-Integrated Introductory Biology Lab (CIBL) project is a three-year development effort to combine an innovative format for undergraduate biology laboratories with a thematic, cross-curricular approach to content instruction that integrates biology, physics, chemistry, atmospheric sciences, and mathematics. The CIBL laboratory supports and extends hands-on "wet" laboratory experiences using computer-based multimedia (interactive video, graphic, sound, and simulations). This will transform the large Introductory Biology Laboratory class at UCLA from a "barrier course" to a "facilitator course" as part of a larger effort at UCLA to recruit and retain student enrollment in science, especially within minority groups whose members are underrepresented in scientific careers. The project will develop and publish eight laboratory modules. Students preparing to be science teachers will be involved with the design, testing and evaluation of the materials.

A New Model for Introductory Biology at Two-Year and Community Colleges

Rodger W. Bybee, Lynda B. Micikas
Biological Sciences Curriculum Study
Colorado Springs, CO 80918-3842
(719) 531-5550

DUE-9455725
FY 1995 $ 650,000
FY 1996 $ 435,000
FY 1997 $ 435,000
Biology

In recognition of the importance of introductory biology courses at two-year and community colleges to the development of scientific literacy among college-educated individuals, Biological Sciences Curriculum Study is conceptualizing, writing, testing, and evaluating a set of innovative curriculum materials for biology students at the college level. Collaborating in the 36-month project are 15 partners. The completed program will offer an integrated and coherent approach to helping students achieve three major goals of biological literacy: (1) to understand the basic unifying principles of biology; (2) to develop the fundamental skills of critical thinking and scientific reasoning; and (3) to recognize the applications of science, especially relationships among science, technology, and society. The materials being developed are of use to future teachers of science at the elementary and secondary levels. Strategies are incorporated that encourage students to reflect on the overall design of the program including strategies to help them learn various teaching techniques and for assessment. The products of the project include student materials (readings, activities, and laboratory exercises) that support both semester- and year-long introductory biology courses and emphasize hands-on, open-ended inquiry, collaborative learning, and the relationships among science, technology, and society; an instructor's guide that provides faculty with extensive background reading and specific implementation support; and a model for a faculty development workshop that is being designed and tested by the partner faculty and supported after the end of the project by revenues realized from sales of the materials.

Computer Applications to Enhance Inquiry-Oriented Laboratory Instruction in Biology at a Two-Year College

William B. Kincaid, Margaret A. Johnson
Mesa Community College District
Tempe, AZ 85281-6941
(602) 461-7103; e-mail: kincaid@next.mc.maricopa.edu

DUE-9254228
FY 1993 $ 132,180
FY 1994 $ 82,125
FY 1995 $ 83,177
Biology

This project addresses the general problem of scientific and technical literacy and specifically the enhancement of inquiry-oriented laboratory instruction in biology. Project goals are to increase scientific literacy, reasoning skills, and the number of students succeeding in introductory biology courses. To achieve these goals, the project is developing, evaluating, and integrating into the curriculum a set of computer applications designed to reinforce biology concepts introduced in exploratory laboratory activities and integrate reasoning skills for use in new contexts. These efforts focus on an introductory biology course at a 2-year college that serves a non-traditional undergraduate population including high numbers of women, Hispanics, Native Americans, and older students. Mesa Community College serves a large transfer and reserve transfer population associated with a nearby comprehensive university. As a result of this instructional intervention,

the college's classes will have improved achievement in biology, scientific reasoning skills, attitudes toward science, retention of underrepresented student populations, computer literacy, and instructor efficiency and effectiveness. The results will document the efficacy of a refinement to inquiry-oriented laboratory instruction and provide a model for the use of technology in education.

Laboratory Exercises in Plant Biochemistry

John P. Markwell
University of Nebraska, Lincoln
Lincoln, NE 68588-0430
(402) 472-7211; e-mail: markwell@unl.edu

DUE-9550791
FY 1995 $ 48,208
Biology (LLD)

This project is developing a series of experiments on plant acids and pigments designed to implement a new approach to engaging students in science. The target audience of these exercises is non-major biochemistry students. The experiments are designed to focus on the development of student expertise in the use of research tools, expose all students to the process of scientific research, and provide a framework for cooperative learning opportunities. Coordinated experiments are being developed which reward students with a sense of progressive mastery of earlier concepts and tools, and foster a holistic view of science. The goal of this tool-based approach is to empower students to generate and answer their own questions about the world around them and lead them into independent investigations. Plant acids are used to provide a pedagogical vehicle for learning about pH and biological buffering, while providing a relevant bridge to familiar commercial products. Plant pigments, specifically anthocyanins, chlorophylls and carotenoids, are used to provide an interesting and colorful approach to an understanding of biochemical phenomena. The developed exercises are being field tested at the PI's institution and disseminated without cost to interested undergraduates and educators via the Internet. The methods and exercises developed as part of this project will be utilized in the development of an advanced science content course for pre-service teachers in collaboration with faculty from the University of Nebraska Teachers College.

An Enhanced Bioscience Education Program for the Introductory Years of the Biology Major and for Interested Preteachers

Wayne E. Magee, Presley F. Martin, Bernard P. Sagik
Drexel University
Philadelphia, PA 19104
(215) 895-2000; e-mail: mageewe@duvm.ocs.drexel.edu

DUE-9253994
FY 1993 $ 269,266
FY 1994 $ 7,728
FY 1995 $ 48,794
Biology

The Enhanced Bioscience Education program greatly increases the effectiveness of undergraduate education in the biological sciences. The new integrated curriculum presents science as it is practiced as a problem-solving, investigative activity. The curriculum is designed for up to 100 bioscience and teacher preparation majors. It is organized around topic areas and extends over five quarters of instruction: (1) Biological Investigation is the heart of the curriculum and consists of a series of laboratory modules covering the important concepts of modern biology, leading students toward design of their own experiments. There is a strong emphasis on use of computers for collecting data and for data analysis and interpretation. (2) Principals of Bioscience

includes the content areas now covered in freshman biology, cell physiology, microbiology and genetics presented as a single, coherent sequence and completely integrated with Biological Investigation laboratories. (3) Physical Sciences and Mathematics covers the topics of freshman and sophomore chemistry, mathematics and physics, with the appropriate information and skills introduced in the order needed. An Undergraduate Research Program includes freshman and sophomore independent research projects, preparation for more advanced projects, and the establishment of the Drexel Journal of Undergraduate Research as a vehicle for dissemination of student research. Special attention is paid to problems of student support and retention. Specific plans are included for evaluation and effective dissemination of the outcomes of the project.

Cellular Biophysics Software

Thomas F. Weiss
Massachusetts Institute of Technology
Cambridge, MA 02139-4307
(617) 253-2594; e-mail: weiss@cbgrle.mit.edu

DUE-9455337
FY 1995 $ 150,000
Biology

The purpose of this project is to make educational software and methodologies for its use in teaching cellular biophysics widely available. Software has been used for 10 years to teach cellular biophysics to juniors majoring in engineering and science at the Massachusetts Institute of Technology (MIT). The software is used in lecture demonstrations, special recitation classes held in electronic classrooms, as a basis of homework assignments, and for more intensive research projects defined by students. Use of the software has greatly enhanced students' interest in and comprehension of topics in cellular biophysics. All the software has been developed by student programmers and is currently available only on UNIX workstations at MIT. The software is written in C and XWindows. The goal of the project is to support undergraduate and graduate students converting this software to run under a vendor distributed computation and visualization software package (MATLAB) which is available on all the common computer platforms, including Macintoshes, PCs running Microsoft Windows, and UNIX workstations running XWindows. The conversion also allows students and instructors to more readily customize the software for their own use, and will greatly facilitate software maintenance for faculty. The plan is to publish a software textbook that will be distributed with floppy disks of the software. The software and software textbook will be companions to a new textbook on cellular biophysics that was scheduled for publication in Fall 1995. The combination should provide a new set of educational materials for teaching cellular biophysics to students in engineering and science. The approach is to provide rigorous, in-depth mathematical treatments as well as the empirical basis of important biological, chemical, and physical principles of cell biophysics. The software, together with the software text, allows students and faculty to explore these principles in new ways. The educational effectiveness of the software will be assessed by an independent evaluator.

Career Direction Through Integrated Introductory Biology-Chemistry Laboratory and Research

Elizabeth A. Godrick, Patricia L. Samuel,
Emma Previato, Robert E. Hausman
Boston University

DUE-9455288
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Biology

Boston, MA 02118-2394
(617) 353-2000; e-mail: godrick@biology.bu.edu

This project is a three-step sequential undergraduate biology-chemistry experience to retain science majors and to inspire them to enter research careers. Step I occurs in a student's first year with an integration of the second semester laboratories of the majors' introductory biology and chemistry courses. Lectures remain separate. To follow the student experience of the integrated laboratories and to retain and build upon student interest in science research, Step II is a required career seminar course in the Spring of the sophomore year. Seminar speakers from academia, medicine, and industry serve as hosts for students participating in Step III, a Summer research internship between the second and third years of college. Steps II and III function together in the sophomore year to provide a practical application of the integrated first year laboratories and to reinforce research career goals. Two laboratory sections concurrently participate in Step I to pursue a number of nontraditional, investigative laboratory modules which integrate concepts from cell biology, molecular genetics, and general chemistry. Seven hours per week is divided into formal laboratory investigation, discussion, and comeback time. Over a 12-week period, four modules are presented. These integrated, modular laboratories examine (1) Vitamin C Metabolism, (2) Reaction Dynamics of Enzymes, (3) Sources of Energy for Life, and (4) Manipulation of Macromolecules. During the final week of each module, students analyze data, draw conclusions and, in selected modules, design their own original investigations based on previous experimentation. Mathematics tutorials are available. This integrated, biological-chemical modular format directly relates to and prepares science majors for modern research-oriented upper division courses and parallels a realistic career research experience. One section of the integrated biology-chemistry laboratories is comprised entirely of women, for comparison with the other two of mixed gender, and with the traditional separate biology and chemistry laboratories for the other students.

Conferences on Communicating and Assessing Innovative Strategies for Life Sciences Teaching to Undergraduates

Paul H. Williams
University of Wisconsin, Madison
Madison, WI 53706-1490
(608) 262-1234; e-mail: phwillia@facstaff.wisc.edu

DUE-9455616
FY 1995 $ 31,236
FY 1996 $ 43,810
FY 1997 $ 35,946
Biology

This project supports the Coalition for Education in the Life Sciences (CELS), a network of life science professional organizations, to convene three conferences on undergraduate life science education. The conferences to be held in 1995, 1996, and 1997 are the fourth, fifth, and sixth in a series. The conferences emphasize assessment of educational programs, development of a life sciences electronic clearinghouse, dissemination of information about exemplary programs, and ways for improving faculty and graduate assistant teaching and course design. The first conference was held in June, 1995, at The University of Wisconsin, Madison; the second will be held in 1996 at the University of Nevada, Las Vegas; and the third will meet in Washington, DC. The conferences are limited to 175 participants to promote interaction, and CELS encourages faculty and administrators from the same institution to attend as teams. The format includes plenary sessions on broad topics like assessment, smaller break-out discussions and hands-on workshops, materials presentations and group discussions, and demonstrations that show effective

teaching. The outcome will be teaching materials and conference proceedings, which will be disseminated through all the professional societies supporting CELS and a self-sustaining CELS network for ongoing work in this important area of undergraduate life sciences education.

Coupling Mathematics and Life Science Courses: Development of Integrated Math and Science Curricula for Undergraduate and Middle School Students

Marlene M. Wilson, Michael D. Snow, David M. Cresap,
Lewis Lum, Christopher R. Kodadek
University of Portland
Portland, OR 97203
(503) 283-7126; e-mail: wilson@uofport.edu

DUE-9455601
FY 1995 $ 51,293
Biology

The goal of this project is to create a unified curriculum which develops the students' quantitative approaches to problems in the life sciences. This project couples an introductory statistics course with a general biology laboratory course at the University and develops teaching units for the middle school level. The key to the long-term benefits and widespread significance of this project is that a teaching circle is being formed which is interdisciplinary and includes middle school teachers. This collaborative team is united by commitment to teach science and mathematics from an integrated, project-based, problem-solving approach. It brings together education and subject matter experts. The summer of 1995 was spent developing flexible teaching modules which can be used to couple general biology and statistics or that can be used with either course independently at the undergraduate level, and in the development of teaching units for middle school concept/process science and mathematics. The following summer the faculty will analyze their experience and revise the materials based on assessment tools that evaluate student attitudes, interest, and skills. Locally, this project is revising the manner in which biology and mathematics are taught at the University of Portland and Portsmouth Middle School. It will impact future teachers through student-teacher placements and through the University's teaching methods courses in the School of Education. Coupling mathematics and science will lower the life science students' math anxiety level and help the student become comfortable with looking at biological phenomena from a quantitative perspective. This approach is especially significant because it will encourage students to stay in science, and the middle school has a high percentage of minority students.

Biological Literacy Through Classroom Community

Jo E. Handelsman, Luis Sequeira
University of Wisconsin, Madison
Madison, WI 53706-1490
(608) 262-1234; e-mail: joh@plantpath.wisc.edu

DUE-9156087
FY 1992 $ 77,702
FY 1995 $ 19,670
Biology

Biology teaching should incorporate the process of scientific inquiry, not just the information resulting from it. Only by involving students directly in scientific experimentation and intellectual debate can they be expected to develop the fundamental understanding of biology required for biological literacy. Engaging students in this process demands a classroom that motivates learning, teaches analytical skills as well as information, and captures the spirit of curiosity and questioning. To meet these demands for the broadest spectrum of students this project addresses three objectives. First, simple, low-cost experimental exercises are being designed that illustrate fundamental biological principles and can be conducted in an introductory course without a laboratory. Second, a set of exercises in scientific study skills is being constructed to address the difficulty, shared by many college students, of learning scientific material. The innovative aspect of this approach to study skills is that the students are in a forum that is tightly coupled with the biology instruction, which provides for exchange between the biology instructor and the study skills instructor. Finally, drawing on cooperative learning approaches that are highly effective in other fields, exercises are being developed that can be used to involve all members of small or large classes in active thinking and learning. The product of this project will be a published manual that explores the philosophy of building community in the classroom and describes the exercises in experimentation, study skills, and cooperative learning that can be incorporated into introductory-level biology curricula.

Computer Graphics in Introductory Biochemistry

Paul A. Karplus
Cornell University
Ithaca, NY 14853-2801
(607) 255-2000; e-mail: andy@penelope.bio.cornell.edu

DUE-9455324
FY 1995 $ 100,000
Biology

The purpose of this project is to introduce interactive tutorials using three-dimensional computer graphics to visualize macromolecular structure and function into introductory biochemistry. Specific goals include the development of 14 computer graphics tutorials to be used in the introductory auto tutorial biochemistry course, the publishing of these tutorials, and the holding of workshops for training teaching faculty at other universities to use these tutorials. One difficulty associated with developing such an interactive curriculum for introductory biochemistry is the large class size. For this reason, this auto tutorial biochemistry course provides an excellent forum for curriculum development, because it has already successfully adopted a highly personal and interactive format. This computer graphics based curriculum should have a large impact on undergraduate education, because many undergraduates take introductory biochemistry courses each year, and very few (if any) such courses currently have interactive, three-dimensional, graphics content. This curriculum should be effective, both for attracting more students to continue in biological sciences and for preparing the scientific and biomedical community of tomorrow so

that they may assimilate and effectively apply structural information about proteins and other biological molecules.

Interactive Multimedia Simulations of Experimental Biotechnology Laboratories for Introductory Biology Students

Mark S. Bergland, Mary A. Lundeberg, Karen K. Klyczek
University of Wisconsin, River Falls
River Falls, WI 54022-5013
(715) 425-3201; e-mail: mark.s.bergland@uwrf.edu

DUE-9455425
FY 1995 $ 108,464
Biology

Over 600 students (mainly non-science majors) take Introductory Biology at the University of Wisconsin-River Falls each year. Many of these students tend to equate success in college with the ability to memorize facts, and need more exposure to critical thinking skills used by scientific investigators. Research on gender issues in science education indicates that computer simulation is a particularly effective way to interest more women in pursuing scientific careers. The project is developing highly interactive experimental simulations based on existing upper-division laboratories in the biotechnology curriculum (Virology, Molecular Biology, and Animal Cell Culture). These simulations are used by Introductory Biology students to generate and test their own hypotheses while working in small collaborative groups. Students manipulate objects on the computer screen much as they would in reality. For example, they can "spin" the dial of a micro pipette or operate the control panel of a spectrophotometer, DNA thermal cycler, or electron microscope. Digitized video images of students using actual equipment are incorporated into the simulations to make them more realistic. Undergraduate education majors enrolled in a teaching methods class are involved in the evaluation of the simulations, which gives them first-hand experience in evaluating the uses of technology in the classroom. The editorial staff of BioQUEST is providing assistance in the dissemination of the simulations.

Molecular Genetics Concepts: An Intelligent Tutor

Shiladitya Das Sarma, Beverly P. Woolf
University of Massachusetts, Amherst
Amherst, MA 01003
(413) 545-0111; e-mail: sds@rna.micro.umass.edu

DUE-9551531
FY 1995 $ 273,459
Biology(LLD)

This project is developing a computer laboratory for tutoring undergraduate students in fundamental concepts of molecular genetics. The topics covered include DNA structure and replication; RNA transcription, translation, and splicing; genetic recombination, repair, and transposition; genetic engineering and recombinant DNA technology; and modern genomic analysis and societal implications. The major challenges in teaching these fundamental genetic concepts to undergraduates are (1) transmitting the visual imagery of dynamic molecular processes; (2) providing a solid intellectual framework to explore interrelationships between genetic processes; and (3) at more advanced levels, conveying the experimental basis for evolution of genetic

principles. The project exploits recent advances in computer hardware (increased memory size and data storage) and software (intelligent tutoring systems) to develop a multimedia tutorial package which conveys the visual imagery, conceptual relationships, and experimental basis of molecular genetics in a deeper and more effective manner than currently possible through lectures or textbooks. The electronic tutor, named "MOLGENT", is being tested during its developmental phase in a variety of undergraduate classes, including introductory biology, microbiology, and molecular and cellular biology courses, and an innovative senior-level course entitled "Concepts in Molecular Genetics." The effectiveness of tutorials is being monitored and improved through student discussion groups. Once developed, the prototype software will be promoted via demonstrations at the educational section of meetings of biological societies (e.g., American Society for Microbiology, Genetics Society of America, and American Society for Biochemistry and Molecular Biology) and distributed broadly via publishers.