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PROGRAMS AND PARTNERSHIPS

Biotechnology training at California State University, Hayward: a model program

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The Biotechnology Certificate Program (BCP) at California State University, Hayward was initiated in 1986 in response to industry demands for qualified employees in the molecular life sciences. This 9-month post-baccalaureate program includes laboratory courses in recombinant DNA techniques, protein chemistry, PCR, DNA sequencing, animal cell culture as well as two lecture courses in molecular biology. Rigorous selection at both entry and exit stages of the program ensures knowledgeable graduates with a greater than 90% employment placement. Corporate participation has been a cornerstone of the BCP and we anticipate continued cooperation in the future as the program evolves to meet the expanding needs of the biotechnology industry. *Journal of Industrial Microbiology & Biotechnology* (2000) **24,** 364–366.

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Introduction

The Biotechnology Certificate Program (BCP) was established in 1986 to meet the personnel requirements of the rapidly expanding Bay Area biotechnology industry. The program is staffed by research faculty from the Departments of Biological Sciences and Chemistry. The BCP is a competitive, limited enrollment program emphasizing close supervision and instruction in current theoretical and practical training in the molecular life sciences.

Over the past 12 years the BCP has graduated 110 students and placed 101 of them in the biotechnology industry and in government and academic laboratories. The program was initiated in response to a series of inquiries from Human Resources personnel from several biotechnology companies including Cetus, Chiron and a Hayward-based company, BioResponse. These companies realized a need for new employees trained in the basics of biochemistry and cell and molecular biology. The companies did not require senior scientist-level applicants, but applicants familiar with the concepts and technologies of the emerging molecular life sciences. There was a perceived lack of qualified applicants with sufficient basic technical skills able to step into a research environment and be trained in the skills required by that company. Given the proximity of several highly regarded universities such as the University of California, Berkeley and Stanford University, this shortfall of qualified applicants appeared a contradiction. Budgetary cutbacks and reallocation of resources had severely curtailed the laboratory components of many curricula to a point where many traditional courses dispensed with the laboratory components. While long on theory, these graduates were short on practical bench experience in molecular and cellular techniques. Many of the techniques we now take for granted such as: HPLC, immunoblotting, restriction mapping, transformation and transfection, DNA sequencing and analysis and PCR techniques were not routinely taught to undergraduates. In response to this industry need the Department of Biological Sciences at Cal State Hayward initiated the Biotechnology Certificate Program.

To establish the curriculum, we conducted a series of interviews with personnel managers and scientists at large and small Bay Area biotechnology companies. We asked them to identify the spectrum of skills they would expect a qualified applicant to have when applying to their company as a Research Associate. Based on the responses we designed a curriculum that would provide students with the basic technical skills which could then be 'fine tuned' to match protocols required by a specific company. Over the years the curriculum has been modified to meet changing demands and techniques required by the biotechnology industry. For example we originally offered a course in Immunochemistry. The major techniques in this course were antibody purification, ELISA, immunoblotting and immunocytochemistry. The Immunochemistry course was eventually eliminated and these techniques were incorporated into a Protein Chemistry and Characterization course.

Admission requirements and progression through the program

Application to the program requires a baccalaureate degree in biology or chemistry. In addition to the baccalaureate degree, applicants are required to have letters of recommendation and to have completed the following prerequisite courses at the junior or senior level: Microbiology (with

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laboratory); Biochemistry (with laboratory); Genetics, Cell or Molecular Biology (with laboratory); and Immunology.

Applications are considered once a year in the Spring. Typically we receive between 30–50 applications and 15 applicants are accepted by July 1. These 15 candidates have 4 weeks to accept the appointment to the program. We maintain a prioritized waiting list which is utilized if primary candidates do not accept the appointment. Usually two or three decide not to attend and we use the waiting list. Students in the BCP are also conditionally admitted to the MS program in Biological Sciences. The 28 quarter-units of the BCP are directly applicable to the 45 quarter-units required for the MS degree. Approximately 30% of the students completing the Certificate elect to matriculate into the MS program and usually take one additional year to complete a research project and thesis.

Students in the BCP progress through the program as a cohort. A grade of 'B' or better in each class is required to remain in the program. Typically one or two students are disqualified each year. Students who leave the program for personal or health reasons must reapply and are not guaranteed readmission. Students must pass a comprehensive objective exam, including mathematical calculations, prior to awarding of the certificate.

Additional information about the program is also available at <http://www.csuhayward.edu/acaprogs/biotech/>.

The curriculum

Biology 6151 and 6152: cell and molecular biology I & II

This is a two-quarter series on contemporary cell and molecular biology. In addition to a traditional textbook and lecture format, extensive use is made of the current scientific literature. Lectures are supplemented with discussion groups and problem-solving projects. Significant use is also made of 'online' databases via the Internet. Topics the first quarter include: current cell and molecular techniques, genetic analysis in molecular biology, molecular anatomy of the genome, DNA replication, repair and recombination, regulation of transcription and RNA processing.

The second quarter (6152) includes protein synthesis and post-transcriptional control of gene expression, intracellular protein targeting and secretion, membrane structure and function, growth factors and signal transduction, cell cycle regulation, extracellular matrix biology, oncogenesis, cell differentiation and apoptosis.

Chemistry 6430: protein chemistry techniques

This course is designed to give the student a broad overview of techniques in protein chemistry. The course stresses good laboratory notebook skills, calculations and experimental write-ups. Topics include: spectrophotometry, enzyme extraction, protein quantification, gel filtration and ion exchange chromatography, affinity chromatography, HPLC, isoelectric focusing, peptide sequencing, recombinant protein isolation, SDS-PAGE, and immunoblot analysis.

Biology 6140: recombinant DNA techniques

This is a lecture/laboratory course presenting the fundamentals of recombinant DNA techniques. The course features in-depth analyses of cloning vectors, library construction and screening, subcloning, site-directed mutagenesis, YAC construction and utilization and mammalian-cell applications. Laboratory exercises include transformation, plasmid and bacteriophage isolation and characterization, subcloning of gel purified fragments, and Southern blot analysis.

Biology 6146: PCR technology

This laboratory course covers the molecular mechanisms of PCR and provides hands-on experience in its use in several research scenarios. Topics include primer design and how to optimize PCR by systematically varying reaction variables including effects of magnesium ion concentration, primer annealing temperature, or template concentration. Other exercises include targeted DNA amplification from plasmid and genomic templates, subcloning PCR products, long-range PCR, RT-PCR to verify the expression of a transfected gene and applications of PCR technology to evolutionary questions.

Biology 4480: DNA sequencing and sequence analysis

This laboratory course covers the determination of DNA nucleotide sequence and Internet utilization of databases for sequence analysis. Exercises include sequencing of single- and double-stranded templates, 'problem' templates and cycle sequencing. All exercises include preparation and running of ABI 377 sequencing gels, automated and manual reading and editing of sequence data, and analysis using contemporary software and Internet databases.

Biology 4450: cell culture techniques

This lecture/laboratory course covers introductory and advanced techniques in mammalian cell culture using attached and suspension cultures. Exercises include methods of cell enumeration, routine maintenance, growth curve establishment and analysis, primary culture, karyotyping, transformation assays, cytotoxicity measurements, cryopreservation, single cell cloning by cylinders and limiting dilution, *in vitro* differentiation systems, suspension cultures, and transient and stable transfection.

Corporate participation

The extent of biotechnology industry participation in our program has been significant and has taken many forms. Companies have served as a source of direct financial contribution to a special departmental account. This account is utilized via a variety of applications including seminar honoraria, consumable reagents and materials, equipment repair and capital purchases. Companies have donated thousands of dollars in surplus capital equipment and consumable supplies such as cell culture plasticware, restriction enzymes, bulk chemicals, and journal subscriptions. Companies have been a source of internships and employment for our students. The key to effective corporate participation has been in establishing personal contacts. Com-

petency is usually a rapidly recognized trait in small to mid-size companies of which we have been the greatest benefactors. Supervisors become aware of our program through the students we place in their units. These individuals are identified by former students and inquiries can then be initiated into corporate donation practices. An advisory council composed of representatives from biotechnology companies serves as a resource for curriculum review, modification, and development; student mentoring; employment opportunities and industry outreach; and fund raising.

Student placement

Although students complete the BCP training in June, placement activity begins in April with the mailing of resumé packages to approximately 200 Bay Area biotechnology companies. Students receive employment counselling including resumé preparation, interview tips and techniques, and review of GLP and GMP concepts.

Future directions

The increasing diversity and maturity of the Bay Area biotechnology community has dictated that we offer new programs and courses that meet the current and perceived needs of the biotechnology industry. The programs outlined below are currently being launched or are under discussion.

Regulatory affairs: San Diego State University is initiating an MS degree in Regulatory Affairs. The first two courses in the curricula, RA 573 The Pharmaceutical and Medical Device Industries and RA 575 Introduction to Food and Drug Law are being offered this year. California State University, Hayward and San Jose State University plan to offer these same two courses in the 2000–2001 academic year. It is anticipated that students completing these two courses plus 2–3 additional courses in business will receive a certificate in Regulatory Affairs.

Clinical research associate: These individuals design, implement and manage clinical and animal trials of new biopharmaceuticals. Plans are being formalized to offer a pilot training program in association with our Depts of Nursing and Statistics.

Bioinformatics: The Human Genome Project and associated genome sequencing projects have increased the demands for individuals who combine computer skills with a background of cell and molecular biology. A series of summer workshops is planned for summer 2000 with industry representatives to finalize a series of courses on bioinformatics with staffing from industry and the Departments of Biology and Computer Science.

Business development, marketing and sales: A scientifically literate sales force for established pharmaceutical companies and biotechnology companies is a necessity. We are working with our School of Business to establish a series of courses that will teach the basics of cell and molecular biology to business students and basic business and marketing concepts to science graduates.

Forensic science: The application of molecular techniques to Forensic Science is well established. The Departments of Biological Science and Criminal Justice have combined to offer a 5-year undergraduate degree in Forensic Science. This program is the only one of its kind in California.