OFFICE OF CURRICULUM, INSTRUCTION, & PROFESSIONAL DEVELOPMENT

HIGH SCHOOL COURSE OUTLINE

(Pilot Board Approved August 18, 2009)

Department	Science	**Course Title**	Biotechnology 3-4			**Course Code**	3868		
Abbreviation	BIOTECH 3-4	**Grade Level**	11, 12		**Grad Requirement**		No		
Course Length	2 semesters	**Credits per Semester**	5	**Approved for Honors**	No	**Required**	No	**Elective**	Yes
CTE Industry Sector	Health Science and Medical Technology			**CTE Pathway**	Biotechnology Research and Development				
Prerequisites	Biotechnology 1-2 with a "B" or better								
Co-requisites	Integrated Math Program (IMP) 7-8 maintaining a “C” or better								
Articulated with LBCC	No	**Articulated with CSULB**	No						
Meets UC “a-f” Requirement	d or g	**Meets NCAA Requirement**	Yes						

COURSE DESCRIPTION:

Biotechnology 3-4 is a continuation of Biotechnology 1-2 and is designed to give students a comprehensive introduction to the scientific concepts and laboratory research techniques currently used in the field of biotechnology. Several topics originally taught in Biotechnology 1-2 are repeated in the 3-4 course but in more depth and with additional applications. In this course, students attain knowledge about the field of biotechnology and deeper understanding of the biological concepts used. In addition, students further develop the laboratory, critical thinking, and communication skills currently used in the biotechnology industry, including use of a laminar flow hood while learning the principles of plant tissue culturing. Furthermore, students will explore and evaluate career opportunities in the field of biotechnology through extensive readings, laboratory experiments, class discussions, research projects, guest speakers, and workplace visits. The objectives covered in this course are both academic and technical in nature and are presented in a progressively rigorous manner.

COURSE PURPOSE: (Student needs the course is intended to meet)

Students will:

CONTENT
- Students will learn the basic biological and chemical processes of cell, tissues, and organisms. They will also learn the historical experiments that led to the central dogma of molecular biology and understand the basic processes of DNA replication, transcription and translation. Students will also gain an understanding of and exposure to assorted topics/concepts in biotechnology.

SKILLS
- Students will apply the basic principles of molecular biology to develop techniques that can indirectly measure the molecular status of cells. They will learn basic laboratory skills used in academic and industrial biotechnology laboratories, including best practices, including the methodologies used in the isolation and analysis of large macromolecules such as DNA and proteins. Students will also model the steps involved in the production of a recombinant DNA biotechnology product.

LITERACY
- Students will learn to understand and use professional biotechnology literature for purposes of research for projects and individual class topics. Written assessments and laboratory analyses will help students learn to write concisely and accurately, while encouraging analytical thinking referenced to observations.

APPLICATIONS
- Students will demonstrate understanding of the role of biotechnology in society, including the risks and benefits. They will learn the significance of biotechnology in pharmaceutical development, agriculture, forensics, genetic testing, industrial products, and scientific research. Students will also learn how a biotechnology company works and the roles of its employees and understand how bioinformatics is used in research.

COURSE PURPOSE: EXPECTED OUTCOMES

CA CAREER TECHNICAL EDUCATION MODEL CURRICULUM STANDARDS:

Health Science and Medical Technology Industry Sector

A. Biotechnology Research and Development Pathway

- A1.0 Students know the role of the biotechnology industry and biotechnology product development in curing diseases:
  - A1.1 Understand the role of the biotechnology industry and its impact on society.
  - A1.2 Understand the role of biotechnology product development in curing genetic, environmental, and behavioral diseases.
  - A1.4 Understand the relationship between biochemistry and biotechnology product development.
- A2.0 Students know the fundamentals of mathematical and scientific concepts related to biotechnology:
  - A2.2 Understand the basic structure of a chromosome and the difference between a dominant homozygous trait and a heterozygous trait.
- A3.0 Students understand the role of recombinant DNA and genetic engineering, bioprocessing, monoclonal antibody production, separation and purification of Biotechnology products, nanotechnology, bioinformatics, genomics, proteomics, and transcriptomics in biotechnical product development:
  - A3.1 Understand recombinant DNA, genetic engineering, monoclonal antibody production, separation and purification of biotechnology products, and bioprocessing.
  - A3.2 Understand how the fields of nanotechnology, bioinformatics, genomics, proteomics, and transcriptomics influence new and emerging career opportunities.
- A4.0 Students understand the principles of solution preparation, contamination control, measurement and calibration, and emergency laboratory response:
  - A4.4 Understand the importance and requirements of using sterile techniques in a laboratory.
  - A4.5 Understand the appropriate responses to a laboratory accident.
- A5.0 Students understand biotechnology product design and development, laboratory procedures, product licensure, and the regulatory process for product development and clinical trials:
  - A5.2 Understand the role of preclinical and clinical trials in biotechnology product development.
  - A5.3 Know the role of quality assurance in clinical trials.

CA SCIENCE CONTENT STANDARDS:

Grade 9-12 Biology/Life Sciences:

Genetics

2. Mutation and sexual reproduction lead to genetic variation in a population. As a basis for understanding this concept, students know:
   a. meiosis is an early step in sexual reproduction in which the pairs of chromosomes separate and segregate randomly during cell division to produce gametes containing one chromosome of each type.
   b. only certain cells in a multicellular organism undergo meiosis.
   c. how random chromosome segregation explains the probability that a particular allele will be in a gamete.
   d. new combinations of alleles may be generated in a zygote through the fusion of male and female gametes (fertilization).
   f. the role of chromosomes in determining an individual's sex.
   g. how to predict possible combinations of alleles in a zygote from the genetic makeup of the parents.
3. A multicellular organism develops from a single zygote, and its phenotype depends on its genotype, which is established at fertilization. As a basis for understanding this concept, students know:
   a. how to predict the probable outcome of phenotypes in a genetic cross from the genotypes of the parents and mode of inheritance (autosomal or X-linked, dominant or recessive).
5. The genetic composition of cells can be altered by incorporation of exogenous DNA into the cells. As a basis for understanding this concept, students know:
   b. how to apply base-pairing rules to explain precise copying of DNA during semiconservative replication and transcription of information from DNA into mRNA. (CST)

Physiology

9. As a result of the coordinated structures and functions of organ systems, the internal environment of the human body remains relatively stable (homeostatic) despite changes in the outside environment. As a basis for understanding this concept, students know:
   i. hormones (including digestive, reproductive, osmoregulatory) provide internal feedback mechanisms for homeostasis at the cellular level and in whole organisms*
10. Organisms have a variety of mechanisms to combat disease. As a basis for understanding the human immune response, students know:
    d. there are important differences between bacteria and viruses with respect to their requirements for growth and replication, the body's primary defenses against bacterial and viral infections, and effective treatments of these infections. (CST)

Grade 9-12 Investigation and Experimentation:

1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:
   a. select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
   b. identify and communicate sources of unavoidable experimental error.
   c. identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.

COURSE PURPOSE: EXPECTED INTEGRATED OUTCOMES

Students are also expected to proficiently apply common skills that are relevant across curriculum areas and career pathways. The following are those skills most applicable to this science course.

CTE Foundation Standards:

from the California Career Technical Education Model Curriculum Standards, adopted by the California State Board of Education in May, 2005.

Foundation Standard 2: Communications

Students understand the principles of effective oral, written and multimedia communication in a variety of formats and contexts.

Reading (Grades 9-10)

1.3 Identify Greek, Roman, and Norse mythology and use the knowledge to understand the origin and meaning of new words.
2.2 Prepare a bibliography of reference materials for a report using a variety of consumer, workplace, and public documents.
2.3 Generate relevant questions about readings on issues that can be researched.
2.8 Evaluate the credibility of an author's argument or defense of a claim by critiquing the relationship between generalizations and evidence, the comprehensiveness of evidence, and the way in which the author's intent affects the structure and tone of the text (e.g., in professional journals, editorials, political speeches).

Writing (Grades 9-10)

1.3 Use clear research questions and suitable research methods (e.g., library, electronic media, personal interview) to elicit and present evidence from primary and secondary sources.
1.5 Synthesize information from multiple sources and identify complexities and discrepancies in the information and the different perspectives found in each medium (e.g., almanacs, microfiche, news sources, in-depth field studies, speeches, journals, technical documents).
2.3 Write expository compositions, including analytical essays and research reports:
   2.3.a Marshal evidence in support of a thesis and related claims, including information on all relevant perspectives.
   2.3.b Convey information and ideas from primary and secondary sources accurately and coherently.
   2.3.c Make distinctions between the relative value and significance of specific data, facts, and ideas.
   2.3.d Include visual aids by employing appropriate technology to organize and record information on charts, maps, and graphs.
   2.3.e Anticipate and address readers' potential misunderstanding, biases, and expectations.
   2.3.f Use technical terms and notations accurately.
2.6 Write technical documents:
   2.6.a Report information and convey ideas logically and correctly.
   2.6.b Offer detailed and accurate specifications.
   2.6.c Include scenarios, definitions, and examples to aid comprehension (e.g., troubleshooting guide).
   2.6.d Anticipate reader's problems, mistakes, and misunderstandings.

Written and Oral English Language Conventions (Grades 9-10)

1.4 Produce legible work that shows accurate spelling and correct use of the conventions of punctuation and capitalization.

Listening and Speaking (Grades 9-10)

1.7 Use props, visual aids, graphs, and electronic media to enhance the appeal and accuracy of presentations.
2.3 Apply appropriate interviewing techniques:
   2.3.a Prepare and ask relevant questions.
   2.3.b Make notes of responses.
   2.3.c Use language that conveys maturity, sensitivity, and respect.
   2.3.d Respond correctly and effectively to questions.
   2.3.e Demonstrate knowledge of the subject or organization.
   2.3.f Compile and report responses.
   2.3.g Evaluate the effectiveness of the interview.

2.5 Deliver persuasive arguments (including evaluation and analysis of problems and solutions and causes and effects).
- 2.5.a Structure ideas and arguments in a coherent, logical fashion.
- 2.5.b Use rhetorical devices to support assertions (e.g., by appeal to logic through reasoning; by appeal to emotion or ethical belief; by use of personal anecdote, case study, or analogy).
- 2.5.c Clarify and defend positions with precise and relevant evidence, including facts, expert opinions, quotations, expressions of commonly accepted beliefs, and logical reasoning.
- 2.5.d Anticipate and address the listener's concerns and counterarguments.

Foundation Standard 3: Career Planning and Management

Students understand how to make effective decisions, use career information, and manage career plans.

3.5 Understand the past, present, and future trends that affect careers, such as technological developments and societal trends, and the resulting need for lifelong learning.

(3.6) Know important strategies for self-promotion in the hiring process, such as job applications, resume writing, interviewing skills, and preparation of a portfolio. [*re: Quality Control*]

Foundation Standard 4: Technology

Students know how to use contemporary and emerging technological resources in diverse and changing personal, community, and workplace environments.

4.2 Understand the use of technological resources to gain access to, manipulate, and produce information, products, and services.

4.3 Understand the influence of current and emerging technology on selected segments of the economy.

Foundation Standard 5: Problem Solving and Critical Thinking

Students understand how to create alternative solutions by using critical and creative thinking skills, such as logical reasoning, analytical thinking, and problem solving techniques.

5.1 Apply appropriate problems-solving strategies and critical thinking skills to work-related issues and tasks.

(5.3) Use critical thinking skills to make informed decisions and solve problems. [*re: Industrial Methodologies*]

Foundation Standard 6: Health and Safety

Students understand health and safety policies, procedures, regulations, and practices, including the use of equipment and handling of hazardous materials.

6.1 Know the policies, procedures, and regulations regarding health and safety in the workplace, including employers' and employees' responsibilities.

6.2 Understand critical elements of health and safety practices related to storing, cleaning, and maintaining tools, equipment, and supplies.

Foundation Standard 7: Responsibility and Flexibility

Students know the behaviors associated with the demonstration of responsibility and flexibility in personal, workplace, and community settings.

7.1 Understand the qualities and behaviors that constitute a positive and professional work demeanor.

(7.2) Understand the importance of accountability and responsibility in fulfilling personal, community, and workplace roles. [*re: Genomics*]

7.3 Understand the need to adapt to varied roles and responsibilities.

7.4 Understand that individual actions can affect the larger community.

Foundation Standard 8: Ethics and Legal Responsibilities

Students understand professional, ethical, and legal behavior consistent with applicable laws, regulations, and organizational norms.

8.2 Understand the concept and application of ethical and legal behavior consistent with workplace standards.

(8.3) Understand the role of personal integrity and ethical behavior in the workplace. [*re: Drug Discovery & Development*]

Foundation Standard 9: Leadership and Teamwork

Students understand effective leadership styles, key concepts of group dynamics, team and individual decision making, the benefits of workplace diversity, and conflict resolution.

9.1 Understand the characteristics and benefits of teamwork, leadership, and citizenship in the school, community, and workplace setting.

9.2 Understand the ways in which pre professional associations and competitive career development activities enhance academic skills, promote career choices, and contribute to employability.

(9.3) Understand how to organize and structure work individually and in teams for effective performance and the attainment of goals. [*re: DNA Sequencing*]

9.4 Understand how to interact with others in ways that demonstrate respect for individual and cultural differences and for the attitudes and feelings of others.

OUTLINE OF CONTENT AND RECOMMENDED TIME ALLOTMENT:

This course represents a blending of science academic content and deep career applications. As such, the two primary sources for content focus are the *CA Science Content Standards* and the *CA Career Technical Education Model Curriculum Standards*. Reference abbreviations used in the Task Analysis section refer to these documents as follows:

PS-A refers to the Biotechnology Research and Development Pathway within the Health Science and Medical Technology Industry Sector of the CA CTE Pathway Standards

FS refers to the Foundation Standards of the CA CTE Model Curriculum Standards [pages 4 through 6].

B refers to the high school Biology/Life Science standards of the CA Science Content Standards

C refers to the high school Chemistry standards of the CA Science Content Standards

P refers to the high school Physics standards of the CA Science Content Standards

IE refers to the high school Investigation and Experimentation skill standards of the CA Science Content Standards

Content sequencing, Labs/Demos, and time allocations are only suggestions and may be adjusted to suit school site curriculum plans, available materials, and student needs.

Plant Biotechnology

Content Standards (CONTENT) "Students know…"	Content Standards (SKILL) "Students are able to …"	Perf. Std. Measures How students DEMONSTRATE KNOWLEDGE and SKILL.	Instructional Support	Appx Time
Introduction to Plant Propogation		***Key Assignments:*** • **Flower and Seed Morphology** [See description on p. 13.] ***Suggested:*** •	**Biotech SNM**, 10.1-3 ***Supplemental Resources:*** • ***Key Vocabulary:*** sexual reproduction, breeding, selective breeding, meiosis, differentiation, plant hormones	15 Days
Meiosis is an early step in sexual reproduction in which the pairs of chromosomes separate and segregate randomly during cell division to produce gametes containing one chromosome of each type. **(B-2a)** Only certain cells in a multicellular organism undergo meiosis. **(B-2b)** New combinations of alleles may be generated in a zygote through the fusion of male and female gametes (fertilization). **(B-2d)**	• Diagram the events in flowering plant sexual reproduction including meiosis, pollination, and fertilization. • Describe the relationship between sexual reproduction and selective breeding. • Compare and contrast the processes of asexual and sexual reproduction in plants. • Identify the number and type of floral structures. • Compare the structure and function of different plant tissues including their role in reproduction. • Outline the steps in germination and plant growth. ***Skills Focus:***			

Content Standards (CONTENT) "Students know…"	Content Standards (SKILL) "Students are able to …"	Perf. Std. Measures How students DEMONSTRATE KNOWLEDGE and SKILL.	Instructional Support	Appx Time
Introduction to Plant Breeding		***Key Assignments:*** • **Seed Germination** [See description on p. 13.] ***Suggested:*** •	**Biotech SNM**, 10.4-5 ***Supplemental Resources:*** • B-SNM, Lab Manual **10e**, pp. 192-194 "How to Determine if the WFP Data are Good Enough" ***Key Vocabulary:*** diploid, haploid, dominant, recessive, homozygous, heterozygous, Punnett Square, dihybrid cross, statistical analysis	15 Days
Meiosis. **(B-2a)** Only certain cells in a multicellular organism undergo meiosis. **(B-2b)** Random chromosome segregation explains the probability that a particular allele will be in a gamete. **(B-2c)** Understand the basic structure of a chromosome and the difference between a dominant homozygous trait and a heterozygous trait. **(PS-A2.2)** Know the role of chromosomes in determining an individual's sex. **(B-2f)** Predict possible combinations of alleles in a zygote from the genetic makeup of the parents. **(B-2g)** Predict the probable outcome of phenotypes in a genetic cross from the genotypes of the parents and mode of inheritance. **(B-3a)**	• Explain how meiosis and crossing-over affect the variety seen in offspring. • Describe how meiosis, crossing-over, recombination, and segregation produce variety in gametes and offspring. • Perform a dihybrid, heterozygous cross of a model genetic organism.			
Understand the role of the biotechnology industry and its impact on society. **(PS-A1.1)**	• Analyze the results of a cross and the significance of data using Chi-square analysis. • Conduct a seed germination experiment. • Use the internet to find the life cycle of a diploid organism. ***Skills Focus:*** Calculate and interpret Chi Square value. Identify and communicate sources of unavoidable experimental error. **(I&E-1b)** Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions. **(I&E-1c)**			

Content Standards (CONTENT) "Students know…"	Content Standards (SKILL) "Students are able to …"	Perf. Std. Measures How students DEMONSTRATE KNOWLEDGE and SKILL.	Instructional Support	Appx Time
Cloning Plants		***Key Assignments:*** • **Plant Tissue Culture Media** [See description on p. 13.] • **Asexual Propogation of Plants** [See description on p. 13.] ***Suggested:*** •	**Biotech SNM**, 11.1-2 ***Supplemental Resources:*** • B-SNM, Lab Manual **11d**, pp. 202-206 "Cloning African Violets" ***Key Vocabulary:*** cross breeding asexual plant propagation plant tissue culture plant growth regulators	13 Days
Understand the importance and requirements of using sterile techniques in a laboratory. **(PS-A4.4)** Hormones provide internal feedback mechanisms for homeostasis at the cellular level and in whole organisms. **(B-9i)**	• Conduct a successful plant tissue culture using sterile technique. • Elucidate the role of hormones in plant tissue culture. ***Skills Focus:***			
Biotechnology in Agriculture and Horticulture		***Key Assignments:*** • **Isolation & Study of Plant DNA** [See description on p. 13.] • **Development of a DNA Concentration Assay / UV Spectrophotometry** [See description on p. 13.] ***Suggested:***	**Biotech SNM**, 11.3-5 ***Supplemental Resources:*** • B-SNM, Lab Manual **11h**, pp. 211-212 "Determining the Presence of DNA in Plant Extractions" ***Key Vocabulary:*** agriculture horticulture hydroponics plant-based pharmaceutical (PBP) genomic DNA plasmid DNA	10 Days
Understand recombinant DNA, genetic engineering, monoclonal antibody production, separation and purification of biotechnology products, and bioprocessing. **(PS-A3.1)** Students understand the principles of solution preparation, contamination control, measurement and calibration, and emergency laboratory response. **(PS-A4.0)**	• Isolate and analyze DNA samples from plant tissue. • Design a protocol for maximizing DNA extraction from plant cells. • Discuss the role of *Agrobacterium* and the Ti plasmid in plant genetic engineering. ***Skills Focus:*** • Use the UV spectrophotometer to measure and calculate the concentration and purity of DNA extracts. • List reasons why *Arabidopsis thaliana* is a model plant of genetic research. [Activity 11.4]			

Bringing the Products of Biotechnology to Market

Content Standards (CONTENT) "Students know…"	Content Standards (SKILL) "Students are able to …"	Perf. Std. Measures How students DEMONSTRATE KNOWLEDGE and SKILL.	Instructional Support	Appx Time
Quality Control		***Key Assignments:*** • **Cell Culture, Growth and Monitoring** [See description on p. 13.] ***Suggested:*** •	**Biotech SNM**, ***Supplemental Resources:*** • ***Key Vocabulary:*** quality control, quality assessment, product integrity, clinical testing	13 Days
Understand the relationship between biochemistry and biotechnology product development. **(PS-A1.4)**	• Outline the steps in product production, recovery, and purification. • Inspect and verify inventory and integrity of products. • Apply quality control and quality assessment techniques to a product.			
Understand the role of preclinical and clinical trials in biotechnology product development. **(PS-A5.2)**				
Know the role of quality assurance in clinical trials. **(PS-A5.3)**	• Summarize the steps in clinical testing and FDA approval for new drugs produced through genetic engineering.			
	Skills Focus: Know important strategies for self-promotion in the hiring process, such as job applications, resume writing, interviewing skills, and preparation of a portfolio. **(FS 3.6)**			
	Identify and communicate sources of unavoidable experimental error. **(IE-1b)**			

Content Standards (CONTENT) "Students know…"	Content Standards (SKILL) "Students are able to …"	Perf. Std. Measures How students DEMONSTRATE KNOWLEDGE and SKILL.	Instructional Support	Appx Time
Industrial Methodologies		***Key Assignments:*** • **Protein Product Purification and Testing** [See description on p. 14.] ***Suggested:***	**Biotech SNM**, 1.3, 9.1-3 ***Supplemental Resources:*** • B-SNM, Lab Manual **9a**, pp. 168-169 "Harvesting Amylase from Bacterial Cultures" • B-SNM, Lab Manual **9b**, pp. 169-171 "Dialysis of Proteins into Different Buffers" • B-SNM, Lab Manual **9c**, pp. 171-174 "Using Ion-Exchange Chromatography to Separate Proteins" • B-SNM, Lab Manual **9d**, pp. 174-176 "Using Ion-Exchange Chromatography to Purify Amylase from Scale-up Broth" • B-SNM, Lab Manual **9e**, pp. 176-177 "Identifying Amylase after Column Chromatography – Using SDS-PAGE" ***Key Vocabulary:*** chromatography fermentation PAGE FPLC HPLC	15 Days
Understand the relationship between biochemistry and biotechnology product development. **(PS-A1.4)**	• Describe the characteristics of proteins that allow for their purification after cloning transformed cells. • Compare and contrast the processes of paper, thin-layer, and column chromatography. • Conduct paper chromatography to isolate molecules with different absorbent/solubility profiles. • Explain how PAGE (polyacrylamide gel electrophoresis) is used with column chromatography to monitor protein products. • Describe the steps in harvesting protein product from fermentation cell culture. • Test for the presence and concentration of proteins in protein processing. • Cite the steps in buffer exchange and dialysis as used in protein processing. • Compare and contrast the mechanism of gel filtration, ion exchange, and affinity chromatography. • Conduct an ion exchange chromatography to isolate proteins of different charge. • Explain the function and use of FPLC (fast protein liquid chromatography) and HPLC (high performance liquid chromatography) in research and production. • Conduct HPLC chromatography to isolate molecules with different hydrophilic profiles. • Confirm the results of a column chromatography using spectrophotometry and PAGE. ***Skills Focus:*** Use critical thinking skills to make informed decisions and solve problems. **(FS 5.3)** Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions. **(IE-1c)**			

Identifying a Potential Biotechnology Product

Content Standards (CONTENT) "Students know…"	Content Standards (SKILL) "Students are able to …"	Perf. Std. Measures How students DEMONSTRATE KNOWLEDGE and SKILL.	Instructional Support	Appx Time
Study Plant Proteins as Possible Products		***Key Assignments:*** • **Identifying Anti-microbial Plant Substances** [See description on p. 14.] • **Extracting Compounds from Plants** [See description on p. 14.] ***Suggested:*** •	**Biotech SNM**, 6.3-5 ***Supplemental Resources:*** • B-SNM, Lab Manual **6h**, pp. 123-124 "Testing for the Presence of Peroxidase Using TMB" ***Key Vocabulary:*** antimicrobial antiseptic genetically modified organism (GMO) transfection	12 Days
Understand the role of biotechnology product development in curing genetic, environmental, and behavioral diseases. **(PS-A1.2)**	• Explain how scientists test the effectiveness of antibiotics and antimicrobials. • Understand the significance of antibiotic resistance. • Describe the role of CHO cells in protein product development. • Describe the typical recombinant DNA protein product pipeline. ***Skills Focus:***			
Understand the relationship between biochemistry and biotechnology product development. **(PS-A1.4)**				
There are important differences between bacteria and viruses with respect to their requirements for growth and replication, the body's primary defenses against bacterial and viral infections, and effective treatments of these infections. **(B-10d)**				

Biotechnology in Medicine

Content Standards (CONTENT) "Students know…"	Content Standards (SKILL) "Students are able to …"	Perf. Std. Measures How students DEMONSTRATE KNOWLEDGE and SKILL.	Instructional Support	Appx Time
Drug Discovery and Development		***Key Assignments:*** • **Chemical Synthesis of a Medicine** [See description on p. 14.] • **Testing the Purity of Synthesized Compounds** [See description on p. 14.] ***Suggested:*** •	**Biotech SNM**, 12.1-4 ***Supplemental Resources:*** • ***Key Vocabulary:*** medical biotechnology drug organic synthesis pathogenesis combinatorial chemistry	20 Days
Understand the relationship between biochemistry and biotechnology product development. **(PS-A1.4)** Understand the appropriate responses to a laboratory accident. **(PS-A4.5)**	• Describe the methods by which pharmaceuticals were produced prior to and after the development of recombinant DNA technology. • Compare combinatorial chemistry techniques to genetic engineering techniques. • Isolate simple organic compounds from plant tissues using extraction and separation technologies. • Conduct a simple organic synthesis using combinatorial chemistry. • Discuss the techniques used to analyze samples for purity including melting point determinations, mass spectrophotometry, and HPLC. • Perform melting point determination to test the purity of extracted and synthesized products. ***Skills Focus:*** Understand the role of personal integrity and ethical behavior in the workplace. **(FS 8.3)** Locate and use MSDS (Material Safety Data Sheets). [Lab 12b]			
Advanced Protein Studies		***Key Assignments:*** ***Suggested:*** •	**Biotech SNM**, 14.3 ***Supplemental Resources:*** • ***Key Vocabulary:*** proteomics proteome protein crystallography mass spectrometry nuclear magnetic resonance (NMR) enzyme-linked immunosorbent assay (ELISA)	4 Days
Understand the relationship between biochemistry and biotechnology product development. **(PS-A1.4)** Understand the appropriate responses to a laboratory accident. **(PS-A4.5)**	• Discuss the value and uses of protein crystallography in biotechnology. • Illustrate how gene therapy may be used in the treatment of genetic disorders. ***Skills Focus:***			

Synthesizing DNA and PCR

Content Standards (CONTENT) "Students know…"	Content Standards (SKILL) "Students are able to …"	Perf. Std. Measures How students DEMONSTRATE KNOWLEDGE and SKILL.	Instructional Support	Appx Time
DNA Synthesis		***Key Assignments:*** • **In Vitro DNA Synthesis, PAGE Analysis, and Southern Blot** [See description on p. 14.] ***Suggested:*** •	**Biotech SNM**, 13.1-2, 12.3 ***Supplemental Resources:*** • ***Key Vocabulary:*** polymerase chain reaction (PCR), homologous pairs, DNA replication, DNA synthesis, in vivo, in vitro, polymerase, loigonucleotides, template, primer, polyacrylamide gel electrophoresis (PAGE), nucleotide triphosphates (dNTPs)	20 Days
Understand recombinant DNA, genetic engineering, monoclonal antibody production, separation and purification of biotechnology products, and bioprocessing. **(PS-A3.1)** Apply base-pairing rules to explain precise copying of DNA during semiconservative replication and transcription of information from DNA into mRNA. **(B-5b)**	• Outline the steps of DNA replication (synthesis) as it occurs in cells. • Outline the steps of DNA synthesis as it occurs in test tubes (in vitro). • Set up and run a PAGE gel apparatus to separate synthesis products. • Prepare DNA synthesis reactions to produce oligonucleotides of varying lengths. • Conduct a Southern Blot of synthesis products and visualize using colorimetric enzyme visualization. • Discuss the history behind the discovery and development of polymerase chain reaction (PCR). ***Skills Focus:***			
Polymerase Chain Reaction		***Key Assignments:*** • **Lambda PCR** [See description on p. 14.] ***Suggested:*** •	**Biotech SNM**, 13.3-4 ***Supplemental Resources:*** • ***Key Vocabulary:*** polymerase chain reaction (PCR), alleles, genotypes, optimization, DNA fingerprinting, forensics	8 Days
Understand recombinant DNA, genetic engineering, monoclonal antibody production, separation and purification of biotechnology products, and bioprocessing. **(PS-A3.1)**	• Outline the steps in a PCR reaction including the use of thermal cycler. • Conduct a PCR to amplify targeted sections of DNA. • Discuss the applications of PCR technology in industry, research, and society. • Optimize the factors and reagents used in PCR. • Discuss the effects of varying the time and temperature of PCRss as well as the volumes and concentrations of reactants. ***Skills Focus:*** • Use internet databases to analyze the frequency of alleles and genotypes found through PCR analysis. • Select and use appropriate tools and technology to perform tests, collect data, analyze relationships, and display data. **(IE-1a)**			

DNA Sequencing and Genomics

Content Standards (CONTENT) "Students know…"	Content Standards (SKILL) "Students are able to …"	Perf. Std. Measures How students DEMONSTRATE KNOWLEDGE and SKILL.	Instructional Support	Appx Time
DNA Sequencing		***Key Assignments:*** • **Protein Extraction from Animal Tissue** [See description on p. 14.] • **Biodiversity and Evolution** [See description on p. 14.] ***Suggested:*** •	**Biotech SNM**, 14.1 ***Supplemental Resources:*** • ***Key Vocabulary:*** DNA sequencing dideoxynucleotide sequencing cycle sequencing Human Genome Project	10 Days
Understand recombinant DNA, genetic engineering, monoclonal antibody production, separation and purification of biotechnology products, and bioprocessing. **(PS-A3.1)** Understand how the fields of nanotechnology, bioinformatics, genomics, proteomics, and transcriptomics influence new and emerging career opportunities. **(PS-A3.2)**	• Explain the steps in dideoxynucleotide sequencing reactions. • Compare and contrast sequencing done using slab gels versus those done using capillary sequencing apparatus. • Read a DNA sequence on a sequencing autoradiogram or computer-generated sequence. • Cite examples of how and where DNA sequencing is used in biotechnology. • Explain how scientists used DNA sequencing to elucidate the human genome. • List the milestones of the Human Genome Project. ***Skills Focus:*** Understand how to organize and structure work individually and in teams for effective performance and the attainment of goals. **(FS 9.3)**			
Genomics		***Key Assignments:*** • **ELISA Technology** [See description on p. 14.] ***Suggested:*** •	**Biotech SNM**, 14.2-3 ***Supplemental Resources:*** • ***Key Vocabulary:*** genomics bioinformatics shotgun cloning RNA interference (RNAi) short-interfering RNA (siRNA) microRNA Northern Blot	8 Days
Understand recombinant DNA, genetic engineering, monoclonal antibody production, separation and purification of biotechnology products, and bioprocessing. **(PS-A3.1)** Understand how the fields of nanotechnology, bioinformatics, genomics, proteomics, and transcriptomics influence new and emerging career opportunities. **(PS-A3.2)**	• Give examples of advances made possible because of the Human Genome Project. • Discuss the causes and effects of point and chromosomal mutations. • Describe how DNA is modified and introduced into cells to change traits. • Discuss the methods and objectives in site-specific mutagenesis. ***Skills Focus:*** Understand the importance of accountability and responsibility in fulfilling personal, community, and workplace roles. **(FS 7.2)** • Research concerns people may have because of information derived from the Human Genome Project.			

This provides all the pieces needed to construct a good curriculum map with the exception of the essential questions and the order which are best developed by the teacher.

KEY ASSIGNMENTS / ASSESSMENTS:

Laboratories	Students will set up and use their own personal lab notebooks to record and evaluate each major laboratory performed. The notebook entries for each laboratory will include hypothesis, protocols, materials used, raw data, analysis, and a detailed discussion section. Students will be required to understand and use professional best laboratory practices as they pertain to the structure and use of their laboratory notebook.
Written tests	These include 4 to 5 essay questions that assess the level of student knowledge and understanding of key concepts. For example, an essay question might ask students to write several paragraphs that discuss the methods used and their understanding of how spectroscopy can be used to measure the concentration of large molecules (i.e., proteins and nucleic acids). In addition, tests would include objective questions that would assess basic knowledge, conceptual understanding, and vocabulary.
Comprehensive Semester Finals	Each semester final includes an objective section, three to four detailed essay questions, and a practical exam section that assesses student knowledge of equipment use, calibration and measurement skills, methods steps, and proper data analysis.
Performance Based Projects	Students develop an independent investigation that incorporates several of the methods that have been used. They will be responsible for the background research needed to develop the experimental design of the investigation as well as the adjustment of methods. They will then carry out the investigation, analyze their data, and prepare a board that communicates their work. Students complete an Interdisciplinary Project (IDP). The project will have a written and presentation portion. Students will relate issues and concepts of Biotechnology to other core subjects including: History, Math, English, Chemistry. The project will have a core theme that allows all subjects to be represented. The project theme can change from year to year as determined by the teachers involved with project. Examples - How has biotechnology been used in Medicine, Agriculture, Politics, Economics, etc.

KEY LABORATORY ACTIVITIES (Key Labs):

A minimum of 30 laboratories is recommended for this course. Our district recommends that approximately 40% of instructional time be devoted to hands-on laboratory and project-based activities. Core experiences for this course include detailed laboratories with complete write-ups on the following topics:

Flower and Seed Morphology

Students will be able to identify various structures and characteristics of flowers and seeds by observation and dissection with an emphasis on function of structures in regards to sexual reproduction. [Labs 10a & 10b]

Seed Germination

Students will determine what seeds are best for growing fast plants by germinating various seeds and measuring root and stem growth. Students then identify the fastest growing plants and make a recommendation as to what plants would be good for genetic studies due to their rapid breeding ability. [Lab 10c]

Plant Tissue Culture Media

Students will measure the effect of hormone concentration on plant propagation by adding various concentration of 1-naphthaleneacetamide for stimulation of rooting in *Fuchsia* stem cuttings. Students will determine the range of effective hormone concentrations. [Labs 11c]

Asexual Propagation of Plants

Students will grow plants through asexual propagation by placing leaf and stem cutting in various rooting mediums to determine effective ways to quickly grow plants for use in biotechnology applications. [Labs 11a]

Isolation & Study of Plant DNA

Students will determine the optimal procedure for extraction of DNA. They will conduct multiple trials of DNA extraction from spinach plants under various conditions to generate data to support recommendations about further DNA extractions. [Labs 11f]

Development of a DNA Concentration Assay / UV Spectrophotometry

Students will determine the purity and concentration of DNA samples by analyzing UV spectrophotometer absorbance ratios to support recommendations regarding DNA extractions. [Lab 11i]

Cell Culture, Growth and Monitoring

Students will grow broth cultures of bacteria. Recovered bacteria will be used for amylase separation and purification techniques in the following lab. [Lab 9a]

Protein Product Purification and Testing

Students will harvest amylase from bacteria in previous lab and use ion exchange chromatography to isolate the amylase from other proteins. Students will identify amylase using SDS-PAGE gels to confirm effectiveness of purification techniques. [Labs 9d & 9g]

Identifying Anti-microbial Plant Substances

Student will search for antibiotics by using local plant material extracts to test for zones of inhibition in an inoculated petri dish. This serves as an introduction to how new biotech products can be developed. [Lab 6d]

Extracting Compounds from Plants

Students will isolate proteins from plant material by extracting horseradish peroxidase from horseradish root to demonstrate how specific compounds are isolated from plant tissue. [Lab 6g]

Chemical Synthesis of a Medicine

Students will synthesize a chemical that could be used as a pharmaceutical by combining salicylic acid and acetic anhydride to produce the modern form of aspirin. [Lab 12c]

Testing the Purity of Synthesized Compounds

Students will determine the purity of the aspirin synthesized in lab 12c by conducting a melting point analysis to determine the effectiveness of the chemical synthesis. [Lab 12d]

In Vitro DNA Synthesis, PAGE Analysis, and Southern Blot

Students will synthesize DNA of various lengths by using a single-stranded DNA fragment as a template and adding primer, DNA nucleotide triphosphates (dNTPs), polymerase and buffer reagents. They will use this synthesized DNA in a PAGE analysis and for making a Southern Blot. [Labs 13a, 13b, & 13c]

Lambda PCR

Students will amplify DNA by using PCR to replicate sections of Lambda DNA for the purpose of studying DNA fragments for Bioinformatics and DNA Fingerprinting and Forensics. [Labs 13e]

Protein Extraction from Animal Tissue / Biodiversity and Evolution

Students will extract DNA from cheek cells for the purpose of DNA typing by measuring the amount of *Alu* insert to determine the frequency of the *Alu* insert genotypes for a given population. [Labs 13f & 13g]

ELISA Technology

Students will identify and quantify a specific protein in a protein mixture by using ELISA (enzyme-linked immunosorbent assay) with the goal of identifying foreign proteins in a food source. [Labs 14a]

INSTRUCTIONAL METHODS AND/OR STRATEGIES:

A variety of instructional strategies will be utilized to accommodate all learning styles:

Biotechnology-specific:

1. lectures, videos, and demonstrations
2. readings from texts, journals, and internet sites
3. laboratory experiments and detailed written laboratory reports that emphasize experimental analysis
4. pre- and post-lab discussions
5. oral PowerPoint presentations
6. field trips, guest speakers
7. long-term research projects and written report using standard journal outlines
8. on-line databases for molecular modeling and bioinformatics

Lesson Design & Delivery: Teachers will incorporate these components of lesson design during direct instruction and inquiry activities. The order of components is flexible, depending on the teacher's vision for the individual lesson. For instance, the objective and purpose, while present in the teacher's lesson plan, are not made known to the students at the beginning of an inquiry lesson.

Essential **E**lements of **E**ffective **I**nstruction Model for Lesson Design Using Task Analysis	Anticipatory Set Objective Standard Reference Purpose Input Modeling Check for Understanding Guided Practice Closure Independent Practice

Some components may occur once in a lesson, but others will recur many times. Checking for understanding occurs continually; input, modeling, guided practice and closure may occur several times. There may even be more than one anticipatory set when more than one content piece is introduced.

Active Participation: Teachers will incorporate the principles of active participation and specific strategies to ensure consistent, simultaneous involvement of the minds of all learners in the classroom. This allows for broad monitoring of student understanding and rapid adjustment of instruction. Teachers should include both covert and overt active participation strategies, incorporating cooperative learning structures and brain research. Some of the possible active participation strategies include:

COVERT	OVERT (Oral)	OVERT (Written)	OVERT (Gestures)
• Recall • Imagine • Observe • Consider	• Pair/Share • Idea Wave • Choral Response • Give One, Get One • Socratic Seminar • Cooperative Discussion Groups (i.e.Talking Chips, Gambit Chips)	• Restate in Journals / Notes • Response Boards • Graphic Organizers • Folded Paper • Ticket Out of Class	• Hand Signals • Model with Manipulatives • Stand up/ Sit down • Point to Examples

Baldridge Quality Tools: Students can become more positively involved in their education through goal setting, self-assessment, and data tracking and analysis by making use of the following strategies:

BALDRIDGE TOOL	PURPOSES
Affinity Diagram	– finding consensus, organizing complex information
Flowchart	– describing a process, planning a project, identifying problem steps in a process
Force Field Diagram	– identifying obstacles, finding causes and solutions to problems
Issues / Ideas Bin	– handling individual questions/requests without stopping a group activity, providing anonymous input, obtaining diverse input in specific areas.
Data Folder	– tracking goals and actual results
Plus / Delta	– tracking improvement efforts, identifying opportunities for change, finding out what's working and what's not working in a process, procedure, activity, etc.
Class Data Graphs	– displaying trends for goal setting

Learning styles and learning challenges of your students may be addressed by implementing combinations of the following:

Learning styles of students may be addressed by implementing combinations of the following:

Significant, Proven Strategies for ALL Students

- ❑ Hands-On Lab's
- ❑ Inquiry Activities
- ❑ Short/Long-term projects
- ❑ Student Presentations
- ❑ Peer Teaching
- ❑ Summarization
- ❑ Essential Questions
- ❑ Thematic Units
- ❑ Field Experiences
- ❑ Current Events
- ❑ Career Choices
- ❑ Guest Speakers

Reading Strategies in Science

- ❑ Learning Logs
- ❑ Pre-teaching
- ❑ Vocabulary
- ❑ Pre-reading
- ❑ Text Structures
- ❑ Trail Markers
- ❑ Reciprocal Teaching
- ❑ Functional Text

SDAIE Strategies for English Learners

- ❑ Tapping/Building Prior Knowledge (Graphic Organizers, Schema)
- ❑ Grouping Strategies
- ❑ Multiple Intelligences
- ❑ Adapt the Text
- ❑ Interactive Learning (Manipulatives, Visuals)
- ❑ Acquisition Levels
- ❑ Language Sensitivity
- ❑ Lower the Affective Filter (including Processing Time)
- ❑ Home/School Connection (including Cultural Aspects)

Differentiation for Advanced Learners

- ❑ Curriculum Compacting
- ❑ Tiered Assignments
- ❑ Flexible Grouping
- ❑ Acceleration
- ❑ Depth and Complexity
- ❑ Independent Study

Please note that these strategies often overlap and should not be limited to specifically defined courses or student populations.

TEXTBOOKS:

Basic Textbook:	☑ Read in entirety over 4 sem course 1/2-3/4 sequence	☐ Excerpts used	Biotechnology: Science for the New Millenium, 1st Ed., Daugherty, Paradigm Publishing, © 2007
Supplemental Texts:	☑ Read in entirety over 4 sem course 1/2-3/4 sequence	☐ Excerpts used	Biotechnology: Lab Manual, 1st Ed., Daugherty, Paradigm Publishing, © 2007

Safety Equipment:	fire extinguisher, eye wash station, goggles
Measuring Devices:	centigram balances, analytical balance, pipettes, micropipettes, volumetric graduated cylinders, colony counters, thermometers, pH meters
Other Laboratory Equipment:	microscopes, Bunsen burners, electrophoresis equipment, spectrophotometer, water baths, incubators, autoclave, DI water system, hot plates, microwave oven, refrigerator, centrifuge, laminar flow hood, pipette pumps, standard equipment comparable to a professional or college laboratory
Laboratory Supplies:	chemical reagents, petri dishes, filter paper, chromatography paper, test tubes, nichrome loops, microtubes, pipette tips
Other:	Word processing, spreadsheet, and presentation programs.

❖ Some generic items are shared in your science department or may be available through Science/Math Resource Center (SMRC).

RESOURCES:

Documents

- ❑ CTE Model Curriculum Standards: .. http://www.cde.ca.gov/ci/ct/sf/documents/ctestandards.pdf
- ❑ Science Framework: ..... http://www.cde.ca.gov/re/pn/fd/sci-frame-dwnld.asp
- ❑ CST / NCLB Test Blueprints: ..... http://www.cde.ca.gov/ta/tg/sr/blueprints.asp
- ❑ CST Reference Sheets: ..... http://www.cde.ca.gov/ta/tg/sr/cstsciref.asp
- ❑ National Science Standards: ..... http://www.nap.edu/readingroom/books/nses/html/
- ❑ Science Safety Handbook for CA Public Schools (1999) *can be ordered Science Curriculum Office*
- ❑ LBUSD Approved Chemicals List, Chemical Hygiene Plan, and Science Fair Resources: http://www.lbusd.k12.ca.us/curriculum/Curriculum%20Services/Science/science.htm

RESOURCES (cont'd):

District Offices

- Science Curriculum Office (562) 997-8000 (ext. 2963)
  - K-12 science standards, curriculum, professional development, science fair
- Science / Math Resource Center (562) 997-8000 (ext. 2964)
  - hands-on materials, consumable material orders, alternative standards-based curriculum packets
- Office of Multimedia Services (OMS) (562) 997-8000 (ext. 7145)
  - videos for check out to fit the curriculum (see your librarian for current catalogs)
  - district TV channels programming
- PALMS Office Program Assistance for Language Minority Students (562) 997-8000 (ext. 8031)
  - technical assistance and professional development for English Language Development (ELD) and Specially Designed Academic Instruction In English (SDAIE)
  - assistance in the implementation and maintenance of programs addressing the needs of English Language Learners (ELLs)

ASSESSMENT METHODS AND/OR TOOLS:

Student achievement in this course will be measured using multiple assessment tools including but not limited to:

Suggested Evaluation Tools:

Source	Diagnose	Monitor	Evaluate
EMC Paradigm: Biotechnology: SNM	Skills evaluation	Notebook Checks	Tests
Teacher Developed Assessments	Quizzes Active Participation strat's	Formal laboratory reports Monthly evaluation of legal scientific notebook	Written, oral, performance-based, and lab. practical examinations

Learning styles of students will be best assessed by implementing combinations of the following:

- laboratory-based performance tasks
- long-term projects and inventions
- portfolios
- model-building
- research projects using primary source
- written reports with oral presentations
- cooperative group assessment
- homework assessment
- notebook organization and note-taking skills
- peer evaluation
- rubric scoring
- open-ended written assessment
- single-response testing

Performance Standards:

Defines how good is good enough on which measures to demonstrate achievement of content standards.

Classroom Performance Standards:

Students must pass all exams with a score of 80% or higher. Students who score lower than 80% on any examination will be assigned mandatory tutorial sessions during their free period.
Students must maintain a complete and accurate scientific notebook.

SUGGESTED GRADE WEIGHTING:

(with some possible examples)

1. Assessment ~30%
   - objective tests including comprehensive finals
   - performance tasks (rubric scored)
   - open-ended questions (rubric scored)
   - portfolios
   - peer evaluations
2. Homework ~10%
   - discovery assignments
   - assignments reinforcing class lesson
   - essays
   - organization
3. Labs ~30%
   - lab reports
   - active participation
4. Projects ~20%
   - science fair projects
   - research-based reports and projects
5. Classwork ~10%
   - note taking skills
   - organization skills
   - oral presentations
   - individual and group projects and assessments

STANDARD GRADING SCALE:

STANDARD GRADING SCALE:		
Advanced Proficient	A	90 – 100%
	B	80 – 89%
Proficient	C	70 – 79%
Partial Proficient	D	60 – 69%
Not Proficient	F	0 – 59%

Submitted by: Cindy Bater / Armando Gonzales II
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