OFFICE OF CURRICULUM, INSTRUCTION, & PROFESSIONAL DEVELOPMENT

HIGH SCHOOL COURSE OUTLINE

(Revised June 2011)

Department	Science		**Course Title**	Biotechnology 1-2		**Course Code**	3867				
Abbreviation	Biotech 1-2		**Grade Level**	10, 11		**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	Biology 1-2 with a "C" or better										
Co-requisites	Integrated Math Program (IMP) 5-6 maintaining a "C" or better										
Articulated with LBCC	No		**Articulated with CSULB**	No							
Meets UC "a-g" Requirement	Yes (d)		**Meets NCAA Requirement**	Yes							

COURSE DESCRIPTION:

Biotechnology 1-2 is a course designed to give students a comprehensive introduction to the scientific concepts and laboratory research techniques currently used in the field of biotechnology. Students attain knowledge about the field of biotechnology and deeper understanding of the biological concepts used. In addition, students develop the laboratory, critical thinking, and communication skills currently used in the biotechnology industry. 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: GOALS (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.
  - A1.3 Understand the legal and ethical issues regarding the use of biotechnology to cure 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:
  - A2.1 Understand basic mathematical concepts related to the field, such as the calculation of percentages and ratios and the difference between standard deviation and various measures of central tendency.
  - A2.2 Understand the basic structure of a chromosome and the difference between a dominant homozygous trait and a heterozygous trait.
  - A2.3 Know the basic structures and functions of cells and how this knowledge is used in biotechnology.
  - A2.4 Understand the central theory of molecular biology.
- 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:
  - A4.1 Students understand how molarity relates to solution preparation.
  - A4.2 Know how to calculate the molarity of a given solution and how to measure the pH of that solution.
  - A4.3 Know how to prepare a serial dilution of a microbial culture.
  - A4.4 Understand the importance and requirements of using sterile techniques in a laboratory.
- A5.0 Students understand biotechnology product design and development, laboratory procedures, product licensure, and the regulatory process for product development and clinical trials:
  - A5.1 Understand the process of developing biotechnology products in an industrial setting.
  - 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.
- A6.0 Students understand the ethical, moral, legal, and cultural issues related to the use of biotechnology research and product development:
  - A6.1 Understand the relationship between morality and ethics in the development of biotechnology health care products.
  - A6.2 Know the differences between personal, professional, and organizational ethics.
  - A6.3 Understand the necessity for accurate documentation and recordkeeping in biotechnology research and product development.
  - A6.4 Understand the need for ethical policies and procedures in institutions engaged in biotechnology research and product development.

CA SCIENCE CONTENT STANDARDS:

Grade 9-12 Biology/Life Sciences:

Cell Biology

1. The fundamental life processes of plants and animals depend on a variety of chemical reactions that occur in specialized areas of the organism's cells. As a basis for understanding this concept, students know:
   a. cells are enclosed within semipermeable membranes that regulate their interaction with their surroundings. (CST)
   b. enzymes are proteins and catalyze biochemical reactions without altering the reaction equilibrium and the activities of enzymes depend on the temperature, ionic conditions, and the pH of the surroundings. (CST)
   c. how prokaryotic cells, eukaryotic cells (including those from plants and animals), and viruses differ in complexity and general structure. (CST)
   d. the Central Dogma of molecular biology outlines the flow of information from transcription of ribonucleic acid (RNA) in the nucleus to translation of proteins on ribosomes in the cytoplasm. (CST)
   e. the role of the endoplasmic reticulum and Golgi apparatus in the secretion of proteins. (CST)
   f. usable energy is captured from sunlight by chloroplasts and is stored through the synthesis of sugar from carbon dioxide. (CST)
   g. the role of the mitochondria in making stored chemical bond energy available to cells by completing the breakdown of glucose to carbon dioxide. (CST)

Genetics

4. Genes are a set of instructions encoded in the DNA sequence of each organism that specify the sequence of amino acids in proteins characteristic of that organism. As a basis for understanding this concept, students know:
   a. the general pathway by which ribosomes synthesize proteins, using tRNAs to translate genetic information in mRNA. (CST)
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:
   a. the general structures and functions of DNA, RNA, and protein. (CST)
   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)
   c. how genetic engineering (biotechnology) is used to produce novel biomedical and agricultural products. (CST)
   d. how basic DNA technology (restriction digestion by endonucleases, gel electrophoresis, ligation, and transformation) is used to construct recombinant DNA molecules.*
   e. how exogenous DNA can be inserted into bacterial cells to alter their genetic makeup and support expression of new protein products.*

Physiology

10. Organisms have a variety of mechanisms to combat disease. As a basis for understanding the human immune response, students know:
    b. the role of antibodies in the body's response to infection. (CST)
    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 Chemistry:

Acids and Bases

5. Acids, bases, and salts are three classes of compounds that form ions in water solutions. As a basis for understanding this concept, students know:
   a. the observable properties of acids, bases, and salt solutions. (CST)
   b. acids are hydrogen-ion-donating and bases are hydrogen-ion-accepting substances. (CST)
   c. strong acids and bases fully dissociate and weak acids and bases partially dissociate. (CST)
   d. how to use the pH scale to characterize acid and base solutions. (CST)

Solutions

6. Solutions are homogenous mixtures of two or more substances. As a basis for understanding this concept, students know:
   a. the definitions of *solute* and *solvent.* (CST)
   b. how to describe the dissolving process at the molecular level by using the concept of random molecular motion. (CST)
   c. temperature, pressure, and surface area affect the dissolving process. (CST)
   d. how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition. (CST)

Organic Chemistry and Biochemistry

10. The bonding characteristics of carbon allow the formation of many different organic molecules of varied sizes, shapes, and chemical properties and provide the biochemical basis of life. As a basis for understanding this concept, students know:
    a. large molecules (polymers), such as proteins, nucleic acids, and starch, are formed by repetitive combinations of simple subunits. (CST)
    b. the bonding characteristics of carbon that result in the formation of a large variety of structures ranging from simple hydrocarbons to complex polymers and biological molecules. (CST)
    c. amino acids are the building blocks of proteins. (CST)
    f. the R-group structure of amino acids and know how they combine to form the polypeptide backbone structure of proteins.*

Grade 9-12 Physics:

Waves

4. Waves have characteristic properties that do not depend on the type of wave. As a basis for understanding this concept, students know:
   e. radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately 3×10^8m/s (186,000 miles/second).

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.
   d. formulate explanations by using logic and evidence.
   f. distinguish between hypothesis and theory as scientific terms.
   j. recognize the issues of statistical variability and the need for controlled tests.
   l. analyze situations and solve problems that require combining and applying concepts from more than one area of science.
   m. investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings.
   n. know that when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent and that the theory is sometimes wrong.

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: Making a Living in Biotecdhnology*]

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: Basic Scientific 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: Basic Biotechnology Methodologies*]

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: Ethics for the Biotechnology Industry*]

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: Biotechnology Management*]

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 [page 2].

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.

Introduction to Biotechnology Past and Present

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
History and Development of Recombinant DNA Technology		***Key Assignments:*** [none] ***Suggested:*** • B-SNM, Lab Manual **1c**, pp. 6-11 "Cheese Production"	**Biotech SNM**, 1.1-2 ***Supplemental Resources:*** • B-SNM, p. 33, Activity 1.3, "Using Sci. Journals Online" • B-SNM, p. 33, Activity 1.4, "Staying Current" ***Key Vocabulary:*** technology, biotechnology, recombinant DNA, pharmaceuticals, diagnostic, industry, agriculture, fermentation	5 Days
Understand the role of the biotechnology industry and its impact on society. **(PS-A1.1)**	• Identify the major scientific discoveries that lead to recombinant DNA technology, including those in chemistry, genetics, microbiology, and fermentation technology.			
Understand the role of biotechnology product development in curing genetic, environmental, and behavioral diseases. **(PS-A1.2)**	• Explain how biotechnology discoveries are used in industry today. • Describe major historic developments in biotechnology fields such as pharmaceuticals, agriculture, diagnostics, industrial products, instrumentation and research and development. ***Skills Focus:*** • **Research Skills** Students will use university library electronic resources to perform thorough literature searches. Evaluate scientific reports with well-supported and clearly presented opinions. • **Presentation Skills** Students will use PowerPoint software to present information on research.			

Introduction to Biotechnology Past and Present

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
Basic Scientific Methodologies		***Key Assignments:*** • **Setting Up a Legal Scientific Notebook** [See description on p. 18.] ***Suggested:*** • B-SNM, Lab Manual **1b**, pp. 4-6 "Laboratory Safety"	**Biotech SNM**, 1.4, 10.5 ***Supplemental Resources:*** • **Data Analysis & Presentation** Students will use Excel and PowerPoint software to create graphs and presentations from raw laboratory data. • B-SNM, Lab Manual **1a**, pp. 2-4 "How to Set Up a Legal Scientific Notebook" ***Key Vocabulary:*** documentation, hazards, qualitative, quantitative	5 Days
Understand the necessity for accurate documentation and recordkeeping in biotechnology research and product development. **(PS-A6.3)**	• Use the scientific method to conduct a valid experiment, including hypothesis formation, data collection, and data analysis. • Develop scientific questions, hypotheses, and experimental plans. • Create data tables and graphs using Excel ® for the purpose of collecting and analyzing data. • Organize and communicate scientific findings by producing written reports and oral presentations that are clear and concise.			
Understand basic mathematical concepts related to the field, such as the calculation of percentages and ratios and the difference between standard deviation and various measures of central tendency. **(PS-A2.1)**	• Interpret and critically analyze quantitative and qualitative data.			
Understand the appropriate responses to a laboratory accident. **(PS-A4.5)**	• Recognize all laboratory safety hazards and learn methods of doing safe procedures. • Identify the location and use of emergency equipment.			
	Skills Focus: Use critical thinking skills to make informed decisions and solve problems. **(FS 5.3)** Distinguish between hypothesis and theory as scientific terms. **(IE-1f)** Select and use appropriate tools and technology to perform tests, collect data, analyze relationships, and display data. **(IE -1a)** Identify and communicate sources of unavoidable experimental error. **(IE-1b)** Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions. **(IE-1c)**			

Introduction to Biotechnology Past and Present

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
Basic Biotechnology Methodologies		***Key Assignments:*** • **Solution and Dilution Preparation** [See description on p. 18.] ***Suggested:*** •	**Biotech SNM**, 3.1-6, 4.2, 2.1-2, 1.3 ***Supplemental Resources:*** • **Safety in Biotech Lab.** • **Set Up, Calibration, Use, and Maintenance of Lab Equipment** – top-loading balance – analytical balance – pH meter and electrodes – spectrophotometer – micro centrifuges – clinical centrifuges – micropipettes – gel electrophoresis equipment – gel documentation systems – fume hoods – vortex mixers – temperature probes – microscopes • B-SNM, Lab Manual **3a**, pp. 32-35 "Measuring Small Volumes" • B-SNM, Lab Manual **3b**, pp. 35-39 "Measuring VERY Small Volumes" • B-SNM, Lab Manual **3c**, pp. 40-42 "Measuring Mass" • B-SNM, Lab Manual **3e**, pp. 45-49 "Making Solutions of Differing Mass/Volume Conc's" • B-SNM, Lab Manual **3f**, pp. 50-54 "Making Solutions of Differing % Mass/Volume Conc's" • B-SNM, Lab Manual **3g**, pp. 55-58 "Making Solutions of Differing Molar Conc's" • B-SNM, Lab Manual **3h**, pp. 59-62 "Making Dilutions" • B-SNM, Lab Manual **2b**, pp. 17-22 "Characteristics of Model Organisms" ***Key Vocabulary:*** calibration, molarity, aliquot, dilution, sterile technique, purification, validity	28 Days
Students understand the principles of solution preparation, contamination control, measurement and calibration, and emergency laboratory response. **(PS-A4.0) also, (C-6a-d)**	• Calculate and prepare solutions based on mass/volume, % mass/volume, and molar concentrations. • Properly and safely use and monitor a variety of scientific equipment, including pH meters, microscopes, spectrophotometers, pipets, micropipettes, balances, etc. • Determine proper equipment to use for a given task and the most appropriate units to use. • Practice proper set up, calibration, and maintenance of common lab equipment. • Prepare and maintain plate and broth cultures of bacteria.			
Students understand how molarity relates to solution preparation. **(PS-A4.1)**	• Prepare solutions of any volume and concentration. • Prepare dilutions from concentrated solutions. • Prepare and aliquot samples, reagents, and buffers.			
Understand the importance and requirements of using sterile techniques in a laboratory. **(PS-A4.4)**	• Maintain personal, equipment, and work surface cleanliness showing awareness of potential microbial and chemical hazards. • Exercise sterile technique, proper use of disinfectants and show knowledge of the use of an autoclave and a laminar flow hood. • Outline the steps in cell culture, sterile techniques, and media preparation.			
Students know how genetic engineering (biotechnology) is used to produce novel biomedical and agricultural products. **(B-5c)**	• Perform chemical reactions and purification procedures similar to those used in product development, testing, and manufacture. • Perform specimen collection, label samples, and prepare them for testing. • Employ proper handling, inventory, and temperature storage of biological samples. • Outline the steps in production and delivery of a product made through recombinant DNA technology. • Work effectively within a team and individually. • Evaluate the validity of results obtained during experimentation and product development. • Compose a thorough concluding statement (abstract) outlining the results of an experiment with evidence, explanations, error analysis, and practical applications.			
Understand the role of biotechnology product development in curing genetic, environmental, and behavioral diseases. **(PS-A1.2)**	***Skills Focus:*** Select and use appropriate tools and technology to perform tests, collect data, analyze relationships, and display data. **(IE-1a)** Understand the importance of accountability and responsibility in fulfilling personal, community, and workplace roles. **(FS 7.2)**			
Understand the role of the biotechnology industry and its impact on society. **(PS-A1.1)**	Formulate explanation by using logic and evidence. **(IE-1d)** Investigate a science-abased societal issue by researching the literature, analyzing data, and communicating the findings. **(IE-1m)** Know that when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent, and that the theory is sometimes wrong. **(IE-1n)**			

Characteristics of Organisms Used in 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
Life at the Cellular Level		***Key Assignments:*** • none ***Suggested:*** •	**Biotech SNM**, 2.1-2, 4.2 ***Supplemental Resources:*** • **Cellular Structures in Biotechnology** Students will research the significant cellular structures used in modern biotechnology, including various nucleic acid structures and organelles needed for protein production. ***Key Vocabulary:*** prokaryotic eukaryotic organelles	2 Days
Students know cells are enclosed within semipermeable membranes that regulate their interaction with their surroundings. **(B-1a)**				
Students know how prokaryotic cells, eukaryotic cells, and viruses differ in complexity and general structure. **(B-1c)**	• Distinguish between prokaryotic cells, eukaryotic cells, and viruses.			
Students know the roles endoplasmic reticulum and Golgi apparatus, and of chloroplasts and mitochondria. **(B-1e,f,g)**	• List and describe the structure and function of cellular organelles.			
Know the basic structures and functions of cells and how this knowledge is used in biotechnology. **(PS-A2.3)**	***Skills Focus:*** research			
Cellular Level Life Cycle		***Key Assignments:*** • none ***Suggested:*** •	**Biotech SNM**, 4.2-3 ***Supplemental Resources:*** • B-SNM, Lab Manual **4f**, pp. 74-76 "Sterile Technique and Pouring Plates" ***Key Vocabulary:*** Central Theory (Dogma)	2 Days
Students know there are important differences between bacteria and viruses with respect to their requirements for growth and replication. **(B-10d)**	• Outline the life cycle and characteristics of model organisms used in the biotechnology industry, including various bacteria (E. coli) and fungi (yeasts and Aspergillus).			
Understand the central theory of molecular biology. **(PS-A2.4)**	• Explain the basic concepts of cell growth. • Explain the integrated processes involved in cellular reproduction, including DNA replication, mitosis, meiosis, and protein synthesis. ***Skills Focus:*** sterile technique			

Characteristics of Organisms Used in 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
Culturing Model Organisms		***Key Assignments:*** • **Model Organism growth / Media Preparation** ***Suggested:*** • **Solution Preparation and Dilution** Students will make appropriate mass/vol and mass/mass solutions and create serial dilutions.	**Biotech SNM**, (no reference) ***Supplemental Resources:*** • **Model Organism Growth / Media Preparation and Cell Culture Using Sterile Technique** Students will prepare and inoculate media plates with model organisms E. coli and Aspergillus and grow broth cultures of them. • B-SNM, Lab Manual **4e**, pp. 71-74 "Media Prep" • B-SNM, Lab Manual **4g**, pp. 76-79 "Bacteria Cell Culture" ***Key Vocabulary:*** serial dilution	5 Days
Know how to prepare a serial dilution of a microbial culture. **(PS-A4.3)**	• Use various methods to monitor the growth of cell cultures. • Describe conditions that promote cell growth under aseptic conditions in the laboratory and workplace. • Explain how environmental factors affect the growth of model organisms in the laboratory. ***Skills Focus:*** aseptic technique			

DNA and Protein Structure / Function

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
Cellular Macromolecules		***Key Assignments:*** • none ***Suggested:*** • **Macromolecule Research** Students will use university library electronic resources to study specific macromolecules, noting how the three dimensional structure determines function through exposed functional groups or allowing for shape change.	**Biotech SNM**, 2.3 ***Supplemental Resources:*** • B-SNM, Lab Manual **2a**, pp. 14-17 "Dissecting a 'Cell' and Examining its Components" ***Key Vocabulary:*** polymer monomer	4 Days
Students know large molecules (polymers) are formed by repetitive combinations of simple subunits, such as amino acids in proteins. **(C-10a,c)**	• Discuss the structure and function of the macromolecules that compose cells: carbohydrates DNA lipids RNA protein • Conduct indicator tests (Benedict's, Iodine, Biuret) for common cellular macromolecules.			
Students know the bonding characteristics of carbon that result in the formation of a large variety of structures ranging from simple hydrocarbons to complex polymers and biological molecules. **(C-10b)**				
Students know the R-group structure of amino acids and know how they combine to form the polypeptide backbone structure of proteins. **(C-10f)**				
Students know the general structures and functions of DNA, RNA, and protein. **(B-5a)**	• Identify the monomers comprising DNA, RNA, and proteins. • Explain how the macromolecule structures facilitate their functions. ***Skills Focus:*** • research and presentation			

DNA and Protein Structure / Function

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 Structure, Function, Isolation and Analysis		***Key Assignments:*** • **DNA Isolation and Indicator Analysis** [See description on p. 18.] • **Agarose Gel Electrophoresis** [See description on p. 18.] • **DNA Synthesis and PCR** [See description on p. 18.] ***Suggested:*** •	**Biotech SNM**, 2.4, 4.1-3 ***Supplemental Resources:*** • B-SNM, Lab Manual **4a**, pp. 64-65 "Making Solutions for DNA Isolation" • B-SNM, Lab Manual **4b**, pp. 65-67 "DNA Spooling" • B-SNM, Lab Manual **4h**, pp. 79-82 "DNA Extraction from Bacteria" ***Key Vocabulary:*** semiconservative replication, transcription, nucleotides, nucleic acids, ligation, isolation, mini-preparation, nitrogen bases, bioprocessing, transformation	15 Days
Understand the central theory of molecular biology. **(PS-A2.4) and (B-1d & 4a)**	• Identify both the general and special routes of information transfer in biological systems. • Describe the roles of DNA, RNA, and ribosomes in protein synthesis. • Apply base-pairing rules to explain precise copying of DNA during semiconservative replication and transcription of information from DNA into mRNA. **(B-5b)** • Explain the basic concepts of cell growth and reproduction: DNA replication, mitosis, meiosis, and protein synthesis.			
Understand the basic structure of a chromosome. **(PS-A2.2)**	• Describe the relationship between nitrogen bases, nucleotides, and nucleic acids. • Recognize nucleotides on a DNA double helix model. • Explain how the structure of DNA affects its function.			
Know the basic structures and functions of cells and how this knowledge is used in biotechnology. **(PS-A2.3)**	• Explain how the structure of DNA affects its isolation from cells and solutions.			
Understand recombinant DNA, genetic engineering, monoclonal antibody production, separation and purification of biotechnology products, and bioprocessing. **(PS-A3.1)**	• Isolate genomic DNA from cells and analyze its purity and concentration. • Perform routine tasks with DNA including extraction from multiple sources, restriction digestion, size determination, ligations and transformations, and gel documentation. • Isolate plasmid DNA from cells (mini-preparation) and analyze its purity and concentration. • Explain the principles involved in agarose gel electrophoresis. • Prepare, load, run, visualize, and analyze DNA samples on an agarose gel. • Describe the differences in samples of eukaryotic and prokaryotic DNA samples on a gel. ***Skills Focus:*** Select and use appropriate tools and technology to perform tests, collect data, analyze relationships, and display data. **(IE-1a)** Identify and communicate sources of unavoidable experimental error. **(IE-1b)** Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions. **(IE-1c)** Analyze situations and solve problems that require combining and applying concepts from more than one area of science. **(IE-1l)**			

DNA and Protein Structure / Function

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
Protein Structure, Function, Isolation and Analysis		***Key Assignments:*** • **Protein Isolation and Indicator Analysis** [See description on p. 18.] • **Polyacrylamide Gel Electrophoresis** [See description on p. 18.] • **Protein and Enzyme Studies / Assays** [See description on p. 18.] ***Suggested:***	**Biotech SNM**, 4.4, 5.1-3 ***Supplemental Resources:*** • **Protein Structure and Function** Students will use university library and electronic resources to research specific proteins' functions and how those functions are made possible by shape. • B-SNM, Lab Manual **4i**, pp. 82-84 "Making Agarose Gels for Separating and Analyzing DNA Fragments" • B-SNM, Lab Manual **4j**, pp. 85-87 "Using Gel Electrophoresis to Study DNA Molecules" • B-SNM, Lab Manual **5b**, pp. 92-94 "Action of Different Enzymes" • B-SNM, Lab Manual **5c**, pp. 95-96 "Developing an Assay for Protease Activity" • B-SNM, Lab Manual **5f**, pp. 101-106 "Characterizing Proteins by PAGE" ***Key Vocabulary:*** catalyze gel electrophoresis	30 Days
Students know proteins can differ from one another in the number and sequence of amino acids. **(B-4e)**	• Identify eight groups of protein based on their functions, citing specific examples of proteins in each group. • Explain the relationship between amino acids, peptides, and proteins.			
Students know why proteins having different amino acid sequences typically have different shapes and chemical properties. **(B-4f*)**	• Describe primary, secondary, tertiary, and quaternary structure in proteins. • Use the internet to find information about the structure and function of specific proteins.			
Students know enzymes are proteins that catalyze biochemical reactions without altering the reaction equilibrium and the activities of enzymes depend on the temperature, ionic conditions, and the pH of the surroundings. **(B-1b)**	• Prepare protein solutions and dilutions at specific concentrations and pH values. • Use protein indicator solutions to identify the presence and concentration of protein in solution. • Explain the principles involved in polyacrylamide gel electrophoresis. • Describe the meaning of differences in peptide bands seen on polyacrylamide gels. • Explain the function of enzymes and how their activity is affected by temperature and pH. • Perform enzyme activity assays. ***Skills Focus:*** Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions. **(IE-1c)**			

Products and Applications of Modern 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
Applying Biotechnology		***Key Assignments:*** • none ***Suggested:*** •	**Biotech SNM**, 6.2-4 ***Supplemental Resources:*** • **Remedies and Treatments** Students will analyze the relative merits of herbal remedies, traditional pharmaceuticals, and recombinant pharmaceuticals. ***Key Vocabulary:*** pure science applied science herbal remedy traditional pharmaceutical recombinant pharmaceutical	5 Days
Students know how genetic engineering (biotechnology) is used to produce novel biomedical and agricultural products. **(B-5c)**	• Compare and contrast pure and applied scientific research in the field of biotechnology. • Identify several products obtained through recombinant DNA technology. • Cite examples of plant parts or extracts used as pharmaceuticals. • Use internet resources to find information about herbal remedies, traditional pharmaceuticals, and recombinant pharmaceuticals. • Identify several local biotechnology companies specializing in the production of pharmaceuticals, agricultural products, industrial products, and research instruments and reagents. ***Skills Focus:*** compare and contrast			

Products and Applications of Modern 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
Industrial Production		***Key Assignments:***	**Biotech SNM**, 6.1	2 Days
Understand the process of developing biotechnology products in an industrial setting. **(PS-A5.1)**	• Explain how companies decide on the research and development targets and potential products. • Describe the major steps as a product moves through a company's product pipeline. • Produce and test plant extracts for anti-microbial activity. • Collect and test native bacteria for amylase production. ***Skills Focus:*** Select and use appropriate tools and technology to perform tests, collect data, analyze relationships, and display data. **(IE-1a)**	• **Assay for Antimicrobial Activity** [See description on p. 18.] • **Amylase Assay Development** [See description on p. 18.] • **Peroxidase Assay Development** [See description on p. 18.] ***Suggested:*** •	***Supplemental Resources:*** • ***Key Vocabulary:*** extract native	

Assays and Assay Development

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
Chemical and Biochemical Assays		***Key Assignments:*** • none	**Biotech SNM**, 5.1	2 Days
	Perform qualitative assays. • Describe how assays for reactants or products can indicate the presence or activity of an enzyme. • Design an assay that shows the presence and activity of an enzyme. • Compare and contrast the use of different assays in research and production of protein products. • Explain how Benedict's Solution and Lugol's Iodine are used in glucose and starch testing. ***Skills Focus:*** Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions. **(IE-1c)**	***Suggested:*** •	***Supplemental Resources:*** • B-SNM, Lab Manual **5d**, pp. 97-99 "Testing for the Presence of Protein in Solution" ***Key Vocabulary:*** assay ELISA	
pH Effects		***Key Assignments:*** • **pH Meter Use** [See description on p. 18.]	**Biotech SNM**, 7.2-3	5 Days
Students know the properties of both strong and weak acids and bases, as well as salt solutions, and how the pH scale characterizes them. **(C-5a-d)** Know how to calculate the molarity of a given solution and how to measure the pH of that solution. **(PS-A4.2)**	• Discuss the difference between acids, bases, and neutral solutions. • Differentiate strong from weak acids and bases based on ionization. • Use pH paper and pH meters to measure and adjust pH. • Define the function of a buffer and give examples of buffers used in a biotechnology lab. • Calculate and create buffer solutions. • Describe how pH affects protein structure and function. ***Skills Focus:*** Identify and communicate sources of unavoidable experimental error. **(IE-1b)**	***Suggested:*** •	***Supplemental Resources:*** • **Making Buffer Solutions** Students will make several buffers at various volumes, concentrations, and pH. They will then use the resulting buffer pH to illustrate percent error and quality control, adjusting the pH of the solutions produced if necessary. • B-SNM, Lab Manual **7c**, pp. 130-132 "Measuring the pH of Solutions" • B-SNM, Lab Manual **7d**, pp. 132-133 "Making an Appropriate Buffer for Protein Storage and Activity" ***Key Vocabulary:*** buffer pH	

Assays and Assay Development

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
Physical Assays Using Spectro-photometer		***Key Assignments:*** • **Using Spectrophotometry to Study Molecules** [See description on p. 18.] • **Protein Concentration Assays** [See description on p. 18.] ***Suggested:*** •	**Biotech SNM**, 7.1,4 ***Supplemental Resources:*** • B-SNM, Lab Manual **7f**, pp. 130-132 "Using the Spectrophotometer to Study the Amylase Protein" ***Key Vocabulary:*** spectrum, wavelength, absorbance, spectrophotometer	2 Days
Students know radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately $3x10^8$ m/s. **(P-4e)**	• Explain the relationship between wavelength and the color of light. • Cite the colors of different wavelengths of light. Perform spectrophotometric analysis. • Identify the common parts found on visible light spectrophotometers and describe their functions. • Outline the steps of using a visible spectrophotometer. • Describe the relationship between light transmittance and light absorbance in a sample. • Use a visible spectrophotometer to produce absorbance spectra. • Prepare a serial dilution of a solution and measure its absorbance at a given wavelength. ***Skills Focus:*** compare and contrast Analyze situations and solve problems that require combining and applying concepts from more than one area of science. **(IE-1l)**			
Determining Validity		***Key Assignments:*** • ***Suggested:*** •	**Biotech SNM**, 7.4, 10.5 ***Supplemental Resources:*** • **Validating Assay Data** Students will analyze date from assays using multiple methods. • B-SNM, Lab Manual **7g**, pp. 137-141 "Determining the Conc. of Amylase in Solution" ***Key Vocabulary:*** standard curve, standard deviation, linear regression, validity	5 Days
Understand basic mathematical concepts related to the field, such as … the difference between standard deviation and various measures of central tendency. **(PS-A2.1)**	• Use a standard curve to determine the concentration of a solution. • Use a spreadsheet to do a linear regression to calculate concentration. • Use statistical analysis including the standard deviation, to determine the validity of data. ***Skills Focus:*** Select and use appropriate tools and technology to perform tests, collect data, analyze relationships, and display data. **(IE-1a)** Identify and communicate sources of unavoidable experimental error. **(IE-1b)** Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions. **(IE-1c)** Recognize the issues of statistical variability and the need for controlled tests. **(IE-1j)**			

Recombinant DNA and Genetic Engineering

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
Isolating Desired DNA		***Key Assignments:*** • **Restriction Digestion / Enzyme Mapping with Agarose Gel Electrophoresis Analysis** [See description on p. 18.] ***Suggested:*** •	**Biotech SNM**, 4.4 ***Supplemental Resources:*** • B-SNM, Lab Manual **4i**, pp. 82-84 "Agarose Gels for Separating and Analyzing DNA Fragments" • B-SNM, Lab Manual **4j**, pp. 85-87 "Using Gel Electrophoresis to Study DNA Molecules" ***Key Vocabulary:*** restriction enzymes	10 Days
Students know how basic DNA technology (restriction digestion by endonucleases, gel electrophoresis, ligation, and transformation) is used to construct recombinant DNA molecules. **(B-5d*)**	• Discuss methods to isolate DNA and specific genes for engineering purposes. • Enumerate the activities and uses of restriction enzymes. • Conduct restriction digestion of a plasmid. ***Skills Focus:*** Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions. **(IE-1c)**			
Recombination		***Key Assignments:*** • **Restriction Digestion / Enzyme Mapping with Agarose Gel Electrophoresis Analysis** [See description on p. 18.] **Recombinant Plasmid / Cloning Vectors** [See description on p. 18.] ***Suggested:*** •	**Biotech SNM**, 8.1-2 ***Supplemental Resources:*** • **Recombinant Plasmid / Cloning Vectors** Students will learn about restriction endonuclease enzymes, their use in making recombinant plasmid vectors and how these cloning vectors may be cloned. • B-SNM, Lab Manual **8a**, pp. 146-148 "Restriction Analysis of the Lambda Phage DNA Sequence" • B-SNM, Lab Manual **8b**, pp. 149-152 "Restriction Digestion Used to Verify the pAmylase Plasmid" • B-SNM, Lab Manual **8c**, pp. 153-156 "Transformation of *E. coli* with pAmylase" ***Key Vocabulary:*** exogenous DNA, recombinant, transformation, transduction, transfection, competency, recovery, transformant	15 Days
Students know how exogenous DNA can be inserted into bacterial cells to alter their genetic makeup and support expression of new protein products. **(B-5e*)**	• List the steps in the production of a recombinant DNA molecule. • Cite examples of vectors used in transformation, transduction, and transfection. • Describe the steps in a bacterial transformation including competency, recovery, and selection. • Conduct a bacterial transformation and select for transformants. ***Skills Focus:*** producing recombinant DNA			
Retrieval		***Key Assignments:*** • **Cell Competency and Bacterial Transformation and Selection** [See description on p. 18.] ***Suggested:*** •	**Biotech SNM**, 1.4 ***Supplemental Resources:*** • ***Key Vocabulary:*** GFP, GUS	5 Days
Understand recombinant DNA, genetic engineering, monoclonal antibody production, separation and purification of biotechnology products, and bioprocessing. **(PS-A3.1)**	• Describe methods by which transformants may be selected including antibiotic resistance, GFP (green fluorescent protein), and GUS (β-glucuronidase gene) activity. • Conduct a mini-prep to retrieve plasmids from transformed cells. ***Skills Focus:*** Select and use appropriate tools and technology to perform tests, collect data, analyze relationships, and display data. **(IE-1a)**			

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
Biotechnology Management		***Key Assignments:*** •	**Biotech SNM**, 1.3-4	5 Days
Understand the process of developing biotechnology products in an industrial setting. **(PS-A5.1)**	• Record and report protocols, procedures, results, conclusions, manuals, and reports. • Write appropriate memos and letters utilizing computer-processing. • Interact with colleagues and supervisors to coordinate tasks. • Perform self-evaluation of progress, work quality, time management, and interpersonal skills. ***Skills Focus:*** Understand how to organize and structure work individually and in teams for effective performance and the attainment of goals. **(FS 9.3)** role play	***Suggested:*** • **Sim-Biotech** Student groups will create and manage a simulated biothech company.	***Supplemental Resources:*** ***Key Vocabulary:*** distribution protocol	

Bioethics, Communication, and Decision Making in the Biotechnology Industry

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
Ethics for the Biotechnology Industry		***Key Assignments:*** •	**Biotech SNM**, 1.6	5 Days
Understand the legal and ethical issues regarding the use of biotechnology to cure diseases. **(PS-A1.3)**	• Cite specific examples of how and where biotechnology is used in medical, agricultural, environmental, and industrial applications as well as social or political situations, including criminal investigations, lawsuits, evolutionary studies, etc.	***Suggested:*** •	***Supplemental Resources:*** • **Bioethical Debate** Students will research and debate both sides of a current bioethical issue. ***Key Vocabulary:*** morality ethics bioethical	
Understand the relationship between morality and ethics in the development of biotechnology health care products. **(PS-A6.1)**	• Illustrate examples of how biotechnology has led to benefits and risks to society and how biotechnical advances affect human lives on a personal level.			
Know the differences between personal, professional, and organizational ethics. **(PS-A6.2)**	• Identify the rights, interests, and responsibilities of people involved in bioethical issues. • Formulate opinions about engineered organisms and products based on current scientific evidence.			
Understand the need for ethical policies and procedures in institutions engaged in biotechnology research and product development. **(PS-A6.4)**	• Describe the need for and function of regulatory agencies such as those in government, industry, and society. Analyze policy-making procedures for products and techniques of biotechnology. ***Skills Focus:*** Understand the role of personal integrity and ethical behavior in the workplace. **(FS 8.3)** research and debate Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. **(IE-1m)**			

Careers in 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
Making a Living in Biotechnology		***Key Assignments:***	**Biotech SNM**, 1.3,5	5 Days
Understand how the fields of nanotechnology, bioinformatics, genomics, proteomics, and transcriptomics influence new and emerging career opportunities. **(PS-A3.2)**	• Elaborate the opportunities for careers in biotechnology in health, medicine, genetics, agriculture, etc. • Present arguments for pursuing careers in biotechnology at differing entry-levels. • Demonstrate knowledge of the vast variety of departments and positions, scientific and nonscientific, at a typical biotechnology company. ***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)** research	• ***Suggested:*** •	***Supplemental Resources:*** • **Biotech Portfolio** Develop a portfolio that demonstrates proficiency in specific tasks including writing samples and performance-based skills. • **Biotech Resume** Create an appropriate resume for use in applying for laboratory positions at a biotechnology company. ***Key Vocabulary:*** resume, nanotechnology, bioinformatics, genomics, proteomics, transcriptomics	

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.
1st Semester Project	Students will investigate a disease and how biotechnology has developed better ways to prevent, diagnose, and/or treat the disease by conducting an in-depth literature search, reading a minimum of five journal articles and using this information to prepare a 15-minute PowerPoint presentation to be presented to peers.
2nd Semester Project	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.

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. The practical portion of the final would ask questions as to the purpose of an instrument, or would require students to use a standard curve to determine the size of an unknown molecule.

KEY LABORATORY ACTIVITIES:

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:

Setting up a Legal Scientific Notebook

Students will set up their own personal lab notebook that will include hypothesis, protocols, materials used, raw data, analysis as well as a detailed discussion section. They will be required to understand and use best laboratory practices as they pertain to the structure and use of their laboratory notebook.

Solution and Dilution Preparation

Students will make appropriate mass per volume, percent mass per volume, molar and serial concentrations of solutions necessary for lab experiments.

Model Organism Growth / Media Preparation

Students will prepare and inoculate media plates with model organisms *E. coli* and *Aspergillus* and use sterile technique to grow broth cultures of model organisms.

DNA Isolation and Indicator Analysis

Students will isolate DNA from *Salmo* (salmon testes), *Fragaria* (strawberries) and *E. coli*. They will also use the DPA (Diphynlamine) Test to detect the presence of DNA and RNA and the Biuret Test to detect the presence of protein in their extracts.

Agarose Gel Electrophoresis

Students will run samples of their *Salmo*, *Fragaria* and *E. Coli* DNA extracts as well as 50 μg/mL samples of yeast DNA, pBR322 DNA (plasmid) and Lambda DNA on 0.8% agarose gels to gain information about the size of the DNA fragments.

Protein Isolation and Indicator Analysis

Students will isolate protein from several animal muscle samples and confirm the presence of protein using Biuret reagent. Students will prepare protein samples of a specified concentration using PAGE (polyacrylamide gel electrophoresis) running buffer for analysis using vertical gel electrophoresis.

Polyacrylamide Gel Electrophoresis

Students will investigate the structural characteristics of amylase, pectinase, cellulase and lysozyme by running and staining PAGE gels.

Protein and Enzyme Studies / Assays

Students will investigate the action of the protease, cellulase, bovine rennin and pectinase on apple juice production. They will also design a valid experiment that demonstrates the presence of proteases such as papain in sample solutions of meat tenderizer, pineapple juice, or laundry detergents. Students will make Biuret reagent and determine the lowest concentration of protein that can be accurately determined using this reagent.

Amylase Assay Development

Students will perform tests on sample solutions of glucose, maltose and gelatin for the presence of starch using iodine and for the presence of sugars using Benedict's solution. They will test the activity of both human and bacterial amylase on the digestion of serial starch solutions using glucose test strips, Benedict's solution and Lugol's Iodine. They will then apply this to search for amylase-producing bacteria from plant, soil and surface area samples using 2% starch/LB agar and observing plates for characteristic "halos" where starch has been digested.

Peroxidase Assay Development

Students will test animal (beef liver, chicken muscle) and plant (apple, potato, onion, carrot, horseradish root) for peroxidase activity. They will then isolate horseradish peroxidase (HRP) from horseradish root extract and assay for its presence using a PAGE. Students will also test for the presence of HRP in horseradish root extracts using the indicator TMB (3,3',5,5'-tetramethylbenzidine).

pH meter use

Students will use both pH paper and pH meters to determine the acid or alkaline properties of buffer solutions.

Using Spectrophotometry to Study Molecules

Students will determine the absorption spectrum for amylase (+Bradford protein reagent) and the lambdamax for the amylase (+ Bradford protein reagent) mixture.

Protein Concentration Assays

- Students will determine the concentrations of two unknown amylase solutions.
- Students will plan and execute trials to compare the concentration sensitivities of both a Bradford assay and a BCA (bicinchoninic acid) assay on amylase solutions using a UV/VIS spectrophotometer.
- Students will prepare absorbance spectra for different concentrations of a colorless protein and determine the lambdamax for this same protein.

Restriction Digestion / Enzyme Mapping with Agarose Gel Electrophoresis Analysis

Students will perform a lambda DNA/HindIII restriction digestion and evaluate the digestion on an agarose gel and compare with commercially available Lambda DNA + HindIII standard markers.

Recombinant Plasmid / Cloning Vectors

Students will learn about restriction endonuclease enzymes, their use in making recombinant plasmid vectors and how these cloning vectors may be cloned.

Cell Competency and Bacterial Transformation and Selection

Students will transform *E. coli* cells with a recombinant pAmylase plasmid containing a gene for ampicillin resistance and a gene for amylase production and select for transformed cells using 2% starch LB agar/ampicillin media. They will then confirm genetically engineered E. coli cells have been transformed with the correct DNA by performing a miniprep procedure to extract plasmids. Then they will use UV spectroscopy to determine the concentration of plasmid DNA and run samples on a 1% agarose gel to confirm that the plasmid is pAmylase. Students will transform *E.coli* cells with a recombinant pGLO plasmid containing a gene for GFP (green fluorescent protein), a gene for ampicillin resistance and gene regulation system for the expression of GFP. Following transformation, the *E.coli* cells will be selected for transformed cells using LB agar/ampicillin/arabinose media. Transformed cells will be observed using UV light and transformation efficiency will be determined.

Protein Product Purification and Testing

Students will harvest GFP using HIC (hydrophobic interaction chromatography) columns. They will also use spectroscopy methods to determine the concentration of GFP extracted from *E. coli* cells.

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
	☐ Read in entirety	☑ Excerpts used	Chemistry, 7th Ed., Zumdahl and Zumdahl, Houghton Mifflin Co., © 2007
	☐ Read in entirety	☑ Excerpts used	Biotechnology: An Introduction, 2nd Ed., Barnum, Thomson Brooks/Cole, © 2006
	☐ Read in entirety	☑ Excerpts used	DNA Science: A First Course in Recombinant DNA Technology, 2nd Ed., Micklos and Freyer, Cold Springs Harbor Laboratory Press, © 2003
	☐ Read in entirety	☑ Excerpts used	An Introduction to Biotechnology, 2nd Ed., Theiman and Palladino, Benjamin Cummings Publishing, © 2008
	☐ Read in entirety	☑ Excerpts used	Human Genetics: Concepts and Applications, 8th Ed., Lewis, McGraw Hill, © 2007
	☐ Read in entirety	☑ Excerpts used	Bioinstrumentation, Wandersee, Wissing, & Lang, Nat'l Assoc. of Biology Teachers, © 1996

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

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 eval 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
   - safety practices
4. Projects ~20%
   - science fair projects
   - research-based reports and projects
5. Classwork ~10%
   - preparation (work environment)
   - interpersonal skills

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:	C. Bater / K. O'Neill
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