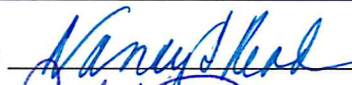

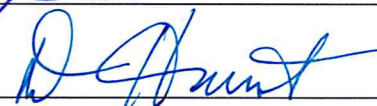



**SECONDARY COURSE DESCRIPTION**  
**SECTION A: COURSE CLASSIFICATION**

1. Course Title: Advanced Principles Chemistry and Biotechnology "Biotech 2"	6. Prerequisite(s): Principles Chemistry and Biotechnology "Biotech 1"
2. Action: <input checked="" type="checkbox"/> New Course <input type="checkbox"/> Course Revision <input type="checkbox"/> Title Change Only	7. Grade Level: 11 & 12
3. Transcript Title/Abbreviation: <b>Biotech 2</b> (For Educational Services)	8. Elective/Required: Elective
4. Transcript Course Code/Course Number: <b>VOKM</b> (For Educational Services)	9. Subject Area: Career Technical Education
5. CBEDS Code: <b>7912</b> (For Educational Services)	10. Department: CTE
11. Length /Credits: <input type="checkbox"/> 0.5 (half year or semester equivalent) <input checked="" type="checkbox"/> 1.0 (one year equivalent) <input type="checkbox"/> 2.0 (two year equivalent)	
12. Was this course previously approved by UC? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No If so, year removed from list: _____	
13. Meets the "_____" requirements in the a-g university/college entrance requirement. Approval date: _____	
14. School Contact Information Name: <u>Alissa Hoeft</u> Title/Position: <u>Teacher</u> Phone: <u>510-337-7022</u> Fax: _____ E-Mail: <u>ahoeft@alamedaunified.org</u>	
16. Signatures: Department Chair: <u></u> Principal: <u></u> Acknowledged by Other Principals: <u></u> Educational Services: <u></u>	
16. BOE Approval Signature of Superintendent: _____ Date of Approval _____	

# **Advanced Principles of Chemistry and Biotechnology**

## **“Biotech 2”**

### **Course Outline**

**Teacher: Alissa Hoeft**  
**Submitted December 2019**

**Adapted from Long Beach Unified School District Biotechnology 3-4**  
**<http://www.lbschools.net/Asset/Files/Curriculum/Science/Courses/Biotechnology-3-4.pdf>**

Biotechnology 2 is a continuation of Biotechnology I 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 covered in Biotechnology I are repeated in this advanced course, however, we will go more in-depth and will explore additional applications. Students will attain knowledge about the field of biotechnology and will gain a deeper understanding of the biological concepts used. Students will continue to develop the laboratory, critical thinking, and communication skills used in the biotechnology industry, including the use of a laminar flow hood while learning the principles of plant tissue culturing. 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. In the second semester, students will develop a research question, and design an experiment that they will conduct through the experiment. They will have an industry advisor to critique their experiment at multiple steps in the research project, and the project will culminate in a research paper and presentation. The course will emphasize job preparatory skills such as job research, internship hunting, resume building, and informational interviews.

**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.

### Foundation Standard 2: Communications

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

#### Reading

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

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

- 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.

#### 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		Perf. Std. Measures	Instructional Support	Appx Time
(CONTENT) "Students know..."	(SKILL) "Students are able to ..."	How students DEMONSTRATE KNOWLEDGE and SKILL.		
<b>Introduction to Plant Propagation</b>		<b>Key Assignments:</b> • <b>Flower and Seed Morphology</b> [See description on p. 13.] <b>Suggested:</b> •	<b>Biotech SNM, 10.1-3</b> <b>Supplemental Resources:</b> • <b>Key Vocabulary:</b> sexual reproduction breeding selective breeding meiosis differentiation plant hormones	15 Days
<p>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)</p> <p>Only certain cells in a multicellular organism undergo meiosis. (B-2b)</p> <p>New combinations of alleles may be generated in a zygote through the fusion of male and female gametes (fertilization). (B-2d)</p>	<ul style="list-style-type: none"> <li>Diagram the events in flowering plant sexual reproduction including meiosis, pollination, and fertilization.</li> <li>Describe the relationship between sexual reproduction and selective breeding.</li> <li>Compare and contrast the processes of asexual and sexual reproduction in plants.</li> <li>Identify the number and type of floral structures.</li> <li>Compare the structure and function of different plant tissues including their role in reproduction.</li> <li>Outline the steps in germination and plant growth.</li> </ul> <p><b>Skills Focus:</b></p>			

Content Standards		Perf. Std. Measures	Instructional Support	Appx Time
(CONTENT) "Students know..."	(SKILL) "Students are able to..."	How students DEMONSTRATE KNOWLEDGE and SKILL.		
<b>Introduction to Plant Breeding</b>		<b>Key Assignments:</b> • <b>Seed Germination</b> [See description on p. 13.] <b>Suggested:</b> •	<b>Biotech SNM, 10.4-5</b> <b>Supplemental Resources:</b> • B-SNM, Lab Manual 10e, pp. 192-194 "How to Determine if the WFP Data are Good Enough" <b>Key Vocabulary:</b> diploid      haploid dominant      recessive homozygous      heterozygous Punnett Square      dihybrid cross statistical analysis	15 Days
<p>Meiosis. (B-2a)</p> <p>Only certain cells in a multicellular organism undergo meiosis. (B-2b)</p> <p>Random chromosome segregation explains the probability that a particular allele will be in a gamete. (B-2c)</p> <p>Understand the basic structure of a chromosome and the difference between a dominant homozygous trait and a heterozygous trait. (PS-A2.2)</p> <p>Know the role of chromosomes in determining an individual's sex. (B-2f)</p> <p>Predict possible combinations of alleles in a zygote from the genetic makeup of the parents. (B-2g)</p> <p>Predict the probable outcome of phenotypes in a genetic cross from the genotypes of the parents and mode of inheritance. (B-3a)</p>	<ul style="list-style-type: none"> <li>Explain how meiosis and crossing-over affect the variety seen in offspring.</li> <li>Describe how meiosis, crossing-over, recombination, and segregation produce variety in gametes and offspring.</li> <li>Perform a dihybrid, heterozygous cross of a model genetic organism.</li> </ul>			
<p>Understand the role of the biotechnology industry and its impact on society. (PS-A1.1)</p>	<ul style="list-style-type: none"> <li>Analyze the results of a cross and the significance of data using Chi-square analysis.</li> <li>Conduct a seed germination experiment.</li> <li>Use the internet to find the life cycle of a diploid organism.</li> </ul> <p><b>Skills Focus:</b> Calculate and interpret Chi Square value.</p> <p>Identify and communicate sources of unavoidable experimental error. (I&amp;E-1b)</p> <p>Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions. (I&amp;E-1c)</p>			

(CONTENT) "Students know..."	(SKILL) "Students are able to..."	How students DEMONSTRATE KNOWLEDGE and SKILL	Instructional Support	Time
<b>Cloning Plants</b>  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)	<ul style="list-style-type: none"> <li>Conduct a successful plant tissue culture using sterile technique.</li> <li>Elucidate the role of hormones in plant tissue culture.</li> </ul> <b>Skills Focus:</b>	<b>Key Assignments:</b> <ul style="list-style-type: none"> <li><b>Plant Tissue Culture Media</b> [See description on p. 13.]</li> <li><b>Asexual Propagation of Plants</b> [See description on p. 13.]</li> </ul> <b>Suggested:</b> <ul style="list-style-type: none"> <li></li> </ul>	<b>Biotech SNM, 11.1-2</b>  <b>Supplemental Resources:</b> <ul style="list-style-type: none"> <li>B-SNM, Lab Manual 11d, pp. 202-206 "Cloning African Violets"</li> </ul> <b>Key Vocabulary:</b> cross breeding asexual plant propagation plant tissue culture plant growth regulators	13 Days
<b>Biotechnology in Agriculture and Horticulture</b>  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)	<ul style="list-style-type: none"> <li>Isolate and analyze DNA samples from plant tissue.</li> <li>Design a protocol for maximizing DNA extraction from plant cells.</li> <li>Discuss the role of <i>Agrobacterium</i> and the Ti plasmid in plant genetic engineering.</li> </ul> <b>Skills Focus:</b> <ul style="list-style-type: none"> <li>Use the UV spectrophotometer to measure and calculate the concentration and purity of DNA extracts.</li> <li>List reasons why <i>Arabidopsis thaliana</i> is a model plant of genetic research. (Activity 11.4)</li> </ul>	<b>Key Assignments:</b> <ul style="list-style-type: none"> <li><b>Isolation &amp; Study of Plant DNA</b> [See description on p. 13.]</li> <li><b>Development of a DNA Concentration Assay / UV Spectrophotometry</b> [See description on p. 13.]</li> </ul> <b>Suggested:</b>	<b>Biotech SNM, 11.3-5</b>  <b>Supplemental Resources:</b> <ul style="list-style-type: none"> <li>B-SNM, Lab Manual 11h, pp. 211-212 "Determining the Presence of DNA in Plant Extractions"</li> </ul> <b>Key Vocabulary:</b> agriculture horticulture hydroponics plant-based pharmaceutical (PBP) genomic DNA plasmid DNA	10 Days

## Bringing the Products of Biotechnology to Market

Content Standards		Perf. Std. Measures	Instructional Support	Appx Time
(CONTENT) "Students know..."	(SKILL) "Students are able to..."	How students DEMONSTRATE KNOWLEDGE and SKILL.		
<b>Quality Control</b>		<b>Key Assignments:</b>	<b>Biotech SNM.</b>	13 Days
Understand the relationship between biochemistry and biotechnology product development. (PS-A1.4)	<ul style="list-style-type: none"> <li>Outline the steps in product production, recovery, and purification.</li> <li>Inspect and verify inventory and integrity of products.</li> <li>Apply quality control and quality assessment techniques to a product.</li> </ul>	<ul style="list-style-type: none"> <li><b>Cell Culture, Growth and Monitoring</b> [See description on p. 13.]</li> </ul>	<b>Supplemental Resources:</b>	
Understand the role of preclinical and clinical trials in biotechnology product development. (PS-A5.2)		<b>Suggested:</b>	<b>Key Vocabulary:</b> quality control quality assessment product integrity clinical testing	
Know the role of quality assurance in clinical trials. (PS-A5.3)	<ul style="list-style-type: none"> <li>Summarize the steps in clinical testing and FDA approval for new drugs produced through genetic engineering.</li> </ul>			
	<b>Skills Focus:</b> 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) "Students know..."	Content Standards (SKILL) "Students are able to..."	Perf. Std. Measures How students DEMONSTRATE KNOWLEDGE and SKILL...	Instructional Support	Appx Time
<b>Industrial Methodologies</b>  Understand the relationship between biochemistry and biotechnology product development. <b>(PS-A1.4)</b>	<ul style="list-style-type: none"> <li>Describe the characteristics of proteins that allow for their purification after cloning transformed cells.</li> <li>Compare and contrast the processes of paper, thin-layer, and column chromatography.</li> <li>Conduct paper chromatography to isolate molecules with different absorbent/solubility profiles.</li> <li>Explain how PAGE (polyacrylamide gel electrophoresis) is used with column chromatography to monitor protein products.</li> <li>Describe the steps in harvesting protein product from fermentation cell culture.</li> <li>Test for the presence and concentration of proteins in protein processing.</li> <li>Cite the steps in buffer exchange and dialysis as used in protein processing.</li> <li>Compare and contrast the mechanism of gel filtration, ion exchange, and affinity chromatography.</li> <li>Conduct an ion exchange chromatography to isolate proteins of different charge.</li> <li>Explain the function and use of FPLC (fast protein liquid chromatography) and HPLC (high performance liquid chromatography) in research and production.</li> <li>Conduct HPLC chromatography to isolate molecules with different hydrophilic profiles.</li> <li>Confirm the results of a column chromatography using spectrophotometry and PAGE.</li> </ul> <p><b>Skills Focus:</b> Use critical thinking skills to make informed decisions and solve problems. <b>(FS 5.3)</b> Identify possible reasons for inconsistent</p>	<p><b>Key Assignments:</b></p> <ul style="list-style-type: none"> <li><b>Protein Product Purification and Testing</b> [See description on p. 14.]</li> </ul> <p><b>Suggested:</b></p>	<p><b>Biotech SNM, 1.3, 9.1-3</b></p> <p><b>Supplemental Resources:</b></p> <ul style="list-style-type: none"> <li>B-SNM, Lab Manual 9a, pp. 168-169 "Harvesting Amylase from Bacterial Cultures"</li> <li>B-SNM, Lab Manual 9b, pp. 169-171 "Dialysis of Proteins into Different Buffers"</li> <li>B-SNM, Lab Manual 9c, pp. 171-174 "Using Ion-Exchange Chromatography to Separate Proteins"</li> <li>B-SNM, Lab Manual 9d, pp. 174-176 "Using Ion-Exchange Chromatography to Purify Amylase from Scale-up Broth"</li> <li>B-SNM, Lab Manual 9e, pp. 176-177 "Identifying Amylase after Column Chromatography – Using SDS-PAGE"</li> </ul> <p><b>Key Vocabulary:</b> chromatography fermentation PAGE FPLC HPLC</p>	<p>15 Days</p>

## Identifying a Potential Biotechnology Product

Content Standards (CONTENT) (SKILL) "Students know..." "Students are able to..."		Perf. Std. Measures How students DEMONSTRATE KNOWLEDGE and SKILL	Instructional Support	Appx Time
<b>Study Plant Proteins as Possible Products</b>		<b>Key Assignments:</b> <ul style="list-style-type: none"> <li>Identifying Anti-microbial Plant Substances [See description on p. 14.]</li> <li>Extracting Compounds from Plants [See description on p. 14.]</li> </ul> <b>Suggested:</b> <ul style="list-style-type: none"> <li></li> </ul>	<b>Biotech SNM. 6.3-5</b> <b>Supplemental Resources:</b> <ul style="list-style-type: none"> <li>B-SNM, Lab Manual 6h, pp. 123-124 "Testing for the Presence of Peroxidase Using TMB"</li> </ul> <b>Key Vocabulary:</b> 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)	<ul style="list-style-type: none"> <li>Explain how scientists test the effectiveness of antibiotics and antimicrobials.</li> <li>Understand the significance of antibiotic resistance.</li> <li>Describe the role of CHO cells in protein product development.</li> <li>Describe the typical recombinant DNA protein product pipeline.</li> </ul> <b>Skills Focus:</b>			
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) (SKILL) "Students know..." "Students are able to..."		Perf. Std. Measures How students DEMONSTRATE KNOWLEDGE and SKILL.	Instructional Support	Appx Time
<b>Drug Discovery and Development</b>		<b>Key Assignments:</b> • <b>Chemical Synthesis of a Medicine</b> [See description on p. 14.] • <b>Testing the Purity of Synthesized Compounds</b> [See description on p. 14.] <b>Suggested:</b> •	<b>Biotech SNM, 12.1-4</b> <b>Supplemental Resources:</b> • <b>Key Vocabulary:</b> 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)	<ul style="list-style-type: none"> <li>Describe the methods by which pharmaceuticals were produced prior to and after the development of recombinant DNA technology.</li> <li>Compare combinatorial chemistry techniques to genetic engineering techniques.</li> <li>Isolate simple organic compounds from plant tissues using extraction and separation technologies.</li> <li>Conduct a simple organic synthesis using combinatorial chemistry.</li> <li>Discuss the techniques used to analyze samples for purity including melting point determinations, mass spectrophotometry, and HPLC.</li> <li>Perform melting point determination to test the purity of extracted and synthesized products.</li> </ul> <b>Skills Focus:</b> 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]			
<b>Advanced Protein Studies</b>		<b>Key Assignments:</b> <b>Suggested:</b> •	<b>Biotech SNM, 14.3</b> <b>Supplemental Resources:</b> • <b>Key Vocabulary:</b> 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)	<ul style="list-style-type: none"> <li>Discuss the value and uses of protein crystallography in biotechnology.</li> <li>Illustrate how gene therapy may be used in the treatment of genetic disorders.</li> </ul> <b>Skills Focus:</b>			

## Synthesizing DNA and PCR

Content Standards (CONTENT) (SKILL) "Students know..." "Students are able to..."		Perf. Std. Measures How students DEMONSTRATE KNOWLEDGE and SKILL...	Instructional Support	Appx Time
<b>DNA Synthesis</b>		<b>Key Assignments:</b> • In Vitro DNA Synthesis, PAGE Analysis, and Southern Blot [See description on p. 14.] <b>Suggested:</b> •	<b>Biotech SNM, 13.1-2, 12.3</b> <b>Supplemental Resources:</b> • <b>Key Vocabulary:</b> polymerase chain reaction (PCR) homologous pairs DNA replication DNA synthesis in vivo in vitro polymerase oligonucleotides 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)	<ul style="list-style-type: none"> <li>Outline the steps of DNA replication (synthesis) as it occurs in cells.</li> <li>Outline the steps of DNA synthesis as it occurs in test tubes (in vitro).</li> <li>Set up and run a PAGE gel apparatus to separate synthesis products.</li> <li>Prepare DNA synthesis reactions to produce oligonucleotides of varying lengths.</li> <li>Conduct a Southern Blot of synthesis products and visualize using colorimetric enzyme visualization.</li> <li>Discuss the history behind the discovery and development of polymerase chain reaction (PCR).</li> </ul> <b>Skills Focus:</b>			
<b>Polymerase Chain Reaction</b>		<b>Key Assignments:</b> • Lambda PCR [See description on p. 14.] <b>Suggested:</b> •	<b>Biotech SNM, 13.3-4</b> <b>Supplemental Resources:</b> • <b>Key Vocabulary:</b> 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)	<ul style="list-style-type: none"> <li>Outline the steps in a PCR reaction including the use of thermal cycler.</li> <li>Conduct a PCR to amplify targeted sections of DNA.</li> <li>Discuss the applications of PCR technology in industry, research, and society.</li> <li>Optimize the factors and reagents used in PCR.</li> <li>Discuss the effects of varying the time and temperature of PCRss as well as the volumes and concentrations of reactants.</li> </ul> <b>Skills Focus:</b> <ul style="list-style-type: none"> <li>Use internet databases to analyze the frequency of alleles and genotypes found through PCR analysis.</li> <li>Select and use appropriate tools and technology to perform tests, collect data, analyze relationships, and display data.</li> </ul> <b>(IE-1a)</b>			

## DNA Sequencing and Genomics

Content Standards (CONTENT) "Students know..." (SKILL) "Students are able to..."		Perf. Std. Measures How students DEMONSTRATE KNOWLEDGE and SKILL.	Instructional Support	Appx Time
<b>DNA Sequencing</b>		<b>Key Assignments:</b> • <b>Protein Extraction from Animal Tissue</b> [See description on p. 14.] • <b>Biodiversity and Evolution</b> [See description on p. 14.] <b>Suggested:</b> •	<b>Biotech SNM, 14.1</b> <b>Supplemental Resources:</b> •  <b>Key Vocabulary:</b> 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)	<ul style="list-style-type: none"> <li>Explain the steps in dideoxynucleotide sequencing reactions.</li> <li>Compare and contrast sequencing done using slab gels versus those done using capillary sequencing apparatus.</li> <li>Read a DNA sequence on a sequencing autoradiogram or computer-generated sequence.</li> <li>Cite examples of how and where DNA sequencing is used in biotechnology.</li> <li>Explain how scientists used DNA sequencing to elucidate the human genome.</li> <li>List the milestones of the Human Genome Project.</li> </ul>			
Understand how the fields of nanotechnology, bioinformatics, genomics, proteomics, and transcriptomics influence new and emerging career opportunities. (PS-A3.2)	<b>Skills Focus:</b> Understand how to organize and structure work individually and in teams for effective performance and the attainment of goals. (FS 9.3)			
<b>Genomics</b>		<b>Key Assignments:</b> • <b>ELISA Technology</b> [See description on p. 14.] <b>Suggested:</b> •	<b>Biotech SNM, 14.2-3</b> <b>Supplemental Resources:</b> •  <b>Key Vocabulary:</b> 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)	<ul style="list-style-type: none"> <li>Give examples of advances made possible because of the Human Genome Project.</li> <li>Discuss the causes and effects of point and chromosomal mutations.</li> <li>Describe how DNA is modified and introduced into cells to change traits.</li> <li>Discuss the methods and objectives in site-specific mutagenesis.</li> </ul>			
Understand how the fields of nanotechnology, bioinformatics, genomics, proteomics, and transcriptomics influence new and emerging career	<b>Skills Focus:</b> 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			

**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	<p>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.</p> <p>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.</p>

**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 11j]

**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]

#### 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
<b>EMC Paradigm: Biotechnology: SNM</b>	Skills evaluation	Notebook Checks	Tests
<b>Teacher Developed Assessments</b>	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.

#### **Grading:**

20% Professionalism Points: Coming to Class (work) on time, bringing all materials, dress appropriately for lab, following all lab and safety protocols

40% Notebook: Pre-labs, Data, Graphs, and Conclusion

40% Assessments: Content Quizzes, Skill Quizzes, and Projects

1st semester: Assessments will be mastery quizzes where students must receive an 80% or higher on ALL Skill and Content quizzes. Projects include job research and resume building.

2nd semester: In addition to quizzes, the majority of the assessment and notebook grade will be for keeping track of data in the student research project and writing a research paper about their findings. Smaller projects include interview skills and job applications.