SAN MATEO UNION HIGH SCHOOL DISTRICT
Course of Study

Biotechnology 3-4

I. DESCRIPTION OF THE COURSE

A. Purpose:

Biotechnology 3-4 is the second-year course of the six-semester San Mateo Biotechnology Career Pathway. Biotechnology 3-4 is designed to give students an introduction to the scientific concepts and advanced laboratory research techniques currently used in the field of biotechnology. Students will develop laboratory skills, critical thinking, and communication skills currently used in the biotechnology industry. Through extensive reading, laboratory work, and workplace experiences, students will evaluate career opportunities in the field of biotechnology.

Biotechnology 3-4 has academic and technical objectives infused throughout the curriculum. Objectives are presented and met in a progressive, and increasingly sophisticated fashion. As a part of the Biotechnology Career Pathway, students enroll in Biotechnology 3 after completing the prerequisite.

B. Grade Placement: 10-12

C. Prerequisites: Completion of Biotechnology 1 with a grade of "B" or better.

D. Submitted to meet The University of California's "D" Laboratory Science requirement.

II. TOPICS OF BIOTECHNOLOGY 3-4

A. Biotechnology, Past and Present

B. The Characteristics of Model Organisms Used in Biotechnology

C. Standard Laboratory Operating Procedures

D. Plant Biotechnology

E. Synthesizing DNA and PCR

F. DNA Sequencing and Genomics

G. Pharmaceutical Biotechnology

H. Bioethics of Biotechnology

I. Careers in Biotechnology including:

Biotechnology 3	Product Pipeline Study
Biotechnology 4	Job-shadow Project

III. THEMES OF INTRODUCTION TO BIOTECHNOLOGY 1, 2, 3, 4

Biotechnology 3	Agricultural and Pharmaceutical Biotechnology
Biotechnology 4	Diagnostic Biotechnology

IV. UNDERSTANDING OBJECTIVES

California Science Content Standards
(B=Biology/Life Science, C=Chemistry, IE=Investigation and Experimentation)

A. Introduction to Biotechnology, Past and Present

The student will be able to:

1. Describe major historic developments in biotechnology fields such as pharmaceuticals, agriculture, diagnostics, industrial products, instrumentation and research and development.

2. Identify the major scientific discoveries that lead to recombinant DNA technology, including those in chemistry, genetics, microbiology, and fermentation technology, and explain how those discoveries are used in industry today.

3. Use the scientific method to conduct a valid experiment, including hypothesis formation, data collection, and data analysis. (IE-1f)

4. Develop scientific questions, hypotheses, and experimental plans. (IE-1f)

5. Create data tables and graphs using Excel® for the purpose of collecting and analyzing data. (IE-1e)

6. Interpret and critically analyze quantitative and qualitative data.

7. Compose a thorough concluding statement outlining the results of an experiment with evidence, explanations, error analysis, and practical applications. (IE-1b, 1c)

8. Organize and communicate scientific findings both orally and in written form and produce clear, concise written and oral reports. (IE-1d)

9. Evaluate the validity of results obtained during experimentation and product development. Evaluate scientific reports with well-supported, clearly presented opinions. (IE-1n)

10. Use the Internet and World Wide Web to collect and share scientific information.

11. Use a variety of methods including literature searches, in libraries, in computer databases, and on-line, for gathering background information, making observations, and collecting and organizing data. (IE-1m)

12. Work effectively individually and within a team.

B. The Characteristics of Common Organisms Used in Biotechnology

The student will be able to:

1. Outline the life cycle and characteristics of model organisms used in the biotechnology industry, including various plants (*Brassica rapa* and *Arabidopsis)* and animals. (B-10d)

2. Use various methods to monitor the growth of cell cultures.

3. Describe conditions that promote cell growth under aseptic conditions in the laboratory and workplace.

4. Explain how environmental factors affect the growth of model organisms in the laboratory.

5. Conduct indicator tests (Bradford, Ethidium bromide) for the common macromolecules of the cell.

6. Explain the basic concepts of cell growth and reproduction, DNA replication, mitosis, meiosis, and protein synthesis.

C. Standard Laboratory Operating Procedures

The student will be able to:

1. Set-up and maintain a legal scientific notebook that includes an account of all laboratory procedures, data, and reflections.

2. Recognize laboratory safety hazards and avoid them. Identify the location and use of emergency equipment.

3. Properly and safely use and monitor a variety of scientific equipment, including pH meters, microscopes, spectrophotometers, pipets, micropipets, balances, etc.

4. Measure mass using electronic and analytical balances.

5. Measure volume using graduated cylinders, pipets, and micropipets.

6. Calculate how to prepare solutions based on mass/volume, % mass/volume, and molar concentrations. (C-3b, C-3c, C-3d, C-6a)

7. Prepare solutions of any volume and concentration. (C-3b, C-3c, C-3d, C-6a)

8. Prepare dilutions of concentrated solutions.

9. Outline the steps in cell and tissue culture, sterile technique, and media preparation.

10. Prepare and maintain plate and broth cultures of bacteria, fungi, and plant samples.

11. Determine which equipment is appropriate to use for a given task and what units of measurement are used. Use laboratory apparatus, materials, and technology in an appropriate and safe manner.

12. Follow written protocols and oral directions to perform a variety of laboratory and technical tasks.

13. Perform a variety of biological tests and chemical assays, collect data, perform calculations and statistical analysis.

14. Prepare and aliquot samples, reagents and buffers. Perform chemical reactions and purification procedures similar to those used in product development, testing, and manufacture.

15. Perform specimen collection, label samples, and prepare samples for testing. Handle, transport, and store samples.

D. Plant Biotechnology

The student will be able to:

1. Diagram the events in flowering plant sexual reproduction including meiosis, pollination and fertilization.

2. Explain how meiosis and crossing-over affect the variety seen in offspring.

3. Describe the relationship between sexual and selective breeding.

4. Identify the number and type of floral structures.

5. Outline the steps in germination and plant growth.

6. Use the Internet to find the life cycle of a diploid organism.

7. Conduct a seed germination experiment.

8. Describe how meiosis, crossing-over, recombination, and segregation produce variety in gametes and offspring. (B-2a, B-2c, B-3b)

9. Perform a dihybrid, heterozygous cross of a model genetic organism. (B-2f, B-2g, B-3a)
10. Analyze the results of a cross and the significance of data using Chi-square analysis. (IE-1b, IE-1c)
11. Compare and contrast the processes of asexual and sexual reproduction in plants. (B-2d)
12. Compare the structure and function of different plant tissues including their role in reproduction.
13. Conduct a successful plant tissue culture using sterile technique. (B-9i)
14. Elucidate the role of hormones in plant tissue culture.
15. Isolate and analyze DNA samples from plant tissue.
16. Design a protocol for maximizing DNA extraction from plant cells.
17. Use the UV spectrophotometer to measure and calculate the concentration and purity of DNA extracts.
18. Discuss the role of *Agrobacterium* and the Ti plasmid in plant genetic engineering.
19. List reasons why *Arabidopsis thaliana* is a model plant of genetic research.
20. Conduct a plant genetic engineering experiment using *Agrobacterium*, the Ti plasmid, and *Arabidopsis thaliana.*

E. Synthesizing DNA and PCR

The student will be able to:

1. Define the terms: template, primer, polymerase, dNTPS, DNA synthesis, oligonucleotides, and PCR.
2. Outline the steps of DNA replication (synthesis) as it occurs in cells. (B-5b)
3. Outline the steps of DNA synthesis as it occurs in test tubes (in vitro). (B-5b)
4. Setup and run a PAGE gel apparatus to separate synthesis products.
5. Prepare DNA synthesis reactions to produce oligonucleotides of varying lengths.
6. Conduct a Southern blot of synthesis products and visualize using colorimetric enzyme visualization.
7. Discuss the history behind the discovery and development of the polymerase chain reaction (PCR).
8. Outline the steps in a PCR reaction including the use of a thermal cycler.
9. Conduct a PCR reaction to amplify targeted sections of DNA.
10. Use Internet databases to analyze the frequency of alleles and genotypes found through PCR analysis. (IE-1a)
11. Discuss the applications of PCR technology in industry, research, and society.
12. Optimize the factors and reagents used in a PCR reaction.
13. Discuss the effects of varying the time and temperature of PCR reactions as well as the volumes and concentrations of reactants.

F. DNA Sequencing and Genomics

The student will be able to:

1. Explain the steps in dideoxynucleotide sequencing reactions.
2. Compare and contrast sequencing done using slab gels versus those done using capillary sequencing apparatus.
3. Read a DNA sequence on a sequencing autoradiogram or computer-generated sequence.
4. Cite examples of how and where DNA sequencing is used during biotechnology.
5. Explain how scientist used DNA sequencing to elucidate the human genome.
6. List the milestones of The Human Genome Project.
7. Give examples of advances made possible because of the Human Genome Project.
8. List concerns people may have because of information derived from the Human Genome Project.
9. Discuss the causes and effects of point and chromosomal mutation.
10. Describe how DNA is modified and introduced into cells to change traits
11. Discuss the methods and objectives in site-specific mutagenesis.

G. Pharmaceuticals

The student will be able to:

1. Describe the methods by which pharmaceuticals were produced prior to and after the development of recombinant DNA technology.
2. Compare combinatorial chemistry techniques to genetic engineering techniques.
3. Locate and use MSDS safety sheets.
4. Isolate simple organic compounds from plant tissues using extraction and separation technologies.
5. Conduct a simple organic synthesis using combinatorial chemistry.
6. Discuss the techniques used in analysis samples for purity including melting point determinations, mass spectrophotometry, and HPLC.
7. Perform melting point determinations to test purity of extracted and synthesized products.
8. Discuss the value and uses of protein crystallography in biotechnology.
9. Grow protein crystals and check them using the light microscope.
10. Illustrate how gene therapy may be used in the treatment of genetic disorders.

H. Bioethics, Communication and Decision Making in the Biotechnology Industry

The student will be able to:

1. 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. (IE-1m)
2. Illustrate examples of how biotechnology has lead to benefits and risks to society and how biotechnical advances affects human lives on a personal level. (IE-1m)
3. Identify the rights, interests, and responsibilities of people involved in bioethical issues.

4. Describe the need for and function of regulatory agencies such as those in government, industry, and society.

5. Analyze policy-making procedures for products and techniques of biotechnology.

6. Formulate opinions about engineered organisms and products based on current scientific evidence.

I. Careers in Biotechnology

The student will be able to:

1. Elaborate the opportunities for careers in biotechnology in health, medicine, genetics, agriculture, etc.

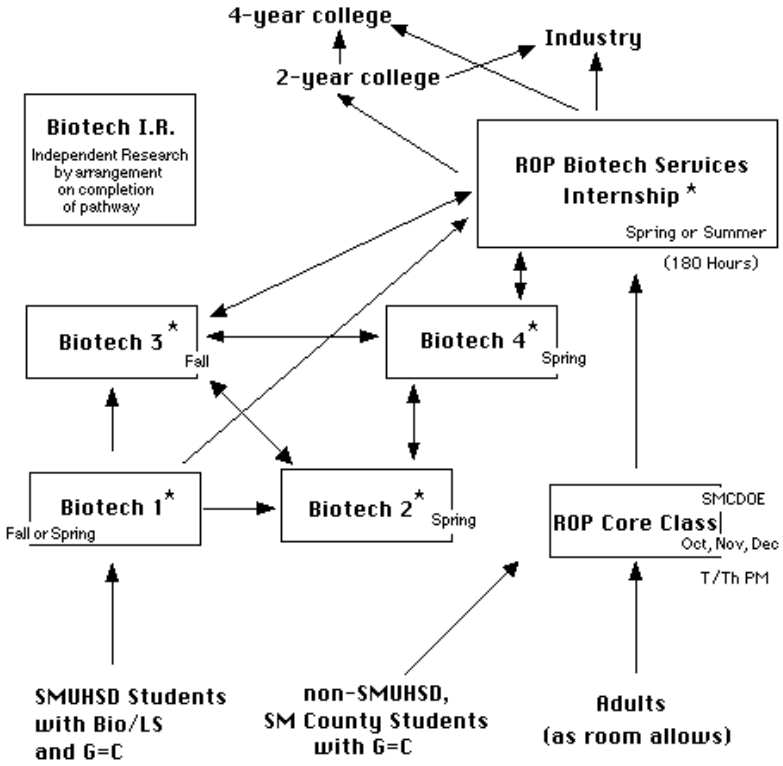
2. Present arguments for pursuing careers in biotechnology at differing entry-levels.

3. Develop a portfolio that demonstrates proficiency in specific tasks including writing samples and performance-based skills.

4. Create an appropriate resume for use in applying for laboratory positions at a biotechnology company.

5. Demonstrate knowledge of the vast variety of departments and positions, scientific and nonscientific, at a typical biotechnology company.

The San Mateo Biotechnology Career Pathway



* Required for San Mateo Biotechnology Career Pathway Certificate of Completion