SAN MATEO UNION HIGH SCHOOL DISTRICT
Course of Study

Biotechnology 1-2

I. DESCRIPTION OF THE COURSE

A. Purpose:

Biotechnology 1-2 is the first-year course of the six-semester San Mateo Biotechnology Career Pathway. Biotechnology 1-2 is designed to give students an introduction to the scientific concepts and 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 1-2 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 1 after completing the prerequisite. Students may enroll in one or more semesters of Biotechnology 2, 3 and 4, in any order, provided they have successfully completed Biotechnology 1.

B. Grade Placement: 10-12

C. Prerequisites: Completion of one year of high school biology or a life science, including a “Gene Connection” Unit, with a grade of C or better.

D. Submitted to meet The University of California’s “D” Laboratory Science requirement.

II. TOPICS OF BIOTECHNOLOGY 1-2

A. Biotechnology, Past and Present

B. The Characteristics of Model Organisms Used in Biotechnology

C. Standard Laboratory Operating Procedures

D. DNA Structure, Function, Isolation and Analysis

E. Protein Structure, Function, Isolation and Analysis

F. The Products and Applications of Modern Biotechnology

G. Assays and Assay Development

H. Recombinant DNA and Genetic Engineering

I. Bring the Products of Biotechnology to Market

J. Bioethics of Biotechnology

K. Careers in Biotechnology including:

Biotechnology 1 Stock Portfolio and field trips

Biotechnology 2 Career Project field trip

III. THEMES OF INTRODUCTION TO BIOTECHNOLOGY 1-2

Biotechnology 1 Introduction to Biotechnology/Basic Lab Skills

Biotechnology 2 Recombinant DNA Technology/Protein Production

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. Outline the steps in production and delivery of a product made through recombinant DNA technology. (B-5c)
4. Use the scientific method to conduct a valid experiment, including hypothesis formation, data collection, and data analysis. (IE-1f)
5. Develop scientific questions, hypotheses, and experimental plans. (IE-1f)
6. Create data tables and graphs using Excel® for the purpose of collecting and analyzing data. (IE-1e)
7. Interpret and critically analyze quantitative and qualitative data.
8. Compose a thorough concluding statement outlining the results of an experiment with evidence, explanations, error analysis, and practical applications. (IE-1b, 1c)
9. Organize and communicate scientific findings both orally and in written form and produce clear, concise written and oral reports. (IE-1d)
10. Evaluate the validity of results obtained during experimentation and product development. Evaluate scientific reports with well-supported, clearly presented opinions. (IE-1n)
11. Use the Internet and World Wide Web to collect and share scientific information.
12. 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)
13. Work effectively individually and within a team.

B. The Characteristics of Common Organisms Used in Biotechnology

The student will be able to:

1. Distinguish between prokaryotic cells, eukaryotic cells, and viruses. (B-1c)
2. Outline the life cycle and characteristics of model organisms used in the biotechnology industry, including various bacteria (*E. coli)* and fungi (yeasts and *Aspergillus*. (B-10d)
3. Use various methods to monitor the growth of cell cultures.
4. Describe conditions that promote cell growth under aseptic conditions in the laboratory and workplace.

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

6. List and describe the structure and function of cellular organelles. (B-1a, B-1e, B-1f, B-1g)

7. Discuss the structure and function of the macromolecules that compose cells, including carbohydrates, lipids, DNA, RNA, and protein molecules. (C-10a, C-10b, C-10c, C-10f)

8. Conduct indicator tests (Benedict's, Iodine, Biuret) for the common macromolecules of the cell.

9. 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 culture, sterile technique, and media preparation.

10. Prepare and maintain plate and broth cultures of bacteria.

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. DNA Structure, Function, Isolation and Analysis

The student will be able to:

1. Describe the relationship between nitrogen bases, nucleotides, and nucleic acids. (B-5a)

2. Recognize nucleotides on a DNA double helix model.

3. Explain how the structure of DNA affects its function.
4. Describe the role of DNA, RNA, and ribosomes in protein synthesis (The Central Dogma). (B-1d, B-4a, B-4b, B-5a))
5. Explain how the structure of DNA affects its isolation from cells and solutions.
6. Isolate genomic DNA from cells and analyze its purity and concentration.
7. Isolate plasmid DNA from cells (mini-preparation) and analyze its purity and concentration.
8. Explain the principles involved in agarose gel electrophoresis.
9. Prepare, load, run, visualize, and analyze DNA samples on an agarose gel.
10. Describe the differences in samples of eukaryotic and prokaryotic DNA samples on a gel.

E. Protein Structure, Function, Isolation and Analysis

The student will be able to:

1. Identify eight groups of protein based on their functions, citing specific examples of proteins in each group. (B-1b, B-10b)
2. Explain the relationship between amino acids, peptides and proteins. (B-4e, B-4f)
3. Describe primary, secondary, tertiary, and quaternary structure in proteins.
4. Use the Internet to find information about the structure and function of specific proteins. (B-10b)
5. Prepare protein solutions and dilutions at specific concentrations and pH.
6. Use protein indicator solutions to identify the presence and concentration of protein in solution.
7. Explain the principles involved in polyacrylamide gel electrophoresis.
8. Prepare, load, run, visualize, and analyze protein samples on a polyacrylamide gel.
9. Describe the meaning in differences in peptide band seen on polyacrylamide gels. (B-4e, B-4f)
10. Explain the function of enzymes and how their activity is affected by temperature and pH. (B-1b)
11. Perform enzyme activity assays.

F. The Products and Applications of Modern Biotechnology

The student will be able to:

1. Compare and contrast pure and applied scientific research in the field of biotechnology. (B-5c)
2. Identify several local biotechnology companies specializing in the production of pharmaceuticals, agricultural products, industrial products, and research instruments and reagents. (B-5c)
3. Describe the major steps is a product's move through a company's product pipeline. (B-5c)
4. Explain how companies decide on the research and development targets and potential products.
5. Identify several products obtained through recombinant DNA technology. (B-5c)
6. Cite examples of plant parts or extracts used as pharmaceuticals.

7. Use the Internet to find information about herbal remedies, traditional pharmaceuticals, and recombinant pharmaceuticals.
8. Produce and test plant extracts for anti-microbial activity.
9. Collect and test native bacteria for amylase production.

G. Assays and Assay Development

The student will be able to:

1. Design an assay that shows the presence and activity of an enzyme.
2. Compare and contrast the use of different assays used in research and production of protein products.
3. Explain how Benedict's Solution and Lugol's Iodine are used in glucose and starch testing.
4. Describe how assays for reactants or products can indicate the presence or activity of an enzyme.
5. Illustrate how an ELISA assay works, the role of antibodies in an ELISA, and how it may be used in industry. (B-10b)
6. Conduct and ELISA assay to test for the presence of a specific protein.
7. Identify the common parts found on visible spectrophotometers and describe their function.
8. Elucidate the relationship between wavelength and the color of light.
9. Cite the colors of different wavelengths of light.
10. Outline the steps of using a visible spectrophotometer.
11. Describe the relationship between light transmittance and light absorbance in a sample.
12. Use a visible spectrophotometer to produce absorbance spectra.
13. Discuss the difference between acids, bases, and neutral solutions. (C-5a, C-5b, C-5c)
14. Use pH paper and pH meters to measure and adjust pH. (C-5d)
15. Define the function of a buffer and give examples of buffers used in a biotechnology lab.
16. Make several buffers at various volumes, concentrations, and pH.
17. Describe how pH affects protein structure and function. (B-1b)
18. Prepare a serial dilution of protein and measure their absorbance at a given wavelength.
19. Use a standard curve to determine the concentration of an unknown protein solution. (IE-1a)
20. Using Excel®, do a linear regression to calculate protein concentration. (IE-1a)
21. Use statistical analysis including the standard deviation, to determine the validity of data. (IE-1b, IE-1c)

H. Recombinant DNA and Genetic Engineering

The student will be able to:

1. Discuss methods to isolate DNA and specific genes for engineering purposes. (B-5c, B-5d)

2. Enumerate the activities and uses of restriction enzymes. (B-5d)
3. Conduct a restriction digestion of a plasmid. (B-5d)
4. List the steps in the production of a recombinant DNA molecule. (B-5c)
5. Cite examples of vectors used in transformation, transduction, and transfection. (B-5d, B-5e)
6. Describe the steps in a bacterial transformation including competency, recovery, and selection. (B-5c, B-5e)
7. Conduct a bacterial transformation and select for transformants. (B-5e)
8. Describe methods by which transformants may be selected including antibiotic resistance, GFP and GUS activity. (B-5e)
9. Conduct a mini-prep to retrieve plasmids from transformed cells.

I. Bringing the Products of Biotechnology to Market

The student will be able to:

1. Outline the steps in product production, recovery, and purification.
2. Describe the characteristics of proteins that allow for their purification after cloning transformed cells.
3. Compare and contrast the processes of paper, thin-layer, and column chromatography. (C-6f)
4. Explain how PAGE is used with column chromatography to monitor protein product.
5. Describe the steps in harvesting protein product from fermentation cell culture.
6. Test for the presence and concentration of proteins in processed samples.
7. Cite the steps in buffer exchange and dialysis as used in protein processing.
8. Compare and contrast the mechanism of gel filtration, ion exchange and affinity chromatography.
9. Conduct an ion exchange chromatography to isolate proteins of different charge.
10. Explain the function and use of FPLC and HPLC in research and production.
11. Confirm the results of a column chromatography using spectrophotometry and PAGE.
12. Summarize the steps in clinical testing and FDA approval for new drugs produced through genetic engineering.
13. Inspect and verify inventory and integrity of products.
14. Discuss techniques of product packaging and distribution.
15. Record and report protocols, procedures, results, conclusions, manuals, reports and write memos and letters utilizing computer -processing.
16. Interact with colleagues and supervisors and coordinate tasks.

J. 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.

K. Careers in Biotechnology

The student will be able to:

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

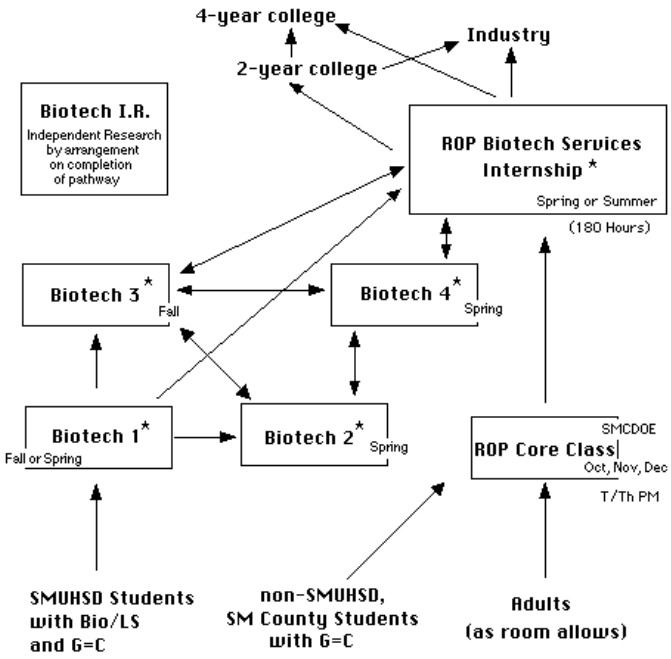
2. Present arguments for pursuing careers in biotechnology at differing entry-levels.

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