1. Cover Page — UC Course Submission

Course	Biotechnology 1, 2, 3, 4	Department/Discipline	Laboratory Science

School	San Mateo High School		
District	San Mateo Union High School District		
City	San Mateo, CA		
School Contact	Ellyn A. Daugherty	Grade Level (s)	10-12
Titles/Position	Biotechnology Teacher	Length of Course	Other (4 semesters)
Contact Information			
Phone	(650) 558-2389		
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School Board Approval	January 2003	Honors Distinction?	No

Was this course previously approved by UC?
No, but a similar course Introduction to Biotechnology 1, 2, 3 (a College Preparatory Elective) was approved in 1995 and taught in the San Mateo Union High School District until 2002.

Prerequisites	Biology 1-2 or a life science course with a "C" or better and the "Gene Connection" Biotechnology Unit
Co-Requisites	Algebra 1-2

Brief Course Description

Biotechnology 1, 2, 3, and 4 are the first four semesters of the six-semester San Mateo Biotechnology Career Pathway. The fifth and sixth semesters of the pathway are the180-hour industry laboratory internship at one of twenty local biotechnology companies. Biotechnology 1, 2, 3, and 4 are designed to give students an introduction to the scientific concepts and laboratory research techniques currently used in the field of biotechnology. Students develop laboratory skills, critical thinking, and communication skills currently used in the biotechnology industry. Through extensive reading, laboratory work, and workplace experiences, students will explore and evaluate career opportunities in the field of biotechnology.

Biotechnology 1, 2, 3, and 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 1-2 after completing the prerequisite.

Optional Background Information

Context for Course:
San Mateo High School has an outstanding Science Department including courses in Biology, Chemistry, AP Biology, AP Chemistry, AP Physics and several science college preparatory electives. Since 1995 when biotechnology pathway courses were first taught at San Mateo High, students are scoring higher on the Golden State Exams in Biology and Chemistry as well as on the Advanced Placement Exams in Biology and Chemistry. We attribute the increase in performance, at least in part, to the rigorous curriculum and emphasis on chemistry and biochemistry found in the biotechnology courses.

The Biotechnology courses also prepare students for post-secondary courses in biology, chemistry, biochemistry, biotechnology, microbiology, molecular and cell biology, genetics and immunology. After completing a minimum of Biotechnology 1-2, students are eligible for a 180-hour laboratory internship at a local biotechnology company. Students may continue into employment after the internship period.

History of Course Development
All of the biotechnology courses in the San Mateo Biotechnology Career Pathway (Biotechnology 1, 2, 3, and 4 as well as the ROP Biotechnology Services Internship class) were written by Ellyn Daugherty, veteran biology teacher of twenty-three years, 1992 Presidential Scholar, and Runner-up 2000 Presidential Award in Science Teaching, California. Ellyn Daugherty has taught Biotechnology at San Mateo High School since 1988.

After meeting with other biotechnology educators and biotechnology industry partners from San Mateo County and adjacent counties, Ellyn Daugherty wrote the Course of Study, Course Objectives, and Scope and Sequence of the Biotechnology classes. Biotechnology 1, 2, and 3 was originally approved as UC "F" electives in1995 and were drafted in collaboration with former SMUHSD Director of Curriculum and Instruction (Dr. Phil Fisher) and UC Admissions personnel. Since 1995 more topics at a higher level have been incorporated into all of the biotechnology courses aligning it with the UC Lab Science courses

Originally, seen as a college preparatory elective course, the content, rigor, and scope of the biotechnology courses are as sophisticated or higher than Biology 1-2 and Chemistry 1-2. The Biotechnology 1, 2, 3 and 4 curriculum has been written into a text that is currently being field tested at eight California high schools. The San Mateo Biotechnology Pathway has received several awards including the Kent Award and the Intel Innovations in Teaching Award, California 2nd Place) and is a model program being duplicated at several California high schools.

A. Course Goals and Major Student Outcomes

Students will:

- **Understand the role of biotechnology in society including the risks and benefits.**
- **Understand the basic biological and chemical processes of cells, tissues, and organisms.**
- **Gain a deeper understanding of the significance of biotechnology in pharmaceutical development, agriculture, forensics, genetic testing, industrial products, and scientific research.**
- **Learn basic laboratory skills used in academic and industrial biotechnology laboratories.**
- **Learn how a biotechnology company works and the roles of its employees.**
- **Model the steps involved in the production of a recombinant DNA biotechnology product.**
- **Gaining an understanding and exposure to assorted topics/concepts in biotechnology.**

B. Course Objectives

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

Biotechnology 1-2

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)**

<u>H. Recombinant DNA and Genetic Engineering</u>

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.**

Biotechnology 3-4

- **Note: Several topics first taught in Biotechnology 1-2 are repeated in Biotechnology 3-4 but in a more in depth way and with additional applications and higher level cognition expected.**

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.**

C. Course Outline/Scope and Sequence of Conceptual and Process Topics

Scope and Sequence of Biotechnology 1

Concepts/Lectures/Readings	Process/Laboratory work
Biotechnology Past/Present	Setting up a Legal Scientific Notebook Safety in the Biotech Laboratory Internet/WWW Research, Word®, Excel®, PowerPoint® Scientific Methodology Laboratory Model Organism Growth/Media Preparation Sterile Technique/Cell Culture Solution and Dilution Preparation
DNA and Protein Structure/Function	DNA Isolation and Indicator Analysis Agarose Gel Electrophoresis, DNA Synthesis and PCR Protein Isolation and Indicator Analysis Polyacyrlamide Gel Electrophoresis Protein and Enzyme Studies/Assays

Scope and Sequence of Biotechnology 2

Concepts/Lectures/Readings	Process/Laboratory work
Assay Development	Amylase Assay Development- Spectrophotometry to Study Molecules Protein Concentration Assays
Recombinant DNA Technology	Recombinant Plasmid /Cloning Vectors Restriction Digestion and Restriction Enzyme Mapping Agarose Gel Electrophoresis Analysis
Transformation /Genetic Engineering	Cell Competency Bacterial Transformation and Selection
Scale-up, Manufacturing, Marketing	Cell Culture, Growth and Monitoring Protein Product Purification and Testing Product Pipelines and Industry Applications Disease and Medicine Clinical Testing and Regulations Bioethics and Decision-Making

Scope and Sequence of Biotechnology 3

Concepts/Lectures/Readings	Process/Laboratory work
Manipulating/Studying Plants	Breeding Wisconsin Fast Plants Asexual Propagation of Plants

	Plant Tissue Culture Media **Cloning African Violets/Orchids**
DNA from Plants	**Isolation/Study of Plant DNA** **Development of a DNA Concentration Assay** **UV Spectrophotometry**
Genetic Engineering of Plants	**Transformation ofArabidopsis** **ArabidopsisPCR** **GMO and the Bioethics of Engineering Foods**
Isolation and ID of Plant Proteins	**Column Chromatography** **SDS-PAGE**
Discovering New Medicines	**Identifying Anti-microbial Plant Substances** **Extracting Compounds from Plants** **Chemical Synthesis of a "New and Improved" Medicine** **Testing the Purity of Synthesized Compounds**

Scope and Sequence of Biotechnology 4

Concepts/Lectures/Readings	**Process/Laboratory work**
DNA Synthesis	**In Vitro DNA Synthesis Reactions** **PAGE Analysis, Southern Blotting, Visualization**
Polymerase Chain Reaction	**Lambda PCR** **Alu PCR and Bioinformatics** **PCR Optimization** **DNA Fingerprinting and Forensics**
DNA Sequencing	**In Vitro DNA Sequencing Reactions** **PAGE Analysis and Gel Capillary Technology** **Bioinformatics and Evolutionary Studies** **Human Genome Project**
Muscle Tissue Protein Studies	**Protein Extractions from Animal Tissue** **PAGE and Column Chromatography Analysis** **Biodiversity and Evolution** **Western Blot** **ELISA technology**

D. Texts and Supplemental Instructional Materials

Primary Texts

- **Molecular Biology Made Simple and Fun, 2nd Edition, Clark and Russell, Cache River Press, 2000 ISBN#0-9627422-9-5**
- **Biotechnology: Science for the New Millenium, Ellyn Daugherty, 2002, Publishing in process.**

Supplemental Texts/Materials

- **DNA Science: A First Course in Recombinant DNA Technology, Micklos and Freyer, Colds Springs Harbor Laboratory Press, 1990, ISBN# 0-89278-411-3**
- **Biotechnology: An Introduction, Barnum, Wadsworth Publishing, 1998, ISBN# 0-5342-34364**
- **Internet and WWW sites**

E. Instructional Methods and Strategies

- **Lectures, videos, demonstrations**
- **In-depth readings from texts and Internet sites**
- **Laboratory experiments and detailed written analysis**
- **Pre-laboratory and post-laboratory discussions**
- **Oral presentations using presentation software**
- **Peer review, ethics debates, and position papers**
- **Field trips, job-shadows, and guest speakers**
- **Exhaustive research leading to written reports**

F. Assessment Methods and/or Tools

- **Written, Oral, and Performance-based Examinations**
- **Formal Laboratory Reports**
- **Legal Scientific Notebook**
- **Participation, Behavior, and Attendance**
- **Research Papers/Semester Projects**

G. Assessment Criteria

- **Students must pass all written, oral, and performance-based examinations with a score of 80% or higher.**
- **Students not scoring 80% or higher on any written, oral, and performance-based examinations are assigned to a mandatory tutorial session at either "advisory period" or lunch.**
- **Students must maintain a complete and accurate scientific notebook.**
- **Students not scoring 80% or higher notebook evaluations are assigned to a mandatory tutorial session at either "advisory period" or lunch. Notebooks are evaluated by the instructor every six weeks.**
- **Students not scoring 80% or higher on any semester project must revise the project and resubmit it.**
- **Students not completing all work with a score of 80% or higher will not be eligible for promotion into the next semester of Biotechnology.**