Course of Study

Biotechnology

Warren County Career Center

3525 North State Route 48
Lebanon, Ohio 45036

Adopted 08-16-07

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Acknowledgements

Biotechnology
Warren County Career Center

We would like to take this opportunity to express our gratitude to the following people for their guidance and support in the preparation of this course of study:

Warren County Career Center Administrative Team
Warren County Educational Service Center
Mr. Karl Flem
Mr. Jeff Little
Mrs. Adrienne Schmidt
Ms. Toni Welles
Ms. Sandi Monti, Greentree Health Science Academy
Mrs. Charla Cornwell, Greentree Health Science Academy
Mr. Dewey Daniel

Warren County Career Center
Resolution Of School Board Approval

WHEREAS, representatives of Science Department of the Warren County Career Center have reviewed the Biotechnology Course of Study; and

WHEREAS, this Course of Study is based upon Integrating Technical and Academic Competencies adopted by the State of Ohio for the Biotechnology program; and

WHEREAS, the Biotechnology faculty and the Career-Technical Advisory Committee have reviewed and added competencies as needed to address local labor market needs and trends in the industry;

NOW, THEREFORE, BE IT RESOLVED, in accordance with the Superintendent's recommendation, that the Warren County Career Center adopt the Biotechnology Course of Study.

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District Superintendent Date

_____

President, Board of Education Date

Statement of Recommendation

The Biotechnology Advisory Committee at Warren County Career Center has reviewed this course of study and recommends it for use as the foundation for instruction in the Biotechnology class.

The developers of this course of study have considered local labor market needs and the school's ability to offer specialized programs. The competencies have been reviewed and accepted as being congruent with our school's vision, mission, and strategic goals. When appropriate, additional competencies related to the program area have been incorporated into this course of study.

Achievement of technical competencies, utilizing proper attitudes, and demonstrating appropriate values are critical for successful employment and for furthering educational opportunities within a student's chosen field. We believe that this course of study adequately and correctly focuses upon student development.

This course of study is recommended on: 08-16-07

Warren County Career Center Vision Statement

WCCC is the valued partner of choice within the educational and economic systems of our communities, by providing quality academic and career technical education.

We pave the way for a future of opportunities unique to each of our learners.

Warren County Career Center Mission Statement

To prepare youths and adults to make informed career choices and to successfully enter, compete, and advance in a changing work world.

Warren County Career Values

- Treating each other with respect, dignity, trust and mutual value
- Communicating openly and honestly
- Taking ownership of personal actions and being held accountable for results
- Upholding and demonstrating high ethical, educational and fiscal standards
- Exhibiting high levels of professionalism
- Providing high quality instruction and highly qualified staff to ensure success for all learners
- Making quality customer service a high priority
- Promoting partnerships and a team environment
- Celebrating team and individual achievements
- Using data to drive planning, decision making and actions
- Embracing educational opportunities for change and diversity

Course Design

Courses are designed to reflect career-focused education, which combines high-level academics with real-life technical skills. The intent is to maximize a student's present and future academic and career success.

Career-focused education enhances the integration of academic and technical skills, designs programs that prepare students with transferable skills and promotes each student's career opportunities.

Course Philosophy

We believe that the philosophy for our science courses to be:

- Prepare students to use appropriate scientific processes and principles to make personal decisions;
- Enable students to engage in intelligent public discourse about matters of scientific and technological concern;
- Help students develop an understanding of themselves and the world in which they live;
- Foster an understanding of the nature of science, the development of science processes, the principles of science, and the connections between all the sciences;
- Increase their future economic productivity through the use of scientific knowledge, understanding, and skills in their careers.

Course Goals

The course goals for Biotechnology are to:

- Set high expectations and provide support for achievement by all students
- Provide balance among conceptual understanding, procedural knowledge and skills, and application and problem-solving
- Provide skills to allow them to be able to apply scientific knowledge and processes to individual and societal issues
- Incorporate the use of technology by all students and the interconnected nature of science and technology
- Understand biological concepts and how they are applied in General science
- Prepare students to work in the bioscience industry in the areas of research and development, quality systems, production, clinical testing, and diagnostic work.

Course Description

Biotechnology is defined as the knowledge of bioprocesses applied to the engineering and use of organisms, cells or bio-molecules to solve problems or make products.

This course is designed to give the student a comprehensive study of biotechnology and to prepare them to work in the bioscience industry in the areas of research and development, quality systems, production, clinical testing, and diagnostic work.

This in depth look at these systems will develop the skills necessary for a successful career in biotechnology or the ability to succeed in college coursework in this area.

Academic and Technical Integration

Expectations of curriculum must be aligned with what is written, taught, assessed, and reported. Student expectations focus on active, project-centered learning—an approach to learning that emphasizes a connection between ideas in a discipline and the outside world. Educational programming and course content will clearly connect career and post-secondary opportunities. At the Warren County Career Center, the main goal is to design courses and projects that use strategies for authentic instruction. These characteristics of instruction focus on deep understanding, established opportunities for concept connections, provide anticipatory and abstract thinking, and emphasize genuine application.

The academic courses at the WCCC follow the state model curricula. They are designed to meet both associate school and state requirements. These standards respond to the need to improve student achievement, quality of curriculum and instruction, and strengthen school and community relationships.

Technology

The Warren County Career Center board and staff believe that technology skills are essential for all students to achieve in the 21st century. It is the goal of this district to infuse technology into all facets of education:

- Instruction
- Assessment
- Administration
- Career planning
- Course design
- Professional development

Strategies to incorporate technology into all facets of education are a priority of the district and there is commitment to a continual process to provide updated hardware, software, and professional development for staff members for the purpose of providing a high quality education, with the integration of technology, for all students.

Students Served

The population served by this program is juniors and seniors.

Scope and Sequence

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.
4. Use the scientific method to conduct a valid experiment, including hypothesis formation, data collection, and data analysis.
5. Develop scientific questions, hypotheses, and experimental plans.
6. Create data tables and graphs using Excel® for the purpose of collecting and analyzing data.
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.
9. Organize and communicate scientific findings both orally and in written form and produce clear, concise written and oral reports.
10. Evaluate the validity of results obtained during experimentation and product development.
11. Evaluate scientific reports with well-supported, clearly presented opinions.
12. Use the Internet and World Wide Web to collect and share scientific information.
13. 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.
14. 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.
2. Outline the life cycle and characteristics of model organisms used in the biotechnology industry, including various bacteria (E. coli) and fungi (yeasts and Aspergillums.

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.

7. Discuss the structure and function of the macromolecules that compose cells, including carbohydrates, lipids, DNA, RNA, and protein molecules.

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.

7. Prepare solutions of any volume and concentration.

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.
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).
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.
2. Explain the relationship between amino acids, peptides and proteins.
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.
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.
10. Explain the function of enzymes and how their activity is affected by temperature and pH.
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.
2. Identify several local biotechnology companies specializing in the production of pharmaceuticals, agricultural products, industrial products, and research instruments and reagents.
3. Describe the major steps is a product's move through a company's product pipeline.
4. Explain how companies decide on the research and development targets and potential products.
5. Identify several products obtained through recombinant DNA technology.
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.
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.

14. Use pH paper and pH meters to measure and adjust pH.

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.

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.

20. Using Excel®, do a linear regression to calculate protein concentration.

21. Use statistical analysis including the standard deviation, to determine the validity of data.

H. Recombinant DNA and Genetic Engineering

The student will be able to:

1. Discuss methods to isolate DNA and specific genes for engineering purposes.

2. Enumerate the activities and uses of restriction enzymes.

3. Conduct a restriction digestion of a plasmid.

4. List the steps in the production of a recombinant DNA molecule.

5. Cite examples of vectors used in transformation, transduction, and transfection.

6. Describe the steps in a bacterial transformation including competency, recovery, and selection.

7. Conduct a bacterial transformation and select for transformants.

8. Describe methods by which transformants may be selected including antibiotic resistance, GFP and GUS activity.

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.

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.

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.

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.

Technology Standards

Standard 1: Nature of Technology

Students develop an understanding of technology, its characteristics, scope, core concepts* and relationships between technologies and other fields.

Benchmark A: Synthesize information, evaluate and make decisions about technologies.

Benchmark B: Apply technological knowledge in decision-making.

Benchmark C: Examine the synergy between and among technologies and other fields of study when solving technological problems.

Standard 2: Technology and Society Interaction

Students recognize interactions among society, the environment and technology, and understand technology's relationship with history. Consideration of these concepts forms a foundation for engaging in responsible and ethical use of technology.

Benchmark A: Interpret and practice responsible citizenship relative to technology.

Benchmark B: Demonstrate the relationship among people, technology and the environment.

Benchmark C: Interpret and evaluate the influence of technology throughout history, and predict its impact on the future.

Benchmark D: Analyze ethical and legal technology issues and formulate solutions and strategies that foster responsible technology usage.

Benchmark E: Forecast the impact of technological products and systems.

Standard 3: Technology for Productivity Applications

Students learn the operations of technology through the usage of technology and productivity tools.

Benchmark A: Integrate conceptual knowledge of technology systems in determining practical applications for learning and technical problem-solving.

Benchmark B: Identify, select and apply appropriate technology tools and resources to produce creative works and to construct technology-enhanced models.

Standard 4: Technology and Communication Applications

Students use an array of technologies and apply design concepts to communicate with multiple audiences, acquire and disseminate information and enhance learning.

Benchmark A: Apply appropriate communication design principles in published and presented projects.

Benchmark B: Create, publish and present information, utilizing formats appropriate to the content and audience.

Benchmark C: Identify communication needs, select appropriate communication tools and design collaborative interactive projects and activities to communicate with others, incorporating emerging technologies.

Standard 5: Technology and Information Literacy

Students engage in information literacy strategies, use the Internet, technology tools and resources, and apply information-management skills to answer questions and expand knowledge.

Benchmark A: Determine and apply an evaluative process to all information sources chosen for a project.

Benchmark B: Apply a research process model to conduct research and meet information needs.

Benchmark C: Formulate advanced search strategies, demonstrating an understanding of the strengths and limitations of the Internet, and evaluate the quality and appropriate use of Internet resources.

Benchmark D: Evaluate choices of electronic resources and determine their strengths and limitations.

Standard 6: Design

Students apply a number of problem-solving strategies demonstrating the nature of design, the role of engineering and the role of assessment.

Benchmark A: Identify and produce a product or system using a design process, evaluate the final solution and communicate the findings.

Benchmark B: Recognize the role of teamwork in engineering design and of prototyping in the design process.

Benchmark C: Understand and apply research, development and experimentation to problem-solving.

Standard 7: Designed World

Students understand how the physical, informational and bio-related technological systems of the designed world are brought about by the design process. Critical to this will be students' understanding of their role in the designed world: its processes, products, standards, services, history, future, issues and career connections.

Benchmark A: Classify, demonstrate, examine, and appraise energy and power technologies.

Benchmark B: Classify, demonstrate, examine and appraise transportation technologies.

Benchmark C: Classify, demonstrate, examine and appraise manufacturing technologies.

Benchmark D: Classify, demonstrate, examine and appraise construction technologies.

Benchmark E: Classify, demonstrate, examine and appraise information and communication technologies

Benchmark F: Classify, demonstrate, examine and appraise medical technologies.

Benchmark G: Classify, demonstrate, examine and appraise agricultural and related biotechnologies.

Performance Measures/Student Assessment/Instructional Strategies

Assessments/Evaluations

- Observations
- Demonstrations
- Portfolios
- Standardized Tests
- Class Assignment
- Quizzes/Tests/Exams
- Web Exam/Certification

Instructional Strategies

- Teacher-Directed & Student-Centered Activities
- Case Study Problem Solving
- Cooperative Learning
- Project-Based Learning
- Career-Based Learning (Internships/Shadowing/Placement)
- Community-Based Learning (CTSOs and Other)
- Exploratory Learning
- Independent Research
- Team Teaching

Content Specific Strategies