Maryland
STATE DEPARTMENT OF EDUCATION

Program of Study Guide: Biotechnology - DRAFT

Comprehensive guidelines and course standards for the Biotechnology

Office of College and Career Pathways

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MARYLAND STATE DEPARTMENT OF EDUCATION

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Purpose

The purpose of this document is to communicate the required Career and Technical Education (CTE) academic standards for the Biotechnology Program of Study. The academic standards in this document are theoretical and performance based. The standards contain content from multiple state departments of education, Biotechnology Aptitude Competency Exam Standards, and Good Laboratory Practices Standards, Bioinformatics and Computational Biology Standards, and have been reviewed and vetted by members of the Maryland business and industry community.

In addition to academic standards, the Maryland State Department of Education (MSDE) has incorporated into this document Labor Market Information (LMI) definitions and explanations for the Program of Study; program aligned Industry Recognized Credentials; and Work-Based Learning resources and requirements by course level.

This document is intended for use by educational administrators and practitioners. A similar document is available for each state-approved CTE Program of Study.

Standards Sources

Biotechnology standards are based on various research-backed sources, best practices, and national frameworks that guide effective K-12 education. The following sources provide a rigorous foundation for the Biotechnology standards, ensuring they are well-rounded, research-driven, and aligned with national expectations and young learners' unique needs.

Here are the primary sources that these standards draw from:

1. **Advance CTE Education Career Cluster Framework: Health and Human Services**
   A. **Description:** The Advance CTE CTE provides a nationally recognized framework for Career and Technical Education (CTE) programs, outlining rigorous academic and technical standards aligned with industry needs. The framework for the Healthcare & Human Services Career Cluster includes standards that emphasize addressing social determinants of health, leveraging health data, and advancing healthcare through scientific research and biotechnology.
   B. **Usage:** The program standards are based on the Healthcare & Human Services Career Cluster framework, particularly the Biotechnology Research & Development Sub-Cluster, ensuring alignment with industry expectations and post-secondary pathways.
   C. **Source:** Advance CTE Career Clusters.

2. **Biotechnology Aptitude and Competency Exam (BACE) Standards**
   A. **Description:** BACE, developed by the Florida Department of Education in partnership with the biotechnology industry, validates the knowledge and skills required for entry-level biotechnicians. The exam covers topics such as molecular biology, laboratory safety, and biotechnology applications.
   B. **Usage:** BACE standards are integrated into the curriculum for Biotechnology II and III, preparing students to demonstrate industry-aligned competencies and earn the certification by the end of Biotechnology II.
   C. **Source:** Biotechnology Aptitude and Competency Exam (BACE)

3. **Occupational Safety and Health Administration (OSHA)**
   A. **Description:** OSHA standards provide guidelines for workplace safety, including hazard communication, laboratory safety protocols, and personal protective equipment (PPE). The OSHA 30 Certification ensures comprehensive understanding of safety practices.
   B. **Usage:** OSHA standards are embedded throughout the program to ensure students develop safe laboratory practices. By the end of Biotechnology II, students are prepared to earn the OSHA 30 Certification.
   C. **Source:** OSHA Certification and Training

4. **Next Generation Science Standards (NGSS)**
   A. **Description:** NGSS provides a framework for science education focused on developing critical thinking, problem-solving, and technical skills. It emphasizes cross-cutting concepts, core ideas, and scientific practices.
   B. **Usage:** NGSS informs the integration of biology, chemistry, and scientific inquiry into the curriculum, ensuring students develop foundational scientific knowledge essential for biotechnology.
   C. **Source:** **Next Generation Science Standards (NGSS)**

5. **Good Laboratory Practices (GLP) Standards**
   A. **Description:** GLP is a set of principles established by regulatory agencies to ensure laboratory practices' reliability, quality, and integrity. It includes documentation, equipment calibration, and data management.
   B. **Usage:** GLP standards are incorporated into Biotechnology II and III to teach students proper laboratory documentation, quality control, and compliance techniques.
   C. **Source:** Good Laboratory Practices by the FDA

6. **Bioinformatics and Computational Biology Standards**
   A. **Description:** These standards outline the skills needed to analyze and interpret biological data, such as genome sequencing and protein modeling, using computational tools.
   B. **Usage:** These standards are emphasized in Biotechnology III and IV to prepare students for advanced biotechnology roles requiring bioinformatics expertise.
   C. **Source:** National Center for Biotechnology Information (NCBI)

Course Descriptions

Course Level	Course Information	Description
Required Core: Course 1	Biotechnology I SCED: <XX> Grades: 9-12 Prerequisite: None Credit: 1	Biotechnology I course provides students with a foundational understanding of biotechnology and its applications in healthcare and research. Students explore the history, principles, and ethical considerations of biotechnology while developing essential laboratory skills. Topics include basic molecular biology, genetics, laboratory safety, and OSHA standards. By the end of the course, students will gain the knowledge and skills to begin preparation for the Biotechnology Aptitude and Competency Exam (BACE) in subsequent courses.
Required Core: Course 2	Biotechnology II SCED: <XX> Grades: 10-12 Prerequisite: Biotechnology I Credit: 1	Biotechnology II course builds upon the foundational skills from the Biotechnology I course. This course emphasizes advanced laboratory techniques and applied biotechnology skills. Students will master aseptic techniques, DNA analysis, protein assays, and data analysis while preparing for industry certifications. Key topics include biomanufacturing, bioinformatics, and the regulatory environment of biotechnology. By the end of the course, students will be prepared to earn the Biotechnology Aptitude and Competency Exam (BACE) and will explore opportunities for dual or articulated college credits.
Optional Flex: Course 1	Biotechnology III SCED: <XX> Grades: 11-12 Prerequisite: Biotechnology I and II Credit: 1	In the Biotechnology III advanced course, students deepen their understanding of biotechnology through independent research and hands-on laboratory experiences. Emphasis is placed on designing and conducting experiments using advanced techniques such as CRISPR, next-generation sequencing, and bioprocessing. Students analyze and present research findings while engaging in ethical and societal discussions related to biotechnology innovations. This course prepares students for work-based learning experiences, including internships, while offering

		opportunities to earn dual or articulated college credits.
Optional Flex: Course 2	Career Connected Learning I SCED: <XX> Grades: 11-12 Prerequisite: Biotechnology I and II Credit: 1	This flexible, work-based learning course introduces students to real-world applications of classroom knowledge and technical skills through on-the-job experiences and reflective practice. Students engage in career exploration, skill development, and professional networking by participating in youth apprenticeships, registered apprenticeships, pre-apprenticeships, internships, capstone projects, or other approved career-connected opportunities. Variable credit (1–3) accommodates the required on-the-job training hours and related instruction. By integrating industry standards, employability skills, and personalized learning goals, Career Connected Learning I equips students to make informed career decisions, develop a professional portfolio, and build a strong foundation for success in postsecondary education, training, or the workforce.
Optional Flex: Course 3	Career Connected Learning II SCED: <XX> Grades: 11-12 Prerequisite: Career Connected Learning I Credit: 1	Building on the foundational experiences of Career Connected Learning I, this advanced work-based learning course provides students with deeper on-the-job practice, leadership opportunities, and refined career exploration. Students continue to enhance their technical and professional skills, expanding their industry networks and aligning personal goals with evolving career interests. Variable credit (1–3) remains aligned with the required training hours and related instruction. Through elevated responsibilities and skill application, Career Connected Learning II prepares students to confidently transition into higher-level postsecondary programs, apprenticeships, or the workforce.

Dual Enrollment and Career Connected Learning Experiences Must be Aligned to the CTE Core.

Industry-Recognized Credentials and Work-Based Learning

Industry-Recognized Credentials
By the end of Biotechnology II: Biotechnology Aptitude and Competency Exam (BACE) **Optional Credentials (via the Flex Course options**): Dual Credit Options, Apprenticeships, Internships

Work-Based Learning Examples and Resources		
Biotechnology I and II**: Career Awareness**	Biotechnology III: **Career Preparation**	**Flex Courses: Career Preparation**
• Industry Visits • Guest Speakers • Participation in Career and Technical Student Organizations • Postsecondary Visits – Program Specific Site Tours • Mock Interviews	• All of Career Awareness plus the following: • Job Shadow • Paid and Unpaid Internships	• Paid and Unpaid Internships • Apprenticeships

Labor Market Information: Definitions and Data

Labor market information (LMI) plays a crucial role in shaping Career and Technical Education (CTE) programs by providing insights into industry demands, employment trends, and skills gaps. This data helps education leaders assess the viability of existing programs and identify opportunities for new offerings. By aligning CTE programs with real-time labor market needs, schools can better prepare students for in-demand careers and ensure that resources are effectively utilized to support pathways that lead to high-quality, sustainable employment.

Standard Occupational Code (SOC) and Aligned Industry:

Indicator	Definition	Pathway Labor Market Data
High Wage[1]	Those occupations that have a 25th percentile wage equal to or greater than the most recent MIT Living Wage Index for one adult in the state of Maryland, and/or leads to a position that pays at least the median hourly or annual wage for the DC-VA-MD-WV Metropolitan Statistical Area (MSA). *Note: A 25th percentile hourly wage of $24.74 or greater is required to meet this definition.*	**Standard Occupational Code:** 19-4021: Biological Technicians 19-1029 Biological Scientists, All Other 17-2031: Bioengineers and Biomedical Engineers **Hourly Wage/Annual Salary:** Bioengineers and Biomedical Engineers: 25th Percentile: $41.49 / $86,299.20 50th Percentile: $52.14 / $108,451.20 75th Percentile: $62.53 / $130,062.40 Biological Scientists, All Other: 25th Percentile: $37.03 / $77,022.40 50th Percentile: $49.11 / $102,148.80 75th Percentile: $61.03 / $126,942.40 Biological Technicians: 25th Percentile: $19.66 / $40,892.80 50th Percentile: $23.54 / $48,963.20 75th Percentile: $29.72 / $61,817.60

[1] Living Wage Calculator: https://livingwage.mit.edu/states/24

High Skill	Those occupations located within the DC-VA-MD-WV Metropolitan Statistical Area (MSA) with the following education or training requirements: completion of an apprenticeship program; completion of an industry-recognized certification or credential; associate's degree, bachelor's degree, or higher.	**Typical Entry-Level Education:** Bachelor's Degree
In-Demand	Annual growth plus replacement, across all Maryland occupations, is 405 openings between 2024-2029.	**Annual Openings –** Biological Technicians - 520 Biological Scientists, All Other - 498 Bioengineers and Biomedical Engineers - 35

Labor Market Information Data Source

Lightcast Q4 2024 Data Set. Lightcast occupation employment data are based on final Lightcast industry data and final Lightcast staffing patterns. Wage estimates are based on Occupational Employment Statistics (QCEW and Non-QCEW Employees classes of worker) and the American Community Survey (Self-Employed and Extended Proprietors). Occupational wage estimates are also affected by county-level Lightcast earnings by industry. Foundational data for the state of Maryland is collected and reported by the Maryland Department of Labor.

Methodology for High Wage Calculations

To combine labor market data across multiple Standard Occupational Classifications (SOCs), a weighted average approach was used to ensure accurate representation of the marketplace. Median wages for each SOC were weighted based on their respective employment levels, reflecting the relative demand for each occupation. This method ensures that occupations with higher employment contribute proportionately to the overall wage calculation. Additionally, job openings from all relevant SOCs were summed to determine the total projected demand. For example, if Mechanical Engineers account for 67% of total employment and Electrical Engineers for 33%, their respective wages are weighted accordingly, and job openings are aggregated to provide a comprehensive view of labor market opportunities. This approach delivers a balanced and accurate representation of both wages and employment demand for the program.

Methodology for In-Demand Calculations

The baseline for annual job openings, taking into account new positions and replacement positions, was determined by taking the average of all annual job openings between 2024 and 2029 across all 797 career sectors at the 5-digit SOC code level. For the 2024-2029 period, average job openings (growth + replacement) is 405.

Course Standards: Biotechnology I

1. **GENERAL REQUIREMENTS.** This course is recommended for students in Grades 9-12, and there are no prerequisites.

2. **INTRODUCTION**
   A. Career and Technical Education (CTE) instruction provides content aligned with challenging academic standards and relevant technical knowledge and skills for students to further their education and succeed in current or emerging professions.
   B. The Health and Human Services Career Cluster promotes whole health in individuals and communities through diverse services. This sector includes technical, mental, and therapeutic services and personal care supported by medical and social sciences. By addressing social determinants of health and leveraging health data and science, this Cluster aims to enhance the overall health and resilience of individuals, families, and communities.
   C. The Biotechnology Program of Study focuses on research and development in the medical field, including biotechnology and scientific research. Professionals in this field develop new treatments, pharmaceuticals, devices, and innovative medical technologies to advance healthcare. Through hands-on laboratory experiences, students develop the technical skills and knowledge necessary to conduct research, analyze data, and contribute to the development of treatments, medical devices, and cutting-edge technologies. The program integrates core academic skills in biology, chemistry, and mathematics with industry-aligned standards to ensure students are prepared for certifications such as the Biotechnology Aptitude and Competency Exam (BACE). Graduates of the program will leave with certifications, college credits, and the technical and professional skills needed to pursue careers in biotechnology or further education in fields such as molecular biology, bioinformatics, or biomedical engineering.
   D. Biotechnology I provides students with a foundational understanding of biotechnology and its applications in healthcare and research. Students explore the history, principles, and ethical considerations of biotechnology while developing essential laboratory skills. Topics include basic molecular biology, genetics, laboratory safety, and OSHA standards. By the end of the course, students will gain the knowledge and skills to begin preparation for the Biotechnology Aptitude and Competency Exam (BACE) in subsequent courses.
   E. Students will participate in at least two Career-Connected Education and Work-Based Learning experiences in this course, which might include informational interviews or job shadowing relevant to the program of study.
   F. Students are encouraged to participate in extended learning experiences through aligned Career and Technical Student Organizations (CTSOs). CTSOs are a cocurricular requirement in the Carl D. Perkins Act, and alignment to CTSO activities is an expectation for CTE programs in the state of Maryland.

3. **KNOWLEDGE AND SKILLS**

   A. The student demonstrates the necessary skills for career development, maintenance of employability, and successful completion of course outcomes. The student is expected to:
      1. Identify and demonstrate positive work behaviors that enhance employability and job advancement, such as regular attendance, promptness, proper attire, maintenance of a clean and safe work environment, and pride in work.

2. Demonstrate positive personal qualities such as flexibility, open-mindedness, initiative, active listening, and a willingness to learn.
3. Employ effective reading, writing, and technical documentation skills.
4. Solve problems using critical thinking techniques and structured troubleshooting methodologies.
5. Demonstrate leadership skills and collaborate effectively as a team member.
6. Implement safety procedures, including proper use of software and following privacy guidelines.
7. Exhibit an understanding of legal and ethical responsibilities in the biotechnology field, following copyright laws and regulations.
8. Demonstrate time-management skills and the ability to prioritize tasks in a technical setting.

B. The student identifies various career pathways in the biotechnology field. The student is expected to:

1. Develop a career plan that includes the necessary education, certifications, job skills, and experience for specific roles in biotechnology.
2. Create a professional resume and portfolio that reflect skills, projects, certifications, and recommendations.
3. Demonstrate effective interview skills for roles in biotechnology fields.

C. The student develops technology and digital literacy skills. The student is expected to:

1. Use technology as a tool for research, organization, communication, and problem-solving.
2. Use digital tools, including computers, mobile devices, collaboration platforms, and cloud services, to access, manage, and create information.
3. Demonstrate proficiency in using emerging and industry-standard technologies.
4. Understand ethical and legal considerations for technology use, including the principles of data protection, copyright, and responsible technology use.

D. The student integrates core academic skills into biotechnology practices. The student is expected to:

1. Demonstrate the use of clear communication techniques, both written and verbal, that are consistent with industry standards.
2. Apply English concepts such as writing informative texts when documenting procedures and articulating goals.
3. Use mathematical concepts for measurement and conversion (Fahrenheit vs. Celsius), ratios and proportions as well as fraction and decimal conversions.

E. The student demonstrates foundational knowledge and skills in biotechnology and its applications. The student is expected to:

1. Explain the role of biotechnology in advancing healthcare and its impact on individuals, families, and communities.
2. Describe key principles of biology, chemistry, and genetics as they relate to biotechnology research and development.
3. Identify and differentiate between major biotechnology sectors, including pharmaceuticals, medical devices, and bioinformatics.

F. The student applies laboratory safety protocols and demonstrates proficiency in using biotechnology tools and equipment. The student is expected to:

1. Demonstrate compliance with OSHA standards and laboratory safety protocols, including proper handling and disposal of hazardous materials.
2. Operate basic laboratory equipment such as microscopes, spectrophotometers, and centrifuges safely and effectively.
3. Perform aseptic techniques, including pipetting and sterile media preparation, to minimize contamination in laboratory settings.

G. The student demonstrates the ability to conduct scientific research and analyze data. The student is expected to:

1. Maintain the scientific method to design and conduct experiments, including forming hypotheses and analyzing results.
2. Utilize data collection techniques and organize findings using charts, graphs, and tables.
3. Interpret data from laboratory experiments and draw evidence-based conclusions.

H. The student develops an understanding of biotechnology-related technical skills aligned with industry standards. The student is expected to:

1. Demonstrate proficiency in DNA extraction, electrophoresis, and PCR techniques to analyze genetic material.
2. Explain the principles of cell culture and its applications in research and development.
3. Conduct basic protein analysis techniques such as chromatography and spectrometry.

I. The student integrates core academic skills into biotechnology practices. The student is expected to:

1. Demonstrate effective written and verbal communication skills in the context of laboratory documentation and reporting.
2. Apply mathematical concepts such as ratios, proportions, and statistical analysis to interpret experimental data.
3. Use critical thinking and problem-solving skills to troubleshoot experimental errors and optimize procedures.

J. The student explores ethical, legal, and societal issues related to biotechnology. The student is expected to:

1. Examine the ethical implications of genetic modification, cloning, and other biotechnological advancements.
2. Identify laws and regulations governing biotechnology research and product development.
3. Discuss the role of biotechnology in addressing global health challenges and environmental issues.

Course Standards: Biotechnology II

1. **GENERAL REQUIREMENTS.** This course is recommended for students in Grades 10-12, and Biotechnology I is the prerequisite.

2. **INTRODUCTION**
   A. Career and Technical Education (CTE) instruction provides content aligned with challenging academic standards and relevant technical knowledge and skills for students to further their education and succeed in current or emerging professions.
   B. The Health and Human Services Career Cluster promotes whole health in individuals and communities through diverse services. This sector includes technical, mental, and therapeutic services and personal care supported by medical and social sciences. By addressing social determinants of health and leveraging health data and science, this Cluster aims to enhance the overall health and resilience of individuals, families, and communities.
   C. The Biotechnology Program of Study focuses on research and development in the medical field, including biotechnology and scientific research. Professionals in this field develop new treatments, pharmaceuticals, devices, and innovative medical technologies to advance healthcare. Through hands-on laboratory experiences, students develop the technical skills and knowledge necessary to conduct research, analyze data, and contribute to the development of treatments, medical devices, and cutting-edge technologies. The program integrates core academic skills in biology, chemistry, and mathematics with industry-aligned standards to ensure students are prepared for certifications such as the Biotechnology Aptitude and Competency Exam (BACE). Graduates of the program will leave with certifications, college credits, and the technical and professional skills needed to pursue careers in biotechnology or further education in fields such as molecular biology, bioinformatics, or biomedical engineering.
   D. Biotechnology II builds upon the foundational skills from the Biotechnology I course. This course emphasizes advanced laboratory techniques and applied biotechnology skills. Students will master aseptic techniques, DNA analysis, protein assays, and data analysis while preparing for industry certifications. Key topics include biomanufacturing, bioinformatics, and the regulatory environment of biotechnology. By the end of the course, students will be prepared to earn the Biotechnology Aptitude and Competency Exam (BACE) and will explore opportunities for dual or articulated college credits.
   E. Students will participate in at least two Career-Connected Education and Work-Based Learning experiences in this course, which might include informational interviews or job shadowing relevant to the program of study.
   F. Students are encouraged to participate in extended learning experiences through aligned Career and Technical Student Organizations (CTSOs). CTSOs are a cocurricular requirement in the Carl D. Perkins Act, and alignment to CTSO activities is an expectation for CTE programs in the state of Maryland.

3. **KNOWLEDGE AND SKILLS**
   A. The student demonstrates the necessary skills for career development, maintenance of employability, and successful completion of course outcomes. The student is expected to:
      1. Identify and demonstrate positive work behaviors that enhance employability and job advancement, such as regular attendance, promptness, proper attire, maintenance of a clean and safe work environment, and pride in work.

2. Demonstrate positive personal qualities such as flexibility, open-mindedness, initiative, active listening, and a willingness to learn.
3. Employ effective reading, writing, and technical documentation skills.
4. Solve problems using critical thinking techniques and structured troubleshooting methodologies.
5. Demonstrate leadership skills and collaborate effectively as a team member.
6. Implement safety procedures, including proper use of software and following privacy guidelines.
7. Exhibit an understanding of legal and ethical responsibilities in the biotechnology field, following copyright laws and regulations.
8. Demonstrate time-management skills and the ability to prioritize tasks in a technical setting.

B. The student identifies various career pathways in the biotechnology field. The student is expected to:

1. Develop a career plan that includes the necessary education, certifications, job skills, and experience for specific roles in biotechnology.
2. Create a professional resume and portfolio that reflects skills, projects, certifications, and recommendations.
3. Demonstrate effective interview skills for roles in biotechnology fields.

C. The student develops technology and digital literacy skills. The student is expected to:

1. Use technology as a tool for research, organization, communication, and problem-solving.
2. Use digital tools, including computers, mobile devices, collaboration platforms, and cloud services, to access, manage, and create information.
3. Demonstrate proficiency in using emerging and industry-standard technologies.
4. Understand ethical and legal considerations for technology use, including the principles of data protection, copyright, and responsible technology use.

D. The student integrates core academic skills into biotechnology practices. The student is expected to:

1. Demonstrate the use of clear communication techniques, both written and verbal, that are consistent with industry standards.
2. Apply English concepts such as writing informative texts when documenting procedures and articulating goals.
3. Use mathematical concepts for measurement and conversion (Fahrenheit vs. Celsius), ratios and proportions as well as fraction and decimal conversions.

E. The student builds on foundational biotechnology skills and demonstrates advanced knowledge in biotechnology applications. The student is expected to:

1. Explain advanced principles of molecular biology, genetics, and biochemistry related to biotechnology.
2. Analyze the role of biotechnology in addressing social determinants of health and promoting individual and community wellness.
3. Investigate current advancements in biotechnology research, including emerging treatments, pharmaceuticals, and medical devices.

F. The student demonstrates advanced laboratory skills and complies with professional safety standards. The student is expected to:

1. Perform advanced techniques such as quantitative PCR, CRISPR gene editing, and recombinant DNA technology.
2. Implement OSHA 30 safety protocols in laboratory settings, including risk assessment and incident response.
3. Safely handle and store biological samples, reagents, and hazardous materials according to industry standards.

G. The student demonstrates proficiency in research design, analysis, and technical reporting. The student is expected to:

1. Design and conduct complex biotechnology experiments, incorporating controls and replicates to ensure accuracy.
2. Analyze experimental data using advanced statistical methods and interpret results in the context of biotechnology research.
3. Produce detailed lab reports and scientific presentations that meet industry and academic standards.

H. The student applies core academic skills to biotechnology practices. The student is expected to:

1. Demonstrate technical writing skills by creating research proposals, abstracts, and summaries.
2. Apply algebraic and statistical concepts to model and predict biological phenomena and analyze experimental outcomes.
3. Use scientific literature and databases to support research findings and explore biotechnology innovations.

I. The student evaluates ethical, legal, and societal considerations in biotechnology. The student is expected to:

1. Analyze ethical issues associated with gene editing, personalized medicine, and biopharmaceutical development.
2. Investigate laws and regulations governing biotechnology research, intellectual property, and product approvals.
3. Discuss the societal implications of biotechnology innovations on healthcare, the environment, and the economy.

J. The student demonstrates professional skills and explores career pathways in biotechnology research and development. The student is expected to:

1. Participate in simulated workplace scenarios to practice problem-solving, teamwork, and communication skills.
2. Explore career pathways in biotechnology and identify required education, certifications, and technical skills for entry-level positions.

K. The student prepares for and demonstrates competency through the Biotechnology Aptitude and Competency Exam (BACE). The student is expected to:

1. Understand the structure and content areas of the Biotechnology Aptitude and Competency Exam (BACE), including molecular biology, laboratory safety, and biotechnology applications.
2. Engage in targeted review sessions and practice assessments to address areas of improvement and reinforce technical knowledge.
3. Complete mock exams and practical assessments aligned with BACE standards to demonstrate readiness for the certification.
4. Register for and take the Biotechnology Aptitude and Competency Exam (BACE) to validate entry-level biotechnology competencies.

Course Standards: Biotechnology III

1. **GENERAL REQUIREMENTS.** This course is recommended for students in Grades 11-12, and Biotechnology I and II are the prerequisites.

2. **INTRODUCTION**

   A. Career and Technical Education (CTE) instruction provides content aligned with challenging academic standards and relevant technical knowledge and skills for students to further their education and succeed in current or emerging professions.
   B. The Health and Human Services Career Cluster promotes whole health in individuals and communities through diverse services. This sector includes technical, mental, and therapeutic services and personal care supported by medical and social sciences. By addressing social determinants of health and leveraging health data and science, this Cluster aims to enhance the overall health and resilience of individuals, families, and communities.
   C. The Biotechnology Program of Study focuses on research and development in the medical field, including biotechnology and scientific research. Professionals in this field develop new treatments, pharmaceuticals, devices, and innovative medical technologies to advance healthcare. Through hands-on laboratory experiences, students develop the technical skills and knowledge necessary to conduct research, analyze data, and contribute to the development of treatments, medical devices, and cutting-edge technologies. The program integrates core academic skills in biology, chemistry, and mathematics with industry-aligned standards to ensure students are prepared for certifications such as the Biotechnology Aptitude and Competency Exam (BACE). Graduates of the program will leave with certifications, college credits, and the technical and professional skills needed to pursue careers in biotechnology or further education in fields such as molecular biology, bioinformatics, or biomedical engineering.
   D. In Biotechnology III advanced course, students deepen their understanding of biotechnology through independent research and hands-on laboratory experiences. Emphasis is placed on designing and conducting experiments using advanced techniques such as CRISPR, next-generation sequencing, and bioprocessing. Students analyze and present research findings while engaging in ethical and societal discussions related to biotechnology innovations. This course prepares students for work-based learning experiences, including internships, while offering opportunities to earn dual or articulated college credits.
   E. Students will participate in at least two Career-Connected Education and Work-Based Learning experiences in this course, which might include informational interviews or job shadowing relevant to the program of study.
   F. Students are encouraged to participate in extended learning experiences through aligned Career and Technical Student Organizations (CTSOs). CTSOs are a co-curricular requirement in the Carl D. Perkins Act, and alignment to CTSO activities is an expectation for CTE programs in the state of Maryland.

3. **KNOWLEDGE AND SKILLS**

   A. The student demonstrates the necessary skills for career development, maintenance of employability, and successful completion of course outcomes. The student is expected to:

1. Identify and demonstrate positive work behaviors that enhance employability and job advancement, such as regular attendance, promptness, proper attire, maintenance of a clean and safe work environment, and pride in work.
2. Demonstrate positive personal qualities such as flexibility, open-mindedness, initiative, active listening, and a willingness to learn.
3. Employ effective reading, writing, and technical documentation skills.
4. Solve problems using critical thinking techniques and structured troubleshooting methodologies.
5. Demonstrate leadership skills and collaborate effectively as a team member.
6. Implement safety procedures, including proper use of software and following privacy guidelines.
7. Exhibit an understanding of legal and ethical responsibilities in the biotechnology field, following copyright laws and regulations.
8. Demonstrate time-management skills and the ability to prioritize tasks in a technical setting.

B. The student identifies various career pathways in the biotechnology field. The student is expected to:

1. Develop a career plan that includes the necessary education, certifications, job skills, and experience for specific roles in biotechnology.
2. Create a professional resume and portfolio that reflect skills, projects, certifications, and recommendations.
3. Demonstrate effective interview skills for roles in biotechnology fields.

C. The student develops technology and digital literacy skills. The student is expected to:

1. Use technology as a tool for research, organization, communication, and problem-solving.
2. Use digital tools, including computers, mobile devices, collaboration platforms, and cloud services, to access, manage, and create information.
3. Demonstrate proficiency in using emerging and industry-standard technologies.
4. Understand ethical and legal considerations for technology use, including the principles of data protection, copyright, and responsible technology use.

D. The student integrates core academic skills into biotechnology practices. The student is expected to:

1. Demonstrate the use of clear communication techniques, both written and verbal, that are consistent with industry standards.
2. Apply English concepts such as writing informative texts when documenting the procedures and articulating goals.
3. Use mathematical concepts for measurement and conversion (Fahrenheit vs. Celsius), ratios and proportions as well as fraction and decimal conversions.

E. The student advances technical proficiency and knowledge in biotechnology to support research and development. The student is expected to:

1. Explore advanced concepts in biotechnology, such as bioinformatics, proteomics, and pharmacogenomics, and their applications in healthcare.
2. Analyze case studies of biotechnology innovations addressing social determinants of health and improving community resilience.

3. Examine the role of biotechnology in the development of treatments, medical devices, and diagnostic tools for addressing global health challenges.

F. The student demonstrates advanced laboratory techniques and integrates professional safety practices. The student is expected to:

1. Perform advanced molecular techniques such as next-generation sequencing, protein engineering, and immunoassays.
2. Implement advanced quality control measures and troubleshoot laboratory protocols to ensure experimental accuracy and compliance.
3. Maintain adherence to OSHA 30 safety protocols while demonstrating proficiency in using specialized biotechnology tools and equipment.

G. The student designs and conducts independent research projects to support work-based learning or further study. The student is expected to:

1. Develop a research proposal, including objectives, methodology, and anticipated outcomes, aligned with biotechnology industry practices.
2. Conduct independent experiments using advanced techniques and document findings in a detailed lab notebook.
3. Present research findings in written, verbal, and multimedia formats consistent with academic and industry standards.

H. The student applies core academic skills to biotechnology practices at an advanced level. The student is expected to:

1. Utilize technical writing skills to draft grant proposals, scientific abstracts, and research papers.
2. Apply statistical models and computational tools to analyze large datasets, such as gene expression or bioinformatics data.
3. Use advanced mathematical concepts, including logarithmic scales and exponential functions, to interpret experimental results.

I. The student evaluates the ethical, legal, and societal implications of advanced biotechnology practices. The student is expected to:

1. Analyze ethical considerations in the use of biotechnology for personalized medicine, genetic modification, and biomanufacturing.
2. Discuss the impact of intellectual property laws, regulatory standards, and patenting on biotechnology innovation.
3. Investigate the societal consequences of emerging technologies, such as artificial intelligence in drug development or CRISPR in agriculture.

J. The student prepares for professional experiences and work-based learning in the biotechnology field. The student is expected to:

1. Demonstrate professional communication and collaboration skills through team-based laboratory projects.
2. Complete a mock job interview or resume tailored to biotechnology careers, highlighting relevant certifications and skills.
3. Participate in work-based learning opportunities, internships, or simulated projects to develop real-world biotechnology experience.

K. The student earns dual or articulated credits through advanced coursework in biotechnology. The student is expected to:

1. Complete advanced biotechnology coursework aligned with local post-secondary institutions to earn dual or articulated credits.
2. Collaborate with industry partners and post-secondary programs to explore career pathways in biotechnology research and development.
3. Document skills mastered in the course through an academic portfolio that aligns with higher education or industry expectations.

Course Standards: Career Connected Learning I and II

Career connected learning is an educational approach that integrates classroom instruction with real-world experiences, enabling high school students to explore potential careers and develop relevant skills before graduation. By participating in work-based learning opportunities—such as apprenticeships, internships, capstone projects, and school-based enterprises—students apply academic concepts in authentic settings, gain practical industry knowledge, and build professional networks. This hands-on engagement helps students connect their studies to future career paths, strengthens their problem-solving and communication skills, and supports a smoother transition into college, vocational programs, or the workforce.

All Career and Technical Education Programs of Study include aspects of work-based learning, and almost all of the programs include two Career Connected Learning (CCL) courses. Below are the course descriptions for CCL I and CCL II. The CCL standards can be found via this link: