# Scope & Sequence

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| Course Name: Biotechnology II**TSDS PEIMS Code:** 13036450 | **Course Credit:** 1.0**Course Requirements:** Recommended for students in Grades 11-12. **Prerequisites:** Biotechnology l and Chemistry. |
| **Course Description:** Biotechnology II has the components of any rigorous scientific or bioengineering program of study from the problem identification, investigation design, data collection, data analysis, and formulation and presentation of the conclusions. This course applies the standard skills mastered in Biotechnology I and includes assay design. After taking this course, students should be prepared for entry-level lab technician jobs. Students must meet the 40% laboratory and fieldwork requirement. |
| **NOTE:** This is a suggested scope and sequence for the course content. This content will work with any textbook or instructional materials. If locally adapted, make sure all TEKS are covered. |
| **Total Number of Periods****Total Number of Minutes****Total Number of Hours** | 175 Periods7875 Minutes131.25 Hours | \*Schedule calculations based on 175/180 calendar days. For 0.5 credit courses, schedule is calculated out of 88/90 days. Scope and sequence allows additional time for guest speakers, student presentations, field trips, remediation, extended learning activities, etc. |
| **Unit Number, Title, and Brief Description** | **# of Class Periods\***(assumes 45-minute periods)Total minutes per unit | **TEKS Covered****130.416. Knowledge and skills** |
| **Unit 1: Using Scientific Methods in Biotechnology** Career and technical education 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. In this unit, the student will plan and implement investigative procedures, including asking questions, formulating testable hypotheses, and selecting, handling, and maintaining appropriate equipment and technology. The culminating activity for this unit will have students analyze, evaluate, make inferences, and predict trends from data, as well as communicate valid conclusions supported by the data through various methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports. | 13 Periods585 Minutes | (3) The student uses scientific methods and equipment during laboratory and field investigations. The student is expected to:(A) know the definition of science and understand that it has limitations, as specified in subsection (b)(4) of this section;(B) know that scientific hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence. Hypotheses of durable explanatory power which have been tested over a wide variety of conditions are incorporated into theories;(C) know that scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well-established and highly-reliable explanations, but may be subject to change as new areas of science and new technologies are developed;(D) distinguish between scientific hypotheses and scientific theories;(E) plan and implement investigative procedures, including making observations, asking well-defined questions, formulating testable hypotheses, identifying variables, selecting appropriate equipment and technology, and evaluating numerical answers for reasonableness;(F) collect and organize qualitative and quantitative data and make measurements with accuracy and precision using tools such as calculators, spreadsheet software, data-collecting probes, computers, standard laboratory glassware, microscopes, various prepared slides, stereoscopes, metric rulers, electronic balances, gel electrophoresis apparatuses, micropipettors, hand lenses, Celsius thermometers, hot plates, lab notebooks or journals, timing devices, cameras, and meter sticks;(G) analyze, evaluate, make inferences, and predict trends from data;(H) identify and quantify causes and effects of uncertainties in measured data;(I) organize and evaluate data and make inferences from data, including the use of tables, charts, and graphs; and(J) communicate valid conclusions supported by the data through various methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports. |
| **Unit 2: Safety Precautions and Regulations in Biotechnology**In this unit, students will comply with federal and state safety regulations as specified by Occupational Safety and Health Administration (OSHA) and other regulatory agencies. Students will identify and obey safety symbols and signs in the biotechnology industry. The culminating activity will have students demonstrate appropriate safety procedures, and guidelines, including chemical hygiene and personal protection. | 6 Periods270 Minutes | (2) The student, for at least 40% of instructional time, conducts laboratory and field investigations using safe, environmentally appropriate, and ethical practices. These investigations must involve actively obtaining and analyzing data with physical equipment, but may also involve experimentation in a simulated environment as well as field observations that extend beyond the classroom. The student is expected to:(A) demonstrate safe practices during laboratory and field investigations; and(B) demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials. |
| **Unit 3: Scientific Reasoning in Biotechnology** Scientific inquiry is the planned and deliberate investigation of the natural world. Scientific methods of investigation can be experimental, descriptive, or comparative. The method chosen should be appropriate to the question being asked. In this unit, students will evaluate models according to their limitations in representing biological objects or events; research and describe the connections between science and future careers. The culminating activity will have students express and interpret relationships symbolically to make predictions and solve problems mathematically, including problems requiring proportional reasoning and graphical vector addition. | 13 Periods585 Minutes | (4) The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:(A) in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking;(B) communicate and apply scientific information extracted from various sources such as current events, news reports, published journal articles, and marketing materials;(C) draw inferences based on data related to promotional materials for products and services;(D) explain the impacts of the scientific contributions of a variety of historical and contemporary scientists on scientific thought and society;(E) evaluate models according to their limitations in representing biological objects or events;(F) research and describe the connections between science and future careers; and(G) express and interpret relationships symbolically to make predictions and solve problems mathematically, including problems requiring proportional reasoning and graphical vector addition. |
| **Unit 4: Formulating Hypotheses**Scientific inquiry is the planned and deliberate investigation of the natural world. Scientific methods of investigation are experimental, descriptive, or comparative. The method chosen should be appropriate to the question being asked. In this unit, students will research and examine hypotheses. | 13 Periods 585 Minutes  | (5) The student formulates hypotheses to guide investigation and data collection. The student is expected to:(A) perform background research with respect to an investigative problem; and(B) examine hypotheses generated to guide a research process by evaluating the merits and feasibility of the hypotheses. |
| **Unit 5: Developing Investigative Designs**Scientific decision-making is a way of answering questions about the natural world. Students should be able to distinguish between scientific decision-making methods (scientific methods) and ethical and social decisions that involve science (the application of scientific information). In this unit, students will interact and collaborate with scientific researchers or other members of the scientific community to complete a research project. The culminating activity will have students design procedures to test hypotheses. | 13 Periods 585 Minutes  | (7) The student develops and implements appropriate investigative designs. The student is expected to:(A) interact and collaborate with scientific researchers or other members of the scientific community to complete a research project;(B) identify and manipulate relevant variables within research situations;(C) use a control in an experimental process; and(D) design procedures to test hypotheses. |
| **Unit 6: Collecting and Evaluating Qualitative and Quantitative Data**The Science, Technology, Engineering, and Mathematics (STEM) Career Cluster focuses on planning, managing, and providing scientific research and professional and technical services, including laboratory and testing services, and research and development services. In this unit, students will differentiate between various forms of data. The culminating activity will have students evaluate data using statistical methods to recognize patterns, trends, and proportional relationships. | 13 Periods 585 Minutes  | (8) The student collects, organizes, and evaluates qualitative and quantitative data obtained through experimentation. The student is expected to:(A) differentiate between qualitative and quantitative data;(B) acquire, manipulate, and analyze data using appropriate equipment and technology, following the rules of significant digits;(C) identify sources of random error and systematic error and differentiate between both types of error;(D) report error of a set of measured data in various formats, including standard deviation and percent error;(E) construct data tables to organize information collected in an experiment;(F) record observations as they occur within an investigation; and(G) evaluate data using statistical methods to recognize patterns, trends, and proportional relationships. |
| **Unit 7 Synthesizing Valid Conclusions from Data**Science, as defined by the National Academy of Sciences, is the "use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process." Physical, mathematical, and conceptual models describe this vast body of changing and increasing knowledge. Students should know that some questions are outside the realm of science because they deal with phenomena that are not scientifically testable. In this unit, students will synthesize and justify conclusions supported by research data. The culminating activity will have students identify limitations within the research process and provide recommendations for additional research. | 13 Periods585 Minutes | (9) The student knows how to synthesize valid conclusions from qualitative and quantitative data. The student is expected to:(A) synthesize and justify conclusions supported by research data;(B) consider and communicate alternative explanations for observations and results; and(C) identify limitations within the research process and provide recommendations for additional research. |
| **Unit 8: Communication Skills in the STEM Field** Students willnowapply technical skills and knowledge of Science, Technology, Engineering, and Mathematics to analyze, evaluate, and communicate problems and solutions in this unit. Students will exhibit professional communication skills to relay this information to others both verbally and written. The culminating activity will have students suggest alternative explanations from observations or trends evident within the data or from prompts provided by a review panel. | 13 Periods585 Minutes | (10) The student communicates conclusions clearly and concisely to an audience of professionals. The student is expected to:(A) communicate experimental results clearly and effectively, including oral presentation of original findings of a research project to an audience of peers and professionals; and(B) suggest alternative explanations from observations or trends evident within the data or from prompts provided by a review panel. |
| **Unit 9: Assay Design Exploration**A system is a collection of cycles, structures, and processes that interact. All systems have basic properties that can be described in space, time, energy, and matter. Change and constancy occur in systems as patterns and can be observed, measured, and modeled. These patterns help to make predictions that can be scientifically tested. Students should analyze a system in terms of its components and how these components relate to each other, to the whole, and to the external environment. In this unit, students will define assay requirements and optimizations. The culminating activity will have students use a colorimetric assay to evaluate enzyme kinetics. | 13 Periods585 Minutes | (11) The student explores assay design in the field of biotechnology. The student is expected to:(A) define assay requirements and optimizations;(B) perform statistical analysis on assay design and experimental data such as linearity, system sustainability, limit of detection, and R2 values;(C) determine an unknown protein concentration using techniques such as a standard curve and a spectrophotometer; and(D) use a colorimetric assay to evaluate enzyme kinetics. |
| **Unit 10: Protein Expression Systems in Biotechnology Exploration** In this unit, students will perform a recombinant protein production such as green fluorescent protein (GFP) and isolate a protein from a biological sample using hydrophobic interaction column chromatography. The culminating activity will have students analyze protein purification methods. | 13 Periods585 Minutes | (12) The student explores protein expression systems in the field of biotechnology. The student is expected to:(A) perform a recombinant protein production such as green fluorescent protein (GFP);(B) isolate a protein from a biological sample using hydrophobic interaction column chromatography; and(C) analyze protein purification methods using spectrophotometry, sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) and Western blotting. |
| **Unit 11: Quality-Control Analysis**In this unity, students will analyze data and perform calculations and statistical analysis on results of quality-control samples. The culminating activity will have students apply and create industry protocols such as standard operating procedures (SOPs) and validation forms.  | 13 Periods585 Minutes | (13) The student conducts quality-control analysis while performing biotechnology laboratory procedures. The student is expected to:(A) perform validation testing on laboratory reagents and equipment;(B) analyze data and perform calculations and statistical analysis on results of quality-control samples such as trending of data; and(C) apply and create industry protocols such as standard operating procedures (SOPs) and validation forms. |
| **Unit 12: Solutions and Reagents Preparation for the Biotechnology Laboratory**In this unit, students will demonstrate techniques for establishing and maintaining a sterile work area. The culminating activity will have students prepare multi-component solutions of given molarity or concentration and volume. | 13 Periods585 Minutes | (14) The student prepares solutions and reagents for the biotechnology laboratory. The student is expected to:(A) demonstrate techniques for establishing and maintaining a sterile work area;(B) prepare, dispense, and monitor physical properties of stock reagents, buffers, media, and solutions;(C) calculate and prepare a dilution series;(D) determine acceptability and optimum conditions of reagents for experimentation; and(E) prepare multi-component solutions of given molarity or concentration and volume. |
| **Unit 13: Employability Skills**This unit offers students basic technical skills necessary to fulfill careers in the workforce. Through group activities, students will demonstrate interpersonal skills, such as: communication, professionalism, time-management and dependability. The unit culminates with a peer review evaluation and reflection upon skills needed for success in the workforce. | 13 Periods585 Minutes | (1) The student demonstrates professional standards/employability skills as required by business and industry. The student is expected to:(A) demonstrate knowledge of how to dress appropriately, speak politely, and conduct oneself in a manner appropriate for the profession;(B) show the ability to cooperate, contribute, and collaborate as a member of a group in an effort to achieve a positive collective outcome;(C) present written and oral communication in a clear, concise, and effective manner;(D) demonstrate time-management skills in prioritizing tasks, following schedules, and performing goal-relevant activities in a way that produces efficient results; and(E) demonstrate punctuality, dependability, reliability, and responsibility in performing assigned tasks as directed. |
| **Unit 14: Extended Learning Experience**In this unit, students are encouraged to expand their learning experiences through avenues such as STEM organizations and other leadership or extracurricular organizations. By connecting with these networks, students will be able to identify the scientific methodology used by a researcher and examine a prescribed research design. The culminating activity will have students reflect on careers in this field evaluate and determine if the data and conclusion support the hypothesis. | 13 Periods585 Minutes | (6) The student analyzes published research. The student is expected to:(A) identify the scientific methodology used by a researcher;(B) examine a prescribed research design and identify dependent and independent variables;(C) evaluate a prescribed research design to determine the purpose for each of the procedures performed; and(D) determine if the data and conclusion support the hypothesis. |