Texas CTE: Health Science

Biotechnology I

Implementation. A

1 The provisions of this section shall be implemented by school districts beginning with the 2023- 2024 school year. A.1

2 School districts shall implement the employability skills student expectations listed in §127.15(d)(1) of this chapter (relating to Career and Technical Education Employability Skills) as an integral part of this course. A.2

General requirements. This course is recommended for students in Grades 11 and 12. Prerequisite: one credit in biology. Recommended prerequisites: Principles of Bioscience and one credit in chemistry. This course satisfies a high school science graduation requirement. Students shall be awarded one credit for successful completion of this course. B

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Introduction. C

1 Career and technical education instruction provides content aligned with challenging academic standards, industry-relevant technical knowledge, and college and career readiness skills for students to further their education and succeed in current and emerging professions. C.1

2 The Health Science Career Cluster focuses on planning, managing, and providing therapeutic services, diagnostics services, health informatics, support services, and biotechnology research and development. C.2

3 In Biotechnology I, students will apply advanced academic knowledge and skills to the emerging fields of biotechnology such as agricultural, medical, regulatory, and forensics. Students will have the opportunity to use sophisticated laboratory equipment, perform statistical analysis, and practice quality-control techniques. Students will conduct laboratory and field investigations and make informed decisions using critical thinking, scientific problem solving, and the engineering

Skip to main content

design process. Students in Biotechnology I will study a variety of topics that include structures and functions of cells, nucleic acids, proteins, and genetics. C.3

4 **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." This vast body of changing and increasing knowledge is described by physical, mathematical, and conceptual models. Students should know that some questions are outside the realm of science because they deal with phenomena that are not currently scientifically testable.** C.4

5 **Students are expected to know that:** C.5

A hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence. Hypotheses of durable explanatory power that have been tested over a wide variety of conditions are incorporated into theories; and C.5.A

B 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 they may be subject to change as new areas of science and new technologies are developed. C.5.B

6 **Scientific inquiry is the planned and deliberate investigation of the natural world using scientific and engineering practices. Scientific methods of investigation are descriptive, comparative, or experimental. The method chosen should be appropriate to the question being asked. Student learning for different types of investigations include descriptive investigations, which involve collecting data and recording observations without making comparisons; comparative investigations, which involve collecting data with variables that are manipulated to compare results; and experimental investigations, which involve processes similar to comparative investigations but in which a control is identified.** C.6

A Scientific practices. Students should be able to ask questions, plan and conduct investigations to answer questions, and explain phenomena using appropriate tools and models. C.6.A

B Engineering practices. Students should be able to identify problems and design solutions using appropriate tools and models C.6.B

7 **Scientific decision making is a way of answering questions about the natural world involving its own set of ethical standards about how the process of science should be carried out. 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).** C.7

8 **Science consists of recurring themes and making connections between overarching concepts. Recurring themes include systems, models, and patterns. 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**

Skip to main content

scientifically tested, while models allow for boundary specification and provide a tool for understanding the ideas presented. 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. C.8

9 **Students are encouraged to participate in extended learning experiences such as career and technical student organizations and other organizations that foster leadership and career development in the profession such as student chapters of related professional associations.** C.9

10 **Statements that contain the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.** C.10

Knowledge and skills. D

1 **The student, for at least 40% of instructional time, asks questions, identifies problems, and plans and safely conducts classroom, laboratory, and field investigations to answer questions, explain phenomena, or design solutions using appropriate tools and models. The student is expected to:** D.1

- A ask questions and define problems based on observations or information from text, phenomena, models, or investigations; D.1.A
- B apply scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems; D.1.B
- C use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards; D.1.C
- D use appropriate tools such as microscopes, thermocyclers, pH meters, hot plate stirrers, glass bulb thermometers, timing devices, electronic balances, vortex mixers, autoclaves, micropipettes, centrifuges, gel and capillary electrophoresis units, cameras, data collection probes, spectrophotometers, transilluminators, incubators, water baths, laboratory glassware, biosafety cabinets, and chemical fume hoods; D.1.D
- E collect quantitative data using the International System of Units (SI) and United States customary units and qualitative data as evidence; D.1.E
- F organize quantitative and qualitative data using laboratory notebooks, written lab reports, graphs, charts, tables, digital tools, diagrams, scientific drawings, and student-prepared models; D.1.F
- G develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and D.1.G
- H distinguish between scientific hypotheses, theories, and laws. D.1.H

2 **The student analyzes and interprets data to derive meaning, identify features and patterns, and discover relationships or correlations to develop evidence-based arguments or evaluate designs. The student is expected to:** D.2

Skip to main content

A identify advantages and limitations of models such as their size, scale, properties, and materials; D.2.A

B analyze data by identifying significant statistical features, patterns, sources of error, and limitations; D.2.B

C use mathematical calculations to assess quantitative relationships in data; and D.2.C

D evaluate experimental and engineering designs. D.2.D

3 The student develops evidence-based explanations and communicates findings, conclusions, and proposed solutions. The student is expected to: D.3

A develop explanations and propose solutions supported by data and models and consistent with scientific ideas, principles, and theories; D.3.A

B communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and D.3.B

C engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence. D.3.C

4 The student knows the contributions of scientists and recognizes the importance of scientific research and innovation on society. The student is expected to: D.4

A analyze, evaluate, and critique scientific explanations and solutions by using empirical evidence, logical reasoning, and experimental and observational testing so as to encourage critical thinking by the student; D.4.A

B relate the impact of past and current research on scientific thought and society, including research methodology, cost-benefit analysis, and contributions of diverse scientists and engineers as related to the content; and D.4.B

C research and explore resources such as museums, libraries, professional organizations, private companies, online platforms, and mentors employed in a STEM field. D.4.C

5 The student explores the emerging field of biotechnology. The student is expected to: D.5

A define biotechnology and provide examples of biotechnology products such as recombinant proteins, fermented foods, biopharmaceuticals, and genetically modified foods; D.5.A

B compare applications of bioinformatics such as deoxyribonucleic acid (DNA) barcoding, sequencing, National Center for Biotechnology Information (NCBI) tools, ClinVar, Genemonon Mastermind, genetic testing, phylogenetic relationships, and the use of online databases; D.5.B

C research and identify career opportunities in genetics, bioinformatics, and in fields such as molecular, forensic, medical, regulatory, and agricultural biotechnology; D.5.C

D identify significant contributions of diverse scientists to biotechnology and explain their impact on society; D.5.D

Skip to main content

E define bioethics and evaluate the applications of bioethics; D.5.E

F evaluate different points of view about issues and current events in biotechnology; D.5.F

G identify applications in agricultural biotechnology such as genetically modified organisms (GMOs), plant propagation from tissue culturing, and aquaculture hydroponics; D.5.G

H identify applications in medical biotechnology such as vaccines production, stem cells therapy, gene therapy, pharmaceutical production, pharmacogenetics, genomics, synthetic biology, and personalized medicine; D.5.H

I identify applications in forensic biotechnology such as capillary electrophoresis, real- time polymerase chain reaction, DNA fingerprinting, restriction fragment length polymorphisms (RFLP) analysis, toxicology, and serology; and D.5.I

J identify solutions to waste through bioremediation and non-biotechnological standard solutions such as landfills, incineration, absorbent materials, and catalytic materials. D.5.J

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6 The student summarizes biotechnology laboratory procedures and their applications in the biotechnology industry. The student is expected to: D.6

A identify the major sectors of the biotechnology industry such as medical and pharmaceutical, agricultural, industrial, forensic, and research and development; D.6.A

B identify the biotechnology laboratory procedures used in each sector such as selective breeding, genetic engineering, DNA analysis, and protein analysis; and D.6.B

C compare and contrast the different applications used in biotechnology laboratory procedures of each sector. D.6.C

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7 The student understands the role of genetics in the biotechnology industry. The student is expected to: D.7

A explain terms related to molecular biology, including nucleic acids, nitrogen bases, nucleotides, mRNA, rRNA, tRNA, ribosomes, amino acids, transcription, translation, polymerase, and protein synthesis; D.7.A

B compare and contrast the structures and functions of DNA and ribonucleic acid (RNA), including nitrogen bases, nucleotides, the helical nature of DNA, and hydrogen bonding between purines and pyrimidines; D.7.B

C distinguish between nuclear and mitochondrial DNA and their gamete sources; D.7.C

D describe the DNA replication process in eukaryotic and prokaryotic cells, including leading and lagging strands and Okazaki fragments; D.7.D

E illustrate the process of protein synthesis, including ribosomal subunits and the role of tRNA; D.7.E

Skip to main content

F describe the structures and functions of proteins, including three-dimensional folding, enzymes, and antibodies; D.7.F

G explain the molecular structures of genes, including enhancers, promoters, exons, introns, and coding regions; D.7.G

H describe the different types of mutations, including inversions, deletions, duplications, and substitutions; D.7.H

I explain the effects of mutation types on phenotype and gene function; and D.7.I

J describe unique elements of the molecular structure of a chromosome such as short tandem repeats (STR), transposons, and methylation and acetylation of DNA. D.7.J

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8 The student analyzes the importance of recombinant DNA technology and genetic engineering. The student is expected to: D.8

A describe the fundamental steps in recombinant DNA technology; D.8.A

B explain how recombinant DNA technology such as nuclear transfer cloning is used to clone genes and create recombinant proteins; D.8.B

C explain the role of tissue cultures in genetic modification procedures; D.8.C

D describe plant- and animal-tissue culture procedures; D.8.D

E compare and contrast growing conditions for plant and animal tissue cultures; D.8.E

F explain the role of restriction enzymes; and D.8.F

G distinguish between vectors commonly used in biotechnology for DNA insertion, including plasmids, adenoviruses, retroviruses, and bacteriophages. D.8.G

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9 The student examines federal, state, local, and industry regulations as related to biotechnology. The student is expected to: D.9

A discuss the relationship between the local, state, and federal agencies responsible for regulation of the biotechnology industry such as the U.S. Department of Agriculture D.9.A

B (USDA), the Environmental Protection Agency (EPA), the U.S. Food and Drug Administration (FDA), and the Centers for Disease Control and Prevention (CDC); and D.9.B

C analyze policies and procedures used in the biotechnology industry such as quality assurance, standard operating procedures (SOPs), Good Manufacturing Practices (GMPs), and International Organization for Standardization (ISO) quality systems. D.9.C

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10 The student performs biotechnology laboratory procedures. The student is expected to: D.10

A measure volumes and weights to industry standards with accuracy and precision; D.10.A

B analyze data and perform calculations and statistical analysis as it relates to biotechnology laboratory experiments; D.10.B

C demonstrate proficiency in pipetting techniques; D.10.C

Skip to main content

D identify microorganisms using staining methods such as the Gram stain, methylene-blue stain, and acid-fast staining; D.10.D

E prepare a restriction digest, isolate nucleic acids, and evaluate results using techniques such as gel and capillary electrophoresis, Northern blot analysis, and Southern blot analysis; D.10.E

F explain the importance of media components to the outcome of cultures; D.10.F

G isolate, maintain, and store microbial cultures safely; D.10.G

H prepare seed inoculum; and D.10.H

I perform plating techniques such as streak plating, spread plating, and the Kirby-Bauer method. D.10.I

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11 The student prepares solutions and reagents for the biotechnology laboratory. The student is expected to: D.11

A demonstrate aseptic techniques for establishing and maintaining a sterile work area; D.11.A

B prepare, dispense, and monitor physical properties of stock reagents, buffers, media, and solutions; D.11.B

C calculate and prepare a dilution series; and D.11.C

D determine optimum conditions of reagents for experimentation. D.11.D

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12 The student conducts quality-control analysis while performing biotechnology laboratory procedures. The student is expected to: D.12

A perform validation testing on laboratory reagents and equipment; and D.12.A

B analyze data and perform calculations and statistical analysis on results of quality-control samples. D.12.B