

Biomedical Applications

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| Primary Career Cluster: | Health Science |
| Consultant: | Sloan Hudson, (615) 532-2839, sloan.hudson@tn.gov |
| Course Code(s): | 5992 |
| Prerequisite(s): | <i>Diagnostic Medicine</i> (5994) |
| Credit: | 1 |
| Grade Level: | 11-12 |
| Graduation Requirements: | This course satisfies one of three credits required for an elective focus when taken in conjunction with other Health Science courses. Satisfies one laboratory science credit in the area of life sciences. |
| Programs of Study and Sequence: | This is a fourth course option in the <i>Biotechnology Research</i> program of study. |
| Aligned Student Organization(s): | HOSA: http://www.tennesseehosa.org Pamela Grega, (615) 532-6270, Pamela.Grega@tn.gov |
| Coordinating Work-Based Learning: | Teachers are encouraged to use embedded WBL activities such as informational interviewing, job shadowing, and career mentoring. For information, visit https://tn.gov/education/topic/work-based-learning . |
| Available Student Industry Certifications: | None |
| Dual Credit or Dual Enrollment Opportunities: | There are no dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement. |
| Teacher Endorsement(s): | 577, 720 |
| Required Teacher Certifications/Training: | None |
| Teacher Resources: | https://tn.gov/education/article/cte-cluster-health-science |

Course Description

Biomedical Applications is a capstone course designed to prepare students to pursue careers in the fields of biotechnology research. This course combines advanced methods and technologies with the scientific principles that comprise today's emerging biomedical fields. Upon completion of this course, proficient students will be able to identify careers in these fields, describe their scientific foundations, research technologies and development in all areas of healthcare, and relate how these technologies are transforming many disciplines and impacting society at large. In addition, students will conduct an ongoing original research project or experiment on an emerging biotechnology application of their choice.

Program of Study Application

This is a capstone course option in the *Biotechnology Research* program of study. For more information on the benefits and requirements of implementing this program in full, please visit the Health Science website at <http://www.tn.gov/education/cte/HealthScience.shtml>.

Course Standards

Scientific Foundations

- 1) Differentiate between the terms biotechnology and biomedicine, noting the impact that each has had on society. Explore the history and development of these scientific fields, as well as the roles that their associated industries have played in the areas of agriculture, manufacturing, health and medicine, the environment, global society and the economy, and forensics.
- 2) Review the structural organization of all living things at the cellular level. Summarize in an oral, written, or digital presentation how cellular organization influences scientific approaches to biotechnology and biomedicine, with specific attention given to the various levels of eukaryotic organisms, cellular molecules, proteins, and nucleic acids.
- 3) Synthesize information from professional journals and/or websites, textbooks, and news articles to compare and contrast the structure and properties of the four macromolecules (carbohydrates, lipids, proteins, and nucleic acids). Describe in an informational artifact how the cell membrane structures may be manipulated to allow the passage of these macromolecules in a cell; relate how this knowledge is used by scientists and applied to biotechnology research.
- 4) Distinguish between a number of strategies used to isolate or clone a gene, such as activation tagging, map-based gene cloning, plasmid cloning vectors, viral vectors, and shuttle vectors. Present an overview of these strategies in a visual format.
- 5) In an argumentative essay, state claims and counterclaims about how DNA structure and function may be exploited using modern genetic engineering methods to produce specific genetic constructs, such as selecting, excising, ligating, and cloning of genetic material. Ensure the documentation is written in domain-specific medical terminology.
- 6) Define the terms DNA replication, DNA transcription, and translation of mRNA. Recount the processes involved in each and describe the negative outcomes if there is an interference in the process. Using domain-specific terminology, develop a scientific explanation to support the claim that the structures and mechanisms of DNA and RNA are the primary sources of heritable information.
- 7) Construct a visual model, annotated with written explanations, detailing how DNA in chromosomes is transmitted to the next generation via mitosis or meiosis. Note qualitative and quantitative traits, mutations, transposable genetic elements, and regulation of gene expressions.

- 8) Research and explain Mendel's model of inheritance. Using this model, trace the pattern of appearance within a family for a heritable disease that is on the recessive allele and one that is on the dominant allele. Develop an argumentative essay regarding how a certain biotechnology could genetically modify a gene to prevent this disorder, citing information from textbooks and/or professional journals and websites.

Technologies and Development

- 9) Investigate and develop a digital, oral, or written presentation on the current and emerging applications of biotechnology and biomedicine, such as bionic prosthesis, nanotechnology, and stem cell research. Cite textual evidence from science or professional journals, websites, and textbooks to explain how the new technologies have contributed to the advancement of diagnostics, therapeutics, genetic mapping, and disease predictions and determinants.
- 10) In an argumentative essay, provide justification for the following statement: "Humans can manipulate heritable information by at least two commonly used technologies in biomedicine" (AP Biology Essential Knowledge, learning objective 3.5). Cite information from professional peer-reviewed articles, textbooks, and/or other scientific journals to support claims.
- 11) Investigate the ethical, social, and medical issues surrounding the research of biotechnology and biomedicine. Debate the claims and counterclaims of the issue in a written or oral format, including aspects such as protecting human subjects from harm or death, affordability of research, privacy of subjects, and the promotion of lifesaving research.
- 12) Review the use of volume measuring devices commonly used by biotechnologists, such as pipettes, micropipettes, and glassware. Prepare solutions and appropriate media, then perform serial dilutions incorporating aseptic techniques.
- 13) Explain in depth the terms and phrases often heard in a biotechnology or biomedical laboratory: quality assurance, quality control, method validation, appropriate documentation, current good manufacturing practices, and good laboratory practices. Relate how these terms and practices are important in the safe development of biomedical/biotechnology products and services.

Safety

- 14) Review guidelines from governmental agencies such as the Office of Safety and Health Administration (OSHA) guidelines for medical and research laboratories, OSHA guidelines for Standard Precautions and personal protective equipment, Safety Data Sheets (MSDS) and storage of reagents and compounds, and Environmental Protection Agency (EPA) laboratory guidelines. Compare and contrast the rules and regulations of each agency to develop clear expectations regarding the maintenance of safety in these laboratories.
- 15) Develop a safety manual for a biological or chemical laboratory, specifically for a lab that is involved with processing or developing biomedical products. Include the following in the manual: safety guidelines, procedures for accident prevention and response, and steps for reporting and documenting hazards. Explain the industry standards to maintain aseptic and

sterile procedures and luminary flow, as well as the purpose of biosafety cabinets. Draw on the standard operating procedures from agencies such as OSHA, EPA, and Centers for Disease Control and Prevention (CDC) when developing the manual.

Methods and Applications

- 16) Differentiate between the terms electrophoresis, blotting, and polymerase chain reaction. Explain how each is used in DNA cloning or sequence identification, and describe the procedures involved with each. Relate how these terms and procedures apply to biotechnology. Compare and contrast the advantages and disadvantages of one method over the other.
- 17) Summarize the historical background and chief purpose of the Human Genome Project. Discuss in the summary the sequence technology utilized and the method for assembly of the draft genome. Then, chart the status of the model organisms such as Arabidopsis, yeast, mouse, fruit fly, rat, nematode, Escherichia coli, and higher plant models. Report the impact that the Human Genome Project has had on medicine to date, and explain what the future holds for the project.

Perceptions and Future

- 18) Summarize research from professional journals or websites, textbooks, and/or newspaper articles surrounding an ethical issue related to biotechnology (i.e., the use of animals for lab testing, genetically modified organisms, or stem cell use). Debate the chosen topics, presenting both sides of the issue. Discuss the moral, ethical, and legal responsibilities of researchers, policymakers, and other actors as they pertain to informing the public and ensuring the safety and well-being of affected populations.
- 19) Develop an original idea for a new biotechnology product, and simulate a situation in which the product must be pitched to a prospective client. Create an informational packet to share during the presentation that includes the following items: definition and protection of intellectual property, type of patent, copyright issues and rules, trademarks, and breeders' rights for plants or animals.
- 20) Develop an argumentative essay surrounding public perceptions and attitudes toward the use of biotechnology in society. Develop claims and counterclaims thoroughly based on facts from research, pointing out the strengths and weaknesses of each claim. Document information using appropriate industry terminology, including areas such as federal and international regulation and oversight, safety assessment, labeling of products, and impact on the economy.
- 21) Understand principles of, and successfully perform skills related to, the biomedical laboratory. Document findings from skills utilizing appropriate medical terminology. Incorporate rubrics from textbooks, National HOSA guidelines, or clinical standards of practice for the following:
 - a. Correct use of an ultraviolet/visible spectrophotometer

- b. Application of principles of electrophoresis and demonstration of skills to separate and identify DNA fragments based on size
- c. Thin-layer Chromatography (TLC)
- d. Isolation of DNA, establishing quantity, quality, and purity
- e. Demonstration of PCR procedures
- f. Conducting a qualitative enzyme-linked immunosorbent assay (ELISA)
- g. Bacterial transformation

Capstone Project

22) Using the scientific method, design a scientific research project or experiment to investigate biotechnology applications in healthcare, industry, environment, agriculture, forensics, or related fields. Summarize the findings in an original research paper or lab report, citing evidence to support conclusions from professional journals and websites, textbooks, and original observations. In addition to the research paper, develop a PowerPoint, tabletop, or poster presentation to deliver before a classroom or community audience. Incorporate the following steps when carrying out the project or experiment (possible topics are listed at the end of this document):

- a. Research to determine the task or topic
- b. Exploration of the task or topic
 - i. Literature review
 - ii. Collection and evaluation of sources
- c. Thesis/hypothesis proposal and annotated bibliography
- d. Revision and final draft of thesis/hypothesis
- e. Outline/plan of action for paper or experiment
- f. Data collection/development of research ideas and narratives
- g. Submission of first draft of paper/lab report
- h. Feedback, revision, and submission of final draft
- i. Reflection and evaluation

Standards Alignment Notes

**References to other standards include:

- P21: Partnership for 21st Century Skills [Framework for 21st Century Learning](#)
 - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.

Additional Notes

Possible topics for the capstone project include:

- 1) Biotechnology in healthcare
 - a. Diagnostic applications
 - b. Therapeutics and pharmaceuticals (gene therapy)
 - c. Bioinformatics to predict disease and determine treatment
 - d. Genetic mapping
 - e. Genetic counseling

- f. STEM cell research and use
- 2) Industrial applications
 - a. Bioprocess
 - b. Microbial growth
 - c. Bioreactors
 - d. Water treatment
 - e. Animal pharming (i.e., the use of plants and animals to make pharmaceuticals)
- 3) Environmental applications
 - a. Bioremediation
 - b. Waste management
 - c. Phytoremediation
 - d. Biocontrol
- 4) Agriculture
 - a. Plants
 - b. GMOs
 - c. Insect resistance
 - d. Viral resistance
 - e. Herbicide resistance
 - f. Nutritional quality
- 5) Animal food biotechnology
 - a. Growth hormones
 - b. Cloning of animals
 - c. Aquaculture
 - d. Microbiology in foods
- 6) Bioterrorism/biotechnology disaster
 - a. Agent payload
 - b. Dispersal mechanisms
 - c. Biological/chemical weapons
 - d. Artificial viruses
- 7) Forensic science
 - a. DNA
 - b. Mechanisms to prevent crime
 - c. Image enhancement technologies
 - d. Data mining