

# BIOTECHNOLOGY

**Levels:** 11-12  
**Units of Credit:** 1.0  
**CIP Code:** 51.1201  
**Prerequisite:** Biology or Chemistry  
**Skill Certificates:** #708

## COURSE DESCRIPTION

Biotechnology is an exploratory course designed to create an awareness of career possibilities in the field of biotechnology. Students are introduced to diagnostic and therapeutic laboratory procedures that support bioscience research and practice.

## CORE STANDARDS, OBJECTIVES AND INDICATORS

### STANDARD 1

**Students will investigate the past, present and future applications of Biotechnology as well as relevant careers.**

**OBJECTIVE 1:** Describe historical applications of Biotechnology.

- a. Create a timeline of historical biotechnology developments.
- b. Replicate a historical application of biotechnology. (e.g., yogurt, cheese, sauerkraut, bread.)

**OBJECTIVE 2:** Describe applications of present technology and theorize future implications.

- a. Evaluate the ethical, legal and social implications in biotechnology.
- b. Describe the technologies that have been developed to identify, diagnose and treat genetic diseases. (i.e., gene therapy, genetic testing, genetic counseling, Human Genome Project.)
- c. Research and present biotechnology concepts using effective communication skills.

**OBJECTIVE 3:** Explore the various science and non-science fields and careers associated with biotechnology.

- a. Use the Internet, field trips, job fairs, interviews and speakers to explore biotechnology.
- b. Outline career paths for various occupations in the biotechnology field.

### STANDARD 2

**Students will demonstrate appropriate safety procedures and equipment use in the laboratory.**

**OBJECTIVE 1:** Demonstrate appropriate use of personal protective devices.

- a. Describe how personal protective devices protect the experiment and the lab worker.
- b. Wear personal protective devices when appropriate. (e.g., lab coats, gloves, eye protection.)
- c. Demonstrate safe removal of gloves.

**OBJECTIVE 2:** Maintain a sanitary laboratory environment.

- a. Explain the appropriate sterilization methods. (e.g., steam, chemical – ethanol and bleach.)
- b. Demonstrate proper aseptic/sterilizing procedures.

**OBJECTIVE 3:** Exhibit appropriate behavior to protect coworkers and self.

- a. Explain the dangers of contamination via food, drink, cosmetics, lotion, eye drops and contact lenses.
- b. Follow proper disposal and clean-up procedures with respect to chemicals and laboratory equipment as indicated by SOPs and MSDS. (e.g., broken glass, sharps, spills.)
- c. Show locations of emergency exits and equipment. (e.g., fire extinguishers, blankets, eye washes, showers.)

**OBJECTIVE 4:** Use biotechnology laboratory equipment correctly and safely.

- a. Identify equipment and describe when to use it.
- b. Demonstrate the proper use of biotechnology equipment (micropipette, centrifuge, spectrophotometer, pH meter, electrophoresis apparatus – protein & DNA, thermocycler, microscope, autoclave, balance, water baths.)
- c. Demonstrate proper use and handling of micropipettes.

### **STANDARD 3**

**Students will follow laboratory procedures properly.**

**OBJECTIVE 1:** Follow laboratory protocols.

- a. Understand the purpose of individual steps within a protocol.
- b. Perform the steps of laboratory protocols accurately and in sequence.

**OBJECTIVE 2:** Comply with policies and requirements for documentation and record keeping.

- a. Follow standard operating procedures.
- b. Maintain accurate records and documentation according to minimum good documentation practices (GDP).

**OBJECTIVE 3:** Demonstrate proper handling of chemicals.

- a. Communicate the rationale for various laboratory-labeling procedures.
- b. Recognize and comply with the labeling of chemicals used in a laboratory setting for safe handling and storage. (flammability, corrosiveness, toxicity, etc.)
- c. Reference and interpret the guidelines in Material Safety Data Sheets (MSDS).

### **STANDARD 4**

**Students will describe the properties of atoms and molecules and prepare lab reagents.**

**OBJECTIVE 1:** Explain chemical concepts relevant to biotechnology.

- a. Atomic mass (molecular weight/formula weight).
- b. Bonding (ionic, covalent, hydrogen).
- c. Characteristics of the four types of bio-molecules (carbohydrates, lipids, proteins, nucleic acids).
- d. Characteristics of molecules in water (hydrophobic vs. hydrophilic, polar vs. non polar).
- e. Acid base chemistry, pH scale and buffer properties.

**OBJECTIVE 2:** Demonstrate accurate and correct solution preparation.

- a. Use proper units of scientific measurement.
- b. Calculate concentrations of solutions (molarity, % volume per volume, % weight per volume).
- c. Calculate how to dilute a stock solution to make a working solution ( $C_1V_1 = C_2V_2$ ).
- d. Measure and adjust the pH of specific solutions with commonly used acids and bases.

- e. Correctly label reagents, specimen samples, and reactions.
- f. Prepare solutions of defined concentrations and pH.

**OBJECTIVE 3:** Relate dilution to solution preparation.

- a. Explain dilution principles. .
- b. Prepare serial dilutions of specific solutions.

## **STANDARD 5**

**Students will describe the structure and function of cells and their components.**

**OBJECTIVE 1:** Identify key cellular components and correlate with function. (i.e., nucleus, chromosomes, ribosomes)

- a. Describe the structure of nucleus, nucleolus, endoplasmic reticulum, golgi apparatus, ribosomes, mitochondria, etc.
- b. Explain the major function of each.

**OBJECTIVE 2:** Compare and contrast prokaryotic and eukaryotic cells.

- a. Describe a prokaryotic cell: example – cell size, cell wall, cell membrane, genetic material, etc.
- b. Describe a eukaryotic cell: example – cell size, cell membrane, genetic material, membrane bound organelles, etc.

## **STANDARD 6**

**Students will demonstrate proper bacterial identification and maintenance of cultures.**

**OBJECTIVE 1:** Prepare bacterial growth media.

- a. Identify growth requirements for common microorganisms.
- b. Utilize the appropriate media and conditions for specific experiments. (i.e. antibiotics, temperatures, selective media.)

**OBJECTIVE 2:** Inoculate agar and broth media.

- a. Explain the different methods of inoculation.
- b. Select the appropriate media and methods of inoculation.
- c. Inoculate media using various techniques. (i.e., streak, spread)
- d. Demonstrate the ability to culture and maintain microorganisms.

**OBJECTIVE 3:** Identify common categories of bacteria.

- a. Explain and identify bacterial properties useful for classification (morphology, cell wall composition, and metabolism).
- b. Perform staining tests to identify bacteria (gram stain).

## **STANDARD 7**

**Students will compare and contrast different types of nucleic acids and proteins and illustrate the flow of genetic information within the cell.**

**OBJECTIVE 1:** Describe the structure of nucleic acids.

- a. Identify the components of nucleotides.
- b. Compare and contrast the structure and function of DNA and RNA.
- c. Explain how the chemical structure of DNA applies to gel electrophoresis.
- d. Perform a restriction digest and analyze the results with gel electrophoresis.

**OBJECTIVE 2:** Describe how DNA functions as a template for DNA replication.

- a. Identify the major components and outline the process of DNA replication.
- b. Explain how DNA replication applies to the amplification of nucleic acids in PCR and DNA sequencing.
- c. Amplify and analyze DNA using PCR and gel electrophoresis.
- d. Demonstrate the ability to use PCR technology.

**OBJECTIVE 3:** Describe the structure and function of proteins.

- a. Describe the four levels of protein structure.
- b. Explain the relationship between the structure and function of proteins.
- c. Identify functional classes of proteins. (i.e., structural, regulatory, enzymes, transport)
- d. Illustrate the primary, secondary, tertiary, and quaternary protein structure.
- e. Discuss ways proteins are used in biotechnology.
- f. Use computer resources to visualize the three dimensional structure of proteins. (Protein data bank, Cn3D, Chime)
- g. Demonstrate the ability to use proper separation techniques to differentiate between proteins based on size and structure (chromatography and SDS-PAGE).
- h. Explore the effects of environment on the function of enzymes (i.e., temperature, pH, salt concentration).

**OBJECTIVE 4:** Outline the process of protein synthesis as related to the Central Dogma of Molecular Biology.

- a. Explain the progression of information from DNA to traits.
- b. Identify the major components, outline the process, and describe the products of transcription.
- c. Distinguish between transcription in prokaryotic and eukaryotic systems. (e.g., introns, exons, post transcriptional modifications, etc.)
- d. Identify the major components, outline the process, and describe the product of translation.
- e. Describe the uses of recombinant proteins in biotechnology. (e.g., medicine, agriculture, etc.)
- f. Manipulate the production of recombinant protein in bacteria. (e.g., GFP)

**OBJECTIVE 5:** Describe how DNA mutations affect the organism.

- a. Characterize the different types of mutations. (e.g., point mutation, frame shift, nonsense, etc.)
- b. Explore the consequences of mutations on the organism. (e.g., cancer, genetic disease)
- c. Explore how DNA differs between individuals within a species.

## **STANDARD 8**

**Students will explain recombinant DNA techniques in bacteria.**

**OBJECTIVE 1:** Describe the use of plasmids in bacterial transformation.

- a. Describe the elements of a functional plasmid (origin of replication, selection gene, multiple cloning sites, and promoter).
- b. Explain the role of restriction enzymes in generating recombinant plasmids.
- c. Describe competent cells, transformation and selection methods.
- d. Perform a bacterial transformation and analyze results.

**OBJECTIVE 2:** Describe the process of plasmid DNA isolation.

- a. Analyze the protocol for isolating plasmid DNA.
- b. Understand how to quantify the amount of DNA purified.

