Biotechnology

Exam Information

Exam number
708

Items
69

Points
70

Prerequisites
None

Recommended course length
One year

National Career Cluster
Agriculture, Food, & Natural Resources

Health Science

Science, Technology, Engineering, & Mathematics

Performance standards
Included (Optional)

Certificate available
Yes

Description

The Biotechnology industry certification exam assesses learners' knowledge of career possibilities in the field of biotechnology as well as diagnostic and therapeutic laboratory procedures that support bioscience research and practice.

Exam Blueprint

Standard	Percentage of exam
1. Application & Careers	1%
2. Safety Procedures	11%
3. Laboratory Procedure	9%
4. Atoms & Molecules	20%
5. Cells	17%
6. DNA replication	17%
7. Nucleic Acids & Proteins	16%
8. DNA Techniques	6%
9. Bioindustrial manufacturing.	3%

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.

1. Create a timeline of historical biotechnology developments (Human Genome Project, fermentation products, structure of Deoxyribonucleic Acid [DNA], pasteurization, etc).
2. Discuss or replicate a historical application of biotechnology (e.g., yogurt, cheese, sauerkraut, bread).

Objective 2 Describe applications of present technology and theorize future implications.

1. Evaluate the ethical, legal, and social implications in biotechnology (e.g. vaccines, genetically modified organisms, cloning, genetic engineering immunizations, and data privacy).
2. Describe the technologies that have been developed to identify, diagnose, and treat genetic diseases (e.g., gene therapy, genetic testing, Real-time PCR, Next Gen sequencing, CRISPR).
3. Obtain, evaluate, and communicate biotechnology concepts and methods using effective communication skills (e.g., Pharmacogenomics, Therapeutic cloning, Genetic Engineering).

Objective 3 Explore the various careers associated with biotechnology.

1. Use the Internet, field trips, job fairs, interviews, and speakers to explore biotechnology.
2. Describe career paths for various occupations in biotechnology.

Performance Skills

1. Research and present biotechnology concepts using effective communication skills.

Standard 1 Performance Evaluation included below (Optional)

Standard 2

Students will practice appropriate safety procedures in the laboratory.

Objective 1 Select and use appropriate personal protective equipment (PPE).

1. Describe how personal protective equipment (PPE) protects the experiment and the lab worker.
2. Wear personal protective equipment (PPE) when appropriate (e.g., lab coats, gloves, and eye protection).

Objective 2 Maintain a sanitary laboratory environment.

1. Explain the appropriate sterilization methods
    a. Autoclave
    b. Chemical (ethanol, bleach)
2. Practice proper aseptic and sterilizing procedures.

Objective 3 Exhibit appropriate behavior to protect coworkers and self.

1. Explain the dangers of contamination of food, drink, electronics, or other personal items.
2. Follow proper disposal and clean-up procedures of chemicals and laboratory equipment as indicated by Standard Operating Procedures (SOP) and Safety Data Sheet (SDS) guidelines (e.g., broken glass, sharps, spills, biohazard waste).
3. Locate emergency exits and equipment (e.g., fire extinguisher, fire blanket, eye wash, shower).

Objective 4 Practice proper handling of chemicals.

1. Label chemicals and samples according to laboratory SOP.
2. Comply with safe handling and storage guidelines as specified by chemical hazard labels.
    a. Pictograms
        i. Flammable
        ii. Corrosive
        iii. Toxic
        iv. Environmental Hazard
        v. Biohazard
        vi. Electrical Shock Hazard
3. National Fire Protection Association (NFPA) 704
    a. White
    b. Yellow
    c. Red
    d. Blue
4. Locate and interpret SDS guidelines for chemicals.

Performance Skills

1. Demonstrate appropriate use of personal protective devices and the safe removal of gloves.

Standard 2 Performance Evaluation included below (Optional)

Standard 3

Students will follow laboratory procedures.

Objective 1 Follow laboratory protocols.

1. Explain the purpose of individual steps within a protocol.
2. Perform the steps of laboratory protocols accurately and in sequence.

Objective 2 Comply with policies and requirements for documentation.

1. Follow standard operating procedures (SOP).
2. Maintain accurate records and documentation according to minimum good documentation practices (GDP).
    a. Attributable
    b. Legible

c. Contemporaneous
d. Original
e. Accurate

Performance Skills

1. Maintain a laboratory notebook according to good documentation practices (GDP).

Objective 3 Use biotechnology laboratory equipment correctly and safely.

1. Identify equipment and describe when to use it.
2. Demonstrate the proper use of biotechnology equipment.
    a. Micropipette
    b. Centrifuge
    c. Spectrophotometer
    d. pH meter
    e. Electrophoresis apparatus-protein & DNA
    f. Thermocycler
    g. Microscope
    h. Autoclave
    i. Balance
    j. Water bath

Performance Skills

1. Demonstrate proper use and handling of micropipettes.

Standard 3 Performance Evaluation included below (Optional)

Standard 4

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

Objective 1 Explain chemical concepts relevant to biotechnology.

1. Atomic mass, molecular mass, and formula weight.
2. Bonding
    a. Ionic
    b. Covalent
    c. Hydrogen
3. Characteristics of the four types of biomolecules/macromolecules.
    a. Carbohydrates
    b. Lipids
    c. Proteins
    d. Nucleic acids
4. Characteristics of molecules in water
    a. Hydrophobic vs. hydrophilic
    b. Polar vs. non-polar
5. Acid base chemistry, pH scale, and uses of buffers.

Objective 2 Calculate accurate and correct solution preparation.

1. Use the metric system, common conversions, and proper units of scientific measurement.
2. Calculate concentrations of solutions
    a. Moles
    b. Molarity
    c. % volume per volume
    d. % weight per volume
    e. Concentration
        i. mg/ml
        ii. ug/ul
        iii. x concentration
3. Calculate how to dilute a stock solution to make the following:
    a. Working solution (C1V1 = C2V2)
    b. Serial dilutions

Objective 3 Prepare and use solutions in the laboratory.

1. Prepare serial dilutions of specific solutions.
2. Measure absorbance and determine concentration of solutions (e.g., spectrophotometer, fluorometry)
3. Measure and adjust the pH of specific solutions with commonly used acids and bases.
4. Correctly label reagents with the following:
    a. Chemical
    b. Concentration and pH
    c. Initials
    d. Date

Performance Skills

1. Prepare a solution of defined concentration and pH.

Standard 5

Students will relate cell structure to bacterial identification and culture maintenance.

Objective 1 Compare and contrast prokaryotic and eukaryotic cells.

1. Cell structure
2. Reproduction
3. Applications in biotechnology

Objective 2 Describe how to prepare bacterial growth media.

1. Identify growth requirements for common microorganisms.
2. Use media preparation techniques needed for specific experiments.
    a. Antibiotics/selective media
    b. Temperatures (avoid inactivation in media)

Performance Skills

1. Demonstrate proper aseptic/sterilizing procedures.
2. Prepare bacterial growth media.

Objective 3 Inoculate agar and broth media.

1. Explain different methods of inoculation.
2. Select the appropriate media and methods of inoculation.
3. Inoculate media using various techniques.
    a. Streak
    b. Spread
4. Correctly label specimen samples (e.g., bacterial strain, antibiotic/media, date, initials).

Performance Skills

1. Demonstrate the ability to culture and maintain microorganisms.

Objective 4 Explain and identify bacterial properties useful for classification.

5. Cell wall composition
6. Morphology (cell and/or colony)
7. Metabolism

Performance Skills

1. Perform gram stain tests to identify bacteria.

Standard 6

Students will describe the structure, function, and application of DNA replication.

Objective 1 Describe the structure of nucleic acids.

1. Identify the components of nucleotides.
2. Compare and contrast the structure and function of DNA and RNA.
3. Explain how the chemical structure of DNA applies to gel electrophoresis.

Performance Skills

1. Perform a restriction digest and analyze the results with gel electrophoresis.

Objective 2 Describe how DNA functions as a template for DNA replication.

1. Identify the major components needed for DNA replication. (i.e. helicase, single strand binding proteins, primase, DNA polymerase, and ligase.)
2. Outline the process of DNA replication

Objective 3 Describe the components and mechanism of Polymerase Chain Reaction (PCR).

1. Explain the steps of the PCR cycle (ie. denature, anneal, extend)
2. Identify the components and their function.

3. Compare PCR to DNA replication in a cell.
    a. Recognize the applications of PCR. (e.g. genetic testing, DNA sequencing, forensics, cloning)

Performance Skills

1. Demonstrate the ability to use PCR technology.

Standard 6 Performance Evaluation included below (Optional)

Standard 7

Students will distinguish between the different types of nucleic acids and proteins and illustrate the flow of genetic information within the cell.

Objective 1 Outline the process of transcription and protein synthesis as related to the Central Dogma of Molecular Biology.

1. Explain the progression of information from DNA to traits.
2. Identify the major components, outline the process, and describe the products of transcription.
3. Distinguish between transcription in prokaryotic and eukaryotic systems.
    a. Introns
    b. Exons
    c. Post transcriptional modifications
    d. Identify the major components, outline the process, and describe the product of translation.

Objective 2 Describe how DNA mutations affect the organism.

1. Characterize the different types of mutations.
    a. Point mutation/substitution
        i. Silent
        ii. Missense
        iii. Nonsense
    b. Frame shift
2. Explore the consequences of mutations on the organism (e.g., cancer, genetic disease).
    a. Identify single nucleotide polymorphisms (SNP).
    b. Describe the role of single nucleotide polymorphisms (SNP) in biotechnology applications (e.g., paternity, forensics, pharmacogenomics, evolutionary origins).

Objective 3 Describe the relationship between the structure and function of proteins.

1. Describe and illustrate the four levels of protein structure.
    a. Primary
    b. Secondary
    c. Tertiary

    d. Quaternary
2. Identify functional classes of proteins (e.g., structural, regulatory, enzymes, transport, cell signaling, defense).
3. Discuss ways proteins are used in biotechnology.
4. Use computer resources to visualize the three-dimensional structure of proteins (e.g., Protein data bank, Cn3D).
5. Explain proper separation techniques to differentiate between proteins based on size and structure (e.g., chromatography, SDS-PAGE).
6. Discuss the effects of environment on the function of enzymes.
    a. Temperature
    b. pH
    c. Salt concentration

Standard 7 Performance Evaluation included below (Optional)

Standard 8

Students will explain recombinant DNA techniques in bacteria.

Objective 1 Describe the use of plasmids in bacterial transformation.

1. Describe the elements of a functional plasmid vector.
    a. Origin of replication
    b. Selection gene
    c. Multiple cloning sites
    d. Promoter
2. Explain the role of restriction enzymes in generating recombinant plasmids.
3. Describe competent cells, transformation, and selection methods.
4. Describe the uses of recombinant proteins in biotechnology (e.g., medicine, agriculture, etc.).
5. Manipulate the production of recombinant protein in bacteria (e.g., Green Fluorescent Protein [GFP]).

Objective 2 Describe the process of plasmid DNA isolation.

1. Analyze the protocol for isolating plasmid DNA.
2. Explain how to quantify the amount of DNA purified.

Performance Skills

1. Perform a bacterial transformation and analyze results.

Standard 8 Performance Evaluation included below (Optional)

Standard 9

Students will investigate how biotechnology relates to bioindustrial manufacturing.

Objective 1 Explore non-medical applications of biotechnology (e.g., energy, bioindustrial materials, textiles, food and agricultural technology, environmental remediation etc.)

Objective 2 Compare and contrast upstream and downstream processing.

Objective 3 Identify and describe the function of the components of a bioreactor.

Objective 4 Describe the Biomanufacturing Readiness Levels (BioMRLs).

Performance Skills

1. Using the BioMRLs, outline a bioindustrial manufacturing process for a product.

Workplace Skills

1. Problem solving
2. Teamwork
3. Critical Thinking
4. Dependability
5. Accountability
6. Legal requirements/expectations

Biotechnology

Performance assessments may be completed and evaluated at any time during the course. The following performance skills are to be used in connection with the associated standards and exam. To pass the performance standard the student must attain a performance standard average of 8 or higher on the rating scale. Students may be encouraged to repeat the objectives until they average 8 or higher.

Student's Name: _____

Class: _____

Performance standards rating scale

0	Limited skills	2	→	4	Moderate skills	6	→	8	High skills	10

Standard 1 – Application & Careers **Score:**

- Research and present biotechnology concepts using effective communication skills.

Standard 2 – Safety Procedures **Score:**

- Demonstrate appropriate use of personal protective devices.
- Demonstrate proper aseptic/sterilizing procedures.
- Demonstrate proper use and handling of micropipettes.

Standard 3 – Laboratory Procedures **Score:**

- Maintain accurate records and documentation according to minimum good documentation practices.

Standard 6 – Bacterial Identification & Cultures **Score:**

- Prepare bacterial growth media.
- Demonstrate the ability to culture and maintain microorganisms.

Standard 7 – Nucleic Acids & Proteins **Score:**

- Perform a restriction digest and analyze the results with gel electrophoresis.
- Demonstrate the ability to use PCR technology.
- Demonstrate the ability to use proper separation techniques to differentiate between proteins based on size/structure.
    - Chromatography and SDS-PAGE.

Standard 8 – Nucleic Acids & Proteins **Score:**

- Perform a bacterial transformation and analyze results.

Performance standard average score:

Evaluator Name: _____

Evaluator Title: _____

Evaluator Signature: _____

Date: _____