

# Biotechnology

**Research and Experiments: Use scientific methodology to conduct problem-based studies, develop products, and interpret results.** 3.1

- 1 Design a research plan, including the significance of the problem, purpose, hypotheses, objectives, appropriate controls, independent variables, dependent variables, methods of study, and a list of materials.** 3.1.1

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- 2 Examine sources for credibility.** 3.1.2

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- 3 Apply sampling methods that appropriately represent the population and implement procedures for systematic data collection.** 3.1.3

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- 4 Explain the importance and design of trialing, and the information gained from it.** 3.1.4

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- 5 Document results of the experiment in a laboratory notebook, including a statement of purpose, experimental design, observations, results, conclusions, and next steps.** 3.1.5

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- 6 Create, interpret, and use tabular and graphical displays and describe the data.** 3.1.6

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- 7 Compute measures of central tendency to interpret results and draw conclusions.** 3.1.7

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- 8 Define the concepts of confidence intervals and significant figures.** 3.1.8

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- 9 Use t-test and p-value to determine statistical significance of results.** 3.1.9

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- 10 Describe the relationships among variables using correlations and draw conclusions.** 3.1.10

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- 11 Draw conclusions based on observations and data analyses, recognizing that experimental results must be open to the scrutiny of others.** 3.1.11

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- 12 Prepare and present findings using scientific reports.** 3.1.12

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- 13 Evaluate experimental failure and use integrity to communicate findings.** 3.1.13

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- 14 Describe how biotechnology products are produced and used in the United States.** 3.1.14

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- 15 Describe how biotechnology products are regulated in the United States.** 3.1.15

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- 16 Describe biotechnology product safety assessment.** 3.1.16

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**17 Identify the purpose of a bioreactor and its use in the agricultural industry.** 3.1.17

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**Laboratory Standards Operational Procedures: Conduct experiments using proper industry-based protocols, methods, and techniques.** 3.2

- 1 Use aseptic techniques to collect, prepare, and test samples.** 3.2.1
  - 2 Prepare and dispense stock reagents, buffers, media, and solutions by calculating concentrations, adjusting factors such as pH, and selecting purification techniques and equipment.** 3.2.2
  - 3 Test and maintain the integrity of stains, reagents, chemicals, and mounts.** 3.2.3
  - 4 Select and apply sterilization methods for reagents, buffers, media, biological samples, and solutions.** 3.2.4
  - 5 Perform laboratory measures by calculating and preparing a serial dilution, calculating quantities needed to perform a test analysis, and calculating unit conversions and concentrations (graphing results).** 3.2.5
  - 6 Monitor physical properties of reagents, buffers, media, and solutions for conductivity and resistivity, pH, and turbidity, and explain the significance of each.** 3.2.6
  - 7 Perform separation techniques, including chemical separations, chromatography, centrifugation, distillation and filtration, and interpret the results.** 3.2.7
  - 8 Titrate liquids.** 3.2.8
  - 9 Create a standard operating procedure and explain its use.** 3.2.9
  - 10 Describe industry-based and required regulatory quality assurance practices for documentation.** 3.2.10
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**Specimen, Equipment and Chemical Handling: Handle, prepare, transport, store, and dispose of specimens and chemicals. Monitor, record, and maintain the integrity of equipment and instrumentation, environmental conditions of the facility and inventory.** 3.3

- 1 Prepare and interpret labels for chemicals, supplies, and equipment.** 3.3.1
- 2 Use chemical references to identify hazards associated with handling and storing chemicals.** 3.3.2
- 3 Safely transfer chemicals from storage containers to equipment used in the laboratory.** 3.3.3
- 4 Neutralize acids, bases, or caustic solutions for handling and disposal.** 3.3.4
- 5 Sample, monitor, and record the environmental conditions of a facility (e.g. air quality, HEPA, temperature, microbial contaminations).** 3.3.5
- 6 Identify and describe the purpose of common laboratory equipment.** 3.3.6
- 7 Select personal protective equipment for various laboratory protocols.** 3.3.7

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**8 Identify required tools and procedures of different biosafety levels.** 3.3.8

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**9 Adjust, calibrate, and perform systems diagnostics on laboratory equipment.** 3.3.9

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**10 Use and maintain a record keeping system for laboratory equipment, chemicals, or products.** 3.3.10

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**11 Use and maintain an inventory management system.** 3.3.11

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**12 Use and calibrate precision weighing and measuring techniques (e.g. analytical balance, micropipette), based on the metric system.** 3.3.12

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**13 Use volumetric glassware to accurately measure liquids.** 3.3.13

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**Applying Chemistry to Laboratory Practices: Using common laboratory equipment, apply general and organic chemistry concepts to examine the structures, functions, binding of molecules, and methodologies for their purity and characterization.** 3.4

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**1 Illustrate electron configurations of elements, compounds, and mixtures.** 3.4.1

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**2 Use the periodic table to describe atomic structure and to characterize molecules based on functional groups.** 3.4.2

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**3 Differentiate between organic and inorganic compounds.** 3.4.3

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**4 Use common and chemical nomenclature for organic and inorganic materials.** 3.4.4

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**5 Write names and formulas for common compounds.** 3.4.5

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**6 Prepare solutions based on molarity, percent weight per volume (w/v) and percent volume per volume (v/v).** 3.4.6

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**7 Describe chemical bonding, bond types, and the relationships that they have with the physical state of materials.** 3.4.7

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**8 Apply the concepts of stoichiometry and the laws of thermodynamics to chemical reactions.** 3.4.8

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**9 Balance chemical reactions.** 3.4.9

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**10 Identify materials that can be used as a catalyst and describe their role in reactions.** 3.4.10

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**11 Predict endothermic and exothermic characteristics of chemical reactions.** 3.4.11

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**12 Use naming systems, including common and International Union of Pure and Applied Chemistry (IUPAC) conventions.** 3.4.12

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**13 Calculate errors in various measurements, based on data acquired using common laboratory equipment.** 3.4.13

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- 14** Apply standard rules for determining the number of significant figures in measurements and in the answers to corresponding calculations. 3.4.14

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  - 15** Convert units of measure from English to metric, within the English system, and within the metric system. 3.4.15

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  - 16** Calculate the volume, temperature, and pressure of gases using the ideal gas law, Charles's Law, and Boyle's Law. 3.4.16
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**Microbiology Testing and Technology: Classify, differentiate between, and test for various kinds of microorganisms and microbial by-products.** 3.5

- 1** Explain classification, composition, and preparation of culture media and prepare media for propagation. 3.5.1

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- 2** Operate centrifuge, dissecting scope, compound microscope, spectrophotometer, incubator, colony counter, pipettes, and other basic microbiology and analytical equipment to examine biological specimens. 3.5.2

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- 3** Explain the principles of microscopy and process a specimen for light microscopy. 3.5.3

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- 4** Perform Gram staining to identify morphology and gram results of bacteria. 3.5.4

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- 5** Prepare, incubate, and identify colonies microscopically and macroscopically (e.g., colonial morphology, staining procedures, biochemical analysis). 3.5.5

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- 6** Use microbial taxonomy and classification systems to identify microbial organisms. 3.5.6

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- 7** Compare and contrast cellular structure and functions of prokaryotic and eukaryotic cells. 3.5.7

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- 8** Identify aerobic bacteria through morphological, physical, and biochemical properties. 3.5.8

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- 9** Obtain specimens for microbiological testing. 3.5.9

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- 10** Differentiate between types of viruses. 3.5.10

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- 11** Explain virulence, pathogenicity, and the factors that contribute to pathogenicity. 3.5.11

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- 12** Explain how chemical energy operates major cell processes (e.g. biosynthesis, movement, transport, growth). 3.5.12

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- 13** Identify bacteriologic methods necessary for the isolation and identification of organisms. 3.5.13

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- 14** Identify factors that affect and optimize rates of enzyme assay reactions. 3.5.14

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- 15** Describe the purpose of an enzyme-linked immunosorbent assay (ELISA) and interpret the results. 3.5.15
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- 16** Describe types of assays and distinguish uses and limitations. 3.5.16
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- 17** Follow complex instructions in performing an assay and explain the role of each step. 3.5.17
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- 18** Perform biochemical assays of proteins, lipids, carbohydrates, nucleic acids, and enzymes. 3.5.18
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- 19** Identify the purpose and implementation of bioassays for pathogens. 3.5.19
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- 20** Apply quality assurance control processes within the lab setting (e.g. pre-analytic, analytic, and post-analytic sources of error). 3.5.20
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- 21** Perform autoclave sterilization. 3.5.21
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**Molecular-Genetics and Technology: Apply knowledge of genetic inheritance and modification to organisms and use genetic information and bioinformatics to analyze specimens.** 3.6

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- 1** Use Punnett Square to predict and explain Mendel's Laws, genotype, and phenotype. 3.6.1
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- 2** Explain epigenetics and provide examples of its effects. 3.6.2
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- 3** Model, predict, and diagram the three-dimensional shape, types of bonds (covalent and hydrogen bonds), and antiparallel nature of DNA. 3.6.3
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- 4** Model central dogma of molecular biology (e.g. replication, transcription, translation). 3.6.4
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- 5** Describe post-transcriptional and post-translational modification of RNA and describe its function. 3.6.5
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- 6** Explain gene editing including the process, possible benefits, and potential risks. 3.6.6
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- 7** Identify, isolate, and manipulate peptides and proteins (i.e. primary, secondary, tertiary, quaternary structures). 3.6.7
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- 8** Analyze DNA using common laboratory techniques (e.g. DNA isolation, gel electrophoresis, restriction enzyme digest, Southern Blotting, Northern Blotting). 3.6.8
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- 9** Use bioinformatics to analyze DNA and proteins. 3.6.9
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- 10** Explain cloning techniques including vector preparation, transformation, and selection. 3.6.10
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- 11** Perform spectroscopy of biological materials explaining the principles behind the procedures, the purpose of a blank, and determine the concentration of biomolecular samples. 3.6.11
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- 12** Evaluate genomes in relation to food, plants, animals, and natural resources. 3.6.12
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- 13** Perform genotyping analysis for genetic diagnostics. 3.6.13
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- 14** Transform bacteria with exogenous DNA to alter bacterial metabolism, reproduction, cell structures, and their functions. 3.6.14
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- 15** Describe types and features of passive and active transport systems. 3.6.15
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- 16** Describe molecular behavior and structure of large molecules, including carbohydrates, lipids, proteins, and nucleic acids. 3.6.16
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- 17** Describe genome sequencing and the information gained from it. 3.6.17
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- 18** Describe artificial selection and how it is used in plant and animal breeding. 3.6.18
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- 19** Define genetically modified organisms and explain their impact on society. 3.6.19
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- 20** Describe how vectors (e.g., plasmids, transposons, viruses) are used to transform hosts and microorganisms. 3.6.20
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- 21** Explain gene by environment interactions. 3.6.21
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- 22** Describe the difference between a quantitative and qualitative gene trait and give examples of each. 3.6.22