

## SECONDARY SCIENCE

## SC-48 Biotechnology Concepts and Techniques

Course #: SC-48	Grade Level: 10-12
Course Name: Biotechnology Concepts and Techniques	Level of Difficulty: Medium
Prerequisites: SC-49 or AG-30 with a "C" or better	# of Credits: 1

### Strand 1: Inquiry Process

*"Science as inquiry is basic to science education and a controlling principle in the continuing organization and selection of students' activities. Students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry..."* (National Science Education Standards, 1995).

Inquiry Process establishes the basis for students' learning in science. Students use scientific processes: questioning, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, and communicating results.

### Concepts

**Concept 1: Observations, Questions, and Hypotheses**

- Formulate predictions, questions, or hypotheses based on observations. Evaluate appropriate resources.

**Concept 2: Scientific Testing (Investigating and Modeling)**

- Design and conduct controlled investigations.

**Concept 3: Analysis, Conclusions, and Refinements**

- Evaluate experimental design, analyze data to explain results and propose further investigations. Design models.

**Concept 4: Communication**

- Communicate results of investigations.

### Students should know and be able to...

Concept Number	Concept	PO No.	Performance Objective	Vocabulary	Notes/Integration/Resources
S1C1	Observations, Questions, and Hypotheses	1	Evaluate scientific information for relevance to a given problem.		
		2	Develop questions from observations that transition into testable hypotheses.		
		3	Formulate a testable hypothesis.		
		4	Predict the outcome of an investigation based on prior evidence, probability, and/or modeling (not guessing or inferring).		

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S1C2	Scientific Testing (Investigating and Modeling)	1	Demonstrate safe and ethical procedures (e.g., use and care of technology, materials, and organisms) and behavior in all science inquiry.		
		2	Identify the resources needed to conduct an investigation.		
		3	Design an appropriate protocol (written plan of action) for testing a hypothesis: <ul style="list-style-type: none"> <li>▪ Identify dependent and independent variables in a controlled investigation.</li> <li>▪ Determine an appropriate method for data collection (e.g., using balances, thermometers, microscopes, spectrophotometer, using qualitative changes).</li> <li>▪ Determine an appropriate method for recording data (e.g., notes, sketches, photographs, videos, journals (logs), charts, computers/calculators).</li> </ul>		
		4	Conduct a scientific investigation that is based on a research design.		
		5	Record observations, notes, sketches, questions, and ideas using tools such as journals, charts, graphs, and computers.		

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Concept Number	Concept	PO No.	Performance Objective	Vocabulary	Notes/Integration/Resources
S1C3	Analysis and Conclusions, and Refinements	1	<i>Interpret data that show a variety of possible relationships between variables, including:</i> <ul style="list-style-type: none"> <li>▪ <i>positive relationship</i></li> <li>▪ <i>negative relationship</i></li> <li>▪ <i>no relationship</i></li> </ul>		
		2	Evaluate whether investigational data support or do not support the proposed hypothesis.		
		3	Critique reports of scientific studies (e.g., published papers, student reports).		
		4	Evaluate the design of an investigation to identify possible sources of procedural error, including: <ul style="list-style-type: none"> <li>▪ sample size</li> <li>▪ trials</li> <li>▪ controls</li> <li>▪ analyses</li> </ul>		
		5	Design models (conceptual or physical) of the following to represent "real world" scenarios. <ul style="list-style-type: none"> <li>▪ phase change</li> </ul>		
		6	Use descriptive statistics to analyze data, including: <ul style="list-style-type: none"> <li>▪ mean</li> <li>▪ frequency</li> <li>▪ range</li> </ul>		
		7	Propose further investigations based on the findings of a conducted investigation.		

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Concept Number	Concept	PO No.	Performance Objective	Vocabulary	Notes/Integration/Resources
S1C4	Communication	1	For a specific investigation, choose an appropriate method for communicating the results.		
		2	Produce graphs that help communicate data.		
		3	Communicate results clearly and logically.		
		4	Support conclusions with logical scientific arguments.		

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### Strand 2: History and Nature of Science

*Knowledge of the nature of science is central to the understanding of the scientific enterprise” (National Assessment of Educational Progress, 2000).*

Scientific investigation grows from the contributions of many people. History and Nature of Science emphasizes the importance of the inclusion of historical perspectives and the advances that each new development brings to technology and human knowledge. This strand focuses on the human aspects of science and the role that scientists play in the development of various cultures.

### Concepts

#### Concept 1: History of Science as a Human Endeavor

- Identify individual, cultural, and technological contributions to scientific knowledge.

#### Concept 2: Nature of Scientific Knowledge

- Understand how science is a process for generating knowledge.

### Students should know and be able to...

Concept Number	Concept	PO No.	Performance Objective	Vocabulary	Notes/Integration/Resources
S2C1	History of Science as a Human Endeavor	1	Describe how human curiosity and needs have influenced science, impacting the quality of life worldwide.		
		2	<i>Describe how diverse people and/or cultures, past and present, have made important contributions to scientific innovations.</i>		
		3	Analyze how specific changes in science have affected society.		
		4	Analyze how specific cultural and/or societal issues promote or hinder scientific advancements.		

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Concept Number	Concept	PO No.	Performance Objective	Vocabulary	Notes/Integration/Resources
S2C2	Nature of Scientific Knowledge	1	<p>Specify the requirements of a valid, scientific explanation (theory), including that it be:</p> <ul style="list-style-type: none"> <li>▪ logical</li> <li>▪ subject to peer review</li> <li>▪ public</li> <li>▪ respectful of rules of evidence</li> </ul>		
		2	<p>Explain the process by which accepted ideas are challenged or extended by scientific innovation.</p>		
		3	<p>Distinguish between pure and applied science.</p>		
		4	<p>Describe how scientists continue to investigate and critically analyze aspects of theories.</p>		

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### Strand 3: Science in Personal and Social Perspectives

Science in Personal and Social Perspectives emphasizes developing the ability to design a solution to a problem, to understand the relationship between science and technology, and the ways people are involved in both. Students understand the impact of science and technology on human activity and the environment. This strand affords students the opportunity to understand their place in the world – as living creatures, consumers, decision makers, problem solvers, managers, and planners.

### Concepts

#### Concept 1: Changes in Environments

- Describe the interactions between human populations, natural hazards, and the environment.

#### Concept 2: Science and Technology in Society

- Develop viable solutions to a need or problem.

#### Concept 3: Human Population Characteristics

- Analyze factors that affect human populations.

### Students should know and be able to...

Concept Number	Concept	PO No.	Performance Objective	Vocabulary	Notes/Integration/Resources
S3C1		3	Assess how human activities can affect the potential for hazards.		
		5	<p>Evaluate the effectiveness of conservation practices and preservation techniques on environmental quality and biodiversity.</p> <ul style="list-style-type: none"> <li>Transgenic plants</li> <li>transformation</li> </ul>		

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Concept Number	Concept	PO No.	Performance Objective	Vocabulary	Notes/Integration/Resources
S3C2	Science and Technology in Society	1	<p>Analyze the costs, benefits, and risks of various ways of dealing with the following needs or problems:</p> <ul style="list-style-type: none"> <li>▪ Product Production</li> <li>▪ biotech stock portfolio</li> <li>▪ Buying seeds</li> <li>▪ Crop production: organic vs. traditional and GM</li> </ul>		
		2	Recognize the importance of basing arguments on a thorough understanding of the core concepts and principles of science and technology.		
		3	Support a position on a science or technology issue.		
		5	Evaluate methods used to manage natural resources.		

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Concept Number	Concept	PO No.	Performance Objective	Vocabulary	Notes/Integration/Resources
S3C3	Human Population Characteristics	3	<p><b>Predict the effect of a change in a specific factor on a human population.</b></p> <ul style="list-style-type: none"> <li>▪ Transformation</li> <li>▪ Transgenic organism</li> <li>▪ Production of human insulin via bacteria</li> </ul>		

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**Strand 4: Life Science**

*“The fundamental goal of life sciences is to attempt to understand and explain the nature of life” (NAEP 2000).*

Life Science expands students’ biological understanding of life by focusing on the characteristics of living things, the diversity of life, and how organisms and populations change over time in terms of biological adaptation and genetics. This understanding includes the relationship of structures to their functions and life cycles, interrelationships of matter and energy in living organisms, and the interactions of living organisms with their environment.

**Concepts**

**Concept 1: The Cell**

- Understand the role of the cell and cellular processes.

**Concept 2: Molecular Basis of Heredity**

- Understand the molecular basis of heredity and resulting genetic diversity.

**Concept 3: Interdependence of Organisms**

- Analyze the relationships among various organisms and their environment.

**Concept 4: Biological Evolution**

- Understand the scientific principles and processes involved in biological evolution.

**Concept 5: Matter, Energy, and Organization in Living Systems (Including Human Systems)**

- Understand the organization of living systems, and the role of energy within those systems.

**Students should know and be able to...**

Concept Number	Concept	PO No.	Performance Objective	Vocabulary	Notes/Integration/Resources
S4C1	The cell	3	Explain the importance of water to cells		
		4	Analyze mechanisms of transport of materials (e.g., water, ions, macromolecules) into and out of cells: <ul style="list-style-type: none"> <li>▪ passive transport</li> <li>▪ active transport</li> </ul>		
		5	Describe the purpose and process of cellular reproduction.		

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S4C2	Molecular Basis of Heredity	1	Analyze the relationships among nucleic acids (DNA, RNA), genes, and chromosomes.		
		2	Describe the molecular basis of heredity, in viruses and living things, including DNA replication and protein synthesis.		
		3	Explain how genotypic variation occurs and results in phenotypic diversity.		
S4C3	Interdependence of Organisms	1	<p>Identify the relationships among organisms within populations, communities, ecosystems, and biomes.</p> <ul style="list-style-type: none"> <li>▪ Culturing cells</li> <li>▪ Plasmids</li> <li>▪ Antibiotic resistance</li> </ul>		
		2	Describe how organisms are influenced by a particular combination of biotic (living) and abiotic (nonliving) factors in an environment.		
		3	<p>Assess how the size and the rate of growth of a population are determined by birth rate, death rate, immigration, emigration, and carrying capacity of the environment.</p> <ul style="list-style-type: none"> <li>▪ Bacteria</li> </ul>		

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S4C4	Biological Evolution	2	<p>Explain how genotypic and phenotypic variation can result in adaptations that influence an organism's success in an environment.</p> <ul style="list-style-type: none"> <li>▪ Gene therapy</li> </ul>		
		3	Describe how the continuing operation of natural selection underlies a population's ability to adapt to changes in the environment and leads to biodiversity and the origin of new species.		
		4	Predict how a change in an environmental factor (e.g., rainfall, habitat loss, non-native species) can affect the number and diversity of species in an ecosystem.		
		5	<p>Analyze how patterns in the fossil record, nuclear chemistry, geology, molecular biology, and geographical distribution give support to the theory of organic evolution through natural selection over billions of years and the resulting present day biodiversity.</p> <ul style="list-style-type: none"> <li>▪ Genome</li> </ul>		
		6	Analyze, using a biological classification system (i.e., morphology, DNA analysis) the degree of relatedness among various species.		
		S4C5	Matter, Energy, and Organization in Living Systems (including Human Systems)	2	Describe the role of organic and inorganic chemicals (e.g., carbohydrates, proteins, lipids, nucleic acids, water, ATP) important to living things.

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### Strand 5: Physical Science

*The physical science component ... should probe the following major topics: matter and its transformations, energy and its transformations, and the motion of things” (NAEP 2000).*

Physical Science affords students the opportunity to increase their understanding of the characteristics of objects and materials they encounter daily. Students gain an understanding of the nature of matter and energy, including their forms, the changes they undergo, and their interactions. By studying objects and the forces that act upon them, students develop an understanding of the fundamental laws of motion, knowledge of the various ways energy is stored in a system, and the processes by which energy is transferred between systems and surroundings.

### Concepts

#### Concept 1: Structure and Properties of Matter

- Understand physical, chemical, and atomic properties of matter.

#### Concept 4: Chemical Reactions

- Investigate relationships between reactants and products in chemical reactions.

#### Concept 5: Interactions of Energy and Matter

- Understand the interactions of energy and matter.

### Students should know and be able to...

Concept Number	Concept	PO No.	Performance Objective	Vocabulary	Notes/Integration/Resources
S5C1	Structure and Properties of Matter	1	Describe substances based on their physical properties.		
		2	Describe substances based on their chemical properties.		
		3	Predict properties of elements and compounds using trends of the periodic table (e.g., metals, non-metals, bonding – ionic/covalent).		

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Concept Number	Concept	PO No.	Performance Objective	Vocabulary	Notes/Integration/Resources
S5C1 (cont.)		4	Separate mixtures of substances based on their physical properties.		
		5	<p>Describe the properties of electric charge and the conservation of electric charge.</p> <ul style="list-style-type: none"> <li>▪ For electrophoresis</li> </ul>		

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S5C4	Chemical Reactions	2	Identify the indicators of chemical change, including formation of a precipitate, evolution of a gas, color change, absorption or release of heat energy.		
		3	Represent a chemical reaction by using a balanced equation.		
		6	Solve problems involving such quantities as moles, mass, molecules, volume of a gas, and molarity using the mole concept and Avogadro's number.		
		8	Quantify the relationships between reactants and products in chemical reactions (e.g., stoichiometry, equilibrium, energy transfers).		
		9	Predict the products of a chemical reaction using types of reactions (e.g., synthesis, decomposition, replacement, combustion).		
		11	Predict the effect of various factors (e.g., temperature, concentration, pressure, catalyst) on the equilibrium state and on the rates of chemical reaction.		
		12	Compare the nature, behavior, concentration, and strengths of acids and bases. <ul style="list-style-type: none"> <li>▪ buffers</li> </ul>		

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Concept Number	Concept	PO No.	Performance Objective	Vocabulary	Notes/Integration/Resources
S5C5	Interactions of Energy and Matter	4	Describe the basic assumptions of kinetic molecular theory.		
		5	Apply kinetic molecular theory to the behavior of matter (e.g., gas laws).		
		9	Quantify the relationships among electric potential, current, and resistance in an ohmic system.		

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