Program Concentration: **Healthcare Science**
Career Pathway: **Biotechnology Research and Development**
Course Title: **Introduction to Biotechnology**

Course Description: Introduction to Biotechnology integrates the fundamental concepts of life and physical sciences together with the basic laboratory skills necessary in the biological sciences. This course serves as the second course in the Biotechnology Research and Development pathway and introduces students to the fundamentals of biotechnology, current trends and careers in biotechnology, and the business, regulatory, and ethical aspects of biotechnology. The knowledge and skills gained in this course will provide students with a broad understanding of biotechnology and its impact on society. The course is intended to meet the needs of a diverse body of learners.

The target audience includes all students who choose postsecondary education, providing them with foundational concepts and established laboratory protocols in a broad spectrum of disciplines such as biology, chemistry, biochemistry, biotechnology, microbiology, molecular and cell biology, genetics, and immunology. In addition, the course has the potential to foster scientific literacy and improve student success on the Georgia High School Graduation Test and to provide entry into the biotechnology career field.

Co-Requisite – Content

HS-IBT-1. Students will demonstrate understanding of required safety practices and procedures in the classroom and laboratory environment.

a. Define health and safety regulations, including Occupational Health and Safety Administration (OSHA), Environmental Protection Agency (EPA), and Right to Know and demonstrate procedures for documenting and reporting hazards and compliance *e.g.*, CFR1910.1450.
b. Demonstrate health and safety practices, including use of Material Safety Data Sheets (MSDS), appropriate personal protective equipment (PPE) for the situation, emergency equipment, storage of chemicals, reagents and compounds, and maintenance of equipment.
c. Demonstrate disaster preparedness procedures for each emergency situation –fire prevention and the emergency evacuation plan, inclement weather, school and workplace violence, bomb threat, and biotechnology related emergencies.
d. Demonstrate knowledge of standard precautions including proper storage, handling and disposal of biohazardous materials.
e. Demonstrate the ability to follow Standard Operating Procedures (SOP).

Academic Standards:

HS-IBT-2. Students will understand the basis for biotechnology products and how such products affect the quality of life.

a. Describe the major scientific discoveries that lead to development of recombinant DNA technology, including those in the fields of biology, chemistry, genetics, and microbiology, and explain how these advances in DNA technology are used today
b. Identify past and current discoveries and developments in fields such as, agriculture, diagnostics, medical devices, pharmaceuticals, and research and development.

c. Justify the steps in production and delivery of a product made using recombinant DNA technology.
d. Discuss the implications of the genomics and proteomics on biotechnology and current healthcare.

Academic Standards:

SB2. Students will analyze how biological traits are passed on to successive generations.
f. Examine the use of DNA technology in forensics, medicine, and agriculture.

ELA10RC2 The student participates in discussions related to curricular learning in all subject areas. The student
c. Relates messages and themes from one subject area to those in another area.

HS-IBT-3. Students will analyze careers in research and development, human health and diagnostics, biomanufacturing, environmental applications, and agriculture that utilize biotechnology.

a. Describe the educational requirements and responsibilities for various positions within the biotechnology industry.
b. Compare and contrast careers within academic, government, and private sectors.
c. Develop a portfolio documenting education, experiences, and acquired skills for a specific careers.
d. Demonstrate understanding of the career development planning process and the process of life-long learning.
e. Describe the role of Student Organizations (e.g., HOSA, FBLA, Key Club, and BETA) and their importance in leadership development.
f. Demonstrate an understanding of the nature of employer-employee relationships.

Academic Standards:

ELA10RC2 The student participates in discussions related to curricular learning in all subject areas. The student
c. Relates messages and themes from one subject area to those in another area.

ELA10RL4 The student employs a variety of writing genres to demonstrate a comprehensive grasp of significant ideas in selected literary works. The student composes essays, narratives, poems, or technical documents. The student
d. Includes a formal works cited or bibliography when applicable.

HS-IBT-4. Students will demonstrate how concepts of physical science connect to biochemical applications and techniques.

a. Calculate and prepare buffers, stock solutions, and reagents.
b. Analyze and apply the concepts of homeostasis and molar relationships to biochemical reactions.
c. Draw conclusions regarding protein function and structure as it relates to the pH of a solution.
d. Analyze enzyme activity using assays for reactants and products.

e. Utilize electrophoresis, chromatography, microscopy and spectrophotometry to identify, separate and to draw conclusions about biological molecules.
f. Use antibody specificity for antigens to test for the presence of protein (*e.g.*, ELISA, Western Blot, antibody staining).

Academic Standards:

SB1. Students will analyze the nature of the relationships between structures and functions in living cells.

b. Explain how enzymes function as catalysts.
c. Identify the function of the four major macromolecules (i.e., carbohydrates, proteins, lipids, nucleic acids).
d. Explain the impact of water on life processes (i.e., osmosis, diffusion).

SPS6. Students will investigate the properties of solutions.

a. Describe solutions in terms of, solute/solvent, conductivity, concentration.
b. Observe factors affecting the rate a solute dissolves in a specific solvent.
c. Demonstrate that solubility is related to temperature by constructing a solubility curve.

SC4. Students will characterize the properties that describe solutions and the nature of acids and bases.

a. Explain the process of dissolving in terms of solute/solvent interactions:
- *Observe factors that effect the rate at which a solute dissolves in a specific solvent,*
- *Express concentrations as molarities,*
- *Prepare and properly label solutions of specified molar concentration,*

MM2P1 Students will solve problems (using appropriate technology).

b. Solve problems that arise in mathematics and in other contexts.
c. Apply and adapt a variety of appropriate strategies to solve problems.

HS-IBT-5. Students will compare and contrast common organisms used in biotechnology and relate the manipulation of living organisms to product and procedure development.

a. Distinguish between prokaryotic cells, eukaryotic cells, and non-living entities such as viruses.
b. Describe the characteristics and life cycles of model organisms used in biotechnology, including bacteria (*e.g.*, E. *coli*), fungi (*e.g.*, yeasts and *Aspergillus*), and animals (*e.g.*, C. *elegans*, fruit flies, and rodents).
c. Monitor how environmental factors affect the growth of cells and model organisms in the laboratory.
d. Apply the basic concepts of cell growth to manipulate cultures under aseptic conditions in the laboratory.
e. Perform transformations, including competency, selection, antibiotic resistance, and analysis of transformation efficiency.

Academic Standards:

SB1. Students will analyze the nature of the relationships between structures and functions in living cells.

a. Explain the role of cell organelles for both prokaryotic and eukaryotic cells, including the cell membrane, in maintaining homeostasis and cell reproduction.

SB2. Students will derive the relationship between single-celled and multi-celled organisms and the increasing complexity of systems.

d. Compare and contrast viruses with living organisms.

SB5. Students will evaluate the role of natural selection in the development of the theory of evolution.

e. Recognize the role of evolution to biological resistance (pesticide and antibiotic resistance).

SZ4. Students will assess how animals interact with their environment including key adaptations found within animal taxa.

c. Explain various life cycles found among animals (e.g., polyp and medusa in cnidarians; multiple hosts and stages in the platyhelminthe life cycle; arthropod metamorphosis; egg, tadpole, adult stages in the amphibian life cycle).

HS-IBT-6. Students will demonstrate how manipulation of nucleic acids through genetic engineering (recombinant DNA and RNA technologies) alters the function of proteins and subsequent cellular processes.

a. Describe the function of DNA, RNA, and protein in living cells and the Central Dogma.
b. Demonstrate how the structure of DNA influences its function, analysis, and manipulation.
   - Isolate genomic and recombinant DNA from cells and solutions and analyze its purity and concentration.
   - Explain and demonstrate the principles involved in DNA analysis via agarose gel electrophoresis.
   - Describe previous and current DNA sequencing technologies.
c. Explain the role of enzymes (*e.g.*, restriction enzymes, DNA polymerases, and nucleases) in the production and manipulation of DNA molecules.
d. Determine and analyze the effect of qualitative and quantitative changes of specific proteins on cell function.

Academic Standards:

SB1. Students will analyze the nature of the relationships between structures and functions in living cells.

b. Explain how enzymes function as catalysts.

c. Identify the function of the four major macromolecules (i.e., carbohydrates, proteins, lipids, nucleic acids).

d. Explain the impact of water on life processes (i.e., osmosis, diffusion).

SB2. Students will analyze how biological traits are passed on to successive generations.

a. Distinguish between DNA and RNA.
b. Explain the role of DNA in storing and transmitting cellular information.
c. Using Mendel's laws, explain the role of meiosis in reproductive variability.
d. Describe the relationships between changes in DNA and potential appearance of new traits including
- *Alterations during replication.*
  - *Insertions*
  - *Deletions*
  - *Substitutions*
- *Mutagenic factors that can alter DNA.*
  - *High energy radiation (x-rays and ultraviolet)*
  - *Chemical*

HS-IBT-7. Students will analyze economic, social, ethical, and legal issues related to the use of biotechnology.

a. Differentiate between moral, ethical, and legal biotechnology issues.
b. Research ethical issues presented by evolving science, including genetically modified foods, cloning, bioterrorism, gene therapy, and stem cells.
c. Compare and contrast attitudes about the use of biotechnology regionally, nationally, and internationally.
d. Evaluate the regulatory policies impacting biotechnology research - *e.g.*, use of animals in research and applications of recombinant DNA.

Academic Standards:

ELA10RC2 The student participates in discussions related to curricular learning in all subject areas. The student

c. Relates messages and themes from one subject area to those in another area.

ELA10RL4 The student employs a variety of writing genres to demonstrate a comprehensive grasp of significant ideas in selected literary works. The student composes essays, narratives, poems, or technical documents. The student

d. Includes a formal works cited or bibliography when applicable.

Co-Requisite – Characteristics of Science

Habits of Mind

SCSh1. Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.

a. Exhibit the above traits in their own scientific activities.
b. Recognize that different explanations often can be given for the same evidence.
c. Explain that further understanding of scientific problems relies on the design and execution of new experiments which may reinforce or weaken opposing explanations.

SCSh2. Students will use standard safety practices for all classroom laboratory and field investigations.
a. Follow correct procedures for use of scientific apparatus.
b. Demonstrate appropriate technique in all laboratory situations.
c. Follow correct protocol for identifying and reporting safety problems and violations.

SCSh3. Students will identify and investigate problems scientifically.
a. Suggest reasonable hypotheses for identified problems.
b. Develop procedures for solving scientific problems.
c. Collect, organize and record appropriate data.
d. Graphically compare and analyze data points and/or summary statistics.
e. Develop reasonable conclusions based on data collected.
f. Evaluate whether conclusions are reasonable by reviewing the process and checking against other available information.

SCSh4. Students use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.
a. Develop and use systematic procedures for recording and organizing information.
b. Use technology to produce tables and graphs.
c. Use technology to develop, test, and revise experimental or mathematical models.

SCSh5. Students will demonstrate the computation and estimation skills necessary for analyzing data and developing reasonable scientific explanations.
a. Trace the source on any large disparity between estimated and calculated answers to problems.
b. Consider possible effects of measurement errors on calculations.
c. Recognize the relationship between accuracy and precision.
d. Express appropriate numbers of significant figures for calculated data, using scientific notation where appropriate.
e. Solve scientific problems by substituting quantitative values, using dimensional analysis and/or simple algebraic formulas as appropriate.

SCSh7. Students will communicate scientific investigations and information clearly.
a. Write clear, coherent laboratory reports related to scientific investigations.
b. Write clear, coherent accounts of current scientific issues, including possible alternative interpretations of the data.
c. Use data as evidence to support scientific arguments and claims in written or oral presentations.
d. Participate in group discussions of scientific investigation and current scientific issues.

The Nature of Science

SCSh7. Students analyze how scientific knowledge is developed.
Students recognize that:

a. The universe is a vast single system in which the basic principles are the same everywhere.
b. Universal principles are discovered through observation and experimental verification.
c. From time to time, major shifts occur in the scientific view of how the world works. More often, however, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. Major shifts in scientific views typically occur after the observation of a new phenomenon or an insightful interpretation of existing data by an individual or research group.
d. Hypotheses often cause scientists to develop new experiments that produce additional data.
e. Testing, revising, and occasionally rejecting new and old theories never ends.

SCSh8. Students will understand important features of the process of scientific inquiry.
Students will apply the following to inquiry learning practices:

a. Scientific investigators control the conditions of their experiments in order to produce valuable data.
b. Scientific researchers are expected to critically assess the quality of data including possible sources of bias in their investigations' hypotheses, observations, data analyses, and interpretations.
c. Scientists use practices such as peer review and publication to reinforce the integrity of scientific activity and reporting.
d. The merit of a new theory is judged by how well scientific data are explained by the new theory.
e. The ultimate goal of science is to develop an understanding of the natural universe which is free of biases.
f. Science disciplines and traditions differ from one another in what is studied, techniques used, and outcomes sought.

Reading Standard Comment

After the elementary years, students are seriously engaged in reading for learning. This process sweeps across all disciplinary domains, extending even to the area of personal learning. Students encounter a variety of informational as well as fictional texts, and they experience text in all genres and modes of discourse. In the study of various disciplines of learning (language arts, mathematics, science, social studies), students must learn through reading the communities of discourse of each of those disciplines. Each subject has its own specific vocabulary, and for students to excel in all subjects, they must learn the specific vocabulary of those subject areas *in context.*

Beginning with the middle grades years, students begin to self-select reading materials based on personal interests established through classroom learning. Students become curious about science, mathematics, history, and literature as they form contexts for those subjects related to their personal and classroom experiences. As students explore academic areas through reading, they develop favorite subjects and become confident in their verbal discourse about those subjects.

Reading across curriculum content develops both academic and personal interests in students. As students read, they develop both content and contextual vocabulary. They also build good habits for reading, researching, and learning. The Reading Across the Curriculum standard focuses on the academic and personal skills students acquire as they read in all areas of learning.

SCSh9. Students will enhance reading in all curriculum areas by:

a. Reading in all curriculum areas
- Read a minimum of 25 grade-level appropriate books per year from a variety of subject disciplines and participate in discussions related to curricular learning in all areas.
- Read both informational and fictional texts in a variety of genres and modes of discourse.
- Read technical texts related to various subject areas.

b. Discussing books
- Discuss messages and themes from books in all subject areas.
- Respond to a variety of texts in multiple modes of discourse.
- Relate messages and themes from one subject area to messages and themes in another area.
- Evaluate the merit of texts in every subject discipline.
- Examine author's purpose in writing.
- Recognize the features of disciplinary texts.

c. Building vocabulary knowledge
- Demonstrate an understanding of contextual vocabulary in various subjects.
- Use content vocabulary in writing and speaking.
- Explore understanding of new words found in subject area texts.

d. Establishing context
- Explore life experiences related to subject area content.
- Discuss in both writing and speaking how certain words are subject area related.
- Determine strategies for finding content and contextual meaning for unknown words.

CTAE Foundation Skills

The Foundation Skills for Career, Technical and Agricultural Education (CTAE) are critical competencies that students pursuing any career pathway should exhibit to be successful. As core standards for all career pathways in all program concentrations, these skills link career, technical and agricultural education to the state's academic performance standards.

The CTAE Foundation Skills are aligned to the foundation of the U. S. Department of Education's 16 Career Clusters. Endorsed by the National Career Technical Education Foundation (NCTEF) and the National Association of State Directors of Career Technical Education Consortium (NASDCTEc), the foundation skills were developed from an analysis of all pathways in the sixteen occupational areas. These standards were identified and validated by a national advisory group of employers, secondary and postsecondary educators, labor associations, and other stakeholders. The Knowledge and Skills provide learners a broad foundation for managing lifelong learning and career transitions in a rapidly changing economy.

CTAE-FS-1 Technical Skills: Learners achieve technical content skills necessary to pursue the full range of careers for all pathways in the program concentration.

CTAE-FS-2 Academic Foundations: Learners achieve state academic standards at or above grade level.

CTAE-FS-3 Communications: Learners use various communication skills in expressing and interpreting information.

CTAE-FS-4 Problem Solving and Critical Thinking: Learners define and solve problems, and use problem-solving and improvement methods and tools.

CTAE-FS-5 Information Technology Applications: Learners use multiple information technology devices to access, organize, process, transmit, and communicate information.

CTAE-FS-6 Systems: Learners understand a variety of organizational structures and functions.

CTAE-FS-7 Safety, Health and Environment: Learners employ safety, health and environmental management systems in corporations and comprehend their importance to organizational performance and regulatory compliance.

CTAE-FS-8 Leadership and Teamwork: Learners apply leadership and teamwork skills in collaborating with others to accomplish organizational goals and objectives.

CTAE-FS-9 Ethics and Legal Responsibilities: Learners commit to work ethics, behavior, and legal responsibilities in the workplace.

CTAE-FS-10 Career Development: Learners plan and manage academic-career plans and employment relations.

CTAE-FS-11 Entrepreneurship: Learners demonstrate understanding of concepts, processes, and behaviors associated with successful entrepreneurial performance.