Implementation date
Fall 2009

GeorgiaStandards.Org
GATEWAY TO EDUCATION & PROFESSIONAL RESOURCES
One Stop Shop For Teachers

PROGRAM CONCENTRATION: Healthcare Science
CAREER PATHWAY: Biotechnology Research and Development
COURSE TITLE: Applications of Biotechnology

Course Description: This course further introduces students to the fundamentals of biotechnology. Included in this course are additional techniques in biotechnology. Additionally, a deeper level of laboratory safety and applications in biotechnology is emphasized. The knowledge and skills gained in this course will provide students with a greater understanding of biotechnology and prepare students for skill application in a workplace setting.

Prerequisites:
Introduction to Healthcare Science, Introduction to Biotechnology

ACADEMIC FOUNDATIONS

HS-ABT-1. Students will demonstrate the ability to use and apply mathematics and language arts skills.

a. Perform mathematical calculations related to biotechnology including statistics.
   Sample Tasks:
   - Prepare solutions and buffers at specific molarities and pH.
   - Perform serial dilutions.
   - Differentiate between mean, median, mode, standard deviation, and R^2 values.
b. Compare the standard deviation and the mean of efficacy testing data of two biotechnology products.
   Sample Tasks:
   - F-Test and T-Test.
   - Cluster statistics Analysis of Variance (ANOVA).
c. Illustrate a set of biotechnology data graphically.
   Sample Task:
   - Select an appropriate graphical representation for a set of data and use appropriate statistics (e.g. quartile or percentile distribution) to communicate information about the data.
d. Convert from one system of measurement to another.
e. Write numbers and perform calculations in scientific notation.
f. Apply English and language arts standards throughout the course using various forms of written and electronic communications.
g. Use biotechnology terminology appropriately.
h. Document projects in writing with emphasis on using the scientific format (abstract, introduction, methods, results, discussion, references, tables, and figures) and through oral presentations with electronic support.

Academic Standards:

ELA9RC2 The student participates in discussions related to curricular learning in all subject areas.

ELA9LSV1 The student participates in student-to-teacher, student-to-student, and group verbal interactions.

ELA9RL5 The student understands and acquires new vocabulary and uses it correctly in reading and writing.

ELA11W3 The student uses research and technology to support writing.

MM1A1 Students will explore and interpret the characteristics of functions, using graphs, tables, and simple algebraic techniques.

MM1P1 Students will solve problems (using appropriate technology).

MM1P4 Students will make connections among mathematical ideas and to other disciplines.

MM1P5 Students will represent mathematics in multiple ways.

MM2D1 Using sample data, students will make formal inferences about population means and standard deviation.

SAFETY APPLICATIONS IN THE BIOTECHNOLOGY CLASSROOM/LABORATORY

HS-ABT-2. Students will incorporate required safety practices and procedures in performing tasks related to biotechnology.

a. Analyze case studies of lab accidents and biohazards in various settings. (Examples include dangers of gases, explosions, electrical shock, biohazards, infectious disease, and genetically modified organisms; also other topics as suggested by current events.)
b. Demonstrate ways to prevent or manage lab accidents and biohazards in various workplace settings.
c. Understand and apply safe methods for transporting chemicals, grounding electrical equipment, sharps disposal, monitoring gas pressures (pressurized tanks), and using secondary containment systems for transport (safe shipping methods).

Academic Standard:
SCSh2 Students will use standard safety practices for all classroom laboratory and workplace investigations.

BIOTECHNOLOGY TRENDS AND ISSUES

HS-ABT-3. Students will demonstrate deeper understanding of current trends and issues in biotechnology.

a. Monitor current trends in biotechnology using a variety of information sources- i.e. *Scientific American, Wall Street Journal, Discovery* magazine, and scientific associations and federal web sites including USDA, NIH, FDA, CDC, NCBI, and BIO.
b. Examine the economic impact of biotechnology on quality of life to include the environment, agriculture, and medicine.

Academic Standards:
ELA11W3 The student uses research and technology to support writing.

SCsh1 Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.

SSEF4 The student will compare and contrast different economic systems, and explain how they answer the three basic economic questions of what to produce, how to produce and for whom to produce.

MM1P1 Students will solve problems (using appropriate technology).

MM1P4 Students will make connections among mathematical ideas and to other disciplines.

THE NATURE OF SCIENCE

HS-ABT-4. Students will use inquiry to demonstrate an understanding of how scientific knowledge is developed.

a. Explain how hypotheses often cause scientists to develop new experiments that produce additional data.
b. Demonstrate an understanding of fundamental scientific principals, such as Koch's Postulates, which affect experimental design.
c. Describe how testing, revising, and occasionally rejecting new and old theories are a continuous process.

Academic Standards:
MM2P1 Students will solve problems (using appropriate technology).

MM2P3 Students will communicate mathematically their ideas.

MM2P4 Students will make connections among mathematical ideas and to other disciplines.

HS-ABT-5. Students will demonstrate understanding of the important features of the process of scientific inquiry.

a. Discuss the importance of appropriate controls, standards, and statistical analysis.
b. Assess the quality of data including possible sources of bias in their investigations' hypotheses, observations, data analyses, and interpretations.
c. Explain the strengths and weaknesses of the use of peer review and publication to reinforce the integrity of scientific activity and reporting.
d. Explain how reproducibility is a cornerstone of scientific inquiry.

Academic Standards:
SCSh8 Students will understand important features of the process of scientific inquiry.

MM2P1 Students will solve problems (using appropriate technology).

MM2P3 Students will communicate mathematically their ideas/Use the language of mathematics to express mathematical ideas precisely.

MM2P4 Students will make connections among mathematical ideas and to other disciplines.

MM2P5 Students will represent mathematics in multiple ways.

MM1D2 Students will use expected value to predict outcomes.

MM1D3 Students will relate samples to a population.

COMMUNICATIONS AND DOCUMENTATION

HS-ABT-6. Students will communicate effectively orally and in writing, applying academic knowledge in biotechnology communications.

a. Understand how to follow a Standard Operating Procedure.
b. Utilize computer based applications in documenting and analyzing data.
c. Maintain a laboratory notebook using proper procedures and attention to the notebook as a legal document.
d. Apply technical writing format for reports, using common scientific formats.

Academic Standards:
SCSh3 Students will identify and investigate problems scientifically.

SCSh4 Students use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.

SCSh5 Students will demonstrate the computation and estimation skills necessary for analyzing data and developing reasonable scientific explanations.

SCSh6 Students will communicate scientific investigations and information clearly.

SC7 Students will characterize the properties that describe solutions and the nature of acids and bases.

ELA9LSV1 The student participates in student-to-teacher, student-to-student, and group verbal interactions.

ELA9RC2 The student participates in discussions related to curricular learning in all subject areas.

MM2P1 Students will solve problems (using appropriate technology).

MM2P3d Use the language of mathematics to express mathematical ideas precisely.

MM2P4 Students will make connections among mathematical ideas and to other disciplines.

ADVANCED LABORATORY SKILLS

HS-ABT-7. Students will demonstrate proficiency in advanced biotechnology techniques.

a. Describe the foundations for molecular analysis – quantity, quality, and purity.
b. Perform DNA isolation and restriction digests.
c. Describe various methods of transformation including chemical, physical, and biological.
d. Describe methods of cloning of individual genes.
e. Perform advanced PCR techniques including primer design.
f. Perform agarose gel techniques as needed during molecular analyses.
g. Prepare DNA samples for sequencing.
h. Manage and analyze DNA sequence data using bioinformatics tools.
i. Perform methods of protein extraction such as salt precipitation and dialysis, chromatography, and antibody purification.
j. Describe and perform methods of protein measurement, quantification, and characterization such as: Western blot, polyacrylamide gel electrophoresis, ELISA, and UV/VIS spectrophotometry.
k. Describe the different cell types and culture methods (i.e. bacteria, yeast, animal, and plant) as used in biotechnology.
l. Review sterile technique and apply it to growing cells in culture (i.e. plant cell culture).
m. Describe techniques for maintenance of cells in culture.

Sample Tasks:

- Maintenance of different (primary vs. immortal) cells in culture.
- What is the difference between suspension vs. attached cell culture?
- Quantitation of cell numbers using a hemacytometer.
- Visualization of different cell types by staining.
- Expansion of cell cultures.
- Cryopreservation of cells.

Academic Standards:

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

SB3 Students will derive the relationship between single-celled and multi-celled organisms and the increasing complexity of systems.

SB4 Students will assess the dependence of all organisms on one another and the flow of energy and matter within their ecosystems.

SCSh3 Students will identify and investigate problems scientifically.

SCSh4 Students use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.

SCSh5 Students will demonstrate the computation and estimation skills necessary for analyzing data and developing reasonable scientific explanations.

SCSh6. Students will communicate scientific investigations and information clearly.

SC7 Students will characterize the properties that describe solutions and the nature of acids and bases.

SCSh8 Students will understand important features of the process of scientific inquiry.

SPS10 Students will investigate the properties of electricity and magnetism.

MM1A1 Students will explore and interpret the characteristics of functions, using graphs, tables, and simple algebraic techniques.

MM1D3 Students will relate samples to a population.

MM1P1 Students will solve problems (using appropriate technology).

MM1P4 Students will make connections among mathematical ideas and to other disciplines.

MM1P5 Students will represent mathematics in multiple ways.

MM2D2 Students will determine an algebraic model to quantify the association between two quantitative variables.

ADVANCED APPLICATIONS

HS-ABT-8. Students will demonstrate understanding of advanced applications in biotechnology.

a. Describe how biotechnology has contributed to the advancement of biology impacting human well being to include: forensics, cell biology, cancer treatment, epidemiology of infectious disease, nanotechnology, bioinformatics, genomics, stem cell biology, transgenics, and gene therapy.

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

ELA10C1 The student demonstrates understanding and control of the rules of the English language, realizing that usage involves the appropriate application of conventions and grammar in both written and spoken formats.

ELA10LSV1(d) Actively solicits another person's comments or opinion. (e) Offers own opinion forcefully without domineering.

BIOETHICAL & LEGAL ISSUES

HS-ABT-9. Students will demonstrate understanding of advanced bioethical and legal issues.

a. Describe the concept of intellectual honesty and the use of statistics, controls, and standards to avoid misinterpretation of data.
b. Apply knowledge of bioethical/legal issues to various scenarios, including clinical trial issues, choice of genetic traits, and use of genetic testing data
   Sample Tasks:
   - How did Vioxx come to market?
   - Who bears responsibility for premature failure of biomechanical planted devices (pacemakers, heart valves)?
   - Assessing risk in biotechnology: Pursuing gene therapy and use of recombinant DNA technology in the face of unexpected therapeutic outcomes such as death.
   - Using populations in third world countries for testing pharmaceuticals.
   - The ethics of parents treating normal stature children with growth hormone to make them taller.

- Review the concept of consent: animals, children, and legally incompetent adults with guardians who cannot give consent.

Academic Standards:
MM1P1 Students will solve problems (using appropriate technology).

MM1P4 Students will make connections among mathematical ideas and to other disciplines.

MM1P5 Students will represent mathematics in multiple ways.

REGULATIONS WITHIN THE BIOTECHNOLOGY INDUSTRY

HS-ABT-10. Students will demonstrate understanding of the impact of regulations on the biotechnology industry.

a. Understand the phase of clinical trials and requirements for obtaining FDA product approval.
b. Demonstrate understanding of the regulatory policies impacting biotechnology research - e.g. use of animals in research and construction of recombinant DNA.
c. Demonstrate understanding of the role of documentation and record keeping in regulatory requirements.

Academic Standards:
MM1P1 Students will solve problems (using appropriate technology).

MM1P4 Students will make connections among mathematical ideas and to other disciplines.

MM1P5 Students will represent mathematics in multiple ways.

Reading Across the Curriculum

Reading Standard Comment
After the elementary years, students engage 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.

CTAE-RC-1 Students will enhance reading in all curriculum areas by:

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.

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.

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.

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.