Essentials of Biotechnology Course Syllabus

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**Course Description:** This course introduces students to the fundamental scientific principles of biotechnology, bioethics, the variety of careers in biosciences, as well as the commercial and regulatory characteristics of the biosciences. The Essentials of Biotechnology course emphasizes how key concepts from biology, chemistry, and physics apply to modern applications within the biological sciences. The knowledge and skills gained in this course provide students with a broad understanding of biotechnology and the impact it makes on society. As students work to master the content, they mirror what scientists and technicians are doing in scientific laboratories. A significant part of the course involves actual and simulated research being done in actual laboratories world‐wide, which gives students the unique opportunity to carry out the world changing experiments about which they are learning. To accomplish this goal, the course is especially laboratory intensive, and students spend 50‐75% of class time carrying out actual experiments. This focus on working knowledge allows students to learn and practice the skills that they would actually use in the field of biotechnology and build up the practical skill set of each student. Ultimately, the content and skills covered offers all students the opportunity to acquire basic competencies required for an entry‐level position in any biotechnology company. The target audience includes all students interested in attending any college or technical schools by providing foundational concepts and established laboratory procedures in a broad spectrum of disciplines such as biology, chemistry, biochemistry, molecular biology, microbiology, genetics, and immunology. Workers in biotechnology create, design, develop, and evaluate systems and products such as artificial organs, artificial limbs, medication information systems, medical equipment and instrumentation. Tasks associated with careers in biotechnology include researching new materials for biomedical equipment, evaluating the safety of such equipment, utilizing computer simulation of the body’s organs and systems, designing and developing new procedures and equipment for detecting disease, and advising hospitals and other medical facilities on the use of new and existing medical equipment.

**Grading Policy: (Subject to change based county policy)**

A 90-100 B 80-89 C 70-79 F below 70

60% summative, 20% formative, 20% final exam

**Textbook:** *Biotechnology* by J. Kirk Brown (2nd Edition; Bio-Rad Laboratories)

**Class/Lab Procedures and Rules:** All school policies in the student handbook and the freshman academy will be followed, as well as all lab safety rules and teacher policies. Tardy policy will be followed as listed in the handbook.

**Performance Assessments** will include but will not be limited to student learning objective assessments (SLOs), quizzes, unit tests, lab reports, research projects, lab practicals, and final exams.

**Recommended Materials:** In addition to paper and a writing utensil, students will also need a graph paper composition notebook for research conducted in the classroom and a designated area in their notebook for biotechnology materials (notes, labs, warm-ups, etc.).

**Essentials of Biotechnology Georgia Performance Standards:**

**HS-EB-1**

**Demonstrate employability skills required by business and industry.**

1.1 Communicate effectively through writing, speaking, listening, reading, and interpersonal abilities.

1.2 Demonstrate creativity with multiple approaches to ask challenging questions resulting in innovative procedures, methods, and products.

1.3 Exhibit critical thinking and problem solving skills to locate, analyze, and apply information in career planning and employment situations.

1.4 Model work readiness traits required for success in the workplace including integrity, honesty, accountability, punctuality, time management, and respect for diversity.

1.5 Apply the appropriate skill sets to be productive in a changing, technological, and diverse workplace to be able to work independently, interpret data, and apply team work skills.

1.6 Present a professional image through appearance, behavior, and language.

**HS-EB-2**

**Research required safety practices and standard operating procedures (SOP) for the classroom and laboratory environment.**

2.1 Define and explain health and safety regulations, including Occupational Health and Safety, risks (i.e., blood-borne pathogens), precautions (i.e., Hep B vaccine), and radiation safety.

2.2 Identify current GHS pictogram and NFPA safety ratings and labels.

2.3 Demonstrate procedures for documenting and reporting hazards and compliance.

2.4 Demonstrate health and safety practices, including use of Safety Data Sheets (SDS), appropriate personal protective equipment (PPE), sterilization techniques, emergency equipment, reagents and compounds, and maintenance of equipment.

2.5 Discuss International Organization for Standardization (ISO) and Biosafety Levels (BSL).

2.6 Identify disaster preparedness procedures related to biotechnology related emergencies.

2.7 Exhibit standard precautions including proper storage of chemicals, documentation, handling and disposal of biohazardous materials and biotechnology related emergencies.

2.8 Perform aseptic technique and demonstrate how to follow Standard Operating Procedures (SOP).

**HS-EB-3**

**Analyze careers in research and development, human health, diagnostics, biomanufacturing, environmental applications, and agriculture that utilize biotechnology.**

3.1 Outline standard corporate structure, departments, and responsibilities.

3.2 Describe the educational, training and/or experience requirements for various positions within the biotechnology industry.

3.3 Compare and contrast careers within academic, government, and private sectors.

3.4 Identify and classify the steps involved in manufacturing a bioengineered product and the differences between small, medium, and large product development.

3.5 Specify the logical steps to develop a new biotech product from R&D, Pre-Clinical, Clinical Trials, small- and large-scale manufacturing to formulation, packaging, and warehousing.

3.6 Discuss the role of the Environmental Protection Agency (EPA), Food and Drug Administration (FDA), the U.S. Department of Agriculture (USDA), and other regulatory agencies for safety and legal compliance.

3.7 Identify the basic structure for the Code of Federal Regulations (CFR), guidelines for Corrective and Preventative Actions (CAPA) and current good practices (cGxP).

3.8 Emphasize the roles and responsibilities of the Quality Control and Quality Assurance professionals and departments within the context of the overall Quality Management System (QMS).

3.9 Explore the use of assays to ensure: Safety, Efficacy, Purity, Identity, Potency, Quality and Stability from R&D through manufacturing and delivery.

3.10 Practice formatting Laboratory Notebooks in compliance with good documentation procedures (GDP) according to FDA standards.

3.11 Identify and explore the essential structure of research papers and documentation (e.g., background, methods, results, interpretation/discussion). Practice reading and writing sections of scientific papers and why it is important to reference previous work.

3.12 Explore “validity” for research data and proper sourcing for scientific documentation.

**HS-EB-4**

**Demonstrate how concepts of physical science connect to biochemical applications and techniques, including proficient use of standard biologics laboratory equipment.**

4.1 Calculate and prepare buffers, stock solutions, and reagents using mass per volume and volume per volume percent solution calculations as well as dilution percent solutions (C1V1=C2V2). Review “dilution factors” and serial dilutions.

4.2 Apply the concepts of homeostasis, normality, and molar relationships to biochemical reactions.

4.3 Demonstrate reading and using graphs (using Microsoft Excel or equivalent software).

4.4 Demonstrate understanding of the role of solution pH, temperature, and salinity on protein function and structure.

4.5 Analyze enzyme activity using assays for reactants and products.

4.6 Demonstrate proficiency in the use of basic laboratory equipment, including electronic and analytical balances, autoclave, micro pipetting, pouring agarose/agar, centrifuge/microcentrifuge, incubators, water baths, and tabletop pH meters and other standard laboratory equipment.

4.7 Apply electrophoresis, chromatography, and microscopy techniques (including oil immersion) and spectrophotometry to identify, separate and draw conclusions about biological molecules.

4.8 Demonstrate using antibody specificity for antigens to test for the presence of protein (e.g., ELISA) (Western Blot and antibody staining removed as they are covered in the Applications course).

**HS-EB-5**

**Compare and contrast common organisms used in biotechnology and relate the manipulation of living organisms to product and procedure development.**

5.1 Distinguish between prokaryotic cells, eukaryotic cells, and non-living entities, such as viruses and how they may be used as vectors.

5.2 Describe the characteristics and life cycles of model organisms used in biotechnology, including bacteria (e.g., E. coli and insulin), fungi (e.g., yeasts and Aspergillus), and animals (e.g., C. elegans, fruit flies, and rodents).

5.3 Monitor how environmental factors affect the growth of cells and model organisms in the laboratory.

5.4 Prepare growth mediums and explore techniques used to culture prokaryotic cells in a biotechnology lab. 5.5 Discuss bacterial growth rates and explore optimal times to harvest colonies.

5.6 Apply the basic concepts of cell growth to manipulate cultures under aseptic conditions in the laboratory and demonstrate proficiency in prokaryotic gram staining, streaking culture plates and stock bacterial cultures. 5.7 Explore Koch’s Postulates and other techniques to isolate and identify pathogenic versus non- pathogenic organisms.

5.8 Identify bacteria using morphology and metabolic analysis.

**HS-EB-6**

**Identify the basis for biotechnology products and how such products affect the quality of life.**

6.1 Explore the fundamentals of molecular biology, the structure of DNA and the central dogma of biology, including transcription, translation, and gene expression.

6.2 Describe the major scientific discoveries that lead to the development of recombinant DNA technology, including those in the fields of biology, chemistry, genetics, and microbiology.

6.3 Identify past and current discoveries and developments in fields such as agriculture, diagnostics, medical devices, pharmaceuticals, and research and development.

6.4 Discuss the implications of genomics on biotechnology, society, and healthcare.

6.5 Perform DNA isolation techniques and discuss recombinant genetics, gene splicing, genetic engineering, and genetically modified organisms.

6.6 Explain how the advances in DNA technology are used today in various fields or industries.

6.7 Perform DNA Fragmentation using restriction enzymes and DNA Fingerprinting using gel electrophoresis to compare genetic profiles. Show competence loading agarose gels and running a gel electrophoresis unit.

6.8 Describe investigational new drugs (INDs) and the future of genomics and proteomics using CRISPR/Cas9 and other recent techniques.

6.9 Introduce the basic concepts of mammalian cell research, gene therapy and “bespoke” therapies showing promise for customized and personalized therapeutics.

**HS-EB-7**

**Analyze economic, social, ethical, and legal issues related to the use of biotechnology.**

7.1 Differentiate between moral, ethical, and legal biotechnology issues.

7.2 Research ethical issues presented by evolving science, including genetically modified foods, cloning, bioterrorism, gene therapy, and stem cells.

7.3 Compare and contrast attitudes about the use of biotechnology regionally, nationally, and internationally.

7.4 Evaluate the regulatory policies impacting biotechnology research (e.g., use of animals in research and applications of recombinant DNA).

**HS-EB-8**

**Explore how related student organizations are integral parts of career and technology education courses through leadership development, school, and community service projects, entrepreneurship development, and competitive events.**

8.1 Research the history of the state supported healthcare science CTSO (Career Technical Student Organization).

8.2 Discuss the mission, purpose, motto, colors, official dress, and other distinguishing characteristics of the state supported healthcare science CTSO.

8.3 Explain how participation in the state supported healthcare science CTSO can promote lifelong responsibility for community service and professional growth and development.

8.4 Create a personal leadership plan to participate in programs, conferences, community service and competitive events on the local, state, and national level that align with the competencies, skills, and knowledge of this course