

TRUMBULL PUBLIC SCHOOLS
Trumbull, Connecticut

ECE Biotechnology
Grade 11
Agriscience Department
Trumbull High School

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Curriculum Writing Team

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The Trumbull Board of Education will continue to take Affirmative Action to ensure that no persons are discriminated against in its employment.

CORE VALUES AND BELIEFS

The Trumbull School Community engages in an environment conducive to learning which believes that all students will **read** and **write effectively**, therefore communicating in an articulate and coherent manner. All students will participate in activities **that present problem-solving through critical thinking**. Students will use technology as a tool applying it to decision making. We believe that by fostering self-confidence, self-directed and student-centered activities, we will promote **independent thinkers and learners**. We believe **ethical conduct** to be paramount in sustaining the welcoming school climate that we presently enjoy.

INTRODUCTION

ECE Biotechnology UCONN SPSS3230– Science, Impact and Perception is designed for the student who has successfully completed Agriscience 9 and Agriscience 10 coursework in introductory biotechnology.

Biotechnology: Science, Application, Impact, Perception introduces the scientific, legal, and ethical aspects of Biotechnology application in agriculture, health medicine, forensics and the environment. The course introduces basic concepts in molecular biology as they apply to biotechnology and also introduces the techniques of biotechnology, including gel electrophoresis, PCR, ELISA plasmid insertion, gel column chromatography and thin layer chromatography. This course will provide the student with an excellent understanding of the science involved in the biotechnology revolution in molecular biology and the political implications of these developments so that the student will be able to make educated decisions regarding the future of the evolution of this technology. This course will be taught through the fall and spring semester.

Students also complete “supervised agricultural experience” (SAE) projects, which help to reinforce career options and skills introduced in the classroom. Involvement in the chapter’s FFA activities reinforces personal growth, premier leadership, and career success while being involved in the local community.

PHILOSOPHY

Success in Agriscience depends upon active involvement in the Three Circle Model of Agricultural Education, including classroom learning experiences, participation in the student organization FFA, and student Supervised Agricultural Experience projects. All areas aim to improve leadership, technical knowledge and skills hands-on, responsibility and accountability, and career readiness for the ever-changing future.

COURSE GOALS

Information, Media And Technology Skills

- Use real-world digital and other research tools to access, evaluate and effectively apply information appropriate for authentic tasks.

Learning and Innovation Skills

- Work independently and collaboratively to solve problems and accomplish goals
- Communicate information clearly and effectively using a variety of tools/media in varied contexts for a variety of purposes.
- Demonstrate innovation, flexibility and adaptability in thinking patterns, work habits, and working/learning conditions.
- Effectively apply the analysis, synthesis, and evaluative processes that enable productive problem solving.

Life and Career Skills

- Value and demonstrate personal responsibility, character, cultural understanding, and ethical behavior.
- Develop appreciation for and relationships with biotechnology research practices.
- Develop responsible management, leadership, and record keeping skills that improve our good laboratory practices.
- Develop and maintain interpersonal relationships through leadership and cooperative activities.

COURSE ENDURING UNDERSTANDINGS

Students will understand and appreciate how agriculture, food, fiber, and biofuels are impacted by modern biotechnology and develop an awareness of the role that Biotechnology science and practices have in production agriculture and human/animal health. Students will develop an understanding of the biotechnology curriculum topics, learn how to conduct molecular biology experiments, compose college level laboratory reports on the research conducted, learn how to write a scientific referee journal publication.

COURSE ESSENTIAL QUESTIONS

- How does agricultural biotechnology impact me and my community?
- What types of biotechnological processes are utilized in American agriculture and for what reasons?
- How can we provide the best care for plants and animals using today's biotechnology advances?
- What career options exist in the field of biotechnology?

COURSE KNOWLEDGE & SKILLS

Students will understand . . .

- the basic principles of modern biotechnology
- the history of the evolution biotechnological advances over time and their benefits to civilization
- how the utilization of molecular biology principles have created advancements in plant and animal breeding that have led to modern transgenic technological applications for plants and animals that have significantly increased levels of global agricultural production.
- how major diseases are diagnosed, treated by using biotechnological applications
- how molecular genetics/genomics discoveries have incorporated genome sequencing, bioinformatics, disease detection and gene modification processes into plant animal and human health.
- How changes in US patent law have enabled commercialization of biotechnological discoveries and led to the biotech revolution that we are experiencing in food production and medicine.
- career opportunities in biotechnology related fields.

Students will be able to . . .

- gain experience in utilizing key laboratory technologies in biotechnology
- understand the current state of US crop production and livestock industries and the positive impact that the science of biotechnology has had in the growth of these market segments
- describe the major concepts of modern biotechnology, including: genome sequencing, transgenic genetic modification using transgenic and CRISPR technologies.
- understand the concept of physiological resistance in disease control and the role that biotechnology plays in recent discoveries in this field
- describe the concepts of utilizing embryonic and induced pluripotent stem cells and how they are used in regenerative medicine for animals and humans.
- design college level biotechnological research protocols and implement them in conducted research
- understand the impact of the informational crisis that exists in the general public regarding the applications of biotechnological advances
- understand the regulatory processes that are in place at federal agencies such as the FDA, USDA, and EPA to insure the safety of agricultural products produced from transgenic organisms.

COURSE SYLLABUS

Unit 1: Introduction to and history of Biotechnology

Unit 2: Biotechnology Laboratory Practices

Unit 3: Cell Biology, Nucleic Acids, and Gene Expression

Unit 4: Microbial Biotechnology

Unit 5: Plant Biotechnology and Food Production

Unit 6: Biofuels

Unit 7: Animal Biotechnology

Unit 8: Stem Cells and Their Biotech Applications

Unit 9: Computational Biology and Bioinformatics

Unit 10: Biotechnology and Cancer

Unit 11: Public Perceptions, Concerns and Government Regulation

Unit 12: Patent Issues in Biotechnology

Unit 13: Careers in Biotechnology

Unit 1: Introduction to and History of Biotechnology

Performance Standards

- The student will demonstrate competence in the application of scientific principles and practices to the science of biotechnology.
- **BS.01 NCAE Standard:** Assess factors that have influenced the evolution of biotechnology in agriculture.
- **BS.01.01. Performance Indicator:** Investigate and explain the relationship between past, current, and emerging applications of biotechnology in agriculture.
- **BS.01.01.01.b.** Analyze the developmental progression of biotechnology and the evolution of scientific knowledge.
- **BS.01.01.03.a.** Distinguish between current and emerging applications of biotechnology in agriculture.

Essential Questions

- What are the basic tenets that are found in all biotechnological discoveries?
- How can we differentiate between biotechnological discoveries from the ancient, classical, and modern eras of biotechnology?
- How did the discovery of ‘Transformation Principle’ and the confirmation of DNA as the molecule of heredity focus the process of the understanding of genetics?
- How did the discovery of the structure of the DNA molecule enable scientists to understand the process of protein synthesis?
- How did the technology of plasmid modification enable the creation of transgenic organisms?

Content (Scope and Sequence)

- Definition of the Term Biotechnology.
- Examples of Modern Biotechnology in our lives.
- History of plant and animal domestication.
- Worldwide parallel invention of domestication.
- Centers of domestication worldwide and the crops/animals associated with each center.
- Collection of germplasm worldwide and the archiving of these materials.
- Important discoveries from ancient biotechnology.
- Important discoveries from classical biotechnology.
- Important discoveries from modern biotechnology.
- The molecular/transgenic revolution and its impact on modern biotechnology.
- Customer/client relationships in biotechnology and their impact on public education to biotechnology principles.

Assured Experiences

- In class essays on selected topics from the Unit.
- In class exam.

Time Allocation

Approximately 3 Weeks

Unit 2: Biotechnology Laboratory Practices**Performance Standards**

- The student will demonstrate understanding and competence in the preparation for and conduct of experiments in the biotechnology research and development environment. Two laboratory projects will be conducted during each quarter of instruction.
- **BS.02. NCAE Standard:** Demonstrate proficiency by safely applying appropriate laboratory skills to complete tasks in a biotechnology laboratory environment
- **CCTC Standard HL-BRD.3:** Demonstrate basic knowledge of recombinant DNA, genetic engineering, bioprocessing, monoclonal antibody applications, bioinformatics, proteomics and transcriptomics to conduct biotechnology research and development.
- **CCTC Standard HL.BRD.4:** Demonstrate the principles of solution preparation, sterile techniques, contamination control, and measurement and calibration of instruments used in biotechnology research.

Essential Questions

- How do we prepare for the running of an experiment in the biotechnology laboratory?
- How can we best utilize record-keeping skills to conduct experiments and collect data in the laboratory?
- How can we implement safe handling and management practices of materials in our laboratory?

Content (Scope and Sequence)

- Establish cooperative laboratory teams who will conduct experiments throughout the school year.
- Take a tour of the biotechnology laboratory to gain exposure to the scientific equipment in the laboratory.
- Learn safe laboratory procedures.
- Achieve mastery of utilization of laboratory equipment such as micropipetter, gel electrophoresis, PCR Thermocycler, gel column chromatography, and laminar flow hoods.

Assured Experiences

- Eight laboratory activities that involve different technologies utilized in biotechnology. Two of these are conducted during each quarter.
- Hands on utilization of laboratory technologies.
- Learning how to write laboratory reports for college level science classes.

Time Allocation

Approximately 8 weeks

Unit 3: Cell Biology, Nucleic Acids, and Gene Expression

Performance Standards

- **BS.03. NCAE Standard:** Demonstrate the application of biotechnology to solve problems in agriculture, food, and natural resources systems.
- **BS.03.01 Performance Indicator:** Apply biotechnology principles, techniques, and processes to create transgenic species through genetic engineering.
- **BS.02.05.01.b.** Characterize the physical and biological properties of organisms.
- **BS.02.05.02.a.** Compare and contrast the structures of DNA and RNA and investigate how genotype influences phenotype.
- **BS.02.05.02.b.** Analyze and interpret the molecular basis for heredity and the tools and techniques used in DNA and RNA manipulations.
- **BS.02.05.02.c.** Evaluate factors that influence gene expression.

Essential Questions

- How did the discovery of the structure of DNA molecules lead to the understanding of the protein synthesis process?
- How did transgenic technology impact the ability modify phenotypes in agricultural plant and animal species?

Content (Scope and Sequence)

- Variation in life forms on earth.
- Explanation of endosymbiosis.
- Comparison of prokaryotes and eukaryotes.
- Understanding of function of nuclear and plastid genomes.
- Understanding the structure and function of chloroplasts.
- Structure and functions of DNA and RNA.
- Role of viruses in function of life forms.

Assured Experiences (Projects)

- Exam on material from Unit 3.
- Essays on protein synthesis and bacteriophage activity in regulating bacterial populations.

Time Allocation

Approximately 3 weeks

Unit 4: Microbial Biotechnology

Performance Standards

- **BS.03.02. Performance Indicator:** Apply biotechnology principles, techniques and processes to enhance the production of food and medicinal biotechnology products through the use of microorganisms and enzymes.
- **BS.03.02.01.a** Summarize reasons for detecting microbes and identifying sources of microbes.
- **BS.03.02.02.b.** Analyze processes by which enzymes are produced through biotechnology.
- **BS.03.02.03.a.** Identify and categorize foods produced through the use of biotechnology to change the chemical properties of food for an intended purpose.
- **BS.03.02.03.c.** Process food using biotechnology to achieve an intended purpose.
- **BS.03.05.03.a.** Research and explain the process of fermentation and its potential applications.

Essential Questions

- How is transcription regulated in prokaryotes and eukaryotes?
- How do operons function?
- What is the function of exons and introns and activity of the spliceosome in modifying mRNA in eukaryotes.
- How does the structure of amino acid R groups influence protein folding and activity?
- What is the catalytic activity of enzymes?
- How have restriction enzymes and plasmids revolutionized DNA cloning and protein production via microbial fermentation?

Content (Scope and Sequence)

- Review of terminology: Trait, gene, allele, genome, chromosome, transcription, translation, operon, spliceosome, protein folding, restriction enzyme, plasmid cloning, vector, gene insertion, genotype vs. phenotype, dominant and recessive, homozygous and heterozygous.
- Qualitative and quantitative traits in molecular biotechnology.
 - Cloning vector creation and applications.
 - Importance of promoter sequence characteristics in protein production.
 - Impact of specific codon distribution translation efficiency.
- Understanding the strengths and weaknesses of genome sequencing technologies.
- Characteristics of cloning vectors and their specific applications.
- Theory of polymerase Chain Reaction and the quantitative and qualitative uses of PCR.
- Separating and visualizing restriction fragments.
- Understanding the process of plasmid vector transformation.
- Importance of antibiotic resistance gene use in marker assisted selection.
- Characteristics of restriction enzymes.

Assured Experiences (Projects)

- Essay assignments on transgenics, gene insertion, and gene cloning.
- Exam on unit material.
- Trait heritability analysis.

Time Allocation

Approximately 2 weeks

Unit 5: Plant Biotechnology and Food Production

Performance Standards

- **NCAE Standard – BS.03:** Demonstrate the application of biotechnology to solve problems in Agriculture, Food and Natural Resources.
- **BS.03.04. Performance Indicator:** Apply biotechnology principles, techniques and processes to enhance plant and animal care and production.
- **BS.03.04.01.a.** Research and describe the aims and techniques involved in the selective plant breeding process.
- **BS.03.04.02.a.** Examine and classify biotechnology processes applicable to plant health.
- **BS.03.04.02.b.** Assess the benefits, risks, and opportunities associated with using biotechnology to promote plant health and crop production.
- **BS.03.04.03.a.** Research and categorize the types of pharmaceuticals developed from plants for humans and animals from biotechnology.
- **BS.03.04.03.c.** Evaluate the processes used to produce pharmaceuticals from transgenic organisms.

Essential Questions

- What are the principles used in plant biotechnology?
- What are the achievements and significance of plant biotechnology to modern plant production?
- What is the significance of the Green Revolution in the ability of the world's farmers to produce the yields needed to feed today's human population?
- What are the differences between input and output traits in transgenic gene insertion?
- How do modern molecular biological technologies increase efficiency in crop production?
- What are the benefits of transgenic plant breeding vs. traditional plant breeding methods?

Content (Scope and Sequence)

- Diversity in phenotypes and products that are obtained from agronomic crops.
- The processes involved in traditional plant breeding.
- History of crop modifications that have arose through plant breeding.
- The emergence of scientific plant breeding
- Benefits derived from the utilization of hybrid seed production in maize and other crops.

- Mutational selection strategies to develop new plant varieties and species.
- Processes that are involved in transgenic gene insertion into plants.
- Comparison of the benefits and drawbacks found in traditional plant breeding, mutation/selection plant breeding and biotechnology based plant breeding.
- Reproductive timelines for horses, cattle, and sheep
- Benefits and application of marker assisted selection strategies.
- Applications of Genome Wide Association Systems in plant breeding.

Assured Experiences (Projects)

- Exam on unit material.
- In class essay assignments that deal with pertinent topics from the unit.

Time Allocation

Approximately 3 weeks

Unit 6: Biofuels

Performance Standards

- **BS.03.05. Performance Indicator:** Apply biotechnology principles, techniques, and processes to produce biofuels.
- **BS.03.05.01.b.** Analyze the impact of the production and use of biofuels on the environment.
- **BS.03.05.02.b.** Assess the characteristics of biomass that make it useful for biofuels production.
- **BS.03.05.04.b.** Analyze and document the process used to produce biodiesel from biomass.

Essential Questions

- How are ethanol and biodiesel produced from plant materials?
- What emerging technologies from biotechnology are being used to improve the efficiency and reduce the carbon footprint of biofuel production.

Content (Scope and Sequence)

- Discuss the issue of maintaining a dependency on the use of fossil fuels.
- Examine the processes by which ethanol and biodiesel are created from plant materials.
- Evaluation of plant species as potential crops for utilization in ethanol and biodiesel production.
- Examine the opportunity for transgenic algae to be used as efficient biodiesel production organisms.
- Evaluate technologies utilizing transgenic plant proteins that will improve the efficiency of ethanol production.
- Discuss the impact of oil prices on the cost efficiency of ethanol production processes.

Assured Experiences (Projects)

- Evaluation in unit exam.
- Essay assignment on global biofuel production.

Time Allocation

Approximately 2 weeks

Unit 7: Animal Biotechnology

Performance Standards

- **BS.03.04. Performance Indicator:** Apply biotechnology principles, techniques and processes to enhance plant and animal care and production.
- **BS.03.04.02.a.** Examine and classify biotechnology processes applicable to animal health.
- **BS.03.04.03.a.** Research and categorize types of pharmaceuticals developed for animals and humans through biotechnology.

Essential Questions

- What is animal Biotechnology?
- Identify and describe examples of animal biotechnology.
- Describe genetic methods used to improve animal growth: artificial insemination, superovulation, and embryo transfer.
- How are transgenics technologies used to produce animal lines with superior characteristics for food production and research purposes?

Content (Scope and Sequence)

- Examples of animal products and services.
- Examples of animal biotechnology: selective breeding, transgenics, somatic cell nuclear transfer, therapeutic proteins, stem cell therapy/gene therapy.
- Genetic improvements that are used to improve growth.
- Factors influenced by genetic selection.
- Myostatin blocking single allele mutation for promoting double muscling.
- Process and benefits of artificial insemination.
- Justification for the use of superovulation and surrogate mothers in cattle production.
- Transgenics using either microinjection or stem cell modification.
- Benefits of creating transgenic animals: superior foundation genetics, xenotransplantation donors, research lines with specific genetics (onco-mouse), pharmaceuticals production, specialty fiber production, stem cell therapy for injured equines, Enviropig.

Assured Experiences (Projects)

- Exam on material in unit
- Essay contrasting positions pro and con for animal transgenics.

Time Allocation

Approximately 2 weeks

Unit 8: Stem Cells and Their Biotech Applications**Performance Standards**

- **BS.01.03. Performance Indicator:** Analyze the relationship and implications of bioethics, laws, and public perceptions of biotechnology in agriculture.
- **BS.03.01.03.c.** Transform plant or animal cells by performing Cellular transformation
- **BS.03.01.03.b.** Research and evaluate genetic engineering procedures used in the production of living species.

Essential Questions

- What are the ethical issues involving embryonic stem cell use in research?
- How does the creation of induced pluripotent stem cells address the concerns raised by the utilization of embryonic stem cells in research?
- What are the potential medical applications of iPSCs?

Content (Scope and Sequence)

- History of Embryonic Stem Cell research.
- Discovery of the process of focused adult stem regression by the use of selected transcription factor proteins.
- Technology involved in the creation of iPSCs.
- Creation of chimeric animals using iPSC technology.
- Medical potential of iPSCs in regenerative medicine: neurological diseases, Spinal chord injuries, Alzheimer’s disease mitigation.

Assured Experiences (Projects)

- Exam section on unit
- Essay dealing with the ethical issues involved in Embryonic Stem Cell use in research.

Time Allocation

Approximately 2 weeks

Unit 9: Computational Biology and Bioinformatics**Performance Standards**

- **BS.02.01.03.a.** Research and summarize the need for data and information security in a laboratory and demonstrate best practices.
- **BS.02.01.03.a.** Evaluate the role of bioinformatics in agriculture and summarize the types of databases that are available.

- BS.02.01.03.a. Critique an application of bioinformatics to solve an agricultural issue and recommend procedures for keeping the information safe.

Essential Questions

- How has the evolution of supercomputers and computational systems advanced the ability to analyze immense data sets in genomic sequencing?
- What is bioinformatics and how does this field expand the data analysis capability of biotechnologists?
- How has systems biology expanded the relationships between genome segments in different species?
- How does reaction directionality assist in understanding the flow of energy in cell physiological systems?
- How can computational biotechnology identify metabolic pathways not currently inferable from genome annotation?

Content (Scope and Sequence)

- The history of the use of supercomputers in the analysis of scientific data in molecular biotechnology.
- Investigation of the example of bioinformatics' role in the human genome project.
- Understanding of the processes of systems biology and how this technology helps identify conserved systems across biomes and across cell systems.
- Explanation of the GWAS (genome wide analysis systems) concept for detecting conserved systems among organisms.

Assured Experiences (Projects)

- Exam on the material in the unit
- Class essay on the impact of computational biology on the success of the human genome project and subsequent advances in genome sequencing technology.

Time Allocation

Approximately 2 weeks.

Unit 10: Biotechnology and Cancer

Performance Standards

- **BS.03.NCAE Standard:** Demonstrate the application of biotechnology to solve problems in Agriculture, Food and Natural Resource systems.

Essential Questions

- What is cancer?
- Why do large animals not get cancer?
- How is biotechnology used to characterize cancers?
- How is biotechnology used to create effective treatments.

Content (Scope and Sequence)

- The importance of mutations in somatic cells.
- The differences between malignant and benign tumors.

- Which genes affect cancer.
- The normal roles of protooncogenes in healthy tissues.
- Process of the creation of an oncogene.
- Importance of the loss of contact inhibition.
- The roles of protein kinases in cell division.
- Tumor suppressor genes/antioncogenes.
- Stages of the cell cycle and their impact on cancerous cell growth.
- The impact of the p53 oncogene on tumor development.
- Stages of tumor formation.
- Inherited susceptibility to cancer.
- Role of nutrition in cancer growth.
- History of chemotherapy.
- Theory of antiangiogenesis.
- Use of biotechnology to characterize individual cancers.
- Use of biotechnology to create targeted anticancer therapeutics.
- Novel therapies (sound, ultrasound, oxygen therapy) for use in cancer control.

Assured Experiences (Projects)

- Exam on the topics in this unit.
- Essay on the history of antiangiogenesis modalities for cancer treatment.

Time Allocation

Approximately 3 weeks

Unit 11: Public Perceptions, Concerns and Government Regulation

Performance Standards

- **BS.01.03 Performance Indicator:** Analyze the relationship and implications of bioethics, laws and public perceptions on applications of biotechnology in agriculture (e.g., legal, social and cultural issues).
- **BS.010301.b.** Analyze the implications bioethics may have on future advancements in AFNR.
- **BS.01.03.03.b.** Analyze the impact of public perceptions on the application of biotechnology in different AFNR systems.
- **BS.01.03.01.c.** Devise and support an argument for or against an ethical issue associated with biotechnology in agriculture.

Essential Questions

- What is the public perception of GMOs?
- How does information from partisan groups that are against GMOs impact public perceptions of this technology?
- What are the benefits that have been derived from having 180 million acres of transgenic crops in the US?

- What are the perceived risks and concerns to human health from the use of transgenic technology in agriculture?
- What are the tangible benefits to humans and the environment from the adoption of transgenic technology in world agriculture?
- What are the legal and scientific safeguards that have been put in place by governmental agencies in the US to insure the safe use of biotechnology in agricultural production?

Content (Scope and Sequence)

- History of modern agriculture.
- Importance of mechanization of farm tasks.
- The development of scientific plant breeding in the late 19th century.
- The adoption of hybrid seed corn technology in the 1930s.
- The increases in crop yield due to the use of commercial fertilizers.
- Creation of ‘Green Revolution’ plant varieties and their massive impact on rice and wheat yields throughout the world.
- Commercial application of GMO technology in agricultural production in the late twentieth century.
- The environmental benefits derived from the reduction in pesticide usage because of adoption of transgenic crop production strategies.
- The actions of special interest group in opposition to transgenic technology adoption in agriculture.
- Comparison between plant breeding strategies that utilize traditional plant breeding techniques and transgenics technologies.
- The application and relevance of mutagenesis strategies for plant breeding.
- Understanding the regulatory process that evaluates and regulates the utilization of transgenic technologies in US agriculture.

Assured Experiences (Projects)

- Essays on the application of Transgenic technologies in agriculture.
- In class presentation on the science of transgenic applications in agriculture.
- Exam on the material presented in the unit.

Time Allocation

Approximately 3 weeks

Unit 12: Patent Issues in Biotechnology

Performance Standards

- **BS.01.01.03.a.** Distinguish between current and emerging applications of biotechnology in agriculture.
- **BS.01.02.01.a.** Compare and contrast differences between regulatory systems worldwide.
- **BS.01.02.03.b.** Research and summarize factors and data that regulatory agencies use to evaluate the potential risks a new application of biotechnology may pose to health, safety and the environment.

- **BS.03.04.03.a.** Research and categorize the types of pharmaceuticals developed for animals and humans through biotechnology.

Essential Questions

- What is a patent?
- What are the components of a patent?
- What are the advantages of obtaining a patent for an invention?
- How did the Bayh-Dole act change the opportunities for biotechnology inventions?

Content (Scope and Sequence)

- Definition of a US Patent.
- History of Patent Law in the US.
- The components of a patent.
- The criteria for patentability of an invention.
- The three types of patents.
- The benefits of obtaining a patent.
- Patents and the birth of the biotech industry.
- Significance of the Diamond vs. Chakrabarty decision.
- The benefits of the Bayh-Dole Act for commercialization of scientific discoveries.
- Biotech development timelines.
- Costs of developing a biotech discovery.
- The national importance of a thriving biotech industry.
- The importance of biotechnology discovery applications to US Agriculture.

Assured Experiences (Projects)

- Essay on the process of patent preparation and submission.
- In class presentation on a patented technology in AG Biotech.
- Exam on the material in this unit.

Time Allocation

Approximately 2 weeks

Unit 13: Careers in Biotechnology

Performance Standards

- BS.03.01 Performance Indicator: Apply biotechnology principles, techniques, and processes to create transgenic species through genetic engineering.
- CRP.10.01. Identify career opportunities within a career cluster that match personal interests, talents, goals and preferences.
- CRP.10.02. Performance Indicator: Examine career advancement requirements (e.g., education, certification, training, etc.) and create goals for continuous growth in a chosen career.
- CRP.10.04. Performance Indicator: Identify, prepare, update and improve the tools and skills necessary to pursue a chosen career path.

Essential Questions

- What are the three main career paths for biotechnologists?
- What are the educational requirements for attaining a successful career in biotech?
- What are the basic steps to finding the right career?
- What are the compensation levels for careers in biotechnology?
- What are the different career opportunities in biotechnology?

Content (Scope and Sequence)

- The basic steps in finding a biotechnology career.
- The career clusters found in biotechnology.
- Compensation levels in biotechnology.
- Academic requirements for various biotech careers.
- Advantages/disadvantages of a biotech career in industry, academia or government agency.
- How to find job openings in the field.
- Navigation of professional organization websites.
- Interviewing skills.
- Contract negotiating strategies.

Assured Experiences (Projects)

- Oral presentation on biotechnology career.
- Exam on unit topics.

Time Allocation

Approximately 1 week

Culminating Activity

Midterm and Final Exams

The midterm and final exams are worth 10% each of the student's Trumbull High School course grade at the end of each year. Students will take midterm and final exams for each of the two years in the class.

Midterm and final exam grades are included in the "tests" portion of a student's ECE grade (60%).

COURSE CREDIT

This class meets for two class periods daily for one full year. Students earn two elective STEM credits.

Students are also able to register for ECE credits through the University of Connecticut for UCONN ECE SPSS3230 Biotechnology: Science, Impact and Perceptions

PREREQUISITES

Completion of Agriscience 9 and Agriscience 10 freshman and sophomore AG Biotechnology coursework.

TEXTS

Molecular Biology Made Simple and Fun, Clark and Russell, third edition, 2005, Cache River Press

SUPPLEMENTARY MATERIALS/RESOURCES/TECHNOLOGY

Biotechnology Lessons from the University of Nebraska at Lincoln Plant and Soil Sciences eLibrary

CURRENT REFERENCES

National Agriculture, Food and Natural Resources (AFNR) Career Cluster Content Standards

ASSURED STUDENT PERFORMANCE RUBRICS

- Trumbull High School School-Wide Writing Rubric
- Trumbull High School School-Wide Problem-Solving Rubric
- Trumbull High School School-Wide Independent Learning and Thinking Rubric

Rubric 2: Write Effectively

Category/ Weight	Exemplary 4 Student work:	Goal 3 Student work:	Working Toward Goal 2 Student work:	Needs Support 1-0 Student work:
Purpose X_____	<ul style="list-style-type: none"> Establishes and maintains a clear purpose Demonstrates an insightful understanding of audience and task 	<ul style="list-style-type: none"> Establishes and maintains a purpose Demonstrates an accurate awareness of audience and task 	<ul style="list-style-type: none"> Establishes a purpose Demonstrates an awareness of audience and task 	<ul style="list-style-type: none"> Does not establish a clear purpose Demonstrates limited/no awareness of audience and task
Organization X_____	<ul style="list-style-type: none"> Reflects sophisticated organization throughout Demonstrates logical progression of ideas Maintains a clear focus Utilizes effective transitions 	<ul style="list-style-type: none"> Reflects organization throughout Demonstrates logical progression of ideas Maintains a focus Utilizes transitions 	<ul style="list-style-type: none"> Reflects some organization throughout Demonstrates logical progression of ideas at times Maintains a vague focus May utilize some ineffective transitions 	<ul style="list-style-type: none"> Reflects little/no organization Lacks logical progression of ideas Maintains little/no focus Utilizes ineffective or no transitions
Content X_____	<ul style="list-style-type: none"> Is accurate, explicit, and vivid Exhibits ideas that are highly developed and enhanced by specific details and examples 	<ul style="list-style-type: none"> Is accurate and relevant Exhibits ideas that are developed and supported by details and examples 	<ul style="list-style-type: none"> May contain some inaccuracies Exhibits ideas that are partially supported by details and examples 	<ul style="list-style-type: none"> Is inaccurate and unclear Exhibits limited/no ideas supported by specific details and examples
Use of Language X_____	<ul style="list-style-type: none"> Demonstrates excellent use of language Demonstrates a highly effective use of standard writing that enhances communication Contains few or no errors. Errors do not detract from meaning 	<ul style="list-style-type: none"> Demonstrates competent use of language Demonstrates effective use of standard writing conventions Contains few errors. Most errors do not detract from meaning 	<ul style="list-style-type: none"> Demonstrates use of language Demonstrates use of standard writing conventions Contains errors that detract from meaning 	<ul style="list-style-type: none"> Demonstrates limited competency in use of language Demonstrates limited use of standard writing conventions Contains errors that make it difficult to determine meaning

Rubric 3: Problem Solving through Critical Thinking

Category/Weight	Exemplary 4	Goal 3	Working Toward Goal 2	Needs Support 1-0
Understanding X_____	Student demonstrates clear understanding of the problem and the complexities of the task	Student demonstrates sufficient understanding of the problem and most of the complexities of the task	Student demonstrates some understanding of the problem but requires assistance to complete the task	Student demonstrates limited or no understanding of the fundamental problem after assistance with the task
Research X_____	Student gathers compelling information from multiple sources including digital, print, and interpersonal	Student gathers sufficient information from multiple sources including digital, print, and interpersonal	Student gathers some information from few sources including digital, print, and interpersonal	Student gathers limited or no information
Reasoning and Strategies X_____	Student demonstrates strong critical thinking skills to develop a comprehensive plan integrating multiple strategies	Student demonstrates sufficient critical thinking skills to develop a cohesive plan integrating strategies	Student demonstrates some critical thinking skills to develop a plan integrating some strategies	Student demonstrates limited or no critical thinking skills and no plan
Final Product and/or Presentation X_____	Solution shows deep understanding of the problem and its components. Solution shows extensive use of 21st Century Technology Skills.	Solution shows sufficient understanding of the problem and its components. Solution shows sufficient use of 21st Century Technology Skills.	Solution shows some understanding of the problem and its components. Solution shows some use of 21st Century Technology Skills.	Solution shows limited or no understanding of the problem and its components. Solution shows limited or no use of 21st Century Technology Skills.

Rubric 5: Independent Learners And Thinkers

Category/Weight	Exemplary 4	Goal 3	Working Toward Goal 2	Needs Support 1-0
Proposal X_____	Student demonstrates a strong sense of initiative by generating compelling questions, creating uniquely original projects/work.	Student demonstrates initiative by generating appropriate questions, creating original projects/work.	Student demonstrates some initiative by generating questions, creating appropriate projects/work.	Student demonstrates limited or no initiative by generating few questions and creating projects/work.
Independent Research & Development X_____	Student is analytical, insightful, and works independently to reach a solution.	Student is analytical, and works productively to reach a solution.	Student reaches a solution with direction.	Student is unable to reach a solution without consistent assistance.
Presentation of Finished Product X_____	Presentation shows compelling evidence of an independent learner and thinker. Solution shows deep understanding of the problem and its components. Solution shows extensive and appropriate application of 21-Century Skills.	Presentation shows clear evidence of an independent learner and thinker. Solution shows adequate understanding of the problem and its components. Solution shows adequate application of 21-Century Skills.	Presentation shows some evidence of an independent learner and thinker. Solution shows some understanding of the problem and its components. Solution shows some application of 21-Century Skills.	Presentation shows limited or no evidence of an independent learner and thinker. Solution shows limited or no understanding of the problem. Solution shows limited or no application of 21-Century Skills.