Washington Township School District

The mission of the Washington Township Public Schools *is to provide a safe, positive, and progressive educational environment that provides opportunity for all students to attain the knowledge and skills specified in the NJ Learning Standards at all grade levels, so as to ensure their full participation in an ever-changing world as responsible, self-directed and civic-minded citizen.*

Course Title:	**CP Biotechnology**
Grade Level(s):	**Grades 11-12**

Duration:	*Full Year:*	**X**	*Semester:*		*Marking Period:*	
Course Description:	Biotechnology is a vast scientific field that uses research tools from chemistry and biology to study or solve problems, including the improvement of human life. Common biotechnologies are used in medical, agricultural, industrial environmental, and research applications. This class includes an exploration of current topics and laboratory techniques in the field of biotechnology. Students will learn the basics needed to work in most entry-level biotechnology environments. Topics studied include: Bioethics; DNA and DNA technologies; genetic engineering; proteins and proteomic studies; biotechnology in medicine and the environment; and advanced topics in and future applications of biotechnology.					
Grading Procedures:	**Tests: 40%** **Quizzes: 10%** **Projects: 20%** **Laboratory Exercises: 20%** **Independent Work: 10%**					
Primary Resources:	**Textbook: Biotechnology; Science for the New Millennium by Ellyn Daugherty** **Online Resources: Mastering Anatomy and Physiology/Interactive Physiology at** www.masteringaandp.com **, Next Generation Science Standards at** www.nextgenscience.org/ **and New Jersey Student Learning Standards at** www.nextgenscience.org/					

Washington Township Principles for Effective Teaching and Learning

- Implementing a standards-based curriculum
- Facilitating a learner-centered environment
- Using academic target language and providing comprehensible instruction
- Adapting and using age-appropriate authentic materials
- Providing performance-based assessment experiences
- Infusing 21st century skills for College and Career Readiness in a global society

Designed by:	Mary Howard

Under the Direction of:	Dr. Patricia Hughes

Written: _____

Revised: _____

BOE Approval: _____

Unit Title: Careers in Biotechnology

Unit Description:

Biotechnology is a field that uses life forms or life processes to make a product or solve a problem. This is not novel to humankind. Yogurt, wine, cheese, sauerkraut, kimchee, and antibiotics are just a few examples of products made with the help of living things (microbes). The new world of biotechnology promises novel ways for treating and preventing disease, growing food, and many other applications. This unit gives students an idea of the many possible applications and career tracks in this new world field of study.

The basic concepts of this unit will be initially presented with introductory materials and revisited in subsequent units as appropriate.

Unit Duration: 1 Week Introduction and Ongoing

Desired Results

Standard(s):

- **Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants (HS-ETS1-1)**

Indicators:

ETS1.A: Defining and Delimiting Engineering Problems

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
- Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

Understandings:

Students will understand that …

- Biotechnology includes all the technical processes that have led to improvements in products and services, and in understanding organisms and their component parts
- Biotechnologists work in a variety of settings, including corporate labs, government agencies/labs, and academic (college and university) research facilities
- Agencies that regulate the development and approval of biotechnology products include the Food and Drug Administration (FDA) the United States Department of Agriculture (USDA) and the Environmental Protection Agency (EPA)
- Most jobs at a biotechnology company are in the following areas: research and development, manufacturing and production, clinical research, quality control, information systems, marketing and sales, regulatory affairs, and administration/legal affairs
- Many laboratory positions require a minimum of a 4-year degree. A scientific background is helpful for nonscientific employees as well

Essential Questions:

- What are the major categories of employment position within the biotechnology industry?
- What are the educational requirements for the primary positions within the biotechnology industry?
- What skills would be necessary for the various positions?
- What are the governmental agencies that regulate the biotechnology industry?
- How are careers in the academic, government and private sectors similar?
- How are careers in the academic, government and private sector different?

Assessment Evidence

Performance Tasks:

Students will be able to …

- Explore different careers and career pathways in Biotechnology
- Give examples of careers and job responsibilities associated with biotechnology.
- Recognize and/or define the following terminology related to careers and career pathways in biotechnology; National Institutes of Health (NIH), Centers for Disease Control and Prevention (CDC), pure science, applied science, research and development (R&D), pharmaceutical, biotechnology, efficacy, large-scale production, clinical trials, Food and Drug Administration (FDA), therapeutic, United States Department of Agriculture (USDA).
- Describe the educational requirements and responsibilities for various positions within the biotechnology industry
- Compare and contrast careers within academic, government, and private sectors
- Demonstrate understanding of the career development planning process and the process of life-long learning
- Create a presentation on a specific job in the field of biotechnology and its contribution to solving societal issues and problems

Other Evidence:

- Cornell Notes/Note Cards on unit reading materials
- Daily Assessments (informal)
  - Bell Work
  - Supplemental Reading
  - Whiteboard Activities
  - Writing Prompts
- Performance Assessments
  - Class Discussion
  - Online Activities
  - Research Journal
- Group Work
  - Career Project
  - Research

Benchmarks:

Career Research Project Presentation

Learning Plan

Learning Activities:

- Lecture Topics:
  - Biotechnology and Careers
- Textbook:
  - Daugherty, Chapter 1
  - The New Genetics, Chapter 5
- Laboratory Exercises:
- Other Activities:
  - Class Discussion: Biotech Careers
  - Biotechnology Careers Activity
  - Biotechnology Career Research E-Project
  - Online Activity: Finding ‘Hot Jobs’; Textbook page 26
- Ongoing Activities:
  - Review ‘Biotech Career’ sidebars that accompany each textbook chapter

Resources:

- Textbook: Biotechnology; Science for the New Millennium by Ellyn Daugherty Chapter1
- Online Resources: Biotechnology Institute at http://www.biotechinstitute.org; Career Pathways Biotechnology: http://www.dpi.state.nc.us/docs/cte/curriculum/clusters/bio-technology.pdf; NIH: The New Genetics: https://publications.nigms.nih.gov/thenewgenetics/chapter5.html
- Technology: Teacher 2 in 1 Device, Short Throw Projector, Student Laptops,
- Other Resources: PowerPoint Presentations (instructor created), supplemental readings and handouts (inclusive of current and emerging research related information) in conjunction with, but not limited to the following topics: biotechnology and careers in biotechnology

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Design a specific pathway within the biotechnology industry on what skills, education and areas of research is needed to solve a specified major global challenge
3.0	**Students will be able to:** • Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants • Identify several biotechnology industry careers that could address a specific global challenge or societal need
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, constraint, criteria, engineering, global challenge, measurable, need qualitative, quantitative, requirement, risk mitigation, societal, solution) • Identify a major global challenge that is addressed by the biotechnology industry • Summarize societal needs and wants related to the challenge or problem
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Develop a portfolio documenting education, experiences, and acquired skills for specific careers in the biotechnology industry • Demonstrate understanding of the career development planning process and the process of life-long learning
3.0	**Students will be able to:** • Compare and contrast careers within the biotechnology industry and address how they work together to solve global issues • Research and create a presentation on a specific career in the biotechnology industry
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, academic sector, associate's degree, bachelor's degree, biomanufacturing, biotechnician, diagnostics, forensic scientist, government, journal, lab assistant, PhD, private sector, professional behavior, quality control, regulatory affairs, research associate, research and development, scientist technician) • Describe the educational requirements and responsibilities for various positions within the biotechnology industry
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Structure the learning around explaining or solving a medical or anatomy field related issue.
Struggling Learners	• Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
English Language Learners (See http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf)	• Provide ELL students with multiple literacy strategies as needed; (for example, alternate response, advance notes, extended time, teacher modeling, simplification of written and verbal instruction, frequent breaks, eDictionaries).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504 Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Interdisciplinary Connections

Indicators:

- **Connections to HS-ETS1.A: Defining and Delimiting Engineering Problems**
  - Physical Science: HS-PS2-3, HS-PS3-3
- **Common Core State Standards Connections: ELA /Literacy**
  - RST .11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video , multimedia) in order to address a question or solve a problem.
  - RST .11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
  - RST .11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
- **Common Core State Standards Connections: Mathematics**
  - MP.2 Reason abstractly and quantitatively.
  - MP.4 Model with mathematics.

Integration of 21st Century Skills

Indicators:

- **Science and Engineering Practices:**
  - Analyzing and interpreting data
  - Asking questions and defining problems
  - Constructing explanations and designing solutions
  - Developing and Using Models
  - Engaging in argument from evidence
  - Obtaining, evaluating, and communicating information
  - Planning and carrying out investigations
  - Using mathematics and computational thinking
- **Crosscutting Concepts**
  - Patterns
  - Cause and Effect
  - Scale, proportion, and quantity
  - Systems and system models
  - Energy and matter: Flows, cycle, and conservation
  - Structure and function
  - Stability
- **Connections to Engineering, Technology and Applications of Science**
  - New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Unit Title: Bioethics

Unit Description:

This unit explores the ethical, moral, legal, and cultural issues related to the use of biotechnology research and product development. Lessons address such topics as the ethics of "invitro meat," fetal tissue transplantation, genetically modified organisms (GMOs) as intellectual property, privacy rights and alternative medicines. In addition, this unit will introduce stems cells, not only as an example of a current ‘ethical issue’ but also to discuss their use in biotechnology.

The basic concepts of this unit will be initially introduced with introductory materials and revisited in subsequent units as appropriate.

Unit Duration: 3 Weeks Instruction and Ongoing

Desired Results

Standard(s):

- **Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics. (HS-ETS1-3.)**
- **Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. (HS-LS1-4.)**

Indicators:

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts, as well as possible social, cultural, and environmental impacts.

LS1.B: Growth and Development of Organisms

In multicellular organisms, individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.

Understandings:

Students will understand that…

- The study of moral standards and how they apply to biotechnology and medicine is called bioethics
- Bioethical issues arise in many areas, including research, manufacturing, and product applications
- A good method of analyzing a bioethical issue or dilemma is to use the Strategy for Values Clarification model
- Stem cells are unspecialized cells that have not yet differentiated into cells with a specific function
- Embryonic stem cells are found only in a developing embryo and are naturally pluripotent
- Adult stem cells are found in tissues and organs of a person from the time it is a fetus through adulthood. Adult stems are programmed to make certain kinds of cells for replacement purposes
- The goal of regenerative medicine is to replace or restore damaged tissues or organs. Stem cell technology is an example of regenerative medicine

Essential Questions:

- What is the difference between morals and ethics?
- What is bioethics?
- What are the characteristics of an ethical question in biotechnology?
- What is a stem cell?
- What does the term pluripotent mean and how does it apply to stem cells?
- What are some of the roles of stem cells in regenerative medicine?
- What are the ethical issues involved in stem cell technology?

Assessment Evidence

Performance Tasks:

Students will be able to…

1. Cite specific examples of how and where biotechnology is used in medical, agricultural, environmental, and industrial applications as well as social or political situations, including criminal investigations, lawsuits, evolutionary studies, etc.
2. Illustrate examples of how biotechnology has led to benefits and risks to society and how biotechnical advances affects human lives on a personal level
3. Identify the rights, interests, and responsibilities of people involved in bioethical issues
4. Describe the need for and function of regulatory agencies such as those in government, industry, and society
5. Analyze policy-making procedures for products and techniques of biotechnology
6. Formulate opinions about engineered organisms and products based on current scientific evidence.
7. Understand the ethical, moral, legal, and cultural issues related to the use of biotechnology research and product development

Other Evidence:

- Cornell Notes/Note Cards on unit reading materials
- Daily Assessments (informal)
  - Bell Work
  - Supplemental Reading
  - Whiteboard Activities
  - Writing Prompts/Reflections
- Quiz: Bioethics
- Quiz: Stem Cells
- Performance Assessments
  - Class Discussion
  - Online Activities
  - Research Journal
- Laboratory Exercises:
  - Planaria Regeneration
- Group Work
  - Infomercial Activity
  - Stem Cells and Bioethics Case Studies

8. Research and discuss/debate the ethical, moral, legal, and cultural issues related to the use of biotechnology research and product development. 9. Investigate stem cell technologies and relate this technology to the study of biotechnology 10. Research the controversies of stem cell use in medicine and formulate an opinion about their use	

Benchmarks:

Writing Assessment: What Do You Think? Bioethics Essay

Infographic on Current Clinical Research Using Stem Cells

Learning Plan

Learning Activities:

<u>Introductory Bioethics</u>:

- Lecture Topics:
  - Introduction to Bioethics
  - What are Morals and Ethics
  - Evolution of Medical Research
- Textbook:
  - Daugherty, Chapter 1, pages 27-29
- Other Activities:
  - Ethics Jigsaw (associated with case study on Fanconi anemia)
  - Infomercial Activity (Government agencies and the roles they play in Medical Research)
- Videos:
  - Ethics of Genetic Testing
  - Trailer: My Sister's Keeper
  - Food, Inc.
  - NOVA: lab meat
  - Tuskegee Syphilis Experiment
- Case Studies:
  - Fanconi Anemia
- Common Reading Project Activities
- Current Event Assignment

<u>Stem Cells:</u>

- Lecture Topics:
  - What are Stem Cells?
  - What is a Stem Cell Niche?
  - Stem Cell Development
  - Techniques for Obtaining Stem Cells
  - Use of Stem Cell to Treat Disease
- Textbook:
  - Daugherty, Chapter 14, pages 449 to 450
- Laboratory Exercises:
  - Plenty of Planaria Regeneration Lab (www.nwabr.org)
- Other Activities:
  - Super Stem Cells
  - Go Go Stem Cells
  - Broken Heart Scenario
  - Seeds of Hope (PBS.org)
- Videos:
  - Stem Cell Basics
- Case Studies:
  - One Family's Dilemma
  - Should Human Embryos Be Used for Research? (Biotechnology: A Laboratory Skills Course, page 72)
- Common Reading Project Activities
- Current Event Assignment

Ongoing Topics:

- Waste Disposal (Implemented during Introduction to Basic Skills and Laboratory Safety Unit)
- Using Animals in Science and Science Industry (Implemented during Introduction to Biotechnology Unit)
- Who Own's DNA? (Implemented during DNA Structure and Function Unit)
- 23 and Me: What are Your Rights? (Implemented during DNA Structure and Function Unit)
- Personal Genetic Information (Implemented during Genetic Engineering Unit)
- A World Without Antibiotics (Implemented during Genetic Engineering Unit)
- Forensic DNA Databases: Is Your Privacy Protected? (Implemented during Genetic Engineering Unit)
- Who Owns the Patent on the Genetic Code for Your Proteins? (Implemented during the Protein Unit)
- Fetal Tissue Transplantation (Implemented during Biotechnology and Medicine Unit)
- Bioethics: Genotypes and Phenotypes (Implemented during Biotechnology and Medicine Unit)
- Food or Fuel? (Implemented during Biotechnology and the Environment Unit)
- The Case of Woo Suk Hwang (Implemented Advanced Topics in Biotechnology)
- Treatment of HIV Positive People in the Developing World (Implemented Advanced Topics in Biotechnology)
- The Pros and Cons of Biosimilars (Implemented Advanced Topics in Biotechnology)

Resources:

- Textbook: Biotechnology; Science for the New Millennium by Ellyn Daugherty Chapters 1
- Lab Manuals: Biotechnology; Laboratory Manual by Ellyn Daugherty; Biotechnology: A Laboratory Skills Course by J. Kirk Brown
- Common Reading Project: The Immortal Life of Henrietta Lacks, by Rebecca Skloot. The book was selected based on the quality of the writing and in-depth coverage of an important topic in biotechnology and scientific research. Student copies of the book will be distributed and are available at the library. This project will be implemented over several units during the first semester of this course.
- Current Event: The field of biotechnology is changing rapidly. Everyday significant new discoveries are bringing new products to market; staying current on these advances is important. In each unit, students will use scientific databases and perform Internet research on current events. Students will summarize what they have learned in various formats and share it with their peers. Topics will be current and unit dependent.
- Online Resources: Ethical, Moral, Legal, and Cultural Issues from CTE Online at https://www.cteonline.org/curriculum/outline/biotechnology-research-and-development-model/CosVxT; Bioethics 101 at http://nwabr.org/sites/default/files/NWABR_Bioethics_101_5.13.pdf; The Science and Ethics of Stem Cell Research at https://www.nwabr.org/sites/default/files/STEM_CELL_CURRICULUM_1109.pdf; Go Go Stem Cells from Learn Genetics at http://learn.genetics.utah.edu/content/stemcells/sctypes/; Additional resources from Georgetown University at https://highschoolbioethics.georgetown.edu/archive/;
- Technology: Teacher 2 in 1 Device, Short Throw Projector, Student Laptops,
- Other Resources: PowerPoint Presentations (instructor created), supplemental readings and handouts (inclusive of current and emerging research related information) in conjunction with, but not limited to the following topics: bioethics, genetic testing, in vitro meat, cloning, fetal tissue transplants, embryology, genetic engineering, stem cells, Planaria and cloning

Unit Learning Goal and Scale

(Level 2.0 reflects a minimal level of proficiency)

Standard(s): When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts, as well as possible social, cultural, and environmental impacts.

4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Compare and contrast attitudes about the use of biotechnology regionally, nationally and internationally • Evaluate the regulatory policies impacting biotechnology research
3.0	**Students will be able to:** • Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics • Research an ethical issue presented by evolving science and reflect on its social, cultural and environmental impacts
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, animal testing, bias, bioethics, bioterrorism, considerations, cloning, ethics, FDA, gene therapy, genetically modified organisms, genetic testing, morals, policy, regulatory affairs, recombinant DNA, stem cells, steroids, vaccines) • Differentiate between moral, ethical, and legal biotechnology issues

1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): In multicellular organisms, individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.

4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Compare embryonic and tissue specific (adult) stem cells (source, function, and potential) • Create a flow chart to simulate the use of growth factors for both adult and embryonic stem cells to create specialized cells that could be used to treat human diseases
3.0	**Students will be able to:** • Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. • Explain why scientists think it is important to be able to do embryonic stem cell research • Create an Infographic on current clinical research using stem cells
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, asexual reproduction, blastocyst, differentiation, directed differentiation, Dolly, ectoderm, embryonic induction, endoderm, germ layers, hematopoietic, human embryo. In vitro fertilization, inner cell mass, membrane, mesenchymal, mesoderm multipotent plasticity, pluripotent, progenitor, reproductive cloning, somatic cell nuclear transfer, stem cell lines therapeutic cloning totipotent, trophoblast) • Define a stem cell • Discuss the different stem cell types • Explain stem cell differentiation
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students

Advanced Learners	• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Structure the learning around explaining or solving a medical or anatomy field related issue.
Struggling Learners	• Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
English Language Learners (See http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf)	• Provide ELL students with multiple literacy strategies as needed; (for example, alternate response, advance notes, extended time, teacher modeling, simplification of written and verbal instruction, frequent breaks, eDictionaries).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications,

		services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504	Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Interdisciplinary Connections

Indicators:

- **Connections to HS-ETS1.A: Defining and Delimiting Engineering Problems**
  - **Physical Science**: HS-PS2-3, HS-PS3-3, HS-PS1-6, HS-PS2-3
  - **Earth and Space Science:** HS-ESS3-2, HS-ESS3-4
  - **Life Science:** HS-LS2-7, HS-LS4-6
- **Common Core State Standards Connections: ELA /Literacy**
  - RST .11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video , multimedia) in order to address a question or solve a problem.
  - RST .11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
  - RST .11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
- **Common Core State Standards Connections: Mathematics**
  - MP.2 Reason abstractly and quantitatively.
  - MP.4 Model with mathematics.

Integration of 21st Century Skills

Indicators:

- **Science and Engineering Practices:**
  - Asking questions and defining problems
  - Using mathematical and computational thinking
  - Constructing explanations and designing solutions
- **Crosscutting Concepts**
  - Systems and system models
  - Stability and change

- **Connections to Engineering, Technology and Applications of Science**
  - New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.
- **Connection to Nature of Science**
  - Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.

Unit Title: Introduction to Biotechnology

Unit Description:

This unit focuses on the role of biotechnology and the biotechnology industry. Additionally, the basic biochemistry necessary to understand major biotechnology concepts is reviewed. Basic research using models and model organisms has taught us much of what we know about living organisms and has led to new methods for maintaining health and for diagnosing and treating disease. The use of models and model organisms is also introduced and discussed in this unit.

Unit Duration: 3 weeks

Desired Results

Standard(s):

- **Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants (HS-ETS1-1)**
- **Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. (HS-LS1-1.)**
- **Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. (HS-LS1-6.)**
- **Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. (HS-ETS1-4.)**

Indicators:

ETS1.A: Defining and Delimiting Engineering Problems

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
- Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

LS1.C: Organization for Matter and Energy Flow in Organisms

- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.

ETS1.B: Developing Possible Solutions

- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.

Understandings:

Students will understand that…

- Biotechnology includes all the technical processes that have led to improvements in products and services, and in understanding organisms and their components
- Products developed through biotechnology must have a market large enough to generate the profit required to fund future research and development

Essential Questions:

- What is Biotechnology?
- What are the major discoveries that led to the development of recombinant DNA technology?
- How is DNA technology being use in modern applications?
- What are the implications of genomics on biotechnology and current healthcare?
- What are the implications of proteomics on biotechnology and current healthcare?

- Living things can be as simple as a unicellular organism, or as complicated as a multicellular organism
- To understand how an organism functions, one needs to know its structure of atoms, molecules, organelles, and other components
- All cells have DNA within chromosomes, cytoplasm, ribosomes, and cell membranes
- Eukaryotic cells contain specialized organelles that carry out complicated functions for the cell and the organism
- Protein production is a common function in all cells. Differences in cells is largely due to the proteins that are produced at any given time
- Macromolecules of the cell include carbohydrates, lipids, proteins, and nucleic acids. These large molecules are polymers made up of repeating units called monomers
- Models are important in helping scientists understand living organisms and how they function

- What are the significant past and current developments in the major fields of biotechnology?
- What are the primary differences between prokaryotes and eukaryotes?
- What are the environmental factors that affect the growth of cells?
- How are prokaryotic and eukaryotic cells used in biotechnology?
- Why are models useful to scientists and their research?
- What are some of the common model organisms in biotechnology?
- Why are model organisms valuable in biotechnology?
- What are the common characteristics of model organisms?
- What are the pros and cons of using model organisms?

Assessment Evidence

Performance Tasks:

Students will be able to…

1. Describe the science of biotechnology and identify its product domains
2. Give examples of different products of the biotechnology industry and how they made a difference in our world
3. Explain the evolution of the science and industry of biotechnology
4. Identify the levels of biological organization and explain their relationships
5. Describe cell structure and its significance in biotechnology research and product development
6. Discuss they types of organisms researched and the types of cells grown and studied in biotechnology facilities plus the products with which they are associated
7. Distinguish between the cellular organization of prokaryotic and eukaryotic cells
8. List the four main classes of macromolecules and describe their structure and function
9. Explain the importance of using model organisms to assist in human genetics research
10. List the characteristics and advantages of the most common model organisms
11. Understand the pros and cons of using model organisms

Other Evidence:

- Cornell Notes/Note Cards on unit reading materials
- Daily Assessments (informal)
  - Bell Work
  - Supplemental Reading
  - Whiteboard Activities
  - Writing Prompts/Reflections
- Quiz: Biochemistry Basics
- Quiz: Model Organisms
- Performance Assessments
  - Class Discussion
  - Online Activities
  - Research Journal
- Laboratory Exercises:
  - Cheese Production
  - Compound Light Microscope
  - Making Measurements
  - Properties of Carbohydrates
  - Characteristics of Model Organisms
- Group Work:
  - Laboratory Exercises
  - Case Studies

Benchmarks:

Unit Test: Introduction to Biotechnology

Writing Assessment: The Use of Animals in Medical Research; Opinion Essay

Learning Plan

Learning Activities:

Classroom Procedures and Grading

Introduction to Biotechnology

- Lecture Topics:
  - What is Biotechnology?
  - History of Biotechnology?
  - The "New" Biotechnology
- Textbook:
  - Daugherty, Chapter 1, pages 1-23, 62-64
  - Biotechnology; Laboratory Manual by Ellyn Daugherty
- Laboratory Exercises:
  - Cheese Production: The Evolution of Cheese Making Technology; Lab Manual, Lab 1c, page 7
- Other Activities:
  - What is Biotechnology Activity
  - GloFish Activity
  - Online: Biotech Products Make a Difference (Textbook, page 63)
  - The Evolution of the Science and Industry of Biotechnology (Activity 14.4, page 393-396)
  - Staying Current in Biotechnology
- Videos:
  - What is Biotechnology?
  - Introduction to Biotechnology?
  - Ted Talk: Bioengineering – The Next Golden Age
- Common Reading Project Activities
- Current Event Assignment

Review of Biology and Chemistry (related to class material):

- Lecture Topics:
  - Atoms and Molecular Structure
  - Chemical Bonds
  - Properties of Acids and Bases
  - Organic Compounds and Macromolecules of Life
  - Cellular Organization and Processes
- Textbook:
  - Daugherty, Chapter 2, pages 41-64
  - Biotechnology; Laboratory Manual by Ellyn Daugherty
- Laboratory Exercises:
  - Using a Compound Light Microscope to Study Cells; Lab Manual, Lab 2c, page 23
  - Microscopic Measurements: Lab Manual, Lab 2d, page 26
  - Variation in the Structure and Properties of Carbohydrates, Lab Manual, Lab 2f, page 30
- Other Activities:
  - Online: Picking the Right Tool for the Job (Textbook, page 45)
- Current Event Assignment

Model Organisms:

- Lecture Topics:
  - Why do Scientists Use Models?
  - What are Model Organisms?
- Textbook:
  - Daugherty, Chapter 2, pages 41-64
  - Biotechnology; Laboratory Manual by Ellyn Daugherty
- Laboratory Exercises:
  - The Characteristics of Model Organisms: Laboratory Manual, Lab2b, page 18
- Other Activities:
  - Reading: Using Model Organisms (NIH)
  - An Egg as a Scientific Model
  - Online: Model Organism Simulation Learning Activity (PBS)
- Videos:
  - Portrait of a Scientist – Scientists and Their Model Organisms (Rockefeller Center)

    - Ted Talk: My Philosophy for a Happy Life; Sam Berns
    - Zebrafish for Research? (YouTube)
    - Model Organisms in Biomedical Research
- Case Studies
    - Inbreeding: From Champion Horses to Life Saving Mice
        - One Note Activity
        - Link: https://www.yourgenome.org/stories/inbreeding-from-champion-horses-to-life-saving-mice
- Common Reading Project Activities
- Current Event Assignment

Resources:

- Textbook: Biotechnology; Science for the New Millennium by Ellyn Daugherty Chapters
- Lab Manuals: Biotechnology; Laboratory Manual by Ellyn Daugherty; Biotechnology: A Laboratory Skills Course by J. Kirk Brown
- Common Reading Project: The Immortal Life of Henrietta Lacks, by Rebecca Skloot. The book was selected based on the quality of the writing and in-depth coverage of an important topic in biotechnology and scientific research. Student copies of the book will be distributed and are available at the library. This project will be implemented over several units during the first semester of this course.
- Current Event: The field of biotechnology is changing rapidly. Everyday significant new discoveries are bringing new products to market; staying current on these advances is important. In each unit, students will use scientific databases and perform Internet research on current events. Students will summarize what they have learned in various formats and share it with their peers. Topics will be current and unit dependent.
- Online Resources: Biology Animation Library: Model Organisms at https://www.dnalc.org/resources/animations/model_organisms.html; Using Model Organisms by NIH at https://www.nigms.nih.gov/Education/Pages/modelorg_factsheet.aspx: Model Organism Simulation at https://nj.pbslearningmedia.org/resource/hew06.sci.life.gen.modelorg/model-organisms/#.WYIM44jyuUk
- Technology: Teacher 2 in 1 Device, Short Throw Projector, Student Laptops,
- Other Resources: PowerPoint Presentations (instructor created), supplemental readings and handouts (inclusive of current and emerging research related information) in conjunction with, but not limited to the following topics: biotechnology, biotechnology industry, bioengineering, history of biotechnology, molecular biology, microscopes and microscope technology, cell structure and function, biological measurements and model organisms

Unit Learning Goal and Scale
(Level 2.0 reflects a minimal level of proficiency)

Standard(s): Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Discuss the implications of genomics and proteomics on biotechnology and current healthcare.
3.0	**Students will be able to:** • Identify past and current discoveries and developments in the biotechnology industry, such as agriculture, diagnostics, medical devices, pharmaceuticals and research and development
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, biochemistry, biotechnology, chromosomes, clinical trials, cloning, DNA fingerprinting, FDA, genetics, genomics, molecular biology pharmaceutical, research and development) • Explain biotechnology and identify some of its current applications
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • **D**emonstrate how the structure of DNA influences its function, analysis and manipulation • Describe the function of DNA, RNA, and protein in living cells and the Central Dogma
3.0	**Students will be able to:** • Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules • List the four main classes of macromolecules and describe their structure and function
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, amino acid, amino acid sequence, biological molecule, carbon, carbon-based molecule, combine, element, hydrogen, molecule, oxygen, sugar) • Describe how the body uses amino acids and other large, carbon-based molecules
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Observe genetic relationships between humans and model organisms. • Use the National Center for Biotechnology Information (NCBI) website to compare DNA sequences of a model organism and a human. • Research a genetic disorder and explain how model organisms are useful in its research to find a cure.
3.0	**Students will be able to:** • Discuss and defend the use of model organisms in medical research • Describe the characteristics of model organisms, including bacteria (E. coli), fungi (yeasts and aspergillus) and animals (C. elegans, fruit flies, and rodents) and their use in biotechnology research
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, aerobic, anaerobic, bacteria, cell, C. elegans, E coli, eukaryote, exponential growth, fruit fly, fungi, media, mitosis, model organism, nucleus, prokaryote, selection, yeast, virus) • Distinguish between prokaryotic cells, eukaryotic cells and non-living entities such as viruses
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Structure the learning around explaining or solving a medical or anatomy field related issue.
Struggling Learners	• Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
English Language Learners (See http://www.state.nj.us/education/model curriculum/ela/ELLSupport.pdf)	• Provide ELL students with multiple literacy strategies as needed; (for example, alternate response, advance notes, extended time, teacher modeling, simplification of written and verbal instruction, frequent breaks, eDictionaries).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504 Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Interdisciplinary Connections

Indicators:

- **Connections to HS-ETS1.A: Defining and Delimiting Engineering Problems**
  - Physical Science: HS-PS2-3, HS-PS3-3
- **Common Core State Standards Connections: ELA /Literacy**
  - RST .11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video , multimedia) in order to address a question or solve a problem.
  - RST .11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
  - RST .11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
- **Common Core State Standards Connections: Mathematics**
  - MP.2 Reason abstractly and quantitatively.
  - MP.4 Model with mathematics.

Integration of 21st Century Skills

Indicators:

- **Science and Engineering Practices:**
  - Using mathematical and computational thinking
  - Constructing explanations and designing solutions
  - Developing and Using Models
  - Engaging in argument from evidence
- **Crosscutting Concepts**
  - Patterns
  - Cause and Effect
  - Scale, proportion, and quantity
  - Systems and system models
  - Structure and function
  - Stability and Change
- **Connections to Engineering, Technology and Applications of Science**
  - New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.
- **Connection to Nature of Science**
  - Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.

Unit Title: Basic Skills and Laboratory Safety

Unit Description:

Working in the laboratory requires skills and behaviors that enable a scientist or technician to operate in a safe environment and produce reproducible data. This unit serves as an introduction to the basic skills and standard operating procedures of a typical research laboratory. Students will learn laboratory safety, laboratory methodologies and basic laboratory skills.

Unit Duration: 3 Weeks

Desired Results

Standard(s):

- **Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. (HS-ETS1-1.)**
- **Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. (HS-ETS1-3.)**
- **Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (HS-ETS1-2.)**

Indicators:

ET S1.A: Defining and Delimiting Engineering Problems

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

ET S1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

ET S1.C: Optimizing the Design Solution

- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

Understandings:

Students will understand that…

- Agencies that regulate the development and approval of biotechnology products include the FDA, the USDA, and the EPA
- All scientists follow a set of procedures to answer their scientific questions. Most follow a scientific methodology that begins with asking a testable question. They predict the answer (hypothesis), and then design and conduct an experiment to test the question. They collect and analyze measurable data, then report their findings relative to their predictions. They report the significant findings and discoveries at scientific meetings and in scientific journals.
- Data are collected and organized into data tables and presented in picture form with graphing. Final data tables and graphs are produced using digital software

Essential Questions:

- What are the general health and safety regulations every laboratory worker should be award of?
- What are the responsibilities of the Occupation Health and Safety Administration (OSHA) as related to the bioscience laboratory?
- What processes or materials are regulated by the Environmental Protection Agency (EPA)?
- What is the proper way to store and handle chemicals and hazardous materials in the laboratory environment?
- What is the proper way to dispose of chemicals and hazardous materials in the laboratory environment?
- What is the purpose of a Standard Operating Procedure (SOP)?
- What is the purpose of a Material Safety Data Sheets (MSDS)?
- How do I make safe and reliable laboratory solutions and reagents?
- How do I properly collect and report data?

Assessment Evidence

Performance Tasks:

Students will be able to …

1. Understand how specific work to be done in the laboratory fits into the organization at a biotechnology facility
2. Define health and safety regulations, including Occupational Health and Safety Administration (OSHA), Environmental Protection Agency (EPA), and Right to Know (RTK) and demonstrate procedures for documenting and reporting hazards and compliance
3. 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.
4. Demonstrate knowledge of standard precautions including proper storage, handling and disposal of biohazards materials.
5. Find and follow oral and written instructions as well as to document and share all procedures used and information and data collected
6. Demonstrate the ability to follow Standard Operating Procedures (SOP).
7. Make measurements of samples and reagents including volume measurement, mass measurement, and sample size

Other Evidence:

- Cornell Notes/Note Cards on unit reading materials
- Daily Assessments (informal)
  - Bell Work
  - Supplemental Reading
  - Whiteboard Activities
  - Writing Prompts/Reflections
- Quiz: Lab Safety
- Quiz: Measurements and Conversion
- Quiz: Scientific Notebook (reoccurring in subsequent units)
- Performance Assessments
  - Class Discussion
  - Online Activities
  - Research Journal
- Laboratory Exercises:
  - Bleach
  - Cheese Production
  - Lab Safety
  - Scientific Notebooks
  - Pipetting
  - Making Solutions
- Group Work
  - Laboratory Exercises
  - Case Studies

8. Recognize the different expressions for units of concentration measurements and use their corresponding equations to calculate the amount of solute needed to make a specified solution or make a dilution
9. Prepare and store reagents, solutions, media and samples for use in DNA and protein studies

Benchmarks:

Scientific Notebook (Ongoing)

Unit Test: Basic Skills and Laboratory Safety

Learning Plan

Learning Activities:

Scientific Methodology:

- Lecture Topics:
  - How to Maintain a Scientific Notebook
  - Writing a Standard Operating Procedure (SOP)
- Textbook:
  - Daugherty, Chapter 1, pages 19-23
- Laboratory Exercises:
  - Bleach Lab
  - Cheese Production Lab
- Other Activities:
  - Laboratory Notebook Activity
  - How to Write an SOP (Activity 3.5, page 94)
- Common Reading Project Activities
- Case Studies:
  - Who Invented Claritin? How Laboratory Notebooks Played Their Part (Kirk Lab Manual, page 26)

Laboratory Safety:

- Lecture Topics:
  - Review Safety Rules
  - Emergency Guidelines
  - Lab procedures and Equipment
  - Material Data Safety Sheets
- Textbook:
- Laboratory Exercises:
  - How to Set up a Legal Scientific Notebook; Daugherty Lab Manual, Lab 1a, page 2
  - Laboratory Safety: Protecting Yourself and Your Coworkers; Daugherty Lab Manual, Lab 1b, page 5
- Other Activities:
  - MSDS and Labeling Activity
- Videos:
  - Cringe Worthy Lab Safety from Flinn at https://www.youtube.com/watch?v=V-fNpaOX0-g
- Case Studies:
  - Waste Disposal

Basic Skills:

- Lecture Topics:
  - Numerical Data
    - Significant Figures
    - Scientific Notation
    - Units of Measure
  - Preparing Solutions
    - Percent Solutions
    - Molar Solutions
  - Introduction to pH Measurement and Adjustment
  - Buffers and their Importance in Biotechnology
- Textbook:
  - Daugherty, Chapter 3, pages 67-87

- Biotechnology; Laboratory Manual by Ellyn Daugherty
- Biotechnology: A Laboratory Skills Course by J. Kirk Brown

- Laboratory Exercises:
  - Pipetting; Kirk Lab Manual, Lab 2.1, page 40
  - Making Solutions; Kirk Lab Manual, Lab 2.4, page 49
- Other Activities:
  - Numerical Data Worksheets/Practice
  - How to Use an Adjustable Volume Pipet Activity
  - Online: How Big is Big? How Small is Small? (Textbook, page 76)
  - Online: Positive Displacement Micropipettes (Textbook, page 81)
  - Online: The Blood Buffer System in Your Body (Textbook, page 97)
- Videos:
  - Blood Buffering System (YouTube)
- Current Event Assignment

Resources:

- Textbook: Biotechnology; Science for the New Millennium by Ellyn Daugherty Chapters
- Lab Manuals: Biotechnology; Laboratory Manual by Ellyn Daugherty; Biotechnology: A Laboratory Skills Course by J. Kirk Brown
- Common Reading Project: The Immortal Life of Henrietta Lacks, by Rebecca Skloot. The book was selected based on the quality of the writing and in-depth coverage of an important topic in biotechnology and scientific research. Student copies of the book will be distributed and are available at the library. This project will be implemented over several units during the first semester of this course.
- Current Event: The field of biotechnology is changing rapidly. Everyday significant new discoveries are bringing new products to market; staying current on these advances is important. In each unit, students will use scientific databases and perform Internet research on current events. Students will summarize what they have learned in various formats and share it with their peers. Topics will be current and unit dependent.
- Online Resources:
- Technology: Teacher 2 in 1 Device, Short Throw Projector, Student Laptops,
- Other Resources: PowerPoint Presentations (instructor created), supplemental readings and handouts (inclusive of current and emerging research related information) in conjunction with, but not limited to the following topics: scientific methodology, laboratory notebooks, standard lab procedures, lab safety and safety procedures, scientific and numerical data, pipets and pipetting, solutions, pH, and buffers

Unit Learning Goal and Scale
(Level 2.0 reflects a minimal level of proficiency)

Standard(s): Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Explain the importance of documenting experiments and other activities in a scientific legal notebook • Maintain their own detailed (following all guidelines) legal scientific notebook for the duration of this course
3.0	**Students will be able to:** • Set up and maintain their own legal scientific notebook
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, data, observation, hypothesis, variable, control, positive control, negative control, concentration, journals) • Demonstrate the ability to follow Standard Operating Procedures (SOP). • Explain the purpose of a legal scientific notebook
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Create a customized biotechnology lab safety video that highlights the necessary safety elements required for the high school biotechnology classroom setting
3.0	**Students will be able to:** • 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. • Draw a safety map of their biotechnology classroom (to include, eye wash station, shower, fire extinguisher, fire blanket, spill kit, exit doors, telephone, first aid, sketch of exit path in case of emergency)
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, EPA, OSHA, Right to Know, hazardous material, good laboratory procedures, material data safety sheets, personal protective equipment, carcinogen, combustible, emergency, explosive, flammable, laboratory, fume hood, oxidizer, physical hazard, unstable, water-reactive) • Describe the use and importance of Material Safety Data Sheets (MSDS). • Describe the importance of personal safety equipment (Lab coat, gloves, eyewear).
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Calculate and prepare buffers, stock solutions and reagents
3.0	**Students will be able to:** • Create solutions with specific percentages or molarities • Understand and demonstrate metric measurements, data collection and analysis • Develop skills necessary to accurately use a micropipette
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, aqueous, balance, base, buffer, dilution, gram, micropipette, molarity, mole, neutral, pH, pipet, positive displacement, solute, solution, solvent, stock solution, volume, weight) • Understand how to accurately measure volumes in milliliters • Practice metric conversions
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Structure the learning around explaining or solving a medical or anatomy field related issue.
Struggling Learners	• Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).

	• Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
English Language Learners (See http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf)	• Provide ELL students with multiple literacy strategies as needed; (for example, alternate response, advance notes, extended time, teacher modeling, simplification of written and verbal instruction, frequent breaks, eDictionaries).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504 Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Interdisciplinary Connections

Indicators:

- **Connections to HS-ETS1.A: Defining and Delimiting Engineering Problems**
  - Physical Science: HS-PS2-3, HS-PS3-3
- **Common Core State Standards Connections: ELA /Literacy**
  - RST .11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video , multimedia) in order to address a question or solve a problem.
  - RST .11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
  - RST .11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
- **Common Core State Standards Connections: Mathematics**
  - MP.2 Reason abstractly and quantitatively.
  - MP.4 Model with mathematics.

Integration of 21st Century Skills

Indicators:

- **Science and Engineering Practices:**
  - Analyzing and interpreting data
  - Asking questions and defining problems
  - Constructing explanations and designing solutions
  - Developing and Using Models
  - Engaging in argument from evidence
  - Obtaining, evaluating, and communicating information
  - Planning and carrying out investigations
  - Using mathematics and computational thinking
- **Crosscutting Concepts**
  - Patterns
  - Cause and Effect
  - Scale, proportion, and quantity
  - Systems and system models
  - Energy and matter: Flows, cycle, and conservation
  - Structure and function
  - Stability
- **Connections to Engineering, Technology and Applications of Science**
  - New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Unit Title: DNA Structure and Function

Unit Description:

The manipulation of genetic information, specifically the deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) codes, is at the center of most biotechnology research and development. This unit focuses on the structure and function of DNA. Additionally, students will focus on the translation of DNA into biological traits. If DNA is mutated, the consequences can be good or bad. Often random mutations, caused by mutagens, result in unexpected outcomes or even harmful consequences. This unit will further discuss genetic mutation and its implications.

Unit Duration: 4 weeks

Desired Results

Standard(s):

- **Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. (HS-LS1-1)**
- **Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. (HS-LS1-6.)**
- **Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. (HS-LS3-1)**

Indicators:

LS1.A : Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life.
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells

LS3.B: Variation of Traits

- In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited

- Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors.

Understandings:

Students will understand that…

- The development of technology for modifying DNA molecules and manipulating protein has been a key factor in the biotechnology revolution
- In cells, DNA holds the code for proteins. To synthesize proteins, sections of the DNA code (genes) are transcribed into mRNA that is translated at ribosomes into the amino acid sequence of the protein
- All DNA molecules are composed of four nucleotides containing the four nitrogen bases. The order of the nucleotides determines which amino acids are found in a protein
- In DNA, the nitrogen bases from on strand bind to the nitrogen bases of the other strand through weak H-bonds
- The DNA strands run antiparallel to each other. This gives DNA directionality, which is important to gene storage and expression
- Advances in computer molecular modeling provide better opportunities to study the structure, function, and interactions of important biomolecules
- DNA replicates through semiconservative replication. The resulting replicate DNA molecules move to daughter cells during cell division
- The DNA of a prokaryote is different for a eukaryote in that a prokaryote has a single, circular DNA molecule sectioned functionally into operons. The DNA is significantly shorter than in a eukaryote and holds fewer genes. Prokaryotic cells may also contain plasmid DNA

Essential Questions:

- Why is knowledge of DNA essential for biotechnology?
- What is the basic structure and function of DNA?
- Why does the sequence of nucleotides in DNA matter?
- How are DNA molecules organized?
- How is DNA replicated?
- How is the process of DNA replication used in biotechnology?
- Do all DNA base pairs code for genes?
- How are enzymes involved in DNA replication?
- Why is DNA important to biotechnology research and industry?
- What is the Central Dogma?
- What is mutation and why is it important?
- How can a specific gene be identified in the genetic sequence of an organism?

Assessment Evidence

Performance Tasks:

Students will be able to …

1. Describe the relationship between nitrogen bases, nucleotides, and nucleic acids
2. Recognize nucleotides on a DNA double helix model
3. Describe the structure and function of DNA and explain the process by which it encodes for proteins
4. Explain how molecular modeling is used to study the structure and function of DNA as well as other biomolecules
5. Describe the role of DNA, RNA, and ribosomes in protein synthesis (The Central Dogma).
6. Explain how the structure of DNA affects its isolation from cells and solutions
7. Isolate genomic DNA from cells and analyze its purity and concentration
8. Differentiate between eukaryotic and prokaryotic chromosomal structure and explain how this difference impacts gene regulation in the two cell types

Other Evidence:

- Cornell Notes/Note Cards on unit reading materials
- Daily Assessments (informal)
  - Bell Work
  - Supplemental Reading
  - Whiteboard Activities
  - Writing Prompts/Reflections
- Quiz: DNA Structure
- Quiz: DNA Extraction
- Performance Assessments
  - Class Discussion
  - Online Activities
  - Research Journal
- Laboratory Exercises:
  - DNA Extraction
  - Genetic Flow of Information
- Group Work
  - Laboratory Exercises
  - Genetic Mutation Activities
  - Case Studies

Benchmarks:

Unit Test: DNA Structure and Function

The Central Dogma Essay

Learning Plan

Learning Activities:

- Lecture Topics:
  - Molecular Biology and the Central Dogma
  - What is DNA?
  - DNA Structure and Function
  - Sources of DNA
  - DNA Replication/Transcription/Translation
  - How is DNA mutated?
- Textbook:
  - Daugherty, Chapter 4, pages 112 to 129
- Laboratory Exercises:
  - DNA Extraction and Isolation
    - DNA Extraction from Fruit
    - DNA Extraction from Cheek Cells (modified from Serendipity)
  - Flow of Genetic Information (3D Molecular Designs)
- Other Activities:
  - DNA Review Jigsaw
  - DNA Modeling (3D Molecular Designs)
  - Codon Sudoku
  - Online: Know Your Genome (Textbook, page 122)
  - Online: Using Viruses to Do Good (Textbook, page 126)
  - Experience a Genetic Mutation; DNA Phone Game (CTE)
- Videos:
  - Double Helix (HHMI)
  - The History of Morse Code (CTE)
  - The Atomic Bomb
- Case Studies:
  - Genetic Mutation: If You are Hit by Two Atomic Bombs, Should You Have Kids? (CTE)
- Common Reading Project Activities
- Current Event Assignment

Resources:

- Textbook: Biotechnology; Science for the New Millennium by Ellyn Daugherty Chapter 4, pages 112 to 129
- Lab Manuals: Biotechnology; Laboratory Manual by Ellyn Daugherty; Biotechnology: A Laboratory Skills Course by J. Kirk Brown
- Lab Manuals: Biotechnology; Laboratory Manual by Ellyn Daugherty; Biotechnology: A Laboratory Skills Course by J. Kirk Brown
- Common Reading Project: The Immortal Life of Henrietta Lacks, by Rebecca Skloot. The book was selected based on the quality of the writing and in-depth coverage of an important topic in biotechnology and scientific research. Student copies of the book will be distributed and are available at the library. This project will be implemented over several units during the first semester of this course.
- Current Event: The field of biotechnology is changing rapidly. Everyday significant new discoveries are bringing new products to market; staying current on these advances is important. In each unit, students will use scientific databases and perform Internet research on current events. Students will summarize what they have learned in various formats and share it with their peers. Topics will be current and unit dependent.
- Online Resources: Flow of Genetic Information from 3D Molecular Designs at http://www.3dmoleculardesigns.com/Education-Products/Flow-of-Genetic-Information-Kit.htm; DNA Extraction Activities from University of Pennsylvania/Serendipity at http://serendip.brynmawr.edu/sci_edu/waldron/; DNA Learning Center at https://www.dnalc.org/; DNA Interactive at http://www.dnai.org/index.htm; The DNA Files at http://www.dnafiles.org/; : How is DNA mutated from CTE at

https://www.cteonline.org/curriculum/lessonplan/dna-how-is-dna-mutated-3-of-4/BLyGMV; Mutation Case Study from CTE at https://www.cteonline.org/curriculum/lessonplan/if-you-are-hit-by-two-atomic-bombs-should-you-have-kids-ela/9VXCTA; Atomic bomb resources from NPR at www.npr.org; Digital World Biology at https://digitalworldbiology.com/

- Technology: Teacher 2 in 1 Device, Short Throw Projector, Student Laptops,
- Other Resources: PowerPoint Presentations (instructor created), supplemental readings and handouts (inclusive of current and emerging research related information) in conjunction with, but not limited to the following topics: History of DNA, DNA structure and function, DNA modeling, genetics, genetic mutation, bacteria and viruses

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): Systems of specialized cells within organisms help them perform the essential functions of life.	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Demonstrate how to use a molecular modeling database to view a DNA structural model
3.0	**Students will be able to:** • Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. • Demonstrate the molecular structure of DNA using a model and explain how the structure of DNA results in a specific protein
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, gene, nitrogenous base, base pair, phosphodiester bond, hydrogen bond, pyrimidine, purine, antiparallel, semiconservative) • Name the four nitrogen-containing bases found in DNA molecules and identify how they create a base pair • Describe the bonds that make up the structure of double stranded DNA.
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Describe a disease, such as Alzheimer's and describe how gene expression transcription factors may be a strategy for combating it
3.0	**Students will be able to:** • Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. • Describe the function of DNA, RNA, and protein in living cells and the Central Dogma • Model the flow of genetic information from DNA to RNA to Protein
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, medium, lysis, transformed, vector, operon, RNA polymerase, promoter, operator, broth, agar, media preparation, autoclave, enhancer, silencer, transcription factor, intron, exon, histones, bacteriophages) • Describe the relationship between genes, mRNA, and proteins
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors.	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Describe the diverse types of mutations that high energy electromagnetic radiation can cause in DNA • Explain how changes in DNA caused by mutation can have good and/or adverse consequences
3.0	**Students will be able to:** • Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. • Explain how changing the DNA code, a mutation, may ultimately change the sequence of amino acids in the protein. • Describe how electromagnetic radiation can damage DNA structure
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, mutation, mutagen, frame shift mutation, deletion, insertion, inversion, translocation, point mutations, chromosomal mismatch, translation) • Understand how a mutation can affect DNA • Identify things that can cause mutations
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Structure the learning around explaining or solving a medical or anatomy field related issue.
Struggling Learners	• Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
English Language Learners (See http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf)	• Provide ELL students with multiple literacy strategies as needed; (for example, alternate response, advance notes, extended time, teacher modeling, simplification of written and verbal instruction, frequent breaks, eDictionaries).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction

		• Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504	Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Interdisciplinary Connections

Indicators:

- **Common Core State Standards Connections: ELA /Literacy**
  - RST .11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
  - RST .11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
  - WHST .9-12.1 Write arguments focused on discipline-specific content.
- **Common Core State Standards Connections: Mathematics**
  - MP.2 Reason abstractly and quantitatively.

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Integration of 21st Century Skills

Indicators:

- **Science and Engineering Practices:**
  - Analyzing and interpreting data
  - Asking questions and defining problems
  - Developing and Using Models
  - Engaging in argument from evidence
  - Obtaining, evaluating, and communicating information
  - Planning and carrying out investigations
  - Using mathematics and computational thinking
- **Crosscutting Concepts**
  - Patterns
  - Cause and Effect
  - Scale, proportion, and quantity
  - Systems and system models
  - Structure and function
  - Stability

- **Connections to Engineering, Technology and Applications of Science**
  - Technological advances have influenced the progress of science and science has influenced advances in technology.
  - Science and engineering are influenced by society and society is influenced by science and engineering.
  - New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Unit Title: Genetic Engineering

Unit Description:

One of the most important methods in biotechnology is genetic engineering, which includes all the techniques and technologies of modifying and manipulating genetic information in cells. In this unit, students will be introduced to the basics of genetic engineering, recombinant biotechnology and its applications.

Unit Duration: 4 weeks

Desired Results

Standard(s):

- **Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. (HS-LS3-2)**
- **Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. (HS-LS3-3.)**

Indicators:

LS3.A: Inheritance of Traits

- Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.

LS3.B: Variation of Traits

- In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited
- Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors.

Understandings:

Students will understand that…

- Genetic engineering is the addition, subtraction, or modification of genetic information in an organism
- Isolation of DNA from cells is required for a source of genetic information
- Finding a gene of interest on a piece of DNA is challenging. Labeled probes are used to find complementary sequences in a DNA sample
- Manipulation of nucleic acids through genetic engineering (recombinant DNA and RNA technologies) alters the function of proteins and subsequent cellular processes
- Transformation is the insertion and expression of foreign DNA into a cell. If the transformation is of a mammalian cell, it is called transfection. Transformations are usually done using recombinant plasmids or recombinant viral DNA
- To make a recombinant plasmid, one or more restriction enzymes are needed to splice the donor and vector (plasmid) DNA molecules
- There are hundreds of different know restriction enzymes. Each recognizes a specific sequence and will make a cut in the double-stranded DNA at or near the recognition sequence

Essential Questions:

- What is genetic engineering?
- What are examples of genetically engineered products?
- How is DNA isolated from cells and used as a source of genetic information?
- How is a gene located in a DNA sequence?
- Why is it important to find specific genes in a DNA sequence?
- What is recombinant DNA?
- What is transformation? How is it different from transfection and transduction?
- What are restriction enzymes and how are they useful to researchers?
- What is a plasmid and what is its usefulness?

- Transformed cells are given a good environment in which to grow and reproduce exact copies, or clones. Clones are grown on Petri plates with section media. This results in cells that demonstrate new, desired phenotypes

Assessment Evidence

Performance Tasks:

Students will be able to …

1. Explain the fundamental process of genetic engineering and give examples of the following applications: recombinant DNA technology, site-specific mutagenesis, and gene therapy
2. Describe the process of gel electrophoresis and discuss how the characteristics of molecules affect their migration through a gel
3. Explain the principals involved in agarose gel electrophoresis
4. Prepare, load, run, visualize, and analyze DNA samples on an agarose gel
5. Discuss methods to isolate DNA and specific genes for engineering purposes
6. Enumerate the activities and uses of restriction enzymes
7. Conduct a restriction digestion of a plasmid
8. List the steps in the production of a recombinant DNA molecule
9. Cite examples of vectors used in transformation, transduction, and transfection
10. Understand the role of recombinant DNA and genetic engineering, bioprocessing, monoclonal antibody production, separation and purification of biotechnology products, nanotechnology, bioinformatics, genomics, proteomics, and transcriptomics in biotechnical product development

Other Evidence:

- Cornell Notes/Note Cards on unit reading materials
- Daily Assessments (informal)
  - Bell Work
  - Supplemental Reading
  - Whiteboard Activities
  - Writing Prompts/Reflections
- Quiz: Plasmids and Restriction Enzymes
- Quiz: Gel Electrophoresis
- Quiz: Transformation
- Performance Assessments
  - Class Discussion
  - Online Activities
  - Research Journal
- Laboratory Exercises:
  - Virtual Gel Electrophoresis
  - Gel Electrophoresis
  - Forensics DNA Fingerprinting
- Group Work
  - Laboratory Exercises
  - Case Studies

Benchmarks:

Biotechnology Midterm Exam

Genetic Mutation Case Study Writing Assessment

Learning Plan

Learning Activities:

- Lecture Topics:
  - Overview of Genetic Engineering
  - What is a Genome?
  - Recombinant DNA Technology
    - Restriction Enzymes
    - Plasmids
    - RFLP
  - Gel Electrophoresis
  - Forensics and DNA
- Textbook:
  - Daugherty, Chapter 4, pages 126 to 135; Chapter 8, pages 240 to 262
- Laboratory Exercises:
  - CSI Wildlife (HHMI)
  - Gel Electrophoresis Lab
  - Forensic DNA Fingerprinting Lab
- Other Activities:
  - Genetic Engineering Activities (HHMI)

- DNA 'Low-tech' Fingerprinting
- DNA Virtual Fingerprinting (NOVA)
- Chop and Go Electrophoresis (Textbook, page 135)
- Plasmid Mapping
- DNA Profiling Activity (HHMI)

- Videos:
  - Genetic Engineering (HHMI)
- Case Studies:
  - Forensics: Did the Baker, Do It? (Brown; Biotechnology: A Laboratory Skills Course)
- Common Reading Project Activities
- Current Event Assignment.

Resources:

- Textbook: Biotechnology; Science for the New Millennium by Ellyn Daugherty Chapters 4 and 8
- Lab Manuals: Biotechnology; Laboratory Manual by Ellyn Daugherty; Biotechnology: A Laboratory Skills Course by J. Kirk Brown
- Common Reading Project: The Immortal Life of Henrietta Lacks, by Rebecca Skloot. The book was selected based on the quality of the writing and in-depth coverage of an important topic in biotechnology and scientific research. Student copies of the book will be distributed and are available at the library. This project will be implemented over several units during the first semester of this course.
- Current Event: The field of biotechnology is changing rapidly. Everyday significant new discoveries are bringing new products to market; staying current on these advances is important. In each unit, students will use scientific databases and perform Internet research on current events. Students will summarize what they have learned in various formats and share it with their peers. Topics will be current and unit dependent.
- Online Resources: Genetic Engineering from HHMI at http://www.hhmi.org/biointeractive/genetic-engineering; CSI Wildlife at http://www.hhmi.org/biointeractive/csi-wildlife; DNA Profiling Activity from HHMI at http://www.hhmi.org/biointeractive/dna-profiling-activity;
- Technology: Teacher 2 in 1 Device, Short Throw Projector, Student Laptops,
- Other Resources: PowerPoint Presentations (instructor created), supplemental readings and handouts (inclusive of current and emerging research related information) in conjunction with, but not limited to the following topics: organismal genomes, genetic engineering, DNA fingerprinting, gel electrophoresis, recombinant DNA technology, forensics, DNA profiling

Unit Learning Goal and Scale
(Level 2.0 reflects a minimal level of proficiency)

Standard(s): Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.

4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Discuss the successes and setbacks of gene therapy attempts • Discuss a position on the continued funding of gene therapy for the treatment of specific disease conditions
3.0	**Students will be able to:** • Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. • List several restriction enzymes and explain how restriction enzymes cleave DNA • Explain the structure and function of bacterial plasmids as they relate to biotechnology and gene therapy
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, agar, agarose, autoclave, bacteriophages, broth, exon, gel electrophoresis, gene, gene therapy, intron, lysis, media preparation, medium, nonpathogenic, operator, operon, promoter, plasmid, restriction enzyme, site-specific mutagenesis, transformed, vector)

	• Define genetic engineering and gene therapy • Identify several restriction enzymes
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Predict electrophoresis results from a restriction digest • Contract and compare different DNA fingerprints
3.0	**Students will be able to:** • Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. • Describe and explain the process of gel electrophoresis • Demonstrate proper technique in the use of gel electrophoresis equipment
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, gel electrophoresis, agarose, polyacrylamide, ethidium bromide) • Define gel electrophoresis • Recall the basic procedural steps of gel electrophoresis
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Structure the learning around explaining or solving a medical or anatomy field related issue.
Struggling Learners	• Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
English Language Learners (See http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf)	• Provide ELL students with multiple literacy strategies as needed; (for example, alternate response, advance notes, extended time, teacher modeling, simplification of written and verbal instruction, frequent breaks, eDictionaries).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will

		enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504	Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Interdisciplinary Connections

Indicators:

- **Common Core State Standards Connections: ELA /Literacy**
  - RST .11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
  - RST .11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
  - WHST .9-12.1 Write arguments focused on discipline-specific content.
- **Common Core State Standards Connections: Mathematics**
  - MP.2 Reason abstractly and quantitatively.

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Integration of 21st Century Skills

Indicators:

- **Science and Engineering Practices:**
  - Analyzing and interpreting data
  - Asking questions and defining problems
  - Developing and Using Models
  - Engaging in argument from evidence
  - Obtaining, evaluating, and communicating information
  - Planning and carrying out investigations
  - Using mathematics and computational thinking
- **Crosscutting Concepts**
  - Patterns
  - Cause and Effect
  - Scale, proportion, and quantity
  - Systems and system models
  - Structure and function
  - Stability

- **Connections to Engineering, Technology and Applications of Science**
  - Technological advances have influenced the progress of science and science has influenced advances in technology.
  - Science and engineering are influenced by society and society is influenced by science and engineering.
  - New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Unit Title: Protein Structure and Function

Unit Description:

Proteins perform most of the work; transmit, most of the signals and form many of the structures required for life. In this unit, students will learn about the structure and function of proteins. Students will focus on what scientists have learned about engineering and manufacturing proteins for biotechnology research. The role of enzymes and their importance to biotechnology will also be discussed.

Unit Duration: 5 weeks

Desired Results

Standard(s):

- **Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. (HS-LS1-1)**
- **Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. (HS-LS1-6.)**
- **Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. (HS-LS3-1)**

Indicators:

LS1.A: Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life.
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells

LS3.A: Inheritance of Traits

- Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.

Understandings:

Students will understand that…

- Most biotechnology products are proteins or protein-related products
- Proteins are composed of some assortment of the 20 amino acids, held together by peptide bonds. The DNA code on the structural gene determines both the number and arrangement of amino acids in a protein
- R groups interact with other R groups to case the folding pattern characteristic of a protein
- Protein synthesis is similar in all cells and occurs in two steps: transcription and translation
- Antibodies are complex proteins composed of four chains, Antibodies recognize and bind specific antigen molecules. The tips of the antibody are variable in the amino acid sequence and recognize specific, unique antigens

Essential Questions:

- How is protein synthesis used in biotechnology?
- How are amino acids related to DNA?
- How do the processes of transcription and translation produce proteins?
- How can I determine the concentration of protein in a solution?
- What is the structure and function of antibodies?
- What are enzymes and why are they important to biological function?
- Why are proteins important to research and development in the biotechnology industry?
- How are specific proteins identified in substances?
- How do protein-detection assays differ?

- Antibodies are used in research and diagnostic testing, including pregnancy, contamination, or disease. Monoclonal antibody technology can produce many identical antibodies for these purposes
- Enzymes are proteins that speed the synthesis or decomposition of substrate molecules
- Enzymes and their substrates must get very close for catalysis to occur. Two models of enzyme-substrate action are the lock and key model and the induced fit model
- Researchers study proteins to understand the structure and function of cells, tissues, and organisms, as well as their behavior and processes
- Protein studies may be used to explain evolutionary relationships, as well as identification for some species. Protein studies lead to understanding of diseases and how to treat them

Assessment Evidence

Performance Tasks:

Students will be able to …

1. Describe the structure of proteins, including the significance of amino acid R-groups and their impact on the three-dimensional structure of proteins
2. Explain the steps of transcription and translation in proteins synthesis
3. Discuss the role of naturally occurring proteins and recombinant proteins in biotechnology
4. Differentiate proteins that function as a part of structure, as antibodies, and as enzymes
5. Describe the classes of enzymes and discuss their effect of reaction condition on enzyme activity

Other Evidence:

- Cornell Notes/Note Cards on unit reading materials
- Daily Assessments (informal)
  - Bell Work
  - Supplemental Reading
  - Whiteboard Activities
  - Writing Prompts/Reflections
- Quiz: Protein Structure
- Quiz: Enzymes
- Performance Assessments
  - Class Discussion
  - Online Activities
  - Research Journal
- Laboratory Exercises:
  - Molecular Modeling
  - Enzyme
- Group Work
  - jMol Project

Benchmarks:

Unit Test: Protein Structure and Function

jMol Project Presentation

Learning Plan

Learning Activities:

- Lecture Topics:
  - Protein Synthesis
  - Protein Structure Basics
  - Proteins in Biology
  - Proteins in Biotechnology/Proteomics
  - Enzymes
  - Basic Protein Analysis
- Textbook:
  - Daugherty, Chapter 5, pages 148 to 171
- Laboratory Exercises:
  - Flow of Genetic Information (3D Molecular Designs)
  - Amino Acid Starter Kits (3D Molecular Designs)
    - Amino Acids and Protein Folding
    - Secondary Structures

        - Folding an Enzyme Active Site
    - Insulin mRNA to Protein Kit (3D Molecular Designs)
    - Enzymes in Action Kits (3D Molecular Designs)
- Other Activities:
    - Amino Acid Building Block Models
    - What is a Protein? (from the RCSB Protein Database)
    - Principles of Protein Folding
    - mRNA/Decoding Worksheet
    - Determining a Consensus Sequence
    - Insulin Supplemental Readings
        - New York Times: New Insulin Given Approval for Use in US
        - Lilly Drops Inhaled Insulin
    - Substrate Specificity Activity
    - Mosquito Borne Viral Disease Activities (HHMI)
    - Acetylcholinesterase and Pesticide Resistance
    - Pesticide Resistance Supplemental Readings
        - Insecticide Resistance in Mosquito Vectors (PDF)
        - Evolution in Action – Emerging Insecticide Resistance in Mosquitoes (PDF)
    - jMol Project
        - Introduction
            - Hemoglobin and Betaglobin
            - Modeling a Protein Story
        - Research/Design
        - 3D printing
        - Presentation
- Videos:
    - Sequence to Structure
    - Insulin and the Regulation of Glucose in the Blood
    - Hemoglobin Structure and Function
    - Globin Fold and Heme Function Summary
- Common Reading Project Activities
- Current Event Assignment

Resources:

- Textbook: Biotechnology; Science for the New Millennium by Ellyn Daugherty Chapter 5
- Common Reading Project: One in a Billion: The Story of Nic Volker and the Dawn of Genomic Medicine, by Mark Johnson and Kathleen Gallagher. The book was selected based on the quality of the writing and in-depth coverage of an important topic in biotechnology and scientific research. Student copies of the book will be distributed and are available at the library. This project will be implemented over several units during the second semester of this course.
- Current Event: The field of biotechnology is changing rapidly. Everyday significant new discoveries are bringing new products to market; staying current on these advances is important. In each unit, students will use scientific databases and perform Internet research on current events. Students will summarize what they have learned in various formats and share it with their peers. Topics will be current and unit dependent.
- Online Resources: Amino Acid Starter Kit Activities at http://www.3dmoleculardesigns.com/Education-Products/Amino-Acid-Starter-Kit.htm; Insulin mRNA to Protein Kit at http://www.3dmoleculardesigns.com/Education-Products/Insulin-mRNA-to-Protein-Kit.htm; New York Times: New Insulin Given Approval for Use in US at http://www.nytimes.com/1982/10/30/us/a-new-insulin-given-approval-for-use-in-us.html; Lilly Drops Inhaled Insulin at http://cen.acs.org/articles/86/i11/Lilly-Drops-Inhaled-Insulin.html; Enzymes in Action at http://www.3dmoleculardesigns.com/Teacher-Resources/Enzymes-in-Action-Kit.htm; Mosquito Born Viral Disease Activities from HHMI at http://www.hhmi.org/biointeractive/mosquito-borne-viral-diseases.
- Technology: Teacher 2 in 1 Device, Short Throw Projector, Student Laptops,
- Other Resources: PowerPoint Presentations (instructor created), supplemental readings and handouts (inclusive of current and emerging research related information) in conjunction with, but not limited to the following topics: Proteins, protein structure, protein folding, codons, mRNA, insulin, hemoglobin, betaglobin enzymes, enzyme specificity, pesticide resistance, mosquito vectors, disease transmission

Unit Learning Goal and Scale

(Level 2.0 reflects a minimal level of proficiency)

Standard(s): Systems of specialized cells within organisms help them perform the essential functions of life.	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Define prions and create an informational fact sheet that describes and illustrates bovine spongiform encephalopathy (Mad Cow disease) and the efforts to diagnosis and treat it
3.0	**Students will be able to:** • Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules • Differentiate proteins that function as part of a structure, as antibodies and, as enzymes • Explain the two theories that describe how enzymes work • Describe a disease or disorder that is caused by a missing or faulty enzyme
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, antigen, biomanufacturing, CD4 cells, cleavage, codon, cofactors, denaturation, ELISA, epitope, glycoprotein, glycosylated, induced fit model, lock and key model, monoclonal antibodies, PAGE, peptidyl transferase, phosphorylation, polar, primary structure, protein synthesis, quaternary structure, secondary structure, substrate, tertiary structure, transcription, translation) • Discuss the role of naturally occurring proteins and recombinant proteins in biotechnology • Define enzyme • List several examples of enzymes and their substrates
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Describe the significance of amino acid R-groups and their impact on the three-dimensional structure of proteins • Discuss the characteristics of human insulin and explain the options that biotechnology has provided for diabetic patients
3.0	**Students will be able to:** • Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells**.** • Research existing information on the size, structure and function of a specific protein • Create an informational poster about a specific protein's structure and function • Explain the steps of transcription and translation in protein synthesis
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, antigen, biomanufacturing, CD4 cells, cleavage, codon, cofactors, denaturation, ELISA, epitope, glycoprotein, glycosylated, induced fit model, lock and key model, monoclonal antibodies, PAGE, peptidyl transferase, phosphorylation, polar, primary structure, protein synthesis, quaternary structure, secondary structure, substrate, tertiary structure, transcription, translation) • Describe the structure and function of proteins
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different

ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Perform the ELISA test for antibodies • Identify a real-world example of mosquito borne viral disease and explain how biotechnology is meeting the challenges of this disease
3.0	**Students will be able to:** • Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. • List possible means for controlling spread of mosquito-borne illness • Magnify and study arthropod structure using a stereoscope • Differentiate between viral and prokaryotic cell (bacterium) structure
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, antigen, biomanufacturing, CD4 cells, cleavage, codon, cofactors, denaturation, ELISA, epitope, glycoprotein, glycosylated, induced fit model, lock and key model, monoclonal antibodies, PAGE, peptidyl transferase, phosphorylation, polar, primary structure, protein synthesis, quaternary structure, secondary structure, substrate, tertiary structure, transcription, translation) • Identify vectors of disease transmission • Identify structure of a mosquito and stages of mosquito life cycle
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Structure the learning around explaining or solving a medical or anatomy field related issue.
Struggling Learners	• Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
English Language Learners (See http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf)	• Provide ELL students with multiple literacy strategies as needed; (for example, alternate response, advance notes, extended time, teacher modeling, simplification of written and verbal instruction, frequent breaks, eDictionaries).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction

		• Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504	Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Interdisciplinary Connections

Indicators:

- **Common Core State Standards Connections: ELA /Literacy**
  - RST .11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
  - RST .11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
  - WHST .9-12.1 Write arguments focused on discipline-specific content.
- **Common Core State Standards Connections: Mathematics**
  - MP.2 Reason abstractly and quantitatively.

Integration of 21st Century Skills

Indicators:

- **Science and Engineering Practices:**
  - Analyzing and interpreting data
  - Asking questions and defining problems
  - Developing and Using Models
  - Engaging in argument from evidence
  - Obtaining, evaluating, and communicating information
  - Planning and carrying out investigations
  - Using mathematics and computational thinking
- **Crosscutting Concepts**
  - Patterns
  - Cause and Effect
  - Scale, proportion, and quantity
  - Systems and system models
  - Structure and function
  - Stability
- **Connections to Engineering, Technology and Applications of Science**
  - Technological advances have influenced the progress of science and science has influenced advances in technology.
  - Science and engineering are influenced by society and society is influenced by science and engineering.
  - New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Unit Title: Biotechnology and Medicine

Unit Description:

Medical biotechnology includes all area of research, development, and manufacturing of items that prevent or treat disease, or alleviate the symptoms of disease. This unit focuses on the role of biotechnology in medicine. In this unit students will explore rare diseases; how biotechnology is involved in finding cures for these diseases and why this research is important to the future of medicine Topics discussed in this unit include; the history of medicine and technology, medical breakthroughs, gene therapy, gene mapping, genomics and personalized medicine, and the drug development process.

Unit Duration: 5 weeks

Desired Results

Standard(s):

- **Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. (HS-LS3-2)**
- **Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. (HS-LS3-3.)**
- **Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants (HS-ETS1-1)**
- **Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (HS-ETS1-2.)**
- **Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics. (HS-ETS1-3.)**

Indicators:

LS3.B: Variation of Traits

- Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors.

ET S1. A: Defining and Delimiting Engineering Problems

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

ET S1. B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

ET S1.C: Optimizing the Design Solution

- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

Understandings:

Students will understand that…

- A medicine is a compound that treats, prevents, or alleviates a disease or its symptoms
- Medical biotechnology includes all areas of research, development, and manufacture of medicines, as well as disease prevention and treatment
- Drugs are chemicals that alter proteins or other compounds responsible for diseases and their symptoms. Drugs are found and isolated from natural sources, or they are synthesized in the lab through chemical combination or genetic engineering
- Pharmacogenetics, the study and use of genetic information to develop targeted therapies, has the

Essential Questions:

- What is a medicine?
- What is the role of biotechnology in medicine?
- What are drugs and how are they developed?
- What are antibiotics and what is the significance of antibiotic resistance?
- What are the uses of antibodies and vaccines in medical biotechnology?
- What is gene therapy?
- How does genetic testing reveal information about a patient's risk of developing disease or disorder?
- What are examples of recent advances in medical biotechnology?

potential to lead to personalized medicines for individuals or groups of people
- Recent advances in medical biotechnology include the development of personalized medicine, the use of biomarkers and monoclonal antibody technology, new gene therapies, the construction of the first artificial organs, and new biomedical instrumentation for diagnostics and therapeutics

Assessment Evidence

Performance Tasks:

Students will be able to …

- Discuss the scope and role of medical biotechnology in the healthcare industry
- Discuss the role of medication in promoting and protecting human health
- Describe and overview of how drugs are developed
- Explain how scientists test the effectiveness of antibiotics and antimicrobials and discuss the significance of antibiotic resistance
- Detail the multiple uses of antibodies and vaccines in medical biotechnology
- Describe how genetic testing can reveal information about a patient's risk of developing a disease or disorder
- List examples of recent advances in medical biotechnology and expected new applications

Other Evidence:

- Cornell Notes/Note Cards on unit reading materials
- Daily Assessments (informal)
  - Bell Work
  - Supplemental Reading
  - Whiteboard Activities
  - Writing Prompts/Reflections
- Quiz: Protein Structure
- Quiz: Gene Therapy
- Performance Assessments
  - Class Discussion
  - Online Activities
  - Research Journal
- Laboratory Exercises:
  - Sepiapterin Reductase
  - Secrets of the Rain Forest
- Group Work
  - Laboratory Exercises
  - Case Studies
  - Genetics Project

Benchmarks:

Unit Test: Biotechnology and Medicine

Genetics Project

Learning Plan

Learning Activities:

- Lecture Topics:
  - Gene Therapy
  - Gene Mapping
  - Genomics and Personalized Medicine
  - Drug Development
- Textbook:
  - Daugherty, Chapter 12, pages 368 to 391
  - Rare Diseases: Diagnosis, Therapies and Hope (digital) at https://www.wtps.org/site/handlers/filedownload.ashx?moduleinstanceid=28149&dataid=29705&FileName=Rare-Diseases-Book-Diagnosis-Therapies-and-Hope-V5-330b.pdf
- Supplemental Reading
  - From Idea to Market: The Drug Approval Process (FDA)
- Laboratory Exercises:
  - Sepiapterin Reductase: The Berry Twin Story Stations Lab
  - Secrets of the Rain Forest (BioRad)
- Other Activities:
  - Exploring Gene Therapy (Learn Genetics)
  - Finding a Gene on the Chromosome Map (Learn Genetics)
  - Map of the Human Beta-Globin Gene (3D Molecular Designs)
  - Zinc Finger Folding Activity
  - Top 10 Medical Breakthroughs
  - Drug Development History and Process

- How are Drugs Developed (CTE Online Simulation)
- Videos:
  - Meet the Berry Twins
  - Ted Talk: Finding Hope in Genome Sequencing
  - One in a Billion the Nick Volker Story (Journal Sentinel)
  - Medical Breakthroughs in History
  - How a Drug becomes a Drug
- Case Studies:
  - The Berry Twins
  - The Nik Volker Story
- Common Reading Project Activities
- Current Event Assignment

Resources:

- Textbook: Biotechnology; Science for the New Millennium by Ellyn Daugherty Chapter 12
- Common Reading Project: One in a Billion: The Story of Nic Volker and the Dawn of Genomic Medicine, by Mark Johnson and Kathleen Gallagher. The book was selected based on the quality of the writing and in-depth coverage of an important topic in biotechnology and scientific research. Student copies of the book will be distributed and are available at the library. This project will be implemented over several units during the second semester of this course.
- Current Event: The field of biotechnology is changing rapidly. Everyday significant new discoveries are bringing new products to market; staying current on these advances is important. In each unit, students will use scientific databases and perform Internet research on current events. Students will summarize what they have learned in various formats and share it with their peers. Topics will be current and unit dependent.
- Online Resources: Human Beta Globin Activities at http://www.3dmoleculardesigns.com/Teacher-Resources/Map-of-the-Human-Globin-Gene.htm; Resources for Berry Twin Stations Lab at http://www.3dmoleculardesigns.com/Teacher-Resources/Neurotransmitters-Module.htm; Resources for the Nick Volker Story at http://archive.jsonline.com/news/health/111641209.html/; The Journey Toward Drug Development from CTE at https://www.cteonline.org/curriculum/project/the-drug-development-process-stem-project/di0zu4#node/1; How a Drug becomes a Drug at http://www.youtube.com/watch?v=U96He401wj4;
- Technology: Teacher 2 in 1 Device, Short Throw Projector, Student Laptops,
- Other Resources: PowerPoint Presentations (instructor created), supplemental readings and handouts (inclusive of current and emerging research related information) in conjunction with, but not limited to the following topics: genomics, gene therapy, gene mapping, personalized medicine, drugs, drug therapies, drug development, 3D printing, dopamine, serotonin, antibiotics and antibiotic resistance, antibodies and vaccines

Unit Learning Goal and Scale
(Level 2.0 reflects a minimal level of proficiency)

Standard(s): Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors

4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Analyze and predict future applications of genome mapping projects • Apply the importance of genetic discoveries and future investigations to ethical and controversial decision-making and debates
3.0	**Students will be able to:** • Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. • Demonstrate and explain how gene maps are produced • Analyze how an effort to map genomes has advanced medical research • Identify human genetic disorders • Describe the processes of genetic research
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, medicine, medical biotechnology, vaccine, drug, drug therapy, drug discovery, organic synthesis, screening, pathogenesis, antiseptic, pharmacology, combinatorial chemistry, parallel synthesis, library, biochip, microarray, peptides, peptide synthesizer,

	oligonucleotides, DNA synthesizer, flow cytometry, B-cells, memory cell, immunity, transgenic, genetic counselor, pedigree, pharmacogenetics, biomarker) • Explain the relationship between DNA, chromosomes, and genes • Explain the importance of the study of genetics to human beings • Identify a gene map and list examples for its use
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Use BLAST to determine the cause of the disorder and then reference the PDB to construct a model of the protein related to the genetic disorder • Explain how having a certain mutation in one individual can make a certain personalized medicine work in another individual
3.0	**Students will be able to:** • Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants • Analyze an enzyme digest of a gene segment to construct a family pedigree tracking a single gene disorder • Describe how genetic testing can reveal information about a patient's risk of developing a disease or disorder
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, medicine, medical biotechnology, vaccine, drug, drug therapy, drug discovery, organic synthesis, screening, pathogenesis, antiseptic, pharmacology, combinatorial chemistry, parallel synthesis, library, biochip, microarray, peptides, peptide synthesizer, oligonucleotides, DNA synthesizer, flow cytometry, B-cells, memory cell, immunity, transgenic, genetic counselor, pedigree, pharmacogenetics, biomarker) • Give an example of a personalized medicine • Explain how genetic disorders are diagnosed
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Research to learn about the number of Americans diagnosed with life-threatening diseases each year and the efforts to combat them • Create a presentation about life-threatening diseases to share with peers
3.0	**Students will be able to:** • Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. • Discuss the scope and role of medical biotechnology in the healthcare industry • Explain how scientists test the effectiveness of antibiotics and antimicrobials • Explain how screening methods are used to discover drug potential • Detail the multiple uses of antibodies and vaccines in medicine
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, medicine, medical biotechnology, vaccine, drug, drug therapy, drug discovery, organic synthesis, screening, pathogenesis, antiseptic, pharmacology, combinatorial chemistry, parallel synthesis, library, biochip, microarray, peptides, peptide synthesizer,

	oligonucleotides, DNA synthesizer, flow cytometry, B-cells, memory cell, immunity, transgenic, genetic counselor, pedigree, pharmacogenetics, biomarker) • Describe the function of drugs and how they may be created • List examples of recent advances in medical biotechnology
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Structure the learning around explaining or solving a medical or anatomy field related issue.
Struggling Learners	• Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
English Language Learners (See http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf)	• Provide ELL students with multiple literacy strategies as needed; (for example, alternate response, advance notes, extended time, teacher modeling, simplification of written and verbal instruction, frequent breaks, eDictionaries).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504 Refer to page four in the Parent and Educator Guide to	

	Section 504 to assist in the development of appropriate plans.	

Interdisciplinary Connections

Indicators:

- **Connections to HS-ETS1.A: Defining and Delimiting Engineering Problems**
  - Physical Science: HS-PS2-3, HS-PS3-3
- **Common Core State Standards Connections: ELA /Literacy**
  - RST .11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video , multimedia) in order to address a question or solve a problem.
  - RST .11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
  - RST .11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
- **Common Core State Standards Connections: Mathematics**
  - MP.2 Reason abstractly and quantitatively.
  - MP.4 Model with mathematics.

Integration of 21st Century Skills

Indicators:

- **Science and Engineering Practices:**
  - Analyzing and interpreting data
  - Asking questions and defining problems
  - Constructing explanations and designing solutions
  - Developing and Using Models
  - Engaging in argument from evidence
  - Obtaining, evaluating, and communicating information
  - Planning and carrying out investigations
  - Using mathematics and computational thinking
- **Crosscutting Concepts**
  - Patterns
  - Cause and Effect
  - Scale, proportion, and quantity
  - Systems and system models
  - Energy and matter: Flows, cycle, and conservation
  - Structure and function
  - Stability
- **Connections to Engineering, Technology and Applications of Science**
  - New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Unit Title: Biotechnology and the Environment

Unit Description:

Research and development of new biotechnology crops for food, traditional medicines, biopharming, food security and fuel alternatives continues to expand. This unit focuses on the practices and advances in agricultural biotechnology. Students will learn about plants and agriculture and explore how this technology provides many opportunities to feed, fuel, heal, and protect the world in a healthy way.

Unit Duration: 3 weeks

Desired Results

Standard(s):

- **Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. (HS-LS3-2)**
- **Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. (HS-LS3-3.)**
- **Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants (HS-ETS1-1)**
- **Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (HS-ETS1-2.)**
- **Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics. (HS-ETS1-3.)**

Indicators:

LS3.B: Variation of Traits

- Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors.

ET S1. A: Defining and Delimiting Engineering Problems

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

ET S1. B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

ET S1.C: Optimizing the Design Solution

- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

Understandings:

Students will understand that…

- Plants propagate through sexual and asexual reproductive means. Sexual reproduction requires two parents and the fusion of their sex cells to produce a zygote, which will grow into the new plant. Asexual plant propagation requires only one parent, and it produces identical offspring. Some methods of asexual plant propagation include cutting and tissue culture
- Sexual reproduction controlled by scientists or farmers is called breeding. Selective breeding occurs when specific parent plants are chosen and bred
- Predictions of the results of a cross can be made using a Punnett Square. IF the parents' genotype can be discovered, possible gametes and the various ways the can fuse are predicted
- Plants have organs and tissues. Recognizing them is important for agriculture, breeding and asexual propagation
- Breeding introduces variety into offspring, and asexual plant propagation produces identical offspring, which are clones of the parent plant
- Agriculture is a broad field that includes growing and harvesting crops, soil management, water management, plant and animal breeding and hybridization, asexual plant propagation, seed production and improvement, crop management and the use of fertilizers, herbicides, insecticides, pesticides, farming tools and equipment
- Agricultural biotechnology is the application of advancements in DNA and protein technologies to improve yield and quantity

Essential Questions:

- How does biotechnology impact agriculture?
- Why are proteins significant in agricultural biotechnology?
- How do genetic modifications occur?
- How are modified genes inserted into plants?
- How do the different methods of inserting genes into plants compare?
- How can a plant be cloned?
- What is the difference between propagation by tissue culture and propagation by cuttings?
- What are the steps required to complete tissue culture?
- What are the steps in engineering a plant?
- Why should I be concerned about GM as an agricultural biotechnician?
- What are the advantages and disadvantages of GM crops?
- How do personal beliefs influence acceptance of GM technologies?

- Horticulture is the area of agriculture focused on growing plants for ornamental purposes
- Agriculture and horticulture have recently seen the introduction of GMOs
- Biotechnology advances have improved the production of several food crops and food products and play a key role in protecting the food supply by monitoring microbial, allergenic, and toxic contaminants, as well as, providing some crops the ability to tolerate extreme environmental conditions

Assessment Evidence

Performance Tasks:

Students will be able to …

- Describe mechanism of plant pollination and differentiate between haploid and diploid cells and their role in sexual reproduction
- Identify various natural and artificial ways to propagate plants to increase genetic variety or maintain the genetic composition
- Discuss the function and composition of different plant structures, tissues, and organelles and give examples of foods that are derived from various plant organs
- Describe the processes of seed germination and plant growth specific genotypes, using Punnett Square analysis in a plant breeding experiment
- Describe the role of meristematic tissue in asexual plant propagation
- Explain the role of plant growth regulators, as well as, the advantages and disadvantages of plant tissue culture
- Define and contrast the terms agriculture and agricultural biotechnology
- Give specific examples of agricultural and horticultural biotechnology
- Discuss how proteins of interest may be purified from plant samples and how DNA or protein samples may be assayed for their concentration and purity
- Describe the role that *Agrobacterium tumefaciens* plays in producing genetically modified plant crops
- Summarize the methods used to produce transgenic plants
- Describe the role of biotechnologists in food production, food processing, and food security

Other Evidence:

- Cornell Notes/Note Cards on unit reading materials
- Daily Assessments (informal)
  - Bell Work
  - Supplemental Reading
  - Whiteboard Activities
  - Writing Prompts/Reflections
- Quiz: Basic Plant Anatomy
- Quiz: Plant Genetics
- Performance Assessments
  - Class Discussion
  - Online Activities
  - Research Journal
- Laboratory Exercises:
  - Plant Anatomy and Tissues (Microscope)
  - African Violet Tissue Culture
- Group Work
  - Laboratory Exercises
  - Case Studies

Benchmarks:

Unit Test: Biotechnology and the Environment

Alien DNA in Your Food? Writing Assessment

Learning Plan

Introduction to Plant Biology:

- Lecture Topics:
  - Plant Propagation
  - Basic Plant Anatomy
  - Plant Growth, Structure and Function
  - Introduction to Plant Breeding
- Textbook:
  - Daugherty, Chapter 10, pages 306 to 333
- Laboratory Exercises:
  - Microscope: Plant Tissues
  - African Violet Tissue Culture (Carolina)
- Other Activities:
  - Online: Seed – The Next Generation of Biotech Products (Textbook, page 307)
  - Online: whatever Happened to the FLAVR SAVR Tomato? (Textbook, page 315)
  - Plant Punnett Square
  - Alien DNA in Your Food (Textbook, page 341)
- Videos:
  - Introduction to Plants (YouTube)
- Case Studies:
  - Wisconsin Fast Plants … How fast is Fast?

Biotechnology in Agriculture:

- Lecture Topics:
  - Hydroponics
  - Agricultural DNA Technology
  - Plant Proteins and Agricultural Products
  - Plants and Pharmaceuticals
  - Plant Genetic Engineering
- Textbook:
  - Daugherty, Chapter 11, pages 342 to360
- Laboratory Exercises:
  - Can You Taste the Difference? (CTE)
- Other Activities:
  - A Picture of Crop Production in the US (Textbook, page 344)
  - Out of this World Hydroponics
  - How Much Do You KNOW about GMO? (Textbook, page349)
  - Golden Rice Activity
- Videos:
  - How Do Hydroponics Work? (YouTube)
  - Are GMOs safe to eat?
- Current Event Assignment

Resources:

- Textbook: Biotechnology; Science for the New Millennium by Ellyn Daugherty Chapters 10 and 11
- Current Event: The field of biotechnology is changing rapidly. Everyday significant new discoveries are bringing new products to market; staying current on these advances is important. In each unit, students will use scientific databases and perform Internet research on current events. Students will summarize what they have learned in various formats and share it with their peers. Topics will be current and unit dependent.
- Online Resources: NonGMO Project at https://www.nongmoproject.org/gmo-facts/; GMO Answers at https://gmoanswers.com/gmo-basics?gclid=Cj0KCQjw8b_MBRDcARIsAKJE7lmpRk9CB5dChPWGxCn0g-a52APl3wcQJrZefngFLujs049K8tr22iwaAjMVEALw_wcB; Can You Taste the Difference? From CTE at https://www.cteonline.org/curriculum/lessonplan/genetically-modified-crops/C8FCXY;
- Technology: Teacher 2 in 1 Device, Short Throw Projector, Student Laptops,
- Other Resources: PowerPoint Presentations (instructor created), supplemental readings and handouts (inclusive of current and emerging research related information) in conjunction with, but not limited to the following topics: plants, plant anatomy, plant propagation, plant breeding, plant genetics, agriculture and DNA, GMOs, plant engineering, plant pharmaceuticals, golden rice, hydroponics

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Explain the role of meristematic tissue in asexual plant propagation • Explain the role of plant growth regulators, as well as the advantages and disadvantages of plant tissue culture • Create a presentation that demonstrates the impact of the traditional plant biotechnology industry
3.0	**Students will be able to:** • Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. • Discuss the function and composition of different plant structures • List examples of foods that are derived from various plant organs • Describe the processes of seed germination and plant growth • Make a time line that demonstrates the major events in recent agricultural biotechnology history
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, alleles, asexual plant propagation, breeding, cross breeding, cuttings, cytokinin, differentiation, dihybrid cross, diploid, dominant, embryo, gametes, germination, haploid, herbaceous plants, heterozygous, homozygous, meiosis, meristematic tissue, meristem, mitosis, monohybrid cross, phytochrome, plant hormones, plant tissue culture, polygenic, recessive, selective breeding, sexual reproduction, tissue culture, zygote) • Describe the mechanisms of plant propagation • Differentiate between haploid and diploid cells and their role in reproduction
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	
4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Create a presentation that demonstrates how biotechnology has impacted the livestock industry • Examine the benefits and risks, and defend an opinion on whether the United States should grow GMOs
3.0	**Students will be able to:** • Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants • Explain how genomic and plasmid DNA can be isolated from cells, including the additional steps required for plant cell DNA isolation • Explain the basics of genetically modifying organisms in crop agriculture • List advantages of using biotechnology in the agriculture industry
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, agriculture, feedstock, foodborne pathogens, genomic DNA, horticulture, hydroponics, in breeding, macronutrients, micronutrients, plant-based pharmaceuticals, transgenic plants) • Define and contrast the terms agriculture and agricultural biotechnology • List specific examples of agricultural and horticultural biotechnology
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Structure the learning around explaining or solving a medical or anatomy field related issue.
Struggling Learners	• Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
English Language Learners (See http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf)	• Provide ELL students with multiple literacy strategies as needed; (for example, alternate response, advance notes, extended time, teacher modeling, simplification of written and verbal instruction, frequent breaks, eDictionaries).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504 Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Interdisciplinary Connections

Indicators:

- **Connections to HS-ETS1.A: Defining and Delimiting Engineering Problems**
  - Physical Science: HS-PS2-3, HS-PS3-3
- **Common Core State Standards Connections: ELA /Literacy**
  - RST .11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video , multimedia) in order to address a question or solve a problem.
  - RST .11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
  - RST .11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
- **Common Core State Standards Connections: Mathematics**
  - MP.2 Reason abstractly and quantitatively.
  - MP.4 Model with mathematics.

Integration of 21st Century Skills

Indicators:

- **Science and Engineering Practices:**
  - Analyzing and interpreting data
  - Asking questions and defining problems
  - Constructing explanations and designing solutions
  - Developing and Using Models
  - Engaging in argument from evidence
  - Obtaining, evaluating, and communicating information
  - Planning and carrying out investigations
  - Using mathematics and computational thinking
- **Crosscutting Concepts**
  - Patterns
  - Cause and Effect
  - Scale, proportion, and quantity
  - Systems and system models
  - Energy and matter: Flows, cycle, and conservation
  - Structure and function
  - Stability
- **Connections to Engineering, Technology and Applications of Science**
  - New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Unit Title: Advanced Topics in Biotechnology

Unit Description:

The field of biotechnology is changing rapidly. Everyday significant new discoveries are providing new products to market. This unit focuses on some of the most recent advances in the field of biotechnology. Students will also explore future trends in the rapidly expanding world of biotechnology.

Unit Duration: 5 weeks

Desired Results

Standard(s):

- **Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. (HS-LS3-2)**
- **Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. (HS-LS3-3.)**
- **Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants (HS-ETS1-1)**
- **Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (HS-ETS1-2.)**

- **Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics. (HS-ETS1-3.)**

Indicators:

LS3.B: Variation of Traits

- Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors.

ET S1. A: Defining and Delimiting Engineering Problems

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

ET S1. B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

ET S1.C: Optimizing the Design Solution

- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

Understandings:

Students will understand that…

- DNA replication can be performed in the lab by technicians. In vitro DNA synthesis is done to produce primers, probes, and genes of interest for research
- Using an automated DNA synthesizer, technicians build DNA strands by coupling nucleotides in a specific order
- PCR is a method used to recognize certain sequences of DNA, and replicate them enough times to have sufficient sample to test or use in research
- Applications of DNA sequencing include gene identification, searching for mutants, confirmation of gene transfer, and comparative DNA studies
- DNA sequencing data can be analyzed using many bioinformatics tools. A common one is BLAST, which allows comparisons of sequences within and between organisms
- Protein structure is determined by several techniques, including x-ray crystallography, protein sequencing, and PAGE
- Protein size, the number of polypeptide chains in a protein, and the approximate concentration of proteins in a solution can be determined by running a PAGE gel
- An ELISA is a test the uses antibodies to recognize and quantify the amount of a specific protein sample
- Protein studies may be used to explain evolutionary relationships, as well as identification for some species. Protein studies lead to understanding of diseases and how to treat them
- Genomics is the study of all the DNA in a cell
- The Human Genome Project published a rough draft of the entire DNA code for the human organism
- The Human Genome sequence information has led to hundreds of studies in gene expression and protein production
- Bioinformatics is the use of computers and statistical analysis to understand biological data

Essential Questions:

- How is DNA synthesized and are its applications?
- What is genomics?
- What is CRISPR? How is it advancing biotechnology?
- What is proteomics?
- What are examples of RNA technologies and how are they being used?
- What is bioremediation?
- What advantages does bioremediation offer over traditional environmental cleanup methods?
- How can biotechnology contribute to solving the world energy crisis?
- What is marine and veterinary biotechnology?
- What is bioinformatics?
- How can I use bioinformatics to further my understanding of a genome?
- How will biotechnology influence my future?
- Where will biotechnological advances go in the coming years?

- Computer programs and databases of computerized information have been developed to manage the enormous amount of genomic and proteomic data
- CRIPSR/Cas (technologies allow for precise and accurate editing of genetic code and the potential for gene therapy
- Proteomics is the study of how, when and where proteins are used in cells
- 3D bioprinting uses a modification of ink-jet technology, stem cells and computer technology to produce new, replicate tissues and organs
- Energy independence and decreasing greenhouse gas emissions are the driving forces in developing new biofuels
- Understanding the diversity and molecular genetics of microbes, and documenting it in one of the microbiome projects, will lead to new uses of microbes and solutions to many of the problems cause by microorganisms
- Nanotechnology is the study, use, and manipulation of things that are about a billionth of a meter in size. Nanotech has many applications in biotechnology
- Biotechnology is being used to study marine organisms and to address animal health

Assessment Evidence

Performance Tasks:

Students will be able to …

- Describe the process of semiconservative DNA replication in cells and compare and contrast this method with DNA synthesis in the laboratory
- Explain the steps of PCR and discuss the components of the process
- Discuss applications of PCR technology
- Discuss the benefits and implications of knowing the DNA sequences of humans and other organisms
- Explain how DNA is sequenced (Sanger and Next Generation Sequencing methods) for research and clinical purposes and how recent improvements have increased the efficiency of the process
- List some of the tools used in genomics and the advance made possible by them
- Describe how bioinformatics and microarray technology are speeding genetic studies and the search for novel pharmaceuticals
- Give examples of how RNA technologies impact research and development of new therapies
- Explain how CRISPR and Cas9 technologies allow for precise and accurate editing of genetic code
- Distinguish between different methods used for protein study and how they have led to advances in proteomic research
- Explain how advances in stem cell research, regenerative medicine, 3D bioprinting, and synthetic biology may lead to improved health care
- Describe how advances in biofuels and other biotechnologies are being used to understand and protect the environment

Other Evidence:

- Cornell Notes/Note Cards on unit reading materials
- Daily Assessments (informal)
  - Bell Work
  - Supplemental Reading
  - Whiteboard Activities
  - Writing Prompts/Reflections
- Quiz: DNA Sequencing and PCR
- Quiz: Proteomics
- Performance Assessments
  - Class Discussion
  - Online Activities
  - Research Journal
- Laboratory Exercises:
  - Molecular Modeling
  - Online: What is the Future of Biotechnology?
- Group Work
  - Genetics Project

• Outline the important applications of the growing biotechnology fields of veterinary biotech, dental biotech, nanotechnology, bioterrorism and biodefense	

Benchmarks:

Biotechnology Final Exam

Genetics Project Presentation

Learning Plan

Learning Activities: In depth coverage of the following topics will be dependent on time availability in the 4th Marking Period. This course is typically comprised of Seniors; availability will vary dependent on pacing, class structure, and out-of-classroom activities (Senior Activities, AP and State Testing, early Final Exams).

- Lecture Topics:
  - Advanced DNA Topics
    - DNA Sequencing
    - Polymerase Chain Reaction – PCR
    - DNA Synthesis Products
    - BLAST
  - Advance Protein Studies
    - X-ray Crystallography
    - Protein Sequencing
    - PAGE
    - ELISA
  - Bioinformatics
  - The Future of Biotechnology
    - Mitochondrial DNA
    - Bioprinting
    - Biofuels
    - BioBugs and Microterrorism
    - The Human Microbiome Project
- Textbook:
  - Daugherty, Chapter 13 and 14, pages 402 to 428 and 436 to 463
  - Rare Diseases: Diagnosis, Therapies and Hope (digital) at https://www.wtps.org/site/handlers/filedownload.ashx?moduleinstanceid=28149&dataid=29705&FileName=Rare-Diseases-Book-Diagnosis-Therapies-and-Hope-V5-330b.pdf
  -
- Laboratory Exercises:
  - Modeling Sanger Sequencing (3D Molecular Designs)
  - Modeling PCR (3D Molecular Designs)
- Other Activities:
  - Human Genome Project
  - Tell Me About Telomeres (Textbook, page 407; Learn Genetics)
  - Snip Snip Here, Snip Snip There (Textbook, page 409)
  - BLAST Activity
  - Mitochondria Have Sequences, Too (Textbook, page 439)
  - Identifying Autism Gene by Tracking Gene Mutations (HHMI)
  - I am All Ears for Bioprinting (Textbook, page 452)
  - What is Bioremediation Activity
  - Algae: Better for Oil than Dinosaurs? (Textbook, page 454)
  - BioBugs Microscopic Terrorist Groups (Textbook, page 455)
  - Microbiome Activity
  - CRISPR Cas9 Activities
  - Bioparts from 3D Printing (Textbook, page 470)
- Videos:
  - The Whitehouse Announcement (HGP)
  - The Human Genome Project (John Hopkins University)
  - PCR (HHMI)
  - Microbiomes and the Human Microbiome Project (Harvard University)
  - TedTalk: The Importance of the Human Microbiome
- Common Reading Project Activities
- Current Event Assignment

Resources:

- Textbook: Biotechnology; Science for the New Millennium by Ellyn Daugherty Chapters 13 and 14
- Common Reading Project: One in a Billion: The Story of Nic Volker and the Dawn of Genomic Medicine, by Mark Johnson and Kathleen Gallagher. The book was selected based on the quality of the writing and in-depth coverage of an important topic in biotechnology and scientific research. Student copies of the book will be distributed and are available at the library. This project will be implemented over several units during the second semester of this course.
- Current Event: The field of biotechnology is changing rapidly. Everyday significant new discoveries are bringing new products to market; staying current on these advances is important. In each unit, students will use scientific databases and perform Internet research on current events. Students will summarize what they have learned in various formats and share it with their peers. Topics will be current and unit dependent.
- Online Resources: Human Genome Project from NIH at http://www.3dmoleculardesigns.com/Teacher-Resources.htm; The Whitehouse Announcement at https://www.youtube.com/watch?v=slRyGLmt3qc; Human Genome Project lecture from John Hopkins at https://www.coursera.org/learn/introduction-genomics/lecture/ykjod/the-human-genome-project; Learn Genetics at http://learn.genetics.utah.edu/; Autism Activities at http://www.hhmi.org/biointeractive/identifying-autism-genes-tracking-gene-mutations; Molecular Modeling Kits from 3D Molecular Designs at http://www.3dmoleculardesigns.com/Teacher-Resources.htm; The Human Microbiome Project from Harvard University at https://www.youtube.com/watch?v=CSFDHyBG2i4; Ted Talk on the Human Microbiome at https://www.youtube.com/watch?v=Dnir-umb0IE;
- Technology: Teacher 2 in 1 Device, Short Throw Projector, Student Laptops,
- Other Resources: PowerPoint Presentations (instructor created), supplemental readings and handouts (inclusive of current and emerging research related information) in conjunction with, but not limited to the following topics: DNA sequencing, PCR, protein sequencing, BLAST, Human Genome Project, telomeres, mDNA, RNA technologies, bioprinting, biofuels, microbiomes, CRISPR/Cas9, 3D printing, bioinformatics, bioremediation, bioterrorism

Unit Learning Goal and Scale
(Level 2.0 reflects a minimal level of proficiency)

Standard(s): Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors

4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Explain how DNA is sequenced (Sanger and Next Generation) for research and clinical purposes • Identify recent advances in DNA technology
3.0	**Students will be able to:** • Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. • Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population • Compare and contrast DNA replication in cells with DNA synthesis in the laboratory • Discuss the application of PCR technology
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, amplification, BLAST, cross-link, cycle sequencing, dideoxy nucleotide sequencing, dideoxynucleosides, DNA polymerase, DNA replication, DNA sequencing, forensics, helicase, homologous pairs, Human Genome Project, karyotyping, primer, probes, reaction buffer, RNA primase, RNase, template, topoisomerase) • Describe the process of semiconservative DNA replication in cells • Explain the steps of PCR
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

4.0	**Students will be able to:** • In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught • Explain how CRISPR and Cas9 technologies allow for precise and accurate editing of genetic code • Develop a presentation that details a specific genetic disorder and describe the biotechnology applications being used to combat the challenges of this disorder
3.0	**Students will be able to:** • Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants • Describe bioinformatics and microarray technology and explain how they are being used in genetic research • Give an example of RNA technologies impact in research and therapeutics • Explain an example of how advances in biotechnology (stem cell research, regenerative medicine, 3D-bioprinting, synthetic biology) may lead to improved health care. • Explain how biofuels and their applications are beneficial to the environment
2.0	**Students will be able to:** • Recognize or recall specific vocabulary (for example, 3-D bioprinting, adult stem cells, biofuels, biodefense, bioinformatics, biometric, bioterrorism, embryonic stem cells, environmental biotechnology, genomics, microbial genomics, microbiology, microbiome, nanotechnology, pluripotent, proteome, proteomics, shotgun cloning, synthetic biology) • List some of the tools in genomics and the advances made possible by them • Create an outline of the important applications of the biotechnology field of veterinary biotech, dental biotech, nanotechnology, bioterrorism and biodefense.
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Structure the learning around explaining or solving a medical or anatomy field related issue.
Struggling Learners	• Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
English Language Learners (See http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf)	• Provide ELL students with multiple literacy strategies as needed; (for example, alternate response, advance notes, extended time, teacher modeling, simplification of written and verbal instruction, frequent breaks, eDictionaries).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered

		• Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504	Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Interdisciplinary Connections

Indicators:

- **Connections to HS-ETS1.A: Defining and Delimiting Engineering Problems**
  - Physical Science: HS-PS2-3, HS-PS3-3
- **Common Core State Standards Connections: ELA /Literacy**
  - RST .11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video , multimedia) in order to address a question or solve a problem.
  - RST .11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
  - RST .11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
- **Common Core State Standards Connections: Mathematics**
  - MP.2 Reason abstractly and quantitatively.
  - MP.4 Model with mathematics.

Integration of 21st Century Skills

Indicators:

- **Science and Engineering Practices:**
  - Analyzing and interpreting data
  - Asking questions and defining problems
  - Constructing explanations and designing solutions
  - Developing and Using Models
  - Engaging in argument from evidence
  - Obtaining, evaluating, and communicating information
  - Planning and carrying out investigations
  - Using mathematics and computational thinking
- **Crosscutting Concepts**
  - Patterns
  - Cause and Effect
  - Scale, proportion, and quantity
  - Systems and system models
  - Energy and matter: Flows, cycle, and conservation
  - Structure and function
  - Stability
- **Connections to Engineering, Technology and Applications of Science**

- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.