



West Windsor-Plainsboro Regional School District
Course Title: Genetics
Grades: 11-12

The Mission of the West Windsor-Plainsboro Science Department

Our mission is to cultivate science learners who have the foundational knowledge to make ethical, scientifically literate decisions and the ability to apply scientific practices in order to contribute to the needs of society and a changing world.

- **Vision**

We envision a K-12 science experience that supports and challenges every student in their science learning journey. We will:

- *Capitalize on diversity by reaching and exciting students at all levels and interests by differentiating learning within classrooms and by offering a robust program of studies.*
- *Emphasize authentic science and engineering practices and leverage the interdisciplinary nature of science with arts, technology, math, reading, and writing.*
- *Integrate scientific knowledge and 21st century competencies to prepare students to make informed decisions and take action to address real world problems.*

Unit 0: General Lab Safety and Procedures	
Content Area: Science	
Course & Grade Level: Genetics (11-12)	
Summary and Rationale	
This unit introduces students to basic chemical laboratory techniques, safety standards, and data analysis methods. The proper handling, storage and disposal of chemicals during a lab is emphasized.	
Recommended Pacing	
1 week	
New Jersey Student Learning Standards for	
Standard	
CPI #	Cumulative Progress Indicator (CPI)
	Demonstrate how to use scientific tools and instruments with respect for student safety.
HS-ETS1-3	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. [Clarification Statement: Emphasis is placed on safety in the laboratory as well as the environmental impact of our actions.]
Instructional Focus	
Unit Enduring Understandings	
<ul style="list-style-type: none"> ● Clear, accurate, organized and concise communication is essential for scientists. ● Safety in the chemistry laboratory requires using your common sense at all times! ● Different systems of measurement are used for different purposes. ● Correct selection of measurement instruments and measurement language will ensure accurate results. 	
Unit Essential Questions	
<ul style="list-style-type: none"> - Are all laboratory activities approached in the same manner? - Why do we need to practice safe habits in the chemistry laboratory? - Is it necessary to use a common set of measurement units? Why or why not? 	
Content Statements	
<ul style="list-style-type: none"> ● Identify common lab equipment. ● Identify the lab book setup and guidelines 	
Ability Objectives	
<ul style="list-style-type: none"> ● Demonstrate safe behavior in the laboratory. ● Properly use common laboratory equipment (Bunsen burner may be covered later). ● Demonstrate proper use and care of triple beam and/or top loading, and electronic balances. ● Demonstrate proficient setup and data collection/analysis in lab notebook. ● Demonstrate proper graphical analysis techniques; including preparing and reading graphs, identifying the dependent and independent variables, interpolating and extrapolating data. 	
Evidence of Learning:	
Demonstrate personal safety while using Bunsen burners, glassware, and handling acids, bases and other chemicals.	
Resources	
WWP Policy: 7420 (pg. 335, 7432)	

Unit 1: Molecular Genetics

Content Area: Science

Course & Grade Level: Genetics (11-12)

Summary and Rationale

The molecules that make up cells work to determine the functions and processes that occur in living things. One of the most crucial molecules for many organisms is deoxyribonucleic acid. In this unit, students will work collaboratively to understand how the structure of DNA allows for DNA replication to occur. Without this replication process, cell division would not occur successfully. Another important point that is the focus of this unit is the process of protein synthesis - how proteins that run many of the body's main processes are created through transcription and translation from the original DNA molecule. Issues with cellular functions and disorders can occur through mutations during this process or DNA replication. Students will demonstrate understanding through building models of DNA structure and replication, communicating information regarding disorders that occur from mutations and constructing explanations about the regulation and expression of genes during changes in the environment.

Recommended Pacing

2-3 weeks

New Jersey Student Learning Standards for

Standard

CPI

Cumulative Progress Indicator (CPI)

HS-LS1-1	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. [Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.]
HS-LS3-1	Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]
HS-LS3-2	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. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]
HS-ESS3-1	The Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

Companion Standards

English Language Arts/Literacy:

- Cite specific textual evidence to support analysis of science and technical texts describing the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, resolving conflicting information when possible.
- Cite specific textual evidence to support analysis of science and technical texts describing the ways that inheritable genetic variation occurs, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Write arguments, based on evidence, that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors.

New Jersey Student Learning Standards for Career Readiness, Life Literacies, Key Skills and Technology

CPI #	Cumulative Progress Indicator (CPI)
9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
9.4.12.CT.2	Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)
9.4.12.TL.1	Assess digital tools based on features such as accessibility options, capacities, and utility for accomplishing a specified task (e.g., W.11-12.6.).

Interdisciplinary Standards (fill-in Science, or SS, or Math, etc..)

Mathematics:

- Represent symbolically evidence that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors, and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the ways in which inheritable genetic variation occurs.
- Represent the variation and distribution of expressed traits in a population symbolically and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the variation and distribution of expressed traits in a population.

Social Studies:

Standard 6.1 U.S. History: America in the World. All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.

Standard 6.2 World History: Global Studies: All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Enduring Understandings

- The structure and replication of DNA allows for the passing down of genetic material ultimately through

reproduction

- A gene is a section of DNA that codes for a specific protein. Proteins carry out the cell's work and its shape helps it carry out its job
- Mutations in the DNA can alter the protein made during protein synthesis, possibly altering the processes occurring in a cell
- Regulation of gene expression plays an important role in allowing cells to react to changes in their environment
- Mutations in the DNA can lead to increased or decreased evolutionary fitness in the changing environment due to climate change in humans
- Students have an understanding of disabilities caused by genetic mutations and how people with those disabilities live and cope with their disability.

Unit Essential Questions

- How does a sequence on a DNA strand ultimately translate into a working protein?
- What are some errors that can occur to change the protein that is made at the end of protein synthesis?
- Why is DNA replication critical for cell division?
- How does the structure of DNA allow for DNA replication to successfully occur?
- How do mutations allow for increased or decreased reproductive success in climate change-affected areas?

Content Statements

Structure and Function

- 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.

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. (HS-LS3-1)

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. (HS-LS3-2)
- 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. (HS-LS3-2),(HS-LS3-3)

Natural Resources

- Resource availability has guided the development of human society. (HS-ESS3-1)

Natural Hazards

- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS3-1)

Ability Objectives

General for all units:

- Develop and carry out scientific investigations.
- Obtain, evaluate and communicate information to develop information literacy and evaluate the quality of a source of information
- Develop and use models to explain complex processes and relationships between and within organisms.
- Analyze and interpret data and communicate information using a variety of modalities.
- Use mathematical and computational data to support scientific conclusions.

- Engage in argument from evidence to explain natural phenomenon.
- Construct explanations and design solutions for complex real world problems.

Unit 1:

- Identify the different components present in the structure of DNA and build a model showing how the components bond together.
- Model the replication of DNA, showing how the semi-conservative model is used to build new DNA strands off of the original strands.
- Explain how the environment can influence the expression of certain traits which may then be passed onto subsequent generations.
- Engage in argument from evidence focusing on the creation of genetic variation from meiosis or mutations.
- Obtain, evaluate and communicate information regarding how mutations can cause incorrect proteins to form through mistakes in DNA replication or transcription and translation.
- Obtain, evaluate and communicate information focusing on the increased or decreased survival potential of organisms with specific mutations in climate change affected areas.

Sample Performance Tasks - Specific for Unit 1: SWBAT:

- **Build a model** showing the **specific structure and bonding pattern** of a molecule of DNA as well as how the **semi-conservative model** is used to build new DNA from the old strands. (HS-LS3-1)
- **Construct an explanation** for how genetic variation can be inherited through and **caused by mutations in protein synthesis or DNA replication**. (HS-LS3-2)
- **Obtain and communicate information** focusing on the **impact/effects** of **genetic mutations** on different processes in the body. (HS-LS1-1, HS-LS3-2)
- **Analyze and interpret data** to show the **relationship** between **environmental factors and gene expression**. (HS-LS3-3)
- **Obtain and communicate information** to an audience about the **effects** of **genetic mutations** on survival rates in climate change affected areas. (HS-ESS3-1)

Resources

Unit 2: Chromosomal Basis of Inheritance

Content Area: Science

Course & Grade Level: Genetics (11-12)

Summary and Rationale

Meiosis and patterns of inheritance provide explanations for how certain traits, diseases or other heritable characteristics can pass through generations. Understanding of this is critical because relationships between genes play a large role in determining how an organism develops and functions. During this unit, students are able to ask questions, make and defend a claim, and use concepts of probability and an understanding of the events in meiosis to explain the genetic variation in a population. Mistakes during the process of meiosis can cause various types of chromosomal disorders. Students will work through different patterns of inheritance in pedigrees and punnett squares in order to construct explanations of the differences and similarities between the patterns.

Recommended Pacing

2-3 weeks

New Jersey Student Learning Standards for

Standard

CPI #	Cumulative Progress Indicator (CPI)
HS-LS3-2.	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. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]
HS-LS3-3.	Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. [Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.] [Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.]
HS-ESS3-1	The Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

New Jersey Student Learning Standards for English Language Arts Companion Standards

English Language Arts/Literacy:

- Cite specific textual evidence to support analysis of science and technical texts describing the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

- Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, resolving conflicting information when possible.
- Cite specific textual evidence to support analysis of science and technical texts describing the ways that inheritable genetic variation occurs, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Write arguments, based on evidence, that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors.

New Jersey Student Learning Standards for Career Readiness, Life Literacies, Key Skills and Technology	
CPI #	Cumulative Progress Indicator (CPI)
9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
9.4.12.CT.2	Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)
9.4.12.TL.1	Assess digital tools based on features such as accessibility options, capacities, and utility for accomplishing a specified task (e.g., W.11-12.6.).
Interdisciplinary Standards (fill-in Science, or SS, or Math, etc..)	
Mathematics:	
<ul style="list-style-type: none"> • Represent symbolically evidence that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors, and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the ways in which inheritable genetic variation occurs. • Represent the variation and distribution of expressed traits in a population symbolically and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the variation and distribution of expressed traits in a population. 	
Social Studies:	
<p>Standard 6.1 U.S. History: America in the World. All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.</p> <p>Standard 6.2 World History: Global Studies: All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.</p>	

Instructional Focus
Unit Enduring Understandings
<ul style="list-style-type: none"> • Meiosis is the process that ensures genetic diversity and continuity whereas mitosis works to maintain genetic consistency and continuity. • Genes exist in different forms called alleles. There are usually more than two alleles for a gene, resulting in more than two phenotypes. • Certain traits and genetic disorders can be traced through a family over a number of generations and used to predict offspring genotypes through a pedigree chart and use of punnett squares. • Traits are controlled by genes, which can be inherited and passed from one generation to the next. • Mistakes in meiosis such as improper separation of chromosomes (nondisjunction) can cause

chromosomal disorders such as Trisomy 21.

- Specific inherited mutations can lead to increased or decreased evolutionary fitness in the changing environment due to climate change in humans

Unit Essential Questions

- How are traits passed from parents to offspring? What mistakes can occur during this process?
- How does an organism's genotype relate to its phenotype for various different inheritance patterns?
- Why is genetic variation important in a population or species in a changing environment?
- Why is meiosis essential for sexual reproduction and what genetic problems can arise if there are errors in the meiosis process?
- How do different alleles allow for increased or decreased reproductive success in climate change-affected areas?

Content Statements

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. (HS-LS3-2)
- 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. (HS-LS3-2),(HS-LS3-3)

Natural Hazards

- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS3-1)

Ability Objectives

General for all units:

- Develop and carry out scientific investigations.
- Obtain, evaluate and communicate information to develop information literacy and evaluate the quality of a source of information
- Develop and use models to explain complex processes and relationships between and within organisms.
- Analyze and interpret data and communicate information using a variety of modalities.
- Use mathematical and computational data to support scientific conclusions.
- Engage in argument from evidence to explain natural phenomenon.
- Construct explanations and design solutions for complex real world problems.

Unit 2:

- Model the process of meiosis stages I and II normally, with nondisjunction in meiosis I and nondisjunction in meiosis II and explain the differences in chromosome number between the resulting cells.
- Construct explanations for how genetic variation is introduced in meiosis through the process of crossing over and independent assortment of chromosomes.
- Differentiate between and solve Mendelian and Non-mendelian patterns of inheritance problems.
- Analyze pedigree charts to identify genetic disorders or traits and their inheritance patterns through multiple generations.
- Explain how different alleles/mutations impact an organism's fitness in changing environments.

Sample Performance Tasks - Specific for Unit 2: SWBAT:

- **Model** the **process of meiosis** to **identify sources** of genetic variation. (HS-LS3-2)
- **Analyze and interpret** genetic data to determine **probability and patterns of inheritance** of various **genetic traits**. (HS-LS3-3)
- **Analyze** how **nondisjunction during the process of meiosis** can **lead to chromosomal disorders** that range in severity. (HS-LS3-2)

Resources

Unit 3: Cancer Genetics

Content Area: Science

Course & Grade Level: Genetics (11-12)

Summary and Rationale

The most fundamental characteristic of cancer is the disruption of the cell cycle. Cancer results when a cell divides more frequently than the noncancerous cell it descended from. A mutation in a gene responsible for the timing/rate of mitosis can lead to uncontrolled mitosis. Most mutations that cause cancer are found in oncogenes and tumor suppressor genes. Cancer is genetic because it is caused by changes in the DNA but it is usually not inherited. The majority of cancers are sporadic and are caused by somatic mutations. Cancers that are inherited result from inheriting a cancer susceptibility allele from a parent. This inherited allele is present in every cell of the individual. Cancer develops when there is a second mutation occurring in the other allele. Scientists have identified several cancer susceptibility genes (p53, BRCA1, BRCA2). An individual's knowledge of possessing these genes allows preventative measures to be taken to prevent the development of cancer. Environmental factors can contribute to cancer by mutating or altering the expression of genes that control cell cycle, apoptosis and cell repair.

Students will demonstrate understanding through modeling the cell cycle and communicating how, why and where cancer causing mutations occurred. Students will investigate cancer susceptibility genes and explain how the mutated version of the gene contributes to cancer. Students will explore environmental factors that cause an increased risk to cancer and propose solutions to reduce these risks.

Recommended Pacing

2-3 weeks

New Jersey Student Learning Standards for

Standard

CPI #

Cumulative Progress Indicator (CPI)

HS-LS1-1

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. [Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.]

HS-LS3-1

Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]

HS-LS3-2

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. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]

HS-ESS3-1

Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such

as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

**New Jersey Student Learning Standards for English Language Arts
Companion Standards**

English Language Arts/Literacy:

- Cite specific textual evidence to support analysis of science and technical texts describing the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
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- Write arguments, based on evidence, that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors.

New Jersey Student Learning Standards for Career Readiness, Life Literacies, Key Skills and Technology

CPI #	Cumulative Progress Indicator (CPI)
9.4.12.TL.4	Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem (e.g., 7.1.AL.IPERS.6).
9.4.12.IML.7	Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change (e.g., NJSLSA.W1, 7.1.AL.PRSNT.4).
9.4.12.IML.2	Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources (e.g., NJSLSA.W8, Social Studies Practice: Gathering and Evaluating Sources)
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)

Interdisciplinary Standards (fill-in Science, or SS, or Math, etc..)

Mathematics:

- Represent symbolically evidence that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors, and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the ways in which inheritable genetic variation occurs.
- Represent the variation and distribution of expressed traits in a population symbolically and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the variation and distribution of expressed traits in a population.

Social Studies:

Standard 6.1 U.S. History: America in the World. All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.

Standard 6.2 World History: Global Studies: All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time

and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Enduring Understandings

- Cancer is due to the occurrence of mutations in genes that are involved in the control of the cell cycle.
- There are two classes of genes that when mutated can contribute to the development of cancer. One class, oncogenes, promotes cell division while the other class, tumor suppressor genes, fails to slow down cell division.
- Most cancers are sporadic but some cancers result from inheriting cancer susceptibility genes from one or both parents.
- Environmental factors such as diet, UV exposure, and air pollution can contribute to the development of cancer.
- Increased fossil fuel combustion due to energy demand increases the prevalence of air pollution, and the rate of climate change, which contributes to the development of cancer.
- Newer approaches based on identifying mutations are used to better target and treat cancer.
- Students will understand disparities in health care as they relate to race, socioeconomic status, gender, and sexual orientation/gender identity.
- Students will examine inequities that lead to disparities in the incidence and prognosis of cancer in different groups.

Unit Essential Questions

- How does the loss of cell cycle control lead to an overgrowth of cells and possibly cancer?
- How do proto-oncogenes (oncogenes) and tumor suppressor genes contribute to the development of cancer?
- How is cancer inherited?
- How does the environment contribute to the development of cancer?
- How is climate change linked to the development of cancer in humans?

Content Statements

Structure and Function

- 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.
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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.

Natural Resources

- Resource availability has guided the development of human society. (HS-ESS3-1)

Natural Hazards

- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS3-1)

Ability Objectives

General for all units:

- Develop and carry out scientific investigations.
- Obtain, evaluate and communicate information to develop information literacy and evaluate the quality of a source of information

- Develop and use models to explain complex processes and relationships between and within organisms.
- Analyze and interpret data and communicate information using a variety of modalities.
- Use mathematical and computational data to support scientific conclusions.
- Engage in argument from evidence to explain natural phenomenon.
- Construct explanations and design solutions for complex real world problems.

Unit 3:

- Model the cell in various phases of the cell cycle and demonstrate/communicate the cancer causing disruptions to take place in the cycle.
- Distinguish between oncogenes and tumor suppressor genes and compare/contrast the mechanisms by which these genes can cause cancer.
- Model a cancer susceptibility gene and explain the normal function of the gene as well as how the mutated version of the gene contributes to the development of cancer.
- Communicate how the environment contributes to cancer.
- Demonstrate an understanding of targeted therapies used to treat cancer.
- Construct a model identifying the connection between fossil fuel burning and increased climate change effects on earth as well as the development of cancer in humans.

Sample Performance Tasks - Specific for Unit 3: SWBAT:

- **Develop and use a model** of the **cell cycle** to **identify differences in a normal cell and a cancerous cell.** (HS-LS1-1) (HS-LS3-2)
- **Develop and use a model** of a **cancer susceptibility gene** and **explain how a mutation in this gene is inherited.**
- **Make and defend a claim** that **environmental factors can cause mutations** that **contribute to cancer.** (HS-LS3-2)
- **Develop and revise a model** that **draws connections** between the **amount of air pollution produced, cancer rates and climate change impacts** in a certain area. (HS-ESS3-1)

Resources

Unit 4: Genetic Testing

Content Area: Science

Course & Grade Level: Genetics (11-12)

Summary and Rationale

Genetic testing is becoming an increasingly important component of our society. Understanding genetic testing is useful in making medical decisions. Anyone can buy a test from 23 and me or Ancestry.com to gain some insight on their health or lineage. In this unit, students will investigate the pros and cons of genetic testing. Students will take on the role of a genetic counselor as they analyze issues of privacy, incidental findings, informed consent, and treatments as they relate to genetic testing. They will determine what diseases we should test for in newborn screening. They will explain how direct to consumer genetic tests pose unique challenges. Students will analyze legal issues in genetic testing, such as the storage of genetic information, reproductive technologies, and gene patents. They will investigate how much a genetic test can actually tell you about your traits.

Recommended Pacing

7 weeks

New Jersey Student Learning Standards for

Standard

CPI

Cumulative Progress Indicator (CPI)

HS-LS3-1.

Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]

HS-LS3-2.

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. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]

HS-PS4-2.

Evaluate questions about the advantages of using digital transmission and storage of information. [Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.]

HS-ETS1-3.

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-ESS3-1

Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

**New Jersey Student Learning Standards for English Language Arts
Companion Standards**

English Language Arts/Literacy:

- Cite specific textual evidence to support analysis of science and technical texts describing the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, resolving conflicting information when possible.
- Cite specific textual evidence to support analysis of science and technical texts describing the ways that inheritable genetic variation occurs, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Write arguments, based on evidence, that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors.

New Jersey Student Learning Standards for Career Readiness, Life Literacies, Key Skills and Technology

CPI #	Cumulative Progress Indicator (CPI)
9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas
9.4.12.CT.1	Identify problem-solving strategies used in the development of an innovative product or practice
9.4.12.CT.2	Explain the potential benefits of collaborating to enhance critical thinking and problem solving
9.4.12.IML.2	Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions
9.4.12.DC.1	Explain the beneficial and harmful effects that intellectual property laws can have on the creation and sharing of content
9.4.12.DC.3	Evaluate the social and economic implications of privacy in the context of safety, law, or ethics
9.4.12.CI.2	Identify career pathways that highlight personal talents, skills, and abilities
9.4.12.CT.3	Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).

Interdisciplinary Standards (fill-in Science, or SS, or Math, etc..)

Mathematics:

- Represent symbolically evidence that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors, and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the ways in which inheritable genetic variation occurs.
- Represent the variation and distribution of expressed traits in a population symbolically and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the variation and distribution of expressed traits in a population.

Social Studies:

Standard 6.1 U.S. History: America in the World. All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.

Standard 6.2 World History: Global Studies: All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Enduring Understandings

- The decision of whether to get a genetic test or not has many pros and cons, with multiple stakeholders. Whether a genetic test is more beneficial or harmful may depend on the age of onset of the disease, the treatment options, the probability of a gene leading to the disease, and a patient's outlook on how a test result would impact their lives.
- Genetic testing has become increasingly inexpensive and easy over recent years. It is now available to almost anyone through direct to consumer (DTC) genetic testing. Without the support of a genetic counselor, DTC poses challenges in how consumers interpret genetic results and make decisions based on these results.
- Storage of genetic information poses unique privacy issues as genetic information is inherently identifying.
- A person's traits are a result of a combination of genetic and environmental influences, as well as chance. While some traits are strongly linked to one gene, many traits are much more complex.
- Environmental factors, such as changes due to climate change, can influence gene expression.
- As new genetic technologies make it possible to select for or against certain traits, students will investigate the unethical history of eugenics and how to ensure a responsible, ethical use of genetic science in the future.

Unit Essential Questions

- What are the pros and cons of genetic testing?
- What are the challenges to maintaining privacy when it comes to storage of genetic information?
- What diseases are good candidates for newborn genetic screening?
- How much can a genetic test tell a person about their traits?
- How much can environmental factors and climate change impact a person's traits?
- How does a genetic counselor help a patient interpret the results of a genetic test and decide what action to take?

Content Statements

Structure and Function

- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.
- 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.

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.

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.

Natural Hazards

- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.

Ability Objectives

General for all units:

- Develop and carry out scientific investigations.
- Obtain, evaluate and communicate information to develop information literacy and evaluate the quality of a source of information
- Develop and use models to explain complex processes and relationships between and within organisms.
- Analyze and interpret data and communicate information using a variety of modalities.
- Use mathematical and computational data to support scientific conclusions.
- Engage in argument from evidence to explain natural phenomenon.
- Construct explanations and design solutions for complex real world problems.

Unit 4:

- Students will evaluate the pros and cons of genetic testing.
- Students will explain why storage of genetic information leads to unique privacy challenges.
- Students will compare and contrast genetic testing in a medical setting with direct to consumer genetic testing.
- Students will take on the role of a genetic counselor and decide how to handle the issue of incidental findings in genetic testing.
- Students will determine which diseases are a good candidate for newborn genetic screening.
- Students will debate whether gene patents should be legal - are they more beneficial or harmful and is a gene eligible to be patented?
- Students will analyze data from twin and adoption studies in comparing and contrasting simple and complex traits
- Students will evaluate the role of nature and nurture in determining one's traits and will explain how these factors are interconnected through epigenetics.
- Students will explain how multi gene traits, expressivity, penetrance, epistasis, environmental influences, and epigenetics contribute to complex traits.
- Students will evaluate how environmental factors such as climate change can influence gene expression.
- Students will explain the role of genetic testing in PGD, and how this genetic technology can help families.

Sample Performance Tasks - Specific for Unit 4: SWBAT:

- Acting as a genetic counselor, **obtain and communicate information** about **patterns** in a patient's family history in order to advise on the **pros and cons of getting a genetic test**. (HS-ETS1-3)
- **Analyze and interpret patterns** in data from twin and adoptive studies in order to determine the **strength of genetic influence on complex traits**. (HS-LS3-2)
- **Make and defend an argument** for what diseases should and should not be required in **newborn genetic screening** in order to **cause** the best health outcomes. (HS-LS3-1)
- **Develop a model** illustrating how **environmental factors from climate change affect gene expression**. (HS-ESS3-1)

Resources

Unit 5: Biotechnology in the Media	
Content Area: Science	
Course & Grade Level: Genetics (11-12)	
Summary and Rationale	
In movies, social media, news and tv shows, scientific techniques are often sensationalized. Producers and newscasters pick the most flashy parts of science to highlight in order to catch and keep the audience’s attention. The same applies specifically to the use of biotechnology in the media. This unit focuses on identifying misconceptions that the public may possess due to the portrayal of biotechnology by various sources. Students will become conscious of the biases that the media possesses, analyze stakeholders of biotechnology media and engage in argument about the role that media plays in shaping public opinion.	
Recommended Pacing	
2 weeks	
New Jersey Student Learning Standards for	
Standard	
CPI #	Cumulative Progress Indicator (CPI)
HS-ETS1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-LS3-1.	Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]
HS-ESS3-6	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change). [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]

New Jersey Student Learning Standards for English Language Arts Companion Standards	
English Language Arts/Literacy:	
<ul style="list-style-type: none"> • Cite specific textual evidence to support analysis of science and technical texts describing the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. • Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, resolving conflicting information when possible. • Cite specific textual evidence to support analysis of science and technical texts describing the ways that inheritable genetic variation occurs, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. 	

- Write arguments, based on evidence, that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors.

New Jersey Student Learning Standards for Career Readiness, Life Literacies, Key Skills and Technology

CPI #	Cumulative Progress Indicator (CPI)
9.1.12.EG.3	Explain how individuals and businesses influence government policies.
9.4.12.IML.8	Evaluate media sources for point of view, bias, and motivations (e.g., NJSLSA.R6, 7.1.AL.IPRET.6).
9.4.12.IML.9	Analyze the decisions creators make to reveal explicit and implicit messages within information and media (e.g., 1.5.12acc.C2a, 7.1.IL.IPRET.4).
9.4.12.DC.3	Evaluate the social and economic implications of privacy in the context of safety, law, or ethics (e.g., 6.3.12.HistoryCA.1).
9.4.12.DC.4	Explain the privacy concerns related to the collection of data (e.g., cookies) and generation of data through automated processes that may not be evident to users (e.g., 8.1.12.NI.3).

Interdisciplinary Standards (fill-in Science, or SS, or Math, etc..)

Mathematics:

- Represent symbolically evidence that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors, and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the ways in which inheritable genetic variation occurs.
- Represent the variation and distribution of expressed traits in a population symbolically and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the variation and distribution of expressed traits in a population.

Social Studies:

Standard 6.1 U.S. History: America in the World. All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.

Standard 6.2 World History: Global Studies: All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Enduring Understandings

- The media can be used to educate the public about the use of biotechnology, but it can also sensationalize the use of the technology and lead to misconceptions if not portrayed properly
- The perspective and potential bias of the reporter, news station, film producer, etc. must be taken into account when consuming media and using it to inform opinions
- Stakeholders play a large role in the messages that media put out to the public and researching these stakeholders allows for a consumer to be knowledgeable about any bias behind the marketing or message shown

Unit Essential Questions

- What are some misconceptions about biotechnology that have come up as a result of media portrayal?
- Why would the media or movies sensationalize the use of biotechnological systems?
- How does the media play into the opinions of consumers?
- How can one evaluate a reliable scientific source?
- Why do stakeholders play a large role in what type of media is put out to consumers?

Content Statements

Influence of Science, Engineering, and Technology on Society and the Natural World

- 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.

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.

ESS3.D: Global Climate Change

- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

Ability Objectives

General for all units:

- Develop and carry out scientific investigations.
- Obtain, evaluate and communicate information to develop information literacy and evaluate the quality of a source of information
- Develop and use models to explain complex processes and relationships between and within organisms.
- Analyze and interpret data and communicate information using a variety of modalities.
- Use mathematical and computational data to support scientific conclusions.
- Engage in argument from evidence to explain natural phenomena.
- Construct explanations and design solutions for complex real world problems.

Unit 5:

- Analyze and interpret data regarding perspectives of consumers before and after viewing a biotechnology-focused movie.
- Identify and communicate information pertaining to the use of bias in the media.
- Develop the science literacy skills to evaluate sources and find reliable scientific information on topics such as biotechnology and climate change.
- Ask questions to identify possible stakeholders of a specific example of biotechnology in the media.
- Engage in argument focusing on the role that media plays in shaping consumer opinion.

Sample Performance Tasks - Specific for Unit 5: SWBAT:

- **Identify and analyze** themes of **bias and portrayal of biotechnologies** in a GATTACA movie case study in order to understand the **patterns of stakeholders** involved. (HS-ETS1-1)
- **Construct an argument** in order to **debate** the **differences between media outputs and primary sources** to see the **relationships** between biased and objective sources. (HS-ETS1-1)
- **Obtain, evaluate and communicate information** regarding the **use of scientific studies in the media** and the **effects of the portrayal of these studies** on public opinion. (HS-ETS1-1)
- **Design possible solutions** to teach and persuade stakeholders to campaign for **objectivity and neutrality in the media, causing change in marketing strategies and portrayal of science to the public.** (HS-ETS1-1)

Resources

Unit 6: Genetic Engineering

Content Area: Science

Course & Grade Level: Genetics (11-12)

Summary and Rationale

Humans have been manipulating genetics for thousands of years, but recent developments in gene editing technology have allowed for new possibilities in biotechnology and medicine. With new technologies like CRISPR, genetic engineering is faster, cheaper, and more accessible than ever before. GMOs have become a ubiquitous but controversial part of our society and, with advances in technology, people have started to question if designer babies are in our future.

In this unit, students will become familiar with the technologies used in genetic engineering. They will focus on GMOs as they investigate how genetically engineered food can impact our health, economy, and environment. Students will analyze the social and ethical implications of designer babies as well as the challenges. They will investigate the history and uses of cloning in our society.

Recommended Pacing

7 weeks

New Jersey Student Learning Standards for

Standard

CPI #	Cumulative Progress Indicator (CPI)
HS-LS1-1.	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. [Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.]
HS-LS3-1.	Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]
HS-LS4-6.	Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]
HS-ESS3-4.	Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]
HS-ETS1-3.	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.

**New Jersey Student Learning Standards for English Language Arts
Companion Standards**

English Language Arts/Literacy:

- Cite specific textual evidence to support analysis of science and technical texts describing the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, resolving conflicting information when possible.
- Cite specific textual evidence to support analysis of science and technical texts describing the ways that inheritable genetic variation occurs, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Write arguments, based on evidence, that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors.

New Jersey Student Learning Standards for Career Readiness, Life Literacies, Key Skills and Technology

CPI #	Cumulative Progress Indicator (CPI)
9.4.12.IML.5	Evaluate, synthesize, and apply information on climate change from various sources appropriately (e.g., 2.1.12.CHSS.6, S.IC.B.4, S.IC.B.6, 8.1.12.DA.1, 6.1.12.GeoHE.14.a, 7.1.AL.PRSNT.2).
9.4.12.IML.2	Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources (e.g., NJSLSA.W8, Social Studies Practice: Gathering and Evaluating Sources.)
.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political, economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3).
9.4.12.CT.1	Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3).

Interdisciplinary Standards (fill-in Science, or SS, or Math, etc..)

Mathematics:

- Represent symbolically evidence that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors, and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the ways in which inheritable genetic variation occurs.
- Represent the variation and distribution of expressed traits in a population symbolically and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the variation and distribution of expressed traits in a population.

Social Studies:

Standard 6.1 U.S. History: America in the World. All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.

Standard 6.2 World History: Global Studies: All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time

and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus
<p>Unit Enduring Understandings</p> <ul style="list-style-type: none"> ● The field of genetic engineering is growing rapidly beyond current social, ethical and political policy, and will undoubtedly force us into moral and ethical dilemmas for which we must prepare. ● New technologies like CRISPR have made genetic engineering more inexpensive and accessible than ever. ● GMOs have health, environmental, and economic implications. ● GMOs allow humans the chance to support their growing population with food in a way that traditional farming methods could never support. ● There are multiple methods of cloning and some are more controversial than others. ● As new genetic technologies make it possible to select for or against certain traits, students will explore the perspective of disability advocacy groups. Students will consider the ethics of genetically engineering humans - what is a disability vs. a difference?
<p>Unit Essential Questions</p> <ul style="list-style-type: none"> ● How does modern genetic engineering compare to the methods humans have used for genetic manipulation for thousands of years? ● Can we trust genetically modified food? ● What are the implications of designer babies and are they realistically in our future? ● How do the ethics of genetic engineering in somatic cells compare to germline editing? ● How do GMOs affect our health, the economy, and the environment? ● What are the uses/purposes of cloning? ● Why is cloning controversial and how do different methods of cloning compare? ● How does GMO technology reduce the impacts of human activity on farmland and soils?
<p>Content Statements</p> <p>Structure and Function</p> <ul style="list-style-type: none"> ● Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. ● 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. <p>Inheritance of Traits</p> <ul style="list-style-type: none"> ● 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. <p>Natural Resources</p> <ul style="list-style-type: none"> ● Resource availability has guided the development of human society. ● All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. <p>Human Impacts on Earth Systems</p> <ul style="list-style-type: none"> ● The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
<p>Ability Objectives</p> <p>General for all units:</p>

- Develop and carry out scientific investigations.
- Obtain, evaluate and communicate information to develop information literacy and evaluate the quality of a source of information
- Develop and use models to explain complex processes and relationships between and within organisms.
- Analyze and interpret data and communicate information using a variety of modalities.
- Use mathematical and computational data to support scientific conclusions.
- Engage in argument from evidence to explain natural phenomenon.
- Construct explanations and design solutions for complex real world problems.

Unit 6:

- Students will compare methods of genetic manipulation such as selective breeding and crossbreeding with modern methods of gene editing and create a definition of what counts as genetic engineering.
- Students will model and/or carry out methods of genetic engineering such as CRISPR and recombinant DNA.
- Students will analyze the ethical implications and controversy of designer babies and will evaluate whether this is realistically in our near future.
- Students will compare and contrast the implications of genetic engineering in somatic cells and germline editing.
- Students will analyze data and primary sources in order to determine the health, environmental, and economic impacts of GMOs.
- Students will investigate the relationship between climate change and GMOs.
- Students will ask questions and define problems related to the use of soil techniques for traditional farming and investigate the use of GMOs to solve these issues.
- Students will compare the advantages and disadvantages of the Green Revolution.
- Students will compare the therapeutic benefits of genetic engineering with gene therapy.
- Students will explain the role of social and political events in the history of cloning.
- Students will model different methods of cloning and compare the controversy and effectiveness of each method.
- Students will explain the history of stem cell research.

Sample Performance Tasks - Specific for Unit 6: SWBAT:

- **Plan and conduct an experiment** to **genetically engineer** bacteria to resist antibiotics and glow in the dark. Analyze how this affected the **structure** of their genes. (HS-LS1-1)
- **Make and defend an argument** for whether the school should switch to **GMO or organic** snacks - what would lead to the best **result**? (HS-ESS3-4)
- **Model** the **structure and process** of creating **recombinant DNA**. (HS-LS3-1)
- **Obtain, evaluate and communicate information** using evidence to support the idea that **GMO technology** reduces the **impacts** of **human activity on farmland and soils**. (HS-ESS3-4)

Resources

Unit 7: DNA Profiling

Content Area: Science

Course & Grade Level: Genetics (11-12)

Summary and Rationale

This unit is meant to familiarize students with all the techniques used to analyze DNA. Through phenomenon based inquiry, students will be challenged to investigate how DNA is analyzed for kinship, crime scene analysis and non-human typing. These applications are made possible through the use of DNA techniques, such as STR analysis, PCR, and gel electrophoresis. Throughout the decades, patterns in DNA have been extensively analyzed and mapped in an effort to determine the meaning behind them. In this unit, students will draw their own conclusions based on their own analysis of DNA patterns.

Recommended Pacing

6 weeks

New Jersey Student Learning Standards for

Standard

CPI #	Cumulative Progress Indicator (CPI)
HS-LS3-1.	Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]
HS-LS3-2.	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. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]
HS-LS3-3.	Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. [Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.] [Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.]
HS-ESS3-1	Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

New Jersey Student Learning Standards for English Language Arts Companion Standards

English Language Arts/Literacy:

- Cite specific textual evidence to support analysis of science and technical texts describing the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, resolving conflicting information when possible.
- Cite specific textual evidence to support analysis of science and technical texts describing the ways that inheritable genetic variation occurs, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Write arguments, based on evidence, that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors.

New Jersey Student Learning Standards for Career Readiness, Life Literacies, Key Skills and Technology

CPI #	Cumulative Progress Indicator (CPI)
9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas
9.4.12.CT.1	Identify problem-solving strategies used in the development of an innovative product or practice
9.4.12.CT.2	Explain the potential benefits of collaborating to enhance critical thinking and problem solving
9.4.12.IML.2	Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions
9.4.12.CI.2	Identify career pathways that highlight personal talents, skills, and abilities
9.4.12.DC.3	Evaluate the social and economic implications of privacy in the context of safety, law, or ethics

Interdisciplinary Standards (fill-in Science, or SS, or Math, etc..)

Mathematics:

- Represent symbolically evidence that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors, and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the ways in which inheritable genetic variation occurs.
- Represent the variation and distribution of expressed traits in a population symbolically and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the variation and distribution of expressed traits in a population.

Social Studies:

Standard 6.1 U.S. History: America in the World. All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.

Standard 6.2 World History: Global Studies: All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Enduring Understandings

- Most of DNA does encode proteins or RNA. Some of this noncoding DNA also consists of repetitive DNA, which is a nucleotide sequence that repeats several times. These repetitive sequences are called short

tandem repeats (STRs). The exact number of times a specific sequence repeats at a specific site in the genome differs from individual to individual. The size of an STR at a specific site can therefore be used as a genetic marker.

- Creation of DNA copies through PCR and DNA fragments through gel electrophoresis allow DNA to be used in a large number of DNA applications.
- DNA profiles provide strong evidence of individual identity; evidence that can be valuable in kinship (ex.paternity) and forensic cases.

Unit Essential Questions

- What are STRs and how are they used in DNA profiling?
- How can scientists turn a small sample of DNA found in the field into a larger sample suitable for further DNA testing?
- How can we measure genetic diversity through DNA sequencing?
- How does gel electrophoresis separate DNA and why do scientists want to separate DNA?
- How do we use DNA evidence and what must be done in order to use it?
- How are DNA profiles used to assist with kinship and criminal cases?

Content Statements

Structure and Function

- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.
- 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.

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.

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.

Natural Hazards

- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.

Ability Objectives

General for all units:

- Develop and carry out scientific investigations.
- Obtain, evaluate and communicate information to develop information literacy and evaluate the quality of a source of information
- Develop and use models to explain complex processes and relationships between and within organisms.
- Analyze and interpret data and communicate information using a variety of modalities.
- Use mathematical and computational data to support scientific conclusions.
- Engage in argument from evidence to explain natural phenomenon.
- Construct explanations and design solutions for complex real world problems.

Unit 7:

- Students will model the process of gel electrophoresis in order to understand how the technique is used to separate DNA fragments and why this is important in DNA applications.
- Students will analyze the results of an STR family relationship test to determine if an individual is related to a family.
- Students will set up, run and analyze an electrophoresis gel to determine if suspects are related to a crime.
- Students will measure genetic diversity through DNA sequencing.
- Students will investigate the relationship between genetic diversity and climate change.

Sample Performance Tasks - Specific for Unit 7: SWBAT:

- Analyze band patterns in a gel and determine the significance of congruent bands. (HS-LS3-3)
- Analyze STR profiles to determine kinship. (HS-LS3-1)
- Design and execute a study using PCR and gel electrophoresis and analyze STR profiles to determine who committed a crime. (HS-LS3-3)

Resources

Content Area: Science	
Course & Grade Level: Genetics (11-12)	
Summary and Rationale	
<p>Genomics is the study of an organism’s genes and focuses on structure, function, evolution, mapping and editing of genomes. The Human Genome Project (HGP) was an international project with the goal of identifying the sequence of the human genome and the genes it contained. The HGP began in 1990 and was completed in 2003. Several universities in the US as well as the UK, France, Germany, Japan and China contributed to the project. The completion of this project has led to major advances in the fields of medicine and biotechnology. Understanding the human genome led to the development of pharmacogenomics and precision medicine. Pharmacogenomics is medicine tailored to an individual based on his/her genes. Genes determine such things as how one responds to a medicine, side effects, appropriate dose, and if a drug is toxic. Precision medicine is an emerging approach for disease treatment and prevention that takes into account individual variability in genes, environment, and lifestyle for each person. This approach will allow doctors and researchers to predict more accurately, which treatment and prevention strategies for a particular disease will work in which groups of people.</p> <p>Students will demonstrate an understanding of genomics and explain how it differs from genetics. They will develop and defend claims about how the HGP has led to advancements in science. Students will perform various activities to show how understanding the human genome has led to medical and biotechnology advances. Examples of these activities include analyzing data to determine which drug will have the best pharmacogenomic outcomes for individuals based on their genetic makeup and proposing potential benefits and challenges of the precision medicine initiative.</p>	
Recommended Pacing	
3 weeks	
New Jersey Student Learning Standards for	
Standard	
CPI #	Cumulative Progress Indicator (CPI)
HS-LS3-1.	Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]
HS-LS3-2.	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. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]
HS-LS3-3.	Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. [Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.] [Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.]
HS-ESS3-4.	Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoeengineering design solutions (such as altering global

	temperatures by making large changes to the atmosphere or ocean).]
HS-ESS3-6	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change). [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]

**New Jersey Student Learning Standards for English Language Arts
Companion Standards**

English Language Arts/Literacy:

- Cite specific textual evidence to support analysis of science and technical texts describing the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, resolving conflicting information when possible.
- Cite specific textual evidence to support analysis of science and technical texts describing the ways that inheritable genetic variation occurs, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Write arguments, based on evidence, that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors.

New Jersey Student Learning Standards for Career Readiness, Life Literacies, Key Skills and Technology

CPI #	Cumulative Progress Indicator (CPI)
9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas
9.4.12.CT.1	Identify problem-solving strategies used in the development of an innovative product or practice
9.4.12.CT.2	Explain the potential benefits of collaborating to enhance critical thinking and problem solving
9.4.12.IML.2	Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions
9.4.12.IML.5	Evaluate, synthesize, and apply information on climate change from various sources appropriately

Interdisciplinary Standards (fill-in Science, or SS, or Math, etc..)

Mathematics:

- Represent symbolically evidence that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors, and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the ways in which inheritable genetic variation occurs.

- Represent the variation and distribution of expressed traits in a population symbolically and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the variation and distribution of expressed traits in a population.

Social Studies:

Standard 6.1 U.S. History: America in the World. All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.

Standard 6.2 World History: Global Studies: All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Enduring Understandings

- Genomics focuses on the structure, function, evolution, mapping, and editing of genomes.
- Genomics gives us a tool to measure and understand genetic diversity, which is critical to the health of populations. Climate change can be a threat to genetic diversity.
- The Human Genome Project led to the complete mapping of the human genome. Mapping the human genome has had a major impact on the medical field including advances in the diagnosis and treatment of cancer.
- Precision medicine is an approach for disease treatment and prevention that takes into account individual variability in genes, environment, and lifestyle for each person. Precision medicine will allow doctors and researchers to predict more accurately which treatment and prevention strategies for a particular disease will work best for specific groups of people.
- Pharmacogenomics is the study of how genes affect a person's response to particular drugs. This relatively new field combines pharmacology (the science of drugs) and genomics (the study of genes and their functions) to develop effective, safe medications and doses that are tailored to variations in a person's genes.
- Genome editing may one day replace gene therapy because it is more precise. It can add, replace or remove a gene in a specific part of the genome or insert, correct or delete multiple genes.
- Students will understand disparities in health care and access to genetic technologies as they relate to race, socioeconomic status, and sexual orientation/gender identity.

Unit Essential Questions

- What is the difference between genomics and genetics?
- Why is it important to preserve genetic diversity?
- What were the goals and impacts of the Human Genome Project?
- What is precision medicine and might it impact healthcare?
- What is pharmacogenomics and how can it benefit the development of medicine?
- What is genome editing? How is it different from gene therapy?

Content Statements

Structure and Function

- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.
- 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.

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.

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

Natural Hazards

- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.

Human Impacts on Earth Systems

- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

Ability Objectives

General for all units:

- Develop and carry out scientific investigations.
- Obtain, evaluate and communicate information to develop information literacy and evaluate the quality of a source of information
- Develop and use models to explain complex processes and relationships between and within organisms.
- Analyze and interpret data and communicate information using a variety of modalities.
- Use mathematical and computational data to support scientific conclusions.
- Engage in argument from evidence to explain natural phenomenon.
- Construct explanations and design solutions for complex real world problems.

Unit 8:

- Relate the knowledge of the human genome and the development of technology to scientific progress.
- Measure genetic diversity and explain its importance to the health of populations.
- Evaluate threats to genetic diversity from climate change and human activity.
- Define precision medicine and explain how it will improve healthcare as well as have an awareness of its challenges.
- Evaluate case studies to determine why individuals respond differently to drugs to gain a better understanding of the benefits of pharmacogenomics.
- Explain how genome editing may be used to help diagnose and develop treatments for single gene diseases.

Sample Performance Tasks - Specific for Unit 8: SWBAT:

- **Model** the process of **sequencing** the **structure of the human genome** through a **DNA microarray**. (HS-L3-1)
- **Construct a solution** to combat the **threat to genetic diversity caused by climate change and human activity**. (HS-ESS3-6).
- **Make and defend an argument** about how the **Human Genome Project** has **led to advancements in genetic science**. (HS-L3-1) (HS-L3-2)
- **Ask questions** about how **precision medicine** could **change** the field of medicine and healthcare. (HS-L3-2)
- **Analyze data** to determine what **drug** will lead to the **best pharmacogenomic outcomes** in **patients with different genes**.

Resources

Unit 9: Evolutionary/Population Genetics

Content Area: Science

Course & Grade Level: Genetics (11-12)

Summary and Rationale

The vast diversity in gene sequences are what create the large variety of plants and animals we see today. Genetic diversity is crucial for adapting to new environments, as more variation in genes leads to more individuals of a population having favorable traits to withstand harsh conditions. Low genetic diversity, on the other hand, can be very problematic during changing environments, as all individuals will react similarly. It is assumed that genetically engineered modifications may affect the genetic diversity of a population through crossbreeding or uncontrolled growth; therefore, many researchers are investigating whether this is true and how it might be prevented. This unit will give students the ability to look at genetic modification and the possible influence in evolution and biodiversity as well to see if possible to track human evolutionary lineage from DNA.

Recommended Pacing

3 weeks

New Jersey Student Learning Standards for

Standard

CPI

Cumulative Progress Indicator (CPI)

HS-LS4-1.	Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. [Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.]
HS-LS3-3.	Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. [Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.] [Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.]
HS-LS4-3.	Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] [Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.]
HS-LS4-6.	Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]
HS-ESS3-6	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change). [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.]

[Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]

**New Jersey Student Learning Standards for English Language Arts
Companion Standards**

English Language Arts/Literacy:

- Cite specific textual evidence to support analysis of science and technical texts describing the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring, resolving conflicting information when possible.
- Cite specific textual evidence to support analysis of science and technical texts describing the ways that inheritable genetic variation occurs, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Write arguments, based on evidence, that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors.

New Jersey Student Learning Standards for Career Readiness, Life Literacies, Key Skills and Technology

CPI #	Cumulative Progress Indicator (CPI)
9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas
9.4.12.CT.1	Identify problem-solving strategies used in the development of an innovative product or practice
9.4.12.CT.2	Explain the potential benefits of collaborating to enhance critical thinking and problem solving
9.4.12.IML.2	Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions
9.4.12.IML.5	Evaluate, synthesize, and apply information on climate change from various sources appropriately
9.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political, economic, cultural) may work better than others

Interdisciplinary Standards (fill-in Science, or SS, or Math, etc..)

Mathematics:

- Represent symbolically evidence that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors, and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the ways in which inheritable genetic variation occurs.
- Represent the variation and distribution of expressed traits in a population symbolically and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the variation and distribution of expressed traits in a population.

Social Studies:

Standard 6.1 U.S. History: America in the World. All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the

American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities. Standard 6.2 World History: Global Studies: All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Enduring Understandings

- All living things share the same genetic code.
- Mutations are random in the sense that which mutations occur cannot be predicted based on which traits would be advantageous for the organism.
- Living things accumulate genetic differences over evolutionary time.
- Biodiversity is essential to the success of a population.
- Human activity can change populations.
- Environmental changes due to climate change act as selective pressures driving evolutionary change.

Unit Essential Questions

- What are the mechanisms by which populations change over time?
- How does biodiversity relate to the health and success of a species?
- How can we use genetic evidence to trace the course of evolution?
- How has human activity impacted the course of evolution?
- How will climate change shape the course of evolution?

Content Statements

Structure and Function

- 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.

Evidence of Common Ancestry and Diversity

- Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.

Adaptation

- Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.
- Adaptation also means that the distribution of traits in a population can change when conditions change.
- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species.

Human Impacts on Earth Systems

- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

Natural Hazards

- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.

Global Climate Change

- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

Ability Objectives:

General for all units:

- Develop and carry out scientific investigations.
- Obtain, evaluate and communicate information to develop information literacy and evaluate the quality of a source of information
- Develop and use models to explain complex processes and relationships between and within organisms.
- Analyze and interpret data and communicate information using a variety of modalities.
- Use mathematical and computational data to support scientific conclusions.
- Engage in argument from evidence to explain natural phenomenon.
- Construct explanations and design solutions for complex real world problems.

Unit 9:

- Students will describe how humans have reduced biodiversity and will propose a solution to mitigate these effects.
- Students will explore conservation genetics and how we can use genetics to help preserve the biodiversity and survival of a population.
- Students will model how the gene pool of populations changes over time through mechanisms like genetic drift, gene flow, and natural selection.
- Students will explain how the effects of climate change, such as increased migrations, extinctions, and natural disasters, affect genetic drift and gene flow.
- Students will describe how reproductive barriers lead to speciation.
- Students will predict evolutionary histories based on various lines of genetic evidence such as protein sequence/structure, DNA sequences, transposons in DNA, and chromosomal structure.
- Students will use molecular clock data to determine the evolutionary divergence of species.
- Students will compare and contrast evolutionary histories made with genetic evidence compared with those made with other lines of evidence (anatomical, embryological, fossil, etc.) and will determine what types of evidence for evolution are most reliable.
- Students will explain why the use of mitochondrial DNA and DNA from the Y chromosome are particularly useful for tracing lineages.
- Students will describe the Human Genographic project: a collective database that allows us to trace the ancient paths of human migration.
- Students will describe how humans have influenced the course of evolution and changed populations through artificial selection, acting as a selective pressure, and genetic engineering.
- Students will investigate the role of climate change in evolutionary genetics.
- Students will describe how the environmental changes caused by climate change act as selective pressures.
- Students will compare and contrast acclimatization and adaptation as responses to climate change.

Sample Performance Tasks - Specific for Unit 9: SWBAT:

- **Analyze biochemical data** from different species in order to create an **evolutionary lineage** showing how living things **changed over time**. (HS-LS4-1)
- **Design a solution** to **cause** improved **biodiversity** in the tiger population. (HS-LS4-6)
- **Construct an argument** for whether **human activity in genetic engineering** could **alter** the course of evolution. (HS-LS3-3)
- **Construct an argument** predicting how **climate change** could **alter** the course of evolution. (HS-ESS3-4)

Resources