Unit 6 | Genetics, Biotech, & Bioethics

Living Environment | **20-28 days**

DNA, as students learned earlier in the year, is found in all living things, and has a common role in heredity. In this unit, students investigate genetic processes including protein synthesis, inheritance, and gene expression. They then learn about modifications of these processes through the lens of genetic engineering, biotechnology, and natural selection. Students will investigate these concepts through background readings, interactive simulations, and hands-on experience with biotechnology labs including analyzing DNA samples using gel electrophoresis.

What are the advantages and possible risks of using biotechnology approaches? How can biotechnology be used to identify relationships and conserve endangered species?

UNIT STORYLINE SNAPSHOT

Anchor Phenomenon: Biotechnology as a Tool for Conservation

What are the advantages and possible risks of using biotechnology approaches? How can biotechnology be used to identify relationships and conserve endangered species?

Performance Task: Conserving the Endangered *Botana curus*

Structures & Mechanisms of Genetics

5E Instructional Model Plan

How are traits inherited?

DNA Structure

3E Instructional Model Plan

How does the structure of DNA support its role in heredity?

Molecular Genetics	Biotechnology
5E Instructional Model Plan	*5E Instructional Model Plan*
	How can biotechnology be used to modify traits? What are some of the advantages and disadvantages?

PLANNING RESOURCES

- Knowledge and Enduring Understandings
- Storyline and Pacing Guide
- Common Core Standards
- NY State Regents Exam Readiness
- NY State Science Standards
- Unit Vocabulary

KNOWLEDGE AND ENDURING UNDERSTANDINGS

Knowledge: (Students will know. . .)	Enduring Understandings

High priority content - required ● structures and mechanisms of genetics ● protein synthesis ● biotechnology (Std. 4, Key Idea 2, PI 2.1, 2.2) ● mutations; natural selection and selective breeding (Std. 4, Key Idea 3, PI 3.1)	**Mid-priority content - recommended** ● Preserving diversity and habitats (Std. 4, Key Idea 6 - PI 6.2) ● Human decision-making and environment (Std. 4, Key Idea 7 - PI 7.3) ● Mitosis and cell division/replication (review) (Std. 4, Key Idea 4 - PI 4.1)	● The genetic information stored in DNA is used to direct the synthesis of proteins which determine an organism's traits. ● Heredity is the passage of genetic information from one generation to another. ● Technology allows for the analysis and modification of genetic information ● Individuals and society must consider both the benefits and ramification of using biotechnology.

✦Storyline and Pacing Guide

	Time	Teacher Resource	Driving Questions	What students figure out *Ideas that contribute to student thinking about the anchor phenomenon and performance task*
Launch Anchor Phenomenon	**1 Days**	Link	*How can we use evidence to identify relationships between organisms?* *Why would we want to conserve biodiversity?*	● Biodiversity provides medicine, ecosystem services, food, and aesthetic values to humans ● There are many ways to compare traits (physical and molecular) to identify relationships between organisms
Introduce Performance Task	**1 Day**	Link	*What types of strategies and tools can we use to conserve biodiversity?*	● Biodiversity can be conserved in many ways including: habitat protection, zoos, and biotechnology techniques such as cloning

	Structure & Mechanisms of Genetics	**5-8 Days**	**5E Plan**	*How are traits passed from parents to offspring?* *How can we describe the role of chromosomes, genes, and alleles in inheritance?* *How can we compare physical traits to gain insight into genetic relationships?*	• Each parent contributes 50% of the genetic material of offspring • Inside of the nucleus, DNA is tightly organized into structures called chromosomes. • Genes are portions of DNA, found on chromosomes, that code for a protein / trait • Alleles are variations of genes • Genes determine physical traits (the phenotype), however some alleles (genotype) are not expressed • Physical traits can provide useful information on genetic relationships, but more evidence is needed to make conclusions
	DNA Structure	**2-4 Days**	**3E Plan**	*How can we represent the structure and function of DNA?* *How does the structure of DNA facilitate inheritance of traits?*	• DNA is composed of repeating units called nucleotides • Nucleotides are composed of a phosphate-sugar backbone, and a nitrogenous base • DNA demonstrates a double helix structure • Complementary base pairing (A-T, C-G) allows for the information in DNA to be expressed (among other functions)

Return to the performance task and engage students in revising their initial response to the cladogram task and their reasoning, based on the new evidence and ideas generated in the Genetics and DNA Structure instructional sequences.

Revisit the **Unit Driving Question Board** - are there questions that have been addressed in these instructional sequences? -- have new questions been brought to the forefront?

Molecular Genetics	**5-8 Days**	[5E Plan]	*How is DNA translated into traits?* *How do mutations impact traits and organisms that possess them?* *How does the environment impact the expression of traits?*	• Protein synthesis is a process in which DNA is 'transcribed' into a single stranded copy, called RNA and then 'translated' into an amino acid sequence • Amino acid sequences form proteins, which regulate or form specific traits • Protein synthesis is regulated by enzymes • Changes in the DNA sequence, called mutations, can result in changes in the a.a. sequence and the trait -- but sometimes there is no impact from a mutation • Environmental variables, including lifestyle factors may change how a gene is expressed, changing a trait

Return to the performance task and engage students in revising their initial response to the cladogram task and their reasoning, based on the new evidence and ideas generated in the Molecular Genetics instructional sequence.

Revisit the **Unit Driving Question Board** - are there questions that have been addressed in these instructional sequences? -- have new questions been brought to the forefront?

Natural Selection**	**4-6 Days**	[5E Plan]	*How do individuals and populations change over time?*	• Populations (not individuals) change over time through the process of natural selection • The process of natural selection requires variations in traits across a population • Some traits are more advantageous for a particular environment, thus those possessing the traits reproduce more, passing those traits onto offspring • Those possessing advantageous traits, for a particular environment, increase over time, changing the genetic makeup of the population -- natural selection

	**Biotechnology**	**4-6 Days**	**5E Plan**	*How can we use biotechnology tools to compare the genetic relationships between organisms?* *How can we modify organisms to possess a specific trait?* *Why clone organisms? How could cloning be used in the conservation of biodiversity?* *How can we compare natural and artificial selection?*	• Gel electrophoresis can be used to compare DNA sequences • Genetic engineering is a process that uses restriction enzymes and the universality of DNA to modify the genetic sequences of organisms. • Genetically modified organisms (GMO) are common and are organisms that possess a gene or genes from another organism • Cloning is a process that creates a new organism that is genetically identical to the parent organism -- this is happens naturally in plants and other organisms • Natural and artificial selection both result in changes, natural selection is facilitated by environmental changes and usually takes an extended period of time. Artificial selection and genetic engineering are facilitated by humans and usually take a short period of time
	**Complete Culminating Task**	**1 Day**	**Link**	*How can we use evidence to identify relationships between organisms?* *How can we evaluate the pros and cons of using biotechnology in conservation?*	• Students identify the most closely related species to Botana curus • Genetic evidence is generally more accurate than physical evidence in identifying relationships between organisms • There are both advantages and disadvantages to using biotechnology in conservation, generating medicine / medical therapies, and in food production.

****Note: Natural selection can be introduced (or reviewed) at this point OR earlier in the course (Unit 4:Disease and Disruption of Homeostasis, Unit 5: Comparative Reproduction) OR it can be introduced formally in Unit 8: Climate Change & Human Impact**

✦NY State Regents Exam Readiness

Regents Topics (from 1996 standards)	Historical Coverage (over the last 5 administrations of LE Regents)[1]	More Details *How is this addressed in the unit?*
Evolution	10%	This unit builds on the concepts of macroevolution and natural selection that have been introduced in Units 1 and 3. In learning about genetics, the universality of DNA, and biotechnology tools, students are able to make connections to common ancestry and how differences between species may be due to adaptation to specific environments.
Replication of Genetic Material	8%	Genetics is a focus of this unit.
NYS Lab: Relationships & Biodiversity	4.5%	Students complete this lab throughout this unit
Genetic Engineering	2.4%	The Biotechnology 5E plan discusses genetic engineering.
Importance of Biodiversity	1%	Students use the lens of conservation biology for the performance task
	Unit 6 Regents Item Bank	

[1] Regents Tool; Awesome table

New York State Science Standards

NY State MST Standards (1996)	NYSSLS (2017)
This unit was designed to address the following NY State 1996 Standards.	*As designed, this unit works towards the following NYSSLS Performance Expectations, with partial alignment.*

PI 2.1 - Explain how the structure and replication of genetic material result in offspring that resemble their parents. 2.1a Genes are inherited, but their expression can be modified by interactions with the environment. 2.1b Every organism requires a set of coded instructions for specifying its traits. For offspring to resemble their parents, there must be a reliable way to transfer information from one generation to the next. Heredity is the passage of these instructions from one generation to another. 2.1c Hereditary information is contained in genes, located in the chromosomes of each cell. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes in its nucleus. 2.1d In asexually reproducing organisms, all the genes come from a single parent. Asexually produced offspring are normally genetically identical to the parent. 2.1f In all organisms, the coded instructions for specifying the characteristics of the organism are carried in DNA, a large molecule formed from subunits arranged in a sequence with bases of four kinds (represented by A, G, C, and T). The chemical and structural properties of DNA are the basis for how the genetic information that underlies heredity is both encoded in genes (as a string of molecular "bases") and replicated by means of a template. 2.1g Cells store and use coded information. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires. 2.1h Genes are segments of DNA molecules. Any alteration of the DNA sequence is a mutation. Usually, an altered gene will be passed on to every cell that develops from it. 2.1i The work of the cell is carried out by the many different types of molecules it assembles, mostly proteins. Protein molecules are long, usually folded chains made from 20 different kinds of amino acids in a specific sequence. This sequence influences the shape of the protein. The shape of the protein, in turn, determines its function. 2.1j Offspring resemble their parents because they inherit similar genes that code for the production of proteins that form similar structures and perform similar functions. 2.1k The many body cells in an individual can be very different from one another, even though they are all descended from a single cell and thus have essentially identical genetic instructions. This is because different parts of these instructions are used in different types of cells, and are influenced by the cell's environment and past history.	**HS-LS4-1: Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.** **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.** **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.** **HS-LS4-4.Construct an explanation based on evidence for how natural selection leads to adaptation of populations.**

PI 2.2 - Explain how the technology of genetic engineering allows humans to alter genetic makeup of organisms.
2.2a For thousands of years new varieties of cultivated plants and domestic animals have resulted from selective breeding for particular traits.
2.2b In recent years new varieties of farm plants and animals have been engineered by manipulating their genetic instructions to produce new characteristics.
2.2c Different enzymes can be used to cut, copy, and move segments of DNA. Characteristics produced by the segments of DNA may be expressed when these segments are inserted into new organisms, such as bacteria.
2.2d Inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it.
2.2e Knowledge of genetics is making possible new fields of health care; for example, finding genes which may have mutations that can cause disease will aid in the development of preventive measures to fight disease. Substances, such as hormones and enzymes, from genetically engineered organisms may reduce the cost and side effects of replacing missing body chemicals.

PI 3.1 - Explain the mechanisms and patterns of evolution
3.1a The basic theory of biological evolution states that the Earth's present-day species developed from earlier, distinctly different species.
3.1b New inheritable characteristics can result from new combinations of existing genes or from mutations of genes in reproductive cells.
3.1c Mutation and the sorting and recombining of genes during meiosis and fertilization result in a great variety of possible gene combinations.
3.1d Mutations occur as random chance events. Gene mutations can also be caused by such agents as radiation and chemicals. When they occur in sex cells, the mutations can be passed on to offspring; if they occur in other cells, they can be passed on to other body cells only.
3.1e Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life-forms, as well as for the molecular and structural similarities observed among the diverse species of living organisms.
3.1f Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.
3.1g Some characteristics give individuals an advantage over others in surviving and reproducing, and the advantaged offspring, in turn, are more

likely than others to survive and reproduce. The proportion of individuals that have advantageous characteristics will increase.
3.1h The variation of organisms within a species increases the likelihood that at least some members of the species will survive under changed environmental conditions.
3.1j Billions of years ago, life on Earth is thought by many scientists to have begun as simple, single-celled organisms. About a billion years ago, increasingly complex multicellular organisms began to evolve.

PI 6.2 - Explain the importance of preserving diversity of species and habitats.
6.2a As a result of evolutionary processes, there is a diversity of organisms and roles in ecosystems. This diversity of species increases the chance that at least some will survive in the face of large environmental changes. Biodiversity increases the stability of the ecosystem.
6.2b Biodiversity also ensures the availability of a rich variety of genetic material that may lead to future agricultural or medical discoveries with significant value to humankind. As diversity is lost, potential sources of these materials may be lost with it.
PI 7.3 - Explain how individual choices and societal actions can contribute to improving the environment.
7.3a Societies must decide on proposals which involve the introduction of new technologies. Individuals need to make decisions which will assess risks, costs, benefits, and trade-offs.
7.3b The decisions of one generation both provide and limit the range of possibilities open to the next generation.

New York State Core Curriculum Standards Crosswalk - Living Environment

✦Common Core Learning Standards

Reading	Writing

9-10.R.ST.2 **Reading: Key Ideas and Details** Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. **9-10.R.ST.3** **Reading: Key Ideas and Details** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks attending to special cases or exceptions defined in the text. **9-10.R.ST.9** **Reading: Integration of Knowledge and Ideas** Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.	**9-10.W.HST.10** **Writing: Range of Writing** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. **9-10.W.HST.10** **Writing: Text Types and Purposes** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
Listening	**Speaking**

✦Unit Vocabulary

Consider using this list to guide the Explain or Elaborate portions of the 5E plans, and use it as reference for peer to peer

vocabulary based discussions.

Unit Vocabulary	Domain Specific	Tier II
5E: STRUCTURES & MECHANICS OF GENETICS	Genetic material Traits Nucleus DNA Chromosomes Gene Code Protein Allele / genotype / phenotype Expression Genetic relationships	Parents / offspring inheritance
3E: DNA STRUCTURE	Nucleotides A C T G Nucleic bases Complementary base pairing Chromosomes Genes Phosphate-sugar backbone Double helix	Universality Model Repeating pairing

5E: MOLECULAR GENETICS	Chromatography DNA RNA Transcription Translation Protein synthesis Amino acid ribosome Trait Gene Molecular Proteins / enzymes DNA replication Mutations Gene expression Identical vs. fraternal twins Genetic variation	Impact Result Beneficial vs. harmful vs. neutral Environmental factor
**5E: NATURAL SELECTION	Natural selection Adaptations Overproduction Genetic variation speciation	Characteristic Population Trend Shift Proportion frequency
5E: BIOTECHNOLOGY	Biotechnology DNA sequence Gel electrophoresis Restriction enzymes DNA fragments plasmid Clone Asexual reproduction Genetic modification Genetically modified organisms Natural vs. artificial selection Selective breeding	Advantageous Population Modify Specific Insert Species Commonality transfer

OVERALL UNIT	Biodiversity Physical vs. molecular ecosystem	Conserve endangered Physical Evidence Relationships alternative analyze sequence indicator beneficial feasible proponent rationale technique innovation isolate demonstrate

*terms that may be encountered, but not fully defined or explored in this 5E Cycle

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