HIGH SCHOOL LIFE SCIENCE: GENETICS

Standards Bundle:

Standards are listed within the bundle. Bundles are created with potential instructional use in mind, based upon the potential for related phenomena that can be used throughout a unit.

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, tissues, and organs. (SEP: 6; DCI: LS1.A; CCC: Structure/Function) [*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. (SEP: 1; DCI: LS1.A, LS3.A; CCC: Cause/Effect) [*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. (SEP: 7; DCI: LS3.B; CCC: Cause/Effect) [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. (SEP: 4; DCI: LS3.B; CCC: Scale/Prop.) [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.*]

Content Overview

This section provides a generic overview of the content or disciplinary core ideas as an entry point to the standards.

Molecules called DNA are the instructions that all living organisms use to create all the characteristics and traits they possess. Cellular structures use the DNA as instructions for expressing traits that are passed down from parents to offspring. Highly similar DNA sequences lead to anatomical similarities, while differences in DNA sequences contribute to the diversity of living things.

Phenomena

Phenomena can be used at varying levels of instruction. One could be used to anchor an entire unit, while another might be more supplemental for anchoring just a unit. Please remember that phenomena should allow students to engage in the SEP and use the CCC/DCI to understand and explain the phenomenon.

- Flower seeds - one set exposed to X-rays, another not exposed - then grown showing variations in colors between the two sets.
- Slides of HeLa cells suspended in mitotic stages and observe chromosomes.
- Slides (prepared or student-made) of onion root tips undergoing mitosis.
- Give students a number of items - pine cones, tree seeds, minnows, etc. - similarities/differences, classifications.
- Protein gel electrophoresis of fish muscle proteins.
- DNA from students' cheek cells has a stringy nature.
- Survey family members for specific traits and look for patterns (e.g., widow's peak, hitch-hiker's thumb, blood type, earlobes, etc.)
- Use video footage of various genetic diseases or conditions that are the result of single nucleotide mutations.
- Cheetahs are the most homogeneous group of mammals on the planet.
- Antibiotic-resistant bacteria are a major health concern.
- When treated with antibiotics, bacteria that are more susceptible to the compounds will die off while some survive.
- Photos of MRSA (methicillin-resistant *Staphylococcus aureus*), flesh-eating bacteria, drug-resistant tuberculosis.
- Different squirrel populations in the Grand Canyon.
- Prehistoric corn and modern-day corn.
- Prehistoric cattle and modern-day cattle photographs.
- Pure-breed domestic animals - parent and young (e.g., cattle, sheep, chickens)
- Examples of different colors of corn.
- Blood type percentages.
- Skin pigmentation, climate, ethnic group date, and photos.
- Darwin's finches (beak shapes and function).
- Galapagos iguanas (land versus aquatic).
- Fiji peacocks (blue vs green dominant feathers).
- Peppered Moths.
- Photos of family (and extended family) - traits (can include wild and domestic animals).
- Photos of embryological stages of different animals.

Storyline

This section aims to decode not only the DCI connections but also the SEP and CCC in a detailed account of how they possibly fit together in a progression for student learning, including both rationale and context for the bundle.

Science and Engineering	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions ● Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, and peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **Asking Questions and Defining Problems** ● Ask questions that arise from examining models or a theory to clarify relationships. **Engaging in Argument from Evidence** ● Make and defend a claim based on evidence about the natural world that reflects scientific knowledge and student-generated evidence. **Analyzing and Interpreting Data** ● Apply concepts of statistics and probability (including determining function fits data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.	**LS1.A: Structure and Function** ● Systems of specialized cells within organisms help them perform the essential functions of life. ● All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. ● 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. ● 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 the expression of traits and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depend on both genetic and environmental factors. ● Environmental factors also affect the expression of traits and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depend on both genetic and environmental factors.	**Structure and Function** ● Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and the connections of components to reveal their function and/or solve a problem. **Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Scale, Proportion, and Quantity** ● Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

In this standard bundle, students will ask questions to clarify how the structure of DNA affects the traits expressed by the organism. Through student investigations, use of models, and/or simulations, students can collect evidence to support the idea that the structure of DNA determines the structure and function of proteins. From this evidence, they will construct explanations describing how all living organisms have DNA which codes for the structures that help them carry out functions necessary for life. Within the DNA, short regions called genes, code for the sequence of amino acids, forming the structure of proteins. Students will be able to identify and describe how proteins can be assembled in various forms to create structures with specific functions such as support for the cell, acting as signal molecules, regulating cell activities, and playing a role in the overall performance of cells by acting as catalysts for essential chemical reactions. Students should be able to use a variety of evidence to explain the relationship between a protein's structure, determined by DNA, and the specialized function(s) that these proteins carry out that help an organism survive.

Students can communicate that an organism's identifiable traits are the result of the proteins being expressed at a given time by the cells that make up that organism. Students will ask questions and eventually construct an explanation that will lead to the conclusion that parents contribute genetic information to their offspring. Students can accomplish this through the examination of DNA models and observations of similarities between sexually producing parents and offspring and identifying patterns in those similarities and differences. This combination of genetic information is a source of variation within species. The inherited genetic information also leads to similarities such as anatomical structures, embryological development, and DNA sequences in closely related organisms. Students should be able to construct an argument for biological diversity and/or relatedness patterns in genetic and anatomic structures as evidence.

Formative Assessment

Formative assessment is crucial because all learners benefit from timely and focused feedback from others. It promotes self-reflection, self-explanation, and social learning. It can also make learning more relevant. Each of the questions below might be used throughout the formative assessment process. Specific prompts may focus on individual practices, core ideas, or crosscutting concepts, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given bundle, standard, or lesson-level performance expectation.

SEP Asking Questions and Defining Problems

- Formulate descriptive questions about the different cells within one's body and how they could have the same DNA but look and function so differently.
- After observing corn from different hybrid crosses, formulate additional questions for the different frequencies of colored kernels.
- How is the use of antibiotics creating antibiotic-resistant bacteria?
- Define the relationship and components involved in the task of finding a cure for genetic diseases such as Tay-Sachs, sickle cell anemia, cystic fibrosis, or another genetic disease.

SEP -Analyzing and Interpreting Data

- Given a model of DNA, identify the components and describe how the sequence of base pairs determines the sequence of amino acids it codes for.
- Using a simulation for natural selection, describe how isolation or changing environmental factors the population is exposed to can lead to different percentages of traits.

- What patterns in chromosome arrangement exist within the mounts of onion root tips??
- Collect data from mitotic onion root tips, and on the frequency of the stages and mathematically analyze. Propose reasons for the different percentages.

SEP Constructing Explanations and Designing Solutions

SEP Engaging in Argument from Evidence

CCC Patterns

- If DNA is composed of only four different nucleotides, how is it possible for DNA to code for different things?
- What patterns are evident in the amino acid codes found within the mRNA of various mammals?
- What patterns are evident in the transcription process of various mammals?

CCC Cause and Effect

- Given a DNA sequence, carry out an investigation to study the effects of changing, deleting, or moving one base pair on the resulting amino acid sequence.

CCC Scale, Proportion, and Quantity

- How would a warming climate change the fur thickness in buffalo? Describe the mechanism behind this phenomenon.

Performance Outcomes

These are statements of how students use knowledge and are similar to the standards in how they blend DCI, SEP, and CCC, but at a smaller grain size. These are potential outcomes for instruction as it plays out in lessons and activities in the classroom. It is important to also think of these as smaller outcomes that build toward the larger goal of mastering the standards.

- **Construct an explanation based on evidence** to **explain** why the changing of one amino acid in hemoglobin results in a change in the molecule's *shape and function.*
- List and describe the *function* of several proteins found in the human body to **create an argument based on evidence** that protein *structures* within a cell are beneficial to the *essential functions* carried out in the cell.
- Explain how, theoretically, any cell (except a red blood cell from humans) from an organism could be used to clone that animal.
- **Use a computer simulation (Molecular Workbench) to model** that genes code for the formation of proteins and their specific *structures*.
- **Develop models** to represent the *relationships* between chromosomes, genes, and DNA.
- **Construct a model** such as Punnett squares, pedigrees, and karyotypes to **make and defend a claim** that the instructions for expressing a species' characteristic traits are carried in DNA.
- Analyze the *proportions* of a specific trait (e.g., kernel color) to determine the parental genotypes.

- Construct explanations for how the same set of DNA in each cell may be regulated/expressed in different ways within an organism to construct cells (e.g. muscle, nerve, white blood cell) of varying *structure and function*.
- **Engage in argumentation from evidence** to determine that some DNA codes for a variety of functions, such as proteins, regulatory or structural and some DNA segments code for *functions* that are not yet known.
- Given a DNA sequence, access a gene sequence database (**Basic Local Alignment Search Tool (BLAST)** to **construct explanations** for how different species have varying DNA sequences they also have many overlaps.
- *Analyze the patterns* found when comparing DNA sequences from different species to make inferences about the **construction of a cladogram** that shows evolutionary relationships.
- **Analyze and interpret data** from the *similarities and differences* in amino acid sequences of shared proteins to make inferences about the lines of descent of related species.