MIDDLE SCHOOL LIFE SCIENCE: CELLULAR GENETICS

Standards Bundle

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

MS-LS3-1 Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.(SEP:2; DCI:LS3.A, LS3.B; CCC:Structure/Function) [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] *[Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.*]

MS-LS3-2 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. (SEP:2; DCI:LS1.B, LS3.A, LS3.B; CCC:Cause/Effect) [Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.]

MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. (SEP:6; DCI:LS1.B; CCC:Cause/Effect) [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.] [*Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.*]

Content Overview

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

Genetic material is made of genes (segments of DNA). These genes tell the body which proteins to make for the body. If a sequence of DNA gets changed that causes a mutation. Mutations can be neutral, beneficial, or harmful to the body and can be passed to offspring. Beneficial mutations enhance the survival of the organism. Neutral mutations neither enhance or hinder survival. Harmful mutations may be lethal and cause the organism to die or not thrive.

Organisms reproduce sexually and asexually. When that happens, there is genetic material passed from the parent to the offspring. That transfer of genetic material could be exactly like the one parent (asexual) or a genetic combination of two parents genes (sexual). Genetic information is transferred to the offspring during sexual reproduction through egg and sperm cells. Variations of those inherited traits between the parent and offspring arise from those genetic differences. Using a model to show those differences would be beneficial. In asexual reproduction, the offspring has identical genetic information as the parent.

Within every population, there are variations of organisms. Some of these variations exhibit traits and behaviors that will favor the chance to survive and

reproduce, while other behaviors will decrease the likelihood to survive and reproduce. Environmental and genetic factors impact the survival of an organism. Environmental factors include both living (biotic) and nonliving (abiotic) factors. Genetic factors are traits of the organism that allow it to grow and survive regardless of changes in environmental conditions. Selective breeding is a method used to produce a desired outcome with breeding. Isolated populations have the potential to gain specialized local adaptations through natural selection.

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.

- Family members have different or the same hair color.
- Children look like one parent more than another.
- Selective breeding is used in livestock to create a breed with desired traits.
- Lemurs of Madagascar differ from lemurs of mainland Africa.
- The potato famine was caused by using the same breed of potato all throughout Ireland.

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 Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions ● Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) 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.	**LS1.B: Growth and Development of Organisms** ● Genetic factors as well as local conditions affect the growth of the adult plant. ● Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. **LS3.A: Inheritance of Traits** ● Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to	**Cause and Effect** ● Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. ● Cause and effect relationships may be used to predict phenomena in natural systems. **Structure and Function** ● Complex and microscopic

Developing and Using Models ● Develop and use a model to describe phenomena.	proteins, which can affect the structures and functions of the organism and thereby change traits. ● Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. **LS3.B: Variation of Traits** ● In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.	structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.

The focus in this science bundle is the relationship of gene transmission from parent(s) to offspring and resulting in genetic variation. In species that reproduce sexually, each cell contains two variants of each chromosome, one inherited from each parent. These variants are called alleles. An allele is defined as one of a pair of genes that appear at a particular location on a particular chromosome and control the same characteristic. Each parent contributes half of the gene, or one allele, acquired at random by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. Sexual reproduction promotes genetic diversity among organisms. Mathematical reasoning is used as a way to predict how sexual reproduction can promote genetic diversity. In organisms that reproduce asexually, a single organism reproduces without the genetic input of another. This process allows for replication of an almost exact copy of the parent's genetic information. While genetic diversity is not served through asexual reproduction, there are some advantages. One is that once an organism is well-suited to its environment, it can quickly reproduce many copies to form many new individuals with that specific gene pattern. This rapid reproduction makes it successful.

Mutations can introduce variations in traits in both sexual and asexual reproduction, which can be harmful, neutral, or advantageous for an organism. A mutation is a permanent change in the sequence of DNA whereby genetic information is altered. Changes (mutations) to genes result in changes to proteins, which affect the structures and resulting functions of the organism's traits.

These traits that have changed are then passed from parent to offspring, therefore, mutations in the DNA can be inherited. Mutations that are not passed down are either lost or become repaired. Hereditary diseases are examples of harmful mutations. There are some mutations that are considered beneficial. Beneficial mutations can, over time, produce brand new alleles (variants of genes) that can create genetic diversity, improving an organism's chances of survival in a particular environment. Color pigments or beak changes of organisms may allow it to better survive in a specific environment. Mutations that have no effect at all are called silent or neutral mutations because they are neither harmful nor helpful. They either make no change in the expression of any gene or the changes do not affect the function of any gene product. A neutral mutation can be explained by just being dormant, but could be used to trace ancestry. Since genes are too small to be seen with the naked eye, we use pedigrees and/or Punnett squares to assist in and demonstrate understanding of inheritance

of trains and mutations. Students analyze patterns of inheritance to determine the possible effects of inheritance. When discussing inheritance of traits, students first need a thorough understanding of sexual and asexual reproduction. Inheritance is the acquisition of traits genetically transmitted from parents to offspring and is the reason that there is a similarity among individuals in a species population. Through inheritance, traits are passed from one generation to the next; therefore, when organisms reproduce, genetic information is transferred to their offspring. A trait is a genetically determined characteristic. An example of a genetic trait is attached earlobes vs free earlobes, rolling tongue vs non-rolling tongue or curly hair vs straight hair. For better understanding, students can use Punnett squares, diagrams, and simulations to model how those traits are passed from parent(s) to offspring and predict the possible resulting traits of that genetic transfer.

The traits and/or behaviors that allow a species to survive and reproduce will increase in frequency in the species as time goes on. The less favorable traits will decrease in frequency and can possibly disappear. This is the idea of natural selection. Natural selection is a key mechanism to showing how species change over time. Those individuals within populations that contain favorable traits will survive, reproduce and pass on the favorable adaptations at a higher rate than those without favorable adaptations. Artificial selection and selective breeding are methods used by humans to breed for specific traits. This method is common in livestock, pets, and plants.

Because of mutations and genetic variation, life on Earth is very diverse. Diversity ranges from archaea bacteria to protozoa, from plants to animals. When studying life, we use patterns to identify similarities and differences among organisms. Students can use graphs, charts, and images to compare patterns used to determine ancestry among organisms.

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.

Resources to inform your formative assessment.

http://stemteachingtools.org/brief/30
http://stemteachingtools.org/brief/41
http://stemteachingtools.org/pd/sessionb

SEP Constructing Explanations and Designing Solutions

- Create a diagram that illustrates how the genetics of the parent(s) impact the genetics of the offspring in sexual reproduction and in asexual reproduction.

SEP Developing and Using Models

- Does knowing parents phenotype for a trait allow you to predict offspring phenotype with certainty? Why or why not? Use a model to demonstrate your understanding.

CCC Cause and Effect

- Explain how a significant drought could change the genetic population of grasses?
- Sickle-cell anemia is a genetic linked disorder. It impacts the ability of red blood cells to transport oxygen. Is this mutation beneficial, harmful, or neutral for the individual? Why?

CCC Structure and Function

- How does the structure of the seed impact the ability of the plant to survive?
- Choose a wetland animal. Identify three adaptations it has. Decide if each adaptation is beneficial, harmful or neutral to the animal? Provide evidence to support your decisions.

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.

- **Use a model** to *describe the structure* of genes located in the chromosomes of cells, with each chromosome pair containing two variants of each distinct gene.
- **Synthesize information from various sources** to *predict* how distinct genes chiefly control the production of specific proteins, which in turn affects the traits of the individual.
- **Develop and use a model** to describe changes (mutations) to genes that *can result* in changes to proteins, which *can affect* both *the structures and, as a result, their function* and thereby change traits.
- **Analyze and interpret data** to describe variations that arise from sexual reproduction.
- **Communicate** that genetic information can be altered *as a result* of a mutation.
- **Create a model** to describe how genetic information is transferred to their offspring.
- **Develop and use a model** to describe sexually reproducing organisms and show how each parent contributes half of the genes *acquired (at random)* by the offspring.
- **Develop a model** to explain how humans have *the capacity to influence* certain characteristics of organisms through artificial selection.