Grade 7 Science, Unit 6

Inheritance and Variations of Traits

Overview

Unit abstract

In this unit of study, students will use models to describe how gene mutations and sexual reproduction contribute to genetic variation. Students will understand how genetic factors determine the growth of an individual organism. They will also demonstrate understanding of the genetic implications of sexual and asexual reproduction. The crosscutting concepts of cause and effect and structure and function provide students with a deeper understanding of how gene structure determines differences in the functioning of organisms. Students will develop and use models to determine phenomena to demonstrate understanding of the disciplinary core ideas.

Essential question

- How do living organisms pass traits from one generation to the next?

Bristol–Warren, Central Falls, Cranston, Segue Institute for Learning, Tiverton, and Woonsocket, with process support from The Charles A. Dana Center at the University of Texas at Austin

Written Curriculum

Next Generation Science Standards

MS. Growth, Development, and Reproduction of Organisms

Students who demonstrate understanding can:

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.** [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.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. ▪ Develop and use a model to describe phenomena. (MS-LS3-1)	**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 proteins, which can affect the structures and functions of the organism and thereby change traits. (MS-LS3-1) **LS3.B: Variation of Traits** ▪ In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. (MS-LS3-1)	**Structure and Function** ▪ Complex and microscopic 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. (MS-LS3-1)

Connections to other DCIs in this grade-band: **MS.LS1.A** (MS-LS3-1); **MS.LS4.A** (MS-LS3-1)

Articulation to DCIs across grade-bands: **3.LS3.A** (MS-LS3-1); **3.LS3.B** (MS-LS3-1); **HS.LS1.A** (MS-LS3-1); **HS.LS1.B** (MS-LS3-1); **HS.LS3.A** (MS-LS3-1); **HS.LS3.B** (MS-LS3-1)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts. *(MS-LS3-1)*
RST.6-8.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics. *(MS-LS3-1)*
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS3-1)
SL.8.5	Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points. *(MS-LS3-1)*

MS. Growth, Development, and Reproduction of Organisms

Students who demonstrate understanding can:

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. [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.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena. (MS-LS3-2)

Disciplinary Core Ideas

LS1.B: Growth and Development of Organisms

- Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. *(secondary to MS-LS3-2)*

LS3.A: Inheritance of Traits

- Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2)

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. (MS-LS3-2)

Crosscutting Concepts

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS3-2)

Connections to other DCIs in this grade-band: N/A

Articulation to DCIs across grade-bands: **3.LS3.A** (MS-LS3-2); **3.LS3.B** (MS-LS3-2); **HS.LS1.B** (MS-LS3-2); **HS.LS3.A** (MS-LS3-2); **HS.LS3.B** (MS-LS3-2)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts. *(MS-LS3-2)*
RST.6-8.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics. *(MS-LS3-2)*
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS3-2)
SL.8.5	Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points. *(MS-LS3-2)*

Mathematics –

MP.4	Model with mathematics. *(MS-LS3-2)*
6.SP.B.5	Summarize numerical data sets in relation to their context. *(MS-LS3-2)*

Clarifying the standards

Prior learning

The following disciplinary core ideas are prior learning for the concepts in this unit of study. By the end of Grade 5, students know that:

- Many characteristics of organisms are inherited from parents.
- Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment.
- Different organisms vary in how they look and function because they have different inherited information.
- The environment also affects the traits that an organism develops.

Progression of current learning

Driving question 1
How do structural changes to genes (mutations) located on chromosomes affect proteins or affect the structure and function of an organism?

Concepts	Practices
• Complex and microscopic structures and systems, such as genes located on chromosomes, can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among the parts of the system; therefore, complex natural structures/systems can be analyzed to determine how they function. • 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 affect the traits of the individual. • In addition to variations that arise from sexual reproduction, genetic information can be altered due to mutations. • Some changes to genetic material are beneficial, others harmful, and some neutral to the organism. • Changes in genetic material may result in the production of different proteins.	• 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.

• Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. • 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 • Though rare, mutations may result in changes to the structure and function of proteins.	
Driving question 2 How do asexual reproduction and sexual reproduction affect the genetic variation of offspring?	
Concepts • Organisms reproduce either sexually or asexually and transfer their genetic information to their offspring. • Asexual reproduction results in offspring with identical genetic information. • Sexual reproduction results in offspring with genetic variation. • Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. • 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. • Punnett squares, diagrams, and simulations can be used to describe the cause-and-effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.	Practices • Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information. • Develop and use a model to describe why sexual reproduction results in offspring with genetic variation. • Use 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.

Integration of content, practices, and crosscutting concepts

Using models, such as electronic simulations, physical models, or drawings, students will learn that genes are located in the chromosomes of cells and each chromosome pair contains two variants of each gene. Students will need to make distinctions between chromosomes and genes and understand the connections between them. DNA will be introduced in high school. Students will learn that chromosomes are the genetic material

that is found in the nucleus of the cell and that chromosomes are made up of genes. They will also learn that each gene chiefly controls the production of specific proteins, which in turn affect the traits of the individual.

Students should be given opportunities to use student-developed conceptual models to visualize how a mutation of genetic material could have positive, negative, or neutral impact on the expression of traits in organisms. Emphasis in this unit is on conceptual understanding that mutations of the genetic material may result in making different proteins; therefore, models and activities that focus on the expression of genetic traits, rather than on the molecular-level mechanisms for protein synthesis or specific types of mutations, are important for this unit of study. For example, models that assign genetic information to specific segments of model chromosomes could be used. Students could add, remove, or exchange genes located on the chromosomes and see that changing or altering a gene can result in a change in gene expression (proteins and therefore traits).

Students will continue this unit of study by describing two of the most common sources of genetic variation, sexual and asexual reproduction. Students will be able to show that in sexual reproduction, each parent contributes half of the genes acquired by offspring, whereas in asexual reproduction, a single parent contributes the genetic makeup of offspring. Using models such as Punnett squares, diagrams, and simulations, students will describe the cause-and-effect relationship between gene transmission from parents(s) to offspring and the resulting genetic variation. Using symbols to represent the two alleles of a gene, one acquired from each parent, students can use Punnett squares to model how sexual reproduction results in offspring that may or may not have a genetic makeup that is different from either parent. Students can observe the same mixing of genetic information using colored counters or electronic simulations. Using other models, students can show that asexual reproduction results in offspring with the same combination of genetic information as the parents. Students can summarize the numerical data they collect during these activities as part of their description of why asexual reproduction results in offspring with identical genetic combinations and sexual reproduction results in offspring with genetic variations.

As a culmination of this unit of study, students could make multimedia presentations to demonstrate their understanding of the key concepts. Students could participate in a short research project and cite the specific textual evidence used to support the analysis of any scientific information they gather. They could integrate quantitative or technical information as part of their presentation. For example, students can take data collected during investigations of genetic mutations and provide a narrative description of their results. They could use data collected during their investigation of sexual and asexual reproduction. They could also include diagrams, graphs, or tables to clarify their data.

Integration of engineering

There are no engineering standards included in this unit of study; however, advances in engineering and technology have made possible the discoveries that make up our current understanding of sexual and asexual reproduction.

Integration of DCI from prior units within this grade level

The following concepts were introduced in prior units of study:

- All living things are made up of cells; cells are the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).
- Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.

- In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.
- The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.
- Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.
- Comparison of the embryological development of different species also reveals similarities among organisms that indicate relationships that are not evident in fully formed anatomies.

Integration of mathematics and/or English language arts/literacy

Mathematics

- Use mathematics to model why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.
- Summarize numerical data sets that describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation in relation to their context.

English language arts/literacy

- Cite specific textual evidence to support analysis of science and technical texts about structural changes to genes (mutations) located on chromosomes that may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.
- Determine the meaning of symbols, key terms, and other domain-specific phrases as they are used 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.
- Integrate quantitative or technical information about 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 that is expressed in words with a version of that information expressed visually in a flowchart, diagram, model, graph, or table.
- Include multimedia components and visual displays in presentations about structural changes to genes (mutations) located on chromosomes that may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism to clarify claims and findings and emphasize salient points.
- Cite specific textual evidence for why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation to support analysis of science and technical texts.
- Determine the meaning of symbols, key terms, and other domain-specific phrases as they are used to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.

- Integrate quantitative or technical information that describes why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation that is expressed in words with a version of that information that is expressed visually in a flowchart, diagram, model, graph, or table.
- Include multimedia components and visual displays in presentations that describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation to clarify claims and findings and emphasize salient points.

Future learning

Life science

Systems of specialized cells within organisms help the organisms 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.

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.

Feedback mechanisms maintain a living system's internal conditions, within certain limits, and mediate behaviors, allowing the system to remain alive and functional even as external conditions change, within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (through negative feedback) what is going on inside the living system.

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

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, as yet, no 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 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.

Number of Instructional Days

Recommended number of instructional days: 15 (1 day = approximately 50 minutes)

Note—The recommended number of days is an estimate based on the information available at this time. Teachers are strongly encouraged to review the entire unit of study carefully and collaboratively to determine whether adjustments to this estimate need to be made.