**Summary:**   
The curricula developed for use with the StepStone software provides a motivating and engaging learning environment. Specific details for using the software are provided in an accompanying “StepStone How-To” document.

The genetics module covers the concepts of heredity, reproduction, DNA, patterns of inheritance, and variation in traits. Students will have the opportunity to guide their own learning through a variety of “learning objects” intended to provide critical thinking about and application of required science standards.

**Keywords:** allele,asexual reproduction, chromosome, DNA, dominant, fertilization, gamete, gene, genotype, heredity, heterozygous, homozygous, meiosis, mitosis, mutation, natural selection, phenotype, recessive, sexual reproduction

**Subject TEKS:**

* 6.12 (D) identify the basic characteristics of organisms, including mode of reproduction
* 7.11 (C) identify some changes in genetic traits that have occurred over several generations through natural selection and selective breeding
* 7.14 (A) define heredity as the passage of genetic instructions from one generation to the next generation;
  + (B) compare the results of uniform or diverse offspring from asexual or sexual reproduction; and
  + (C) recognize that inherited traits of individuals are governed in the genetic material found in the genes within chromosomes in the nucleus.
* Biology 6 (A) identify components of DNA, identify how information for specifying the traits of an organism is carried in the DNA;
  + (E) identify and illustrate changes in DNA and evaluate the significance of these changes;
  + (F) predict possible outcomes of various genetic combinations such as monohybrid crosses;
  + (G) recognize the significance of meiosis to sexual reproduction.

**NGSS Science and Engineering Practices:**

* LS1.B: 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 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. 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.

**Grade Level:** 6th - 9th

**Learning Objectives:**

1. Define heredity
2. Describe and differentiate between sexual and asexual reproduction.
3. Identify the components of DNA.
4. Explain how allele forms determine an organism’s traits.
5. Distinguish between genotype and phenotype.
6. Create Punnett squares to predict the genotype and phenotype of offspring from a particular cross.
7. Describe the various ways for variation to occur in organisms.

**Time Required:** will vary depending on lesson implementation and learning objectives chosen

**Materials:**

* Devices with internet access

**Background and Concepts for Teachers:**

Heredity and Reproduction

Heredity is the passing of traits from parents to offspring and is accomplished through reproduction. Asexual reproduction occurs when a new organism is produced from a part of another organism via cell division. During cell division genetic material (DNA) in the nucleus is copied and then the nucleus divides into two identical nuclei. This process is called mitosis and results in two nuclei with identical genetic information. Sexual reproduction produces new organisms when the genetic material of two specialized cells, called gametes, join together during fertilization. These sex cells consist of egg and sperm and, unlike body cells, are formed by meiosis. Before meiosis begins, DNA is duplicated. During meiosis, the nucleus divides twice and four gametes are formed, each with half the genetic material of the original cell. Humans have 46 chromosomes; meiosis then, produces 4 gametes with 23 chromosomes each. Sexual reproduction results in greater genetic diversity than does asexual reproduction.

DNA

Deoxyribonucleic acid, DNA, is the genetic material found in the nucleus of every cell. The structure of DNA is similar to a twisted ladder comprised of sides made of sugar-phosphate molecules and rungs made of nitrogen bases. The four nitrogen bases, adenine (A), guanine (G), cytosine (C), and thymine (T), always occur as pairs; A-T and G-C.

Long strands of DNA wrap around proteins forming chromosomes. Sections of DNA found on chromosomes are called genes. These genes contain the instructions for specific proteins a cell will make, which in turn determine an organism’s traits.

Body, or somatic, cells contain pairs of chromosomes. Each gene on one chromosome has a similar gene on the other chromosome that code for the same trait. These different forms of a trait that a gene may have are called alleles. If the alleles contain different information about the trait they are heterozygous. If the alleles contain the same information they are homozygous.

How a trait is expressed depends on whether the allele is dominant or recessive. A dominant allele masks another allele of the trait. Recessive alleles are only expressed when the gene is homozygous recessive for the trait.

The types of alleles an organism has is its genotype. The genotype, to a large extent, determines the physical expression, or phenotype, of a trait.

Predicting Traits

A Punnett square is a chart used to determine the expected percentage of different genotypes in the offspring of two parents. In a single trait/allele cross, the gametes produced by the male parent are written at the top of a 2x2 chart, and the gametes produced by the female parent are along the side. The different possible combinations of alleles (genotypes) in their offspring are determined by filling in the cells of the Punnett square with the individual alleles of the parents. Based on the resulting genotypes, the phenotypes of the offspring can also be predicted.

Keep in mind that Punnett squares only provide the probability of particular genotypes resulting from a certain cross. Just like flipping a coin does not always produce 50% heads and 50% tails, the exact genotypes of a cross may vary by chance from the prediction.

Variation in Traits

Genetic variations are the different expressions of a certain trait. Both natural and artificial processes result in variation.

Not all traits follow a simple two allele, dominant or recessive inheritance pattern. Incomplete dominance occurs when a heterozygous genotype produces a phenotype that is intermediate between the two homozygous parents. Four O’clock flowers have red, white, and pink varieties; with the pink resulting from a cross of pure red and pure white. Traits controlled by multiple alleles produce more than three phenotypes of that trait. An example is human blood type which can be A, B, AB, and O. Both blood types A and B are fully expressed in the AB blood type; it is not an intermediate of A and B.

Polygenic inheritance occurs when a group of gene pairs acts together to produce a trait. The effects of many alleles produces a wide variety of phenotypes. Height, eye and skin color are the result of polygenic inheritance.

Errors that occur in a cell during meiosis or mitosis may result in mutations, changes in a gene or chromosome. Mutations can have no effect, be beneficial, or harmful to an organism.

Natural selection occurs when individuals with certain traits are more likely than individuals with different traits to survive and reproduce. These traits/alleles selected by nature are passed on to the next generation.

Artificial genetic variation is introduced when humans select organisms with certain traits to reproduce. The many breeds of dogs or livestock are due to artificial selection or selective breeding.

**Vocabulary / Definitions:**

* **Allele** – an alternate form that a gene may have for a single trait; can be dominant or recessive
* **Asexual reproduction** – a type of reproduction in which a new organism is produced from one parent and has DNA identical to the parent
* **Chromosome** – structure in a cell’s nucleus contains genetic material
* **DNA** – deoxyribonucleic acid; which is the genetic material of all organisms, made up of two twisted strands of sugar-phosphate molecules and nitrogen bases
* **Dominant –** describes a trait that covers over or dominates another form of that trait
* **Fertilization** – in sexual reproduction, the joining of a sperm and egg
* **Gamete –** the male or female reproductive cell that contains half the genetic material of the organism
* **Gene –** section of DNA on a chromosome that contains instructions for making specific proteins.
* **Genotype -** an organism’s genetic makeup
* **Heredity –** the passing of traits from parents to offspring
* **Heterozygous –** describes an organism with two different alleles for a trait
* **Homozygous –** describes an organism with two of the same alleles for a trait
* **Meiosis –** reproductive processes that produces four haploid sex cells from one diploid cell and ensures offspring will have the same number of chromosomes as the parent organisms.
* **Mitosis –** cell process in which the nucleus divides to form two nuclei identical to each other, and identical to the original nucleus
* **Mutation –** any permanent change in a gene or chromosome of a cell; may be beneficial, harmful, or have little effect on an organism
* **Natural selection -** the process where organisms with favorable traits are more likely to survive and reproduce
* **Phenotype** – outward physical appearance and behavior of an organism
* **Recessive –** describes a trait that is covered over, or dominated, by another form of that trait and seems to disappear
* **Sexual reproduction –** a type of reproduction in which two sex cells, an egg and a sperm, join to form a zygote which will develop into a new organism with a unique identity.

**Lesson Introduction/Motivation:**   
Students begin by taking the “pre-test” in order to assess their current knowledge and understanding. This may also enable students to recognize concepts about which they would like to learn more or to which they need to pay particular attention.

The student-centered design of this module allows for multiple introduction/motivation activities. Students may begin the unit on their own by reading the “Meet a Scientist” biography or “Backpack Adventure” stories or by watching one or more “Scientist Videos”. Each of these learning objects provide students with insights into the history or application of genetics and should motivate students to dig deeper into the required standards presented/studied later. These learning objects also contain processing questions that can be answered and shared in class or in an on-line portfolio such as Google docs.

Alternately, teachers could introduce the module to their classes by having students take an inventory of their own easily observable genetic traits. Working in small groups, they observe how their trait inventories differ from those of others. Students can record their observations in a data table and make a bar graph to show the most and least common traits in the group.

**Exploration/Explanation:**   
Students should next examine the required concepts (standards) of genetics. Setting up classroom stations can promote student collaboration, problem solving, and critical thinking. Stations also provide students with a common base of experiences. These stations may include any or all of the following learning objects:

* *Essential Knowledge* – students use various types of note outlines to record information about required content from an interactive video presentation. Students can then compare and discuss their notes to ensure the acquisition of key concepts.
* *Backpack Adventures* – students read (independently or as a read aloud) a fictional story with factual content about key concepts and individuals related to genetics. Students can then answer questions, create timelines, compare fact vs. fiction, or perform other related activities to reinforce required concepts.
* *Meet a Scientist* – students read (independently or as a read aloud) a short biography about a scientist instrumental to the field of genetics. They will then answer questions relating to the scientist and his work. Students could also role-play and describe how they would have solved the problem/answered the question facing the scientist. Additionally, students could ask additional questions they have about genetics after reading about the scientist’s work.
* *Scientist Videos* – students learn how real scientists study genetics in various short videos describing research, careers, or other aspects of the field. Students will then answer questions and/or discuss how the concepts they learn in class are applied in the real world.
* *Real Science Review* – students read an actual research article related to genetics (edited to middle school readability) and then review it using the scientific method as scaffolding. For instance, students will identify the hypothesis, data collection methods, relevance, etc.
* *Practice* – students can choose various on-line activities to gain or reinforce knowledge about genetics. Activities include videos, matching/labeling games, flashcards, mnemonics, quizzes, etc.

Another option for utilizing this module is to have students choose either “Backpack Adventures”, “Meet a Scientist”, “Scientist Videos”, or “Real Science Review” and complete (read/watch and answer questions) accompanying activities at home. They would journal on paper or through an on-line portfolio such as Google Docs about three main ideas, provide three vocabulary words and definitions, and/or construct three questions. As a class or in small groups students would share information and use it to complete note outlines, practice activities, or other class activities (see “Elaborate” section).

**Elaborate:**

* Genetics Activities - This compilation of activities enables teachers to choose which of several principles of genetics to reinforce. These activities cover genotype and phenotype, impacts of environmental influences on species adaptations, impacts of mutations on a species and properties of inheritance. Included in this document is the “Trait Assessment” lesson introduction activity.
* Mars Needs Animals! – Students build animal colonies on Mars using basic genetics, creating Punnett Squares, and then analyzing ecological affects. This lesson challenges students to calculate the genotypes of various animals and allows them to construct populations, proportions, and percentages of different animals and then examine how populations change based on selection.

**Assessment/Evaluation:**

The Genetics Module includes a post-test, which can be used for an overall learning assessment. Other opportunities for assessment include student output at any of the learning object stations, journaling requirements as detailed in the “Explore/Explain” section above and/or any of the “Elaborate” activities.

Please email us your comments on this lesson: [cvmpeer@cvm.tamu.edu](mailto:cvmpeer@cvm.tamu.edu).  
In your email, please include the title of the lesson and the grade level to which the lesson was applied.