Historic Heredity

Context

Hereditary will be examined as the transmission of the physical and genetic qualities of parents. The study of genetics includes the important role of genes in the development of human beings. Genes make up genetic codes. All living beings have DNA, which carries the genetic code. The structure and function of genes, chromosomes, and DNA, as well as reproduction, mutation, and environmental factors will be examined.

Essential Questions

- What connections are found between genetics and heredity by examining the cellular structures of genes?
- What is the role of DNA and chromosomes in the coding of traits?
- What are inheritable genetic variations? What causes genetic variations?

Enduring Understandings

- Cells are the basic building blocks of all living things. A gene is the basic physical and functional unit of heredity. Genes are made up of DNA found in cells, which act as instructions to make molecules called proteins.
- DNA contains the code, or instructions for building an organism and ensuring that organism functions correctly. Stretches of chromosomes, which are located in the nucleus of every cell, code for genes.
- Inheritable genetic variations may be caused by: meiosis, errors during replication, and mutations, including those caused by environmental factors.

Time

These activities can be completed in 1–2 class periods of approximately 50 minutes.

Grade Level

Grades 6–12. Activities can easily be adapted to fit grade and ability levels.

Differentiation

These inquiry activities can be completed as a class guided by the teacher, in groups, pairs, or individually based on students' abilities.

Materials

- Rosen Digital's Core Concepts: Biology database
- Computers
- Smart Board, iPad, or other computer projection presentation device (optional if Teacher/Librarian wants to demonstrate worksheets and/or have one group worksheet)
- Appropriate Assistive Technology for students with special needs (if applicable)
- Supplement 1 - DNA Model
- Supplement 2 - Mitosis and Meiosis Diagrams
- Supplement 3 - Mitosis Worksheet
- Supplement 4 - Meiosis Worksheet
- Supplement 5 - Multimedia Presentation Rubric
- Licorice

- Different color soft candies (e.g., gum drops or mini-marshmallows)
- Box of toothpicks
- Blue, red, and black pens or markers (blue: father; red: mother; black: centromere)
- Research materials (access to books and the Internet)
- Paper/pencils

Student Learning Objectives

- Students will be able to develop and use a model to describe genes and structural changes to genes (mutations).
- Students will be able to explain the role of DNA and chromosomes in coding of traits.
- Students will be able to provide evidence of inheritable genetic variations resulting from: meiosis, errors during replication, and mutations, including those caused by environmental factors.

Next Generation Science Standards Addressed	
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.*]
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.]
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.** [*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.** [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.** [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.*]

NGSS Science and Engineering Practices Addressed

- **Developing and using models**
- **Asking questions and defining problems**
- **Engaging in argument from evidence**
- **Analyzing and interpreting data**

NGSS Crosscutting Concepts Addressed

- **Structure and function.** Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts; therefore complex natural structures/systems can be analyzed to determine how they function.
- **Cause and effect.** Cause and effect relationships may be used to predict phenomena in natural systems. 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).

Common Core ELA Standards

CCSS.ELA-Literacy.RST.6-8.1, 9-10.1, 11-12.1

Cite specific textual evidence to support analysis of science and technical texts.

CCSS.ELA-Literacy.RST.6-8.2, 9-10.2, 11-12.2

Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

CCSS.ELA-Literacy.RST.6-8.4, 9-10.4, 11.12.4

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, grades 9–10, and grades 11–12 texts and topics.

CCSS.ELA-Literacy.RST.6-8.7, 9-10.7, 11-12.7

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).

Activity 1: DNA Model

Introduction

Everything about you, from the way you look to how your body functions, is controlled by genes. Genes are packets of information that form a code. Genes occur on stretches of long chemicals called deoxyribonucleic acid, or DNA. A DNA molecule is shaped like a ladder that has been twisted around itself many times without breaking the rungs. This shape is called a double helix. The building blocks of DNA are called nucleotides. They are made of chemicals called phosphates as well as sugars. The sugars and phosphates form the "sides" of the DNA ladder.

Nucleotides also contain one of four other chemicals called bases. They are adenine (A), thymine (T), guanine (G), and cytosine (C). The bases form the ladder's "rungs." Bases on one side of the DNA ladder bind with bases on the other in a very specific way. Adenine in one strand always forms a bond to thymine in the other, while guanine always bonds with cytosine.

Teacher Tip!
As an introduction, show students the structure of DNA video in the *From DNA to RNA to Protein* article.

As a class, define the following words/terms: *chromosomes, genes, traits, phenotype, genotype, alleles, homozygous, heterozygous, adenine, thymine, cytosine, and guanine*.

Teacher Tip!
For help with definitions, see the *From DNA to RNA to Protein*, *Concepts of Human Genetics*, and *Principles of Inheritance* articles.

Materials

- Supplement 1 - DNA Model
- 2 pieces of licorice (for each group)
- 4 each of 4 different color soft candies e.g., gum drops or mini-marshmallows (for each group)
- Box of toothpicks

Procedure

1. Divide the class into groups or pairs. Provide each group with a copy of Supplement 1 (DNA Model) or project the model on a whiteboard or overhead projector.
2. Each model is going to need to be constructed with four different colored candies. Take out four of each color, for a total of sixteen candies for each group.
3. Take two of the color groups, for example green and blue, and thread one green candy and one blue candy on a toothpick so that the candies touch in the middle of the toothpick. Do this with all the candies of that color.
4. Now thread the other two colors, for example red and orange, as above. There should be a total of eight candy-filled toothpicks.
5. Alternate connecting the toothpick "rungs" to the "ladder" of the licorice until all eight rungs are connected.
6. To give the model its corkscrew shape, twist the model.

Have students think about how genetic mutations occur. Ask students to use their DNA model to demonstrate how a mutation may look. Upper-level students can research to find out the resulting condition of the mutation they demonstrated with their DNA model. At the conclusion of the discussion, students may eat their candy models.

Teacher Tip!
Students can study Quizlet flashcard sets to learn genetics key terms on the Core Concepts: Biology database or by visiting Rosen Digital's Quizlet page.

Activity 2: The Code

Introduction

Project Supplement 2 (Mitosis and Meiosis Diagrams) on a whiteboard or overhead projector. Explain that structures containing DNA called chromatids join to form chromosomes, which contain alleles of genes that are responsible for the characteristics of living things. DNA is what is inherited when cells grow and divide. When cells grow and divide, the DNA is replicated and passed on to the daughter cells. Cells can grow and divide by meiosis and mitosis. Mitosis results in diploid cells, which are copies of the parent cells. Meiosis results in haploid cells which each contain half of the DNA.

Materials

- Supplement 2 - Mitosis and Meiosis Diagrams
- Supplement 3 - Mitosis Worksheet
- Supplement 4 - Meiosis Worksheet
- Blue, red, and black pens or markers (blue: father; red: mother; black: centromere)

Procedure

1. Divide class into pairs and give each pair three colored pens and Supplement 3 (Mitosis Worksheet) and Supplement 4 (Meiosis Worksheet). Using the information provided in the Mitosis and Meiosis Diagrams, have students work to replicate each process.

2. Have students draw the chromosomes on the Mitosis Worksheet, showing the essential chromosome arrangements during mitosis. When done, raise your hand to be checked.

3. Have students draw the chromosomes on the Meiosis sheet. Remember to show the essential differences between mitosis and meiosis. Note: Check position of chromosomes in completed worksheets.

Summarize

Mitosis leads to the production of two daughter cells, each of which also has 46 chromosomes. Meiosis is the process of cell division that leads to the production of sex cells.

Activity 3: Genetic Variations

Introduction

Genes make us what we are. They control the way cells develop and function. A sudden, permanent change in the genetic material of a cell is called a mutation. Some mutations are negative, some are positive, and some are neutral. To understand how mutations arise, scientists had to unravel the mystery of DNA, the molecule that forms the genetic code. When DNA replicates (copies itself) during cell division, mistakes can occur. Mutations occur at a faster rate when DNA is bombarded with ultraviolet radiation or comes into contact with certain types of chemicals.

Materials (for each group)

- Research materials (access to books and the Internet)
- Pencil/paper
- Supplement 5 - Multimedia Presentation Rubric

Procedure

1. Divide the class into six to eight expert groups. Each group will research a disorder caused by genetic mutation. Some suggested disorders are: sickle cell disease, Cystic fibrosis, Down syndrome, color blindness, Tay-Sachs disease, Turner syndrome, neurofibromatosis, Prader-Willi syndrome, Hutchinson-Gilford progeria.

Teacher Tip!
Distribute copies of the Research Sheet to help students organize their notes.

2. Research should include the type of mutation (substitution, insertion, deletion, frameshift) and the chromosome (where applicable). Students should focus on the causes (including environmental factors), population affected, the outcome and affected functions, current research, cures and organizations that support people with the genetic disorders.

3. Encourage students to prepare presentations to be share with the class. Distribute Supplement 5 (Multimedia Presentation Rubric). Students may also use the Create a Multimedia Presentation interactive activity when planning their presentations.

Teacher Tip!
Students can also create multimedia slideshows or presentations using online resources such as Animoto, Glogster, or Prezi.

Assessment Evidence

Ongoing Assessment

- DNA guided discussion
- Genetic Variations group research

Summative Assessment

- DNA model
- Mitosis and Meiosis Worksheets
- Genetic Variations presentations