Unit 3: Heredity: Inheritance and Variation of Traits

Content Area: **Science**
Course(s):
Time Period: **Trimester 2**
Length: **6-7 weeks**
Status: **Published**

Summary

Students will develop and use models to describe how DNA stores genetic information and how replication ensures accurate transfer of that information during cell division. They explore the structure of DNA, including nucleotides, sugar-phosphate backbones, and nitrogen base pairings, while connecting the work of key scientists like Watson, Crick, Franklin, and Chargaff to modern genetics. Students demonstrate how mutations in DNA can alter protein structure, leading to changes in traits that may be beneficial, harmful, or neutral. Through hands-on labs and simulations, students analyze how proteins are produced through transcription and translation and how these proteins control the physical traits of an organism. Students investigate patterns of inheritance, including dominant and recessive alleles, incomplete dominance, codominance, multiple alleles, polygenic traits, and sex-linked traits, using Punnett squares, genetic dice labs, and pedigrees. They explore how sexual reproduction through meiosis creates genetic variation, while forensics, genetic engineering, and real-world case studies provide authentic applications of genetic knowledge. The crosscutting concepts of cause and effect, structure and function, and heredity provide a framework for students to demonstrate proficiency in modeling genetic processes and understanding how genetic information leads to variation in all living organisms.

Revision Date: July 2025

Essential Questions

Essential Questions:

How do combinations of genes and chance lead to genetic variation and make every individual unique?

How can mutations in DNA affect proteins and result in different inherited traits or disorders?

How does the environment influence gene expression and the traits an organism develops?

How do dominant, recessive, and other patterns of inheritance control the traits passed from parents to offspring?

How are DNA, RNA, and proteins connected in the process that leads from genetic information to physical traits?

Enduring Understandings:

Organisms reproduce, grow, and follow predictable life cycles, passing genetic information to offspring

through patterns of inheritance.

Genetic variation results from the unique combination of alleles, ensuring that no two individuals are genetically identical except identical twins.

Mutations in DNA sequences can be harmful, beneficial, or neutral, introducing additional variation that may affect protein function and physical traits.

The expression of traits is determined by multiple inheritance patterns, including dominant, recessive, incomplete dominance, codominance, multiple alleles, polygenic inheritance, and sex-linked traits.

Genetic variation provides the foundation for natural selection, allowing populations to adapt to changing environmental conditions over time.

The processes of DNA replication, protein synthesis, mitosis, and meiosis ensure the accurate transfer and expression of genetic information across generations.

Objectives

Students will know…

Organisms reproduce, develop, have predictable life cycles, and pass on traits to their offspring.

The historical contributions of Chargaff, Rosalind Franklin, Watson, and Crick in the discovery of DNA.

That DNA consists of sugars, phosphates, and nitrogen bases arranged in a double helix structure.

The structure of DNA: nucleotides, sugar-phosphate backbone, and base-pairing rules (A-T, C-G).

That changing the DNA code can change the protein that forms and alter the trait.

Mutations can be harmful, beneficial, or benign, and may affect protein function.

The purpose and process of DNA replication.

The role of DNA in storing genetic information and directing protein synthesis.

The differences between DNA and RNA, including structure and nucleotide bases.

The steps of protein synthesis: transcription and translation.

How proteins are built based on the sequence of DNA bases and how they influence physical traits.

The stages and purposes of mitosis and meiosis in growth, repair, and reproduction.

During meiosis, organisms that reproduce sexually inherit half of their genetic material from each parent.

The differences between mitosis and meiosis and their outcomes.

Mendel's role in discovering basic inheritance patterns.

The expression of traits is determined by the inheritance of dominant and recessive alleles.

The definitions of genotype, phenotype, dominant, recessive, homozygous, and heterozygous.

The results of genetic crosses may sometimes vary from Mendel's predictions due to probability and other inheritance patterns.

The inheritance patterns of incomplete dominance, codominance, multiple alleles, and polygenic inheritance.

That no two people are truly genetically identical (except identical twins).

Sex-linked disorders are more common in males, and why.

How pedigrees are used to track inherited traits across generations.

The ethical considerations and potential applications of genetic research and engineering.

The real-world applications of genetics are in fields such as medicine, forensics, and paternity testing.

How blood types demonstrate multiple alleles and codominance.

Students will be skilled at…

Using Punnett squares to show possible gene combinations and predict genetic outcomes for monohybrid, dihybrid, and complex crosses.

Matching base pairs correctly during DNA modeling, simulations, and transcription practice.

Extracting DNA from cells through lab investigations.

Constructing DNA models to demonstrate nucleotide structure and base pairing.

Modeling DNA replication and simulating the role of replication enzymes.

Modeling and simulating the stages of mitosis and meiosis using diagrams and manipulatives.

Transcribing DNA sequences into mRNA and translating mRNA into amino acid sequences using codon charts.

Identifying how mutations can change proteins and result in genetic disorders.

Differentiating between different types of inheritance patterns, including incomplete dominance, codominance, multiple alleles, polygenic traits, and sex-linked traits.

Using pedigrees to help trace the occurrence of a trait within a family.

Participating in hands-on labs and simulations, including DNA extraction, Genetic Dice Lab, Probability Lab, Dragon Genetics, Taste Tests, Bloops Lab, and Blood Type Simulation.

Researching and presenting on genetic disorders and genetic engineering topics.

Applying their understanding of inheritance to real-world forensics, including solving cases such as the Forensic Detectives and Recovering the Romanovs.

Learning Plan

DNA

Review the essential questions and introduce DNA as the molecule of heredity.

Class discussion on what genetic information is and where it's stored.

Direct instruction on the history of DNA: Chargaff's rule, Rosalind Franklin's X-ray images, Watson & Crick's double helix model.

History of DNA Discovery

View Video: The Secret of Photo 51 (Rosalind Franklin's contribution).

Brief discussion on the roles of Watson, Crick, Franklin, and Chargaff.

DNA Structure - Review nucleotides: sugar, phosphate, and nitrogen base.

Build a paper or 3D model of DNA showing base pairs: A-T, C-G.

Students will use the website, biomanbio.com, to match up base pairs.

DNA Extraction LAB - Conduct a DNA extraction lab using simple materials (strawberries/bananas, alcohol, and dish soap)

Students observe physical DNA strands and review nucleotide components.

DNA Role Play and Interactive Modeling

Reinforce the concept of base pairing and complementary strands.

Protein Connection and Summary

Brief introduction of DNA's role in building proteins (without a full transcription/translation unit yet).

Review vocabulary: DNA, nucleotide, replication, base pairs, double helix, genetic code.

DNA Replication

Review DNA structure (link back to DNA model building and DNA Play Activity).

Use models, diagrams, and video clips to introduce semi-conservative replication.

Hands-on paper model of DNA replication (unzipping, pairing, bonding).

DNA Replication

Students work in small groups to act out replication with colored beads or paper nucleotides.

Practice labeling enzymes: helicase, DNA polymerase, ligase (basic overview).

Mitosis

Introduction to Mitosis

Direct instruction and guided notes on stages: prophase, metaphase, anaphase, telophase, cytokinesis.

Use labeled diagrams and visuals

Mitosis Modeling

Students physically model mitosis using string chromosomes.

Practice and Assessment

Exit ticket or short quiz on mitosis stages.

Optional: Create a stop-motion video of mitosis using classroom supplies.

Meiosis

Review Meiosis vs. Mitosis

View Teacher's Domain Virtual Meiosis

Meiosis Instruction

Introduce stages: Meiosis I and Meiosis II.

Use diagrams, chromosomal models, and class notes.

Emphasize crossing over, independent assortment, and genetic variation.

Application of Meiosis

View The Power of Genes Video (by Discovery).

Protein Synthesis

Review essential questions.

Review DNA structure through previously completed: DNA extraction lab DNA models DNA Play

Activity Video: The Secret of Photo 51

Connect how the sequence of DNA nucleotides provides the instructions for building proteins.

Transcription

Introduce transcription: DNA → mRNA.

Model transcription step-by-step as a class.

Students practice transcribing given DNA sequences.

Emphasize differences: uracil (U) replaces thymine (T), ribose sugar, single-stranded RNA.

Translation

Introduce translation: mRNA → protein.

Demonstrate codon usage with a codon chart.

Students practice translating mRNA codons into amino acids.

Hands-on role play: Assign students as mRNA, tRNA, ribosome, and amino acids to physically simulate translation (use of parts from DNA Play Activity).

Practice with Mutations and Effects on Proteins

Discuss mutations and their potential effects

Students practice how changes in DNA sequences can lead to different proteins.

Tie in how protein changes can lead to genetic disorders: Use Research two human genetic disorders as a project.

Students investigate how mutations affect protein function in disorders.

Inheritance Link to Proteins

Genetics

Mendelian Genetics

Preview Essential Questions and connect to previous DNA and meiosis units.

Direct instruction on Mendel's pea plant experiments. View The Secret of Photo 51 (review of DNA discovery and link to inheritance).

Traits and Vocabulary

Introduce genotype, phenotype, dominant, and recessive.

Class activity: sorting traits into dominant/recessive categories.

Use DNA Play Activity (previously completed) to reinforce DNA as the foundation of inherited traits.

Monohybrid Crosses

Teach simple Punnett squares.

Students practice predicting single trait crosses.

Genetic Probability

Conduct Probability Lab to reinforce the concept of chance in inheritance.

Discuss the relationship between Punnett squares and probability.

Genetic Dice Lab

Students simulate inheritance using dice to model gene combinations.

Compare class data to expected Mendelian ratios.

Incomplete Dominance and Codominance

Teach incomplete dominance and codominance.

Complete Incomplete Dominance Worksheet.

Conduct The Genetics of Bloops Lab to model incomplete dominance.

Multiple Alleles and Polygenic Inheritance

Teach multiple alleles (e.g., blood type) and polygenic inheritance (e.g., height, eye color).

Conduct Blood Type Simulation.

Sex-Linked Traits

Teach inheritance of sex-linked traits.

Connect to real-world examples (colorblindness, hemophilia).

Genetic Taste Test - Students participate in Genetic Taste Test Activity (PTC tasting and other traits).

Application of Genetic Research

Research two human genetic disorders.

Begin Genetic Engineering Project: advantages and disadvantages.

Pedigrees

Teach pedigree symbols and analysis.

Conduct A Family Puzzle Pedigree Activity.

Complete Baffling Baby Mix-Up Activity to solve a hospital mix-up.

Complete Beautiful Baby Activity to predict trait combinations in offspring.

A Quick Switch Activity

Students simulate how mutations can affect genes and traits.

Discuss mutations and their role in genetic disorders.

Forensic Applications

View Forensic Detectives and Recovering the Romanovs videos.

Class discussion on real-world applications of genetics in forensics.

Blood Type Simulation

Conduct a Blood Type Simulation where students apply their knowledge of multiple alleles, codominance, and Punnett squares.

Use blood typing kits or simulated data.

Practice determining blood types (A, B, AB, O) and Rh factor (+ or -).

Apply Punnett squares to predict possible offspring blood types.

Discuss real-world applications for blood typing in medicine, transfusions, and paternity testing.

Lab Safety will be reviewed before all Lab Activities

Assessment

Science courses are designed to promote skill attainment. Student progression and pace through which they proceed through the performance tasks is based on their affinity for and ability to reach skill attainment. The teacher will determine formative and summative skill attainment; alternative assessments will be incorporated for each student based on their strengths and challenges.

Formative Assessments:

Worksheets

Exit Tickets

Class Discussion

Quizzes:

Punnett Square Quiz

Genetics Vocabulary Quiz

Summative:

Cell Division Test

DNA Unit Test

Genetics Unit Test

Bench Marks:

Formal Lab Reports/Lab Write-ups:

A Family Puzzle Lab Write-up

Alternative:

Dragon Genetics Activity

Baby Mix-up Project Poster

Materials

Elevate Science Life- Savvas

Safety Equipment

Computer(s)

Smartboard

Powerpoints

Relevant worksheets/notes

Relevant videos

Relevant virtual activities

Relevant interactive programs

Dragon genetics chromosomes

Dragon Pictures

Colored Pencils/scissors

colored chalk

string/pipe cleaner "chromosomes"

DNA Models

DNA Extraction lab supplies

Dry-erase boards and markers/erasers

Protein synthesis magnet kit

Genetic Dice

genetic taste test strips

Pennies

Red/White beans for probabilities

Standards

9.2.8.CAP	Career Awareness and Planning
9.2.8.CAP.2	Develop a plan that includes information about career areas of interest.
TECH.K-12.1.1.c	use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways.
TECH.K-12.1.1.d	understand the fundamental concepts of technology operations, demonstrate the ability

	to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.
L.KL.7.2	Use knowledge of language and its conventions when writing, speaking, reading, or listening.
L.KL.7.2.B	Gather vocabulary knowledge when selecting a word or phrase important to comprehension or expression.
TECH.K-12.1.3	Knowledge Constructor
TECH.K-12.1.3.c	curate information from digital resources using a variety of tools and methods to create collections of artifacts that demonstrate meaningful connections or conclusions.
TECH.K-12.1.3.d	build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.
TECH.K-12.1.5.b	collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.
W	Writing
W.AW.7.1	Write arguments on discipline-specific content (e.g., social studies, science, technical subjects, English/Language Arts) to support claims with clear reasons and relevant evidence.
W.AW.7.1.A	Introduce claim(s) about a topic or issue, acknowledge alternate or opposing claims, and organize the reasons and evidence logically.
W.AW.7.1.B	Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
W.AW.7.1.C	Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), reasons, and evidence.
W.AW.7.1.E	Provide a concluding statement or section that follows from and supports the argument presented.
W.IW.7.2	Write informative/explanatory texts (including the narration of historical events, scientific procedures/experiments, or technical processes) to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
W.IW.7.2.A	Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information, using text structures (e.g., definition, classification, comparison/contrast, cause/effect, etc.) and text features (e.g., headings, graphics, and multimedia) when useful to aid in comprehension.
7.SP	Statistics and Probability
7.SP.A	Use random sampling to draw inferences about a population
7.SP.A.1	Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid inferences.
7.SP.A.2	Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions.
7.SP.C	Investigate chance processes and develop, use, & evaluate probability models
8.SP	Statistics and Probability
7.SP.C.5	Understand that the probability of a chance event is a number between 0 and 1 that expresses the likelihood of the event occurring. Larger numbers indicate greater likelihood. A probability near 0 indicates an unlikely event, a probability around ½ indicates an event that is neither unlikely nor likely, and a probability near 1 indicates a

	likely event.
7.SP.C.6	Approximate the probability of a chance event by collecting data on the chance process that produces it and observing its long-run relative frequency, and predict the approximate relative frequency given the probability. For example, when rolling a number cube 600 times, predict that a 3 or 6 would be rolled roughly 200 times, but probably not exactly 200 times.
SL.PE.7.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.
7.SP.C.7	Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy.
SL.PE.7.1.A	Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.
SL.PE.7.1.B	Follow rules for collegial discussions, track progress toward specific goals and deadlines, and define individual roles as needed.
MS-LS1	From Molecules to Organisms: Structures and Processes
MS-LS1-2	Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
MS-LS1-5	Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. 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.
MS-LS3	Heredity: Inheritance and Variation of Traits
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. Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins. Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations. 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.
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.
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.
	Structure and Function
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.
	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.
	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.
LS1.B	Growth and Development of Organisms
	Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring.
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.
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.
	Cause and Effect
	Cause and effect relationships may be used to predict phenomena in natural systems.

Modifications/Accommodations

This link includes content specific accommodations and modifications for the populations listed below the link

https://docs.google.com/spreadsheets/d/1QL15CF_i_gwqtoPintFW-FmY85ALeKv4J1PQQxb-vbM/edit?usp=sharing