Course: *Genetics* **Unit #3:** *Gene Expression, Inheritance and Statistical Analysis*	**Year of Implementation:** 2024-2025

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Stage One - Desired Results

Link(s) to New Jersey Student Learning Standards for this course:
{provide all applicable links to standards here}
https://www.state.nj.us/education/cccs/2020/

Science and Engineering Practices
The content of this unit will strengthen student skills in the following SEPs.

- Practice 1 Ask Questions
- Practice 2 Developing and Using Models
- Practice 3 Planning and Carrying Out Investigations
- Practice 4 Analyzing and Interpreting Data
- Practice 5 Using Mathematics and Computational Thinking
- Practice 6 Constructing Explanations and Designing Solutions
- Practice 7 Engaging in Argument from Evidence
- Practice 8 Obtain, Evaluate and Communicate Information

LS1.A: Structure and Function
- 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. (secondary to HS-LS3-1) (Note: This Disciplinary Core Idea is also addressed by HS -LS1-1.) (SEP 1, 2, 3, 4)

LS3.A: Inheritance of Traits
- 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 no as-yet known function. (HS-LS3-1) (SEP 1, 4)

LS3.B: Variation of Traits

- 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. (HS-LS3-2) (SEP 1, 2, 3, 4, 5)
- 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. (HS-LS3-2),(HS-LS3-3) (SEP 1, 3, 4)

LS4.A: Evidence of Common Ancestry and Diversity

- Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. (HS-LS4-1) (SEP 1, 3, 4)

WHST.9-12.2

- Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS1- 1),(HS-LS1-6) (SEP 3, 4, 6)

WHST.9-12.7

- Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. *(HS-LS4-6) (SEP 4, 6, 7, 8)*

WHST.11-12.8

- Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-LS1-3) (SEP 4, 6, 8)

RST.11-12.1

- Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS1-1),(HS-LS1-6) (SEP 4,6)

- **Unit Standards:** *(keep each of the following headings in place)*
  - ***Content Standards***
    - List all content-specific standards that apply to this unit here
  - ***21st Century Life & Career Standards***
    - Use data and statistics from the CDC website and NHI on various genetic disorders that affect the

human population to communicate scientific findings about the disorders over time through the use charts, tables, graphs, and timelines (**9.4.12.CT.3**: Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue) **9.4.12.TL.2:** Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.)

- ***English Companion Standards***
  - List grade-level appropriate companion standards for History, Social Studies, Science and Technical Subjects (CTE/Arts) 9-12. English Companion Standards are required only in these subject/content areas. This section can be deleted for all other content areas.
  - Grade 9-10 Companion Standards: https://www.nj.gov/education/standards/ela/Docs/2016NJSLS-ELA_Companion9-10.pdf
  - Grade 11-12 Companion Standards: https://www.nj.gov/education/standards/ela/Docs/2016NJSLS-ELA_Companion11-12.pdf
- ***Interdisciplinary Content Standards***
  - List any standards from other content areas that apply to this unit.
- ***NJ Statutes:*** NJ State law mandates the inclusion of the following topics in lesson design and instruction as aligned to elementary and secondary curriculum.

Amistad Law: N.J.S.A. 18A 52:16A-88 Every board of education shall incorporate the information regarding the contributions of African-Americans to our country in an appropriate place in the curriculum of elementary and secondary school students.

Holocaust Law: N.J.S.A. 18A:35-28 Every board of education shall include instruction on the Holocaust and genocides in an appropriate place in the curriculum of all elementary and secondary school pupils. The instruction shall further emphasize the personal responsibility that each citizen bears to fight racism and hatred whenever and wherever it happens.

LGBT and Disabilities Law: N.J.S.A. 18A:35-4.35 A board of education shall include instruction on the political, economic, and social contributions of persons with disabilities and lesbian, gay, bisexual, and transgender people, in an appropriate place in the curriculum of middle school and high school students as part of the district's implementation of the New Jersey Student Learning Standards (N.J.S.A.18A:35-4.36) A board of education shall

have policies and procedures in place pertaining to the selection of instructional materials to implement the requirements of N.J.S.A. 18A:35-4.35.

Diversity and Inclusion (N.J.S.A. 18A:35-4.36a) A board of education shall incorporate instruction on diversity and inclusion in an appropriate place in the curriculum of students in grades kindergarten through 12 as part of the district's implementation of the New Jersey Student Learning Standards.

Asian American and Pacific Islanders (AAPI) P.L.2021, c.410 Ensures that the contributions, history, and heritage of Asian Americans and Pacific Islanders (AAPI) are included in the New Jersey Student Learning Standards (NJSLS) for Social Studies in kindergarten through Grade 12 (P.L.2021, c.416)

For additional information, see

NJ Amistad Curriculum: ***https://www.nj.gov/education/amistad/about/***

Diversity and Inclusion: ***https://www.nj.gov/education/standards/dei/index.shtml***

- *(Sample Activities/ Lessons):* ***https://www.nj.gov/education/standards/dei/samples/index.shtml***

Asian American and Pacific Islanders:

- ***Asian American and Pacific Islander Heritage and History in the U.S.***
  A Teacher's Guide from EDSITEment offering a collection of lessons and resources for K-12 social studies, literature and arts classrooms that center around the experiences, achievements and perspectives of Asian Americans and Pacific Islanders across U.S. history.

Transfer Goal:
Students will be able to independently use their learning to predict gene expression and interpret statistical analysis to determine genetic outcomes and make informed decisions regarding personal health, scientific advancements, and ethical considerations.

As aligned with LRHSD Long Term Learning Goal(s):https://www.lrhsd.org/Page/6163

- design, critique, and carry out experiments in order to investigate scientific questions and/or propose solutions
- collect, interpret, and analyze data in order to solve a defined problem
- apply mathematics to express relationships efficiently and accurately
- draw evidence-based conclusions from data in order to make informed decisions;
- construct, interpret, and refine models (scientific and mathematical) to explain the physical and natural world

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- effectively communicate scientific ideas and evidence-based arguments to an appropriate audience through written and oral means
- evaluate for their validity arguments that rely on scientific reasoning presented in the popular press and informational sources

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<u>*Enduring Understandings*</u>
Students will understand that. . .

EU 1
DNA structure and function play a central role in genetic expression.

EU 2
Genetic traits can be regulated and inherited through various mechanisms.

EU 3
Genetic knowledge opens doors to understanding diverse biological phenomena and applications.

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<u>*Essential Questions*</u>

- How does DNA structure and the central dogma of molecular biology influence gene expression and protein synthesis?
- What factors influence gene expression and inheritance patterns, and how can they be mathematically quantified?

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<u>*Knowledge*</u>
Students will know . . .

EU1

- the structure of DNA, RNA and proteins. (LS1.A) (SEP 1, 2, 3, 4)
- the processes of DNA replication and protein synthesis. (LS1.A) (SEP 1, 2, 3, 4)
- how feedback mechanisms drive operons in prokaryotic gene expression. (LS1.A) (SEP 1, 2, 3, 4)
- the function of the promoter region in eukaryotic gene expression. (LS1.A) (SEP 1, 2, 3, 4)
- that cell differentiation selects which genes are expressed. (LS1.A) (SEP 1, 2, 3, 4)

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<u>*Skills*</u>
Students will be able to. . .

EU1

- build a model of DNA. (LS1.A) (SEP 1, 2, 3, 4)
- illustrate the processes of DNA replication and protein synthesis. (LS1.A) (SEP 1, 2, 3, 4)
- model gene expression in prokaryotic and eukaryotic cells. (LS1.A) (SEP 1, 2, 3, 4)
- predict which genes are turned on in various cell types. (LS1.A, LS3.A) (SEP 1, 2, 3, 4)

EU2

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EU2 ● how to use mathematical equations to predict inheritance outcomes. (LS3.A) (SEP 1, 2, 3, 4) ● that single gene inheritance rarely follows a dominant/recessive model. (LS3.A, LS3.B) (SEP 1, 2, 3, 4, 5) *EU3* ● neo-Mendelian gene inheritance can be expressed as codominance, incomplete dominance or sex-linked (LS3.B) (SEP 1, 2, 3, 4, 5) ● that multiple genes can interact to produce a single phenotype such as polygenic inheritance and epistasis (LS3.B) (SEP 1, 2, 3, 4, 5) ● that genetic mutations can happen in a variety of ways such as spontaneously and exposure to mutagens (LS3.B) (SEP 1, 2, 3, 4, 5)	● use Punnett square analysis and/or simple algebra to predict the outcome of various case scenarios. (LS3.A) (SEP 1, 2, 3, 4) ● algebraically solve multifactorial probability using binomial expansion and chi square analysis. (LS3.A) (SEP 1, 2, 3, 4) *EU3* ● predict the outcome of Neo-Mendelian traits (codominance, incomplete dominance, sex-linkage, polygenic inheritance, epistasis). (LS3.B) (SEP 1, 2, 3, 4, 5) ● calculate the impact of lethal alleles on offspring probability. (LS3.B) (SEP 1, 2, 3, 4, 5) ● predict the origin of novel phenotypes. (LS3.B) (SEP 1, 2, 3, 4, 5)
Stage Two - Assessment	
●	
Stage Three - Instruction	

Learning Plan: **Suggested Learning Activities to Include Differentiated Instruction and Interdisciplinary Connections: Each learning activity listed must be accompanied by a learning goal of A= Acquiring basic knowledge and skills, M= Making meaning and/or a T= Transfer.** *{place A, M and/or T along with the applicable EU number in parentheses after each statement} All knowledge and skills must be addressed in this section with a corresponding lesson/activity which teaches each concept. The following color codes are used to notate activities that correspond with interdisciplinary connections and 21st Century Life & Career Connections (which involves Technology Literacy): Red = Interdisciplinary Connection; Purple = 21st Century Life & Career Connection*

PHENOMENON: Genetic differences control pea shape.
Link: https://www.minipcr.com/product/dye-electrophoresis-mendels-peas/?mc_cid=940c840717&mc_eid=353218e8ff

GOAL: Students will use gel electrophoresis to examine how genetic differences control pea shape, and connect Mendel's famous experiments with our modern understanding of DNA, inheritance, and probability of gene frequency. (EU1, EU2, EU3)

Learning Plan: Gel Electrophoresis and Understanding Genetic Differences in Pea Shape

1. Activity 1: Introduction to Mendel's Experiments and Inheritance Patterns: A, M (EU1, EU2)
    a. Provide an overview of Gregor Mendel's experiments on pea plants and his discoveries regarding inheritance patterns.
    b. Discuss the concepts of dominant and recessive traits, genotype and phenotype, and Punnett squares.
    c. Engage students in a class discussion or small group activity to analyze and interpret Mendel's experimental results.

2. Activity 2: DNA and Genetic Differences: A, M (EU1, EU2)
    a. Introduce the concept of DNA and its role in genetic inheritance.
    b. Explain the structure of DNA and its relationship to genes and alleles.
    c. Discuss the connection between genetic differences (variations in DNA sequences) and observable traits.
    d. Use interactive visuals or models to illustrate the relationship between DNA and genetic differences. (see Supporting Instructional Framework for examples of labs)
3. Activity 3: Gel Electrophoresis Basics: A (EU2)
    a. Explain the principles of gel electrophoresis and its use in separating DNA fragments based on size.
    b. Demonstrate the setup and procedure of gel electrophoresis using a mock DNA sample. (see Supporting Instructional Framework for examples of labs)
    c. Guide students in analyzing the results of gel electrophoresis to determine DNA fragment sizes. (see Supporting Instructional Framework for examples of labs)

4. Activity 4: Investigating Genetic Differences in Pea Shape: A, M, T (EU1, EU2, EU3)

a. Provide pea plant samples with known genetic differences in pea shape (e.g., wrinkled vs. round).
b. In small groups, students extract DNA from the pea plant samples using a DNA extraction kit or protocol. (see Supporting Instructional Framework for examples of labs)
c. Guide students in preparing DNA samples and running gel electrophoresis to compare the DNA fragment sizes associated with different pea shapes. (see Supporting Instructional Framework for examples of labs)
d. Analyze the gel electrophoresis results and connect the observed DNA fragment patterns with the genetic differences in pea shape.(see Supporting Instructional Framework for examples of labs)

5. Activity 5: Connecting Mendel's Experiments to Modern Understanding: A, M, T (EU1, EU2, EU3)
    a. Engage students in a class discussion on the connection between Mendel's experiments and the gel electrophoresis results.
    b. Connect Mendel's observation of traits to our modern understanding of DNA, inheritance, and gene frequency.
    c. Discuss how the probability of gene frequency relates to the occurrence of different traits in a population.
    d. Guide students in reflecting on the significance of Mendel's work in laying the foundation for our understanding of genetics and its practical applications.

Interdisciplinary Connections:
Language Arts: Have students write a reflective essay or create a presentation summarizing the connections between Mendel's experiments and modern genetic understanding. (EU1, EU2, EU3)
Mathematics: Integrate probability calculations into the discussion of gene frequency and inheritance patterns.(EU1, EU3)
Technology Literacy: Use online simulations or virtual labs to supplement the gel electrophoresis activity and reinforce the concepts learned.(EU1, EU2, EU3)

Supporting Instructional Framework:

- Presentation review of the laws of probability and their calculation as it relates to genotypic and phenotypic ratios - A (EU3)
- Probability/Statistics/Chi Square Problems – A, M, T (EU3)
- Chi Square Lab/ Probability Labs (m&m lab or equivalent) – A, M, T (EU3)

- Presentation review of the process of protein synthesis leading to gene and trait expression - A (EU1, EU2, EU3)
- Intro to Gene regulation/Gene Expression [modeling kits] – A, M (EU1, EU2, EU3)
- Central Dogma/Gene Expression Lab - A, M, T (EU1, EU2, EU3)

- Presentation review of Mendelian genetics and Punnett squares - A (EU1, EU2, EU3)
- Carolina Biological - Mendelian Genetics of Corn Lab – A, M, T (EU1, EU2, EU3)
- Carolina Biological - Nature's Dice: A Genetics Screening Simulation (Sex linked traits) – A, M, T (EU1, EU2, EU3)

- Fly Lab and/or Brassica Rapa Fast Plants Lab (through 2 generations to demonstrate Mendelian Genetics and x2) *There are many varieties of Fast Plant Labs on Carolina Biological that you can select from – A, M, T (EU1, EU2, EU3)
- Plant Genetics Lab - A, M, T (EU1, EU2, EU3)
- Mendel's Peas Lab - A, M, T (EU1, EU2, EU3)
- Punnett Squares – A, M, T (EU3)
- Forked Line Method problems – A, M (EU3)
- Presentation of neo-Mendelian genetic inheritance - A (EU1, EU2, EU3)
- Neo-Mendelian Genetic problems – A, M (EU1, EU2, EU3)
- Binomial Expansion problems – A, M (EU3)
- Epistasis problems – A, M (EU1, EU2, EU3)
- Dog Genetics Lab - A, M, T (EU1, EU2, EU3)
- Edvotek #118 – Hypercholesterolemia Lab– A, M, T (EU1, EU2, EU3)
- Carolina Biological - Alcohol Tolerance in Fruit Fly– A, M, T (EU1, EU2, EU3)
- Edvotek #S-49 – In Search of my Father – A, M, T (EU1, EU2, EU3)
- Edvotek #S-51 – Whose DNA was left behind? – A, M, T (EU1, EU2, EU3)
- Romanovs (dnai.org activities) – A, M (EU1, EU3)
- Genetic Origins (dnai.org activities) – A, M (EU1, EU3)
- mtDNA lab and/or ALU lab and/or DS180 lab– A, M, T (EU1, EU2, EU3)
- Carolina Biological – Using SNP to predict bitter tasting ability (PTC) or Edvotek #345 – Exploring the Genetics of Taste– A, M, T LRHSD (2011) Adapted from ASCD © 2004 (EU1, EU2, EU3)
- SNP to predict bitter taste video link - A (EU1, EU2, EU3)
- NOVA video – Ghost in your Genes - A (EU3)
- Mutter Museum Field Trip (February/March timeframe) – docent led workshop and tour– A, M, T (EU1, EU3)
- Philadelphia Zoo Behind the Scenes Breeding/Genetics Tour– A, M, T (EU1, EU2, EU3)
- Dr. Mutter's Marvels by Christin O'Keefe Aptowicz – A, M (EU1, EU2, EU3)
- The Sports Gene Inside the Science of Extraordinary Athletic Performance by David Epstein– A, M (EU1, EU2, EU3)
- Race for the Double Helix Video – A (EU1, EU2, EU3)

- Review of chromosomal vs gene mutation types - A (EU1, EU2, EU3)
- Chromosome Mapping and Gene/Genetic Disorder project – A, M (EU1, EU2, EU3)
- Carolina Disorder Detectives - A, M, T (EU1, EU2, EU3)
- Carolina Genes and ConSEQUENCES - A, M, T (EU1, EU2, EU3)

Pacing Guide

{This chart will be identical in all of the units for this course.}

Unit #	***Title of Unit***	***Approximate # of teaching days***
1	*Fundamental Concepts, Bioethics, and Applications for the Modern Geneticist*	33
2	*Cellular Basis of Cancer*	34
3	*Gene Expression, Inheritance and Statistical Analysis*	34
4	*Applying Modern Technology, Lab Skills, and Bioinformatics to Investigate Current Genetic Issues*	34

Instructional Materials

- *Micropipettes and tips (various sizes)*
- *Gel electrophoresis machine(s) and consumables*
- *PCR/thermal cyclers and PCR tubes*
- *Microwave*
- *Melt & pour agarose*
- *Buffer(s)*
- *e-Gels*
- *Graduated cylinders*
- *Various lab kits/perishables (*see learning plan for specific kit numbers/vendors)*
- *Large Post-It Note Presentation boards*
- *Genome book by Matthew Ridley*

Accommodations

Special Education: The curriculum will be modified as per the Individualized Education Plan (IEP). Students will be accommodated based on specific accommodations listed in the IEP.
Students with 504 Plans: Students will be accommodated based on specific accommodations listed in the 504 Plan.
English Language Learners: Students will be accommodated based on individual need and in consultation with the ELL teacher.
Students at Risk of School Failure: Students will be accommodated based on individual need and provided various structural supports through their school.
Gifted and Talented Students: Students will be challenged to enhance their knowledge and skills through acceleration and additional independent research on the subject matter.