

Course: *Genetics*

Unit #1: *Fundamental Concepts, Bioethics, and Applications for the Modern Geneticist*

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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

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, 2, 3, 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)

- 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, 5)

LS4.C: Adaptation

- Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2) (SEP 1, 4)
- Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically , behaviorally , and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS-LS4-3),(HS-LS4-4) (SEP 1, 4)
- Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3) (SEP 1, 4)
- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. (HS-LS4-5),(HS-LS4-6) (SEP 1, 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 1, 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)

- **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 school databases such as but not limited to Ferguson's Career Cruising Database to research a career in the medical profession and create a visual presentation that provides an overall understanding of what the career entails, educational pathway to achieve the certification, personality traits one must have, employment outlook, salary. Create a resume and a business card. Present student presentations during a Classroom Career Day (**9.4.12.CI.1:** Demonstrate the ability to reflect, analyze, and use creative skills and ideas, **9.4.12.CI.2:** Identify career pathways that highlight personal talents, skills, and abilities, **9.4.12.CI.3:** Investigate new challenges and opportunities for personal growth, advancement, and transition)

- **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 intelligently and ethically analyze and communicate current scientific data collected using various tools and technologies of a modern day geneticist.

As aligned with LRHSD Long Term Learning Goal(s): <https://www.lrhdsd.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
- 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

Enduring Understandings

Students will understand that. . .

EU 1

The development and evolution of the DNA model rely on a combination of experimental evidence and mathematical analysis.

EU 2

Proficiency in specific tools and techniques is crucial for effective practice in genetics.

EU 3

Advances in genetic understanding have created new professional opportunities and careers, while highlighting the importance of communication skills for ethical decision-making.

Essential Questions

- How have diverse perspectives, stakeholders, historical events and scientific discoveries shaped our current understanding of genetics and its applications in order to make ethical decisions in this field of science?
- How have the evolution of tools and techniques of a geneticist led to the advancements in the field of genetics, forensics and molecular biology?

Knowledge

Students will know . . .

EU1

- scientists that have contributed to current genetic understanding such as Mendel, Crick, Watson, Franklin, Griffith, Mullis, etc. (LS3.B)
- Conservation of genes throughout organisms allows for cross-species studies of DNA and human systems. (LS4.C, WHST.9-12.2, WHST.9-12.7, WHST.11-12.8, RST.11-12.1)

EU2

- studies that have contributed to current genetic understanding such as Chargaff ratios, X-ray diffraction, gene linkage, DNA sequencing, PCR, etc. (LS1.B)
- the different types of tools and equipment used within a molecular biology lab such as micropipettes, electrophoresis boxes, microarrays, thermal cyclers, centrifuge, vortex, etc. (PS1.A)

EU3

- the expansive career opportunities within the field of genetics such as cancer research, biomedical engineer, bioinformatics specialist, genetic counselor, genetic teacher, etc. (WHST.9-12.7)
- that scientific data supports different, sometimes opposing, conclusions but should always be evaluated in an ethical manner. (RST.11-12.1, WHST.11-12.8)

Skills

Students will be able to . . .

EU1

- evaluate contributions of scientists that have played a role and/or led up to the discovery of DNA, inheritance, human disease, biotechnology, and beyond. (LS3.B)
- evaluate various model organisms, characteristics of model organisms that make them a viable resource to study human disorders and human systems (LS4-B)
- research past and current discoveries related to specific model organisms, and contributions and applications to science in regards to human disorders and diseases. (LS4-B)

EU2

- perform experimental protocols utilizing appropriate equipment (micropipettes, gel electrophoresis, thermal cycler, centrifuge, vortex, UV transilluminator) for a variety of experiments. (LS1.B, PS1.A)

EU3

- research the criteria necessary to succeed in a specific career in the field of genetics. (SEP 8) (RST.11-12.1, WHST.11-12.8)
- differentiate between debate and Socratic seminar and be able to respectfully discuss controversial topics related to genetic ethics. (SEP 7) (RST.11-12.1, WHST.11-12.8)
- participate and appropriately exchange sometimes opposing viewpoints. (SEP 6, SEP 8) (RST.11-12.1, WHST.11-12.8)
- identify and appreciate opposing viewpoints. (SEP 8, SEP 9) (RST.11-12.1, WHST.11-12.8)
- support various viewpoints with factual information and/or data and statistics. (SEP 6, SEP 8) (RST.11-12.1, WHST.11-12.8)

- identify scientifically accurate information gathered through the scientific method, in contrast to inaccurate information presented through various media outlets. (SEP 3) (RST.11-12.1, WHST.11-12.8)

Stage Two - Assessment

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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: How DNA and Genealogy is being used to solve crimes?

Link: [Electrophoresis Forensics Lab: Wrongfully Convicted](#)

GOAL: Students will explore how new tools, technologies, history, and bioethics have advanced the field of genetics.

1. Activity 1:**How DNA helps solve crimes** - Show video link: <https://www.youtube.com/watch?v=nO6Fu5zSxko>(**EU1, EU2, EU3**)
 - a. Paired discussion about observations from video (A/M)
 - b. Use QFT (Question Formulation Technique) to generate a class discussion to determine driving questions for the lesson based upon observations from the video (A/M) - for more detailed information on the QFT technique please click this link: <http://rightquestion.org/what-is-the-qft/>

- c. Research other various case studies and present other examples to the class (T)
2. Activity 2: Identify students' knowledge on different resources used to solve crimes (EU2, EU3)
 - a. Students will create KWL charts about resources (A/M)
3. Activity 3: Teacher-led discussion on resources utilized to solve crimes ("tools of a geneticist/forensic scientist") (A/M) (EU2, EU3)
4. Activity 4: Introductory Labs to introduce equipment (EU2, EU3)
 - a. Micropipetting Lab(s) (see Supporting Instructional Framework for examples of labs) (A/M/T)
 - b. Gel Electrophoresis Lab(s) (see Supporting Instructional Framework for examples of labs) (A/M/T)
 - c. PCR Lab(s) (can be done in Unit 4, rather than introducing in Unit 1) (see Supporting Instructional Framework for examples of labs) (A/M/T)
 - d. Connection/Relate back to phenomenon on how these tools can be used to solve crimes (T)
5. Activity 5: Teacher-led discussion on Model Organisms and how they are used as model systems for research (EU1, EU2, EU3)
 - a. Model Organism Research Project (A)
 - b. Model Organism Introductory Lab (see Supporting Instructional Framework for examples of labs) (A/M/T)
 - c. Connection/Relate back to phenomenon on how these living tools can be used to solve crimes and/or study DNA/Genetics (T)
6. Culminating Activity: Synthesis and Reflection (M/T) (EU1, EU2, EU3)
 - a. Assign an individual or group project where students synthesize their learning from the previous activities.
 - b. Incorporate reflective prompts to encourage students to analyze their own perspectives and insights gained throughout the learning process.

Interdisciplinary Connections:

Language Arts: Research and present a case study on a high-profile crime solved using DNA and genealogy. (EU2, EU3)

Write a persuasive essay or argumentative speech discussing the ethical considerations of using DNA and genealogy in criminal investigations. (EU2, EU3)

Social Studies: Explore the historical context of DNA and genealogy in solving crimes, including landmark cases that established the admissibility of DNA evidence. Investigate the impact of DNA and genealogy on wrongful convictions and the criminal justice system. Engage in discussions or debates on the ethical considerations of using genetic information in criminal investigations. Examine the balance between individual privacy rights and public safety concerns in the context of DNA and genealogy. (EU1, EU2, EU3)

Mathematics: Analyze and interpret data collected during the gel electrophoresis lab to determine the genetic profiles of individuals.

Calculate the probability of a match in a DNA database search based on allele frequencies. (EU2, EU3)

Technology Literacy: Research and analyze the advancements in DNA sequencing technologies and their impact on forensic investigations. Utilize online databases and software tools for DNA profiling and genealogical research. (EU1, EU2, EU3)

Supporting Instructional Framework:

- Presentation of skills and appropriate technique of basic laboratory skills needed for Genetics – A (EU2)
- [HHMI Small and Large Volumes Lab](#) (micropipetting basics) – M, T (EU2)
- [Micropipet Art Lab to review basic skills](#) - A, M, T (EU2)
- [Gel electrophoresis Introductory Lab](#) (link provides example) (prep gel and buffer, pour gel, load samples, and analyze results) – M, T (EU2)
- [Make your own Gel Electrophoresis Machine](#) - A, M, T (EU2)
- [Using gel electrophoresis to analyze data](#) - A, M, T (EU2, EU3)
- [Edvotek #372 - Quick PCR Lab](#) or equivalent introductory PCR lab – M, T (EU2, EU3)
- [Using PCR to study Covid](#) - A, M, T (EU2, EU3)
- [Using Gel Electrophoresis to study pandemics \(pair with Covid lab\)](#) - A, M, T (EU2, EU3)
- [Using PCR and gel electrophoresis to study genotypes lab](#) (this can also be done in Unit 3)- A, M, T (EU1, EU2, EU3)
- [miniPCR Genes in Space Contest](#) - A, M, T (EU1, EU2, EU3)
- [Food Safety Lab: Mars Colony at Risk](#) (pair with Genes in Space Contest as an example problem) - A, M, T (EU1, EU2, EU3)
- Presentation of past and present model organisms and their role in genetics - A (EU2, EU3)
- [Edvotek #851 - Effects of Alcohol on C.elegans](#) (model organism or equivalent model organism lab) A, M, T (EU1, EU2, EU3)
- [Model Organism Research Project](#) (Link provides example) – A, M, T (EU2, EU3)
 - Why the organism is an ideal model
 - Genetic information known about the organism
 - Past/Current research with this organism
 - Contributions to science
 - Application to human disorders/disease
- Discussion of the importance of early and present scientists in the field of genetics - A (EU3)
- [Famous Geneticists/Scientists Timeline](#) - A, M, T (EU3)
 - select famous scientist from [dnai.org](#) timeline website
 - create presentation on their life & scientific discoveries & accomplishments
 - or complete a famous scientist scavenger hunt using this site
https://docs.google.com/document/d/1CLY_YLDK8UQYMTiRdu7K0X5bqtEwxluoK3mc8MiaTJ8/edit#heading=h.gjdgxs
- Explore various careers in genetics – A, M, T (EU3)
 - Create presentation that includes

- Description of career
 - Daily activities
 - Average salary
 - Type of personality you may need for your career
 - Classes you should take in high school/activities outside of school you may want to participate in
 - 2 undergraduate colleges you can attend to achieve your career & does your career require you to go further than just getting your undergraduate degree?
 - Helpful websites for anyone who may be interested in your career
 - Resumé of someone in an entry level position within this field
 - Business card matching the resumé
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- Instruction on writing Socratic seminar-type questions for bioethical topics - A **(EU3)**
 - Student-lead Socratic seminar using the text *Genome* by Matthew Ridley – A, M, T **(EU1, EU2, EU3)**
 - Case Studies/Law [study of bioethical issues such as cloning, stem cell research, reproductive technologies, genetic privacy and discrimination] – 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	<i>Fundamental Concepts, Bioethics, and Applications for the Modern Geneticist</i>	33
2	<i>Cellular Basis of Cancer</i>	34
3	<i>Gene Expression, Inheritance and Statistical Analysis</i>	34
4	<i>Applying Modern Technology, Lab Skills, and Bioinformatics to Investigate Current Genetic Issues</i>	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.