Course: *Genetics* **Unit #4:** *Applying Modern Technology, Lab Skills, and Bioinformatics to Investigate Current Genetic Issues*	**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, 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, 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, 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)

LS4.B: Natural Selection

- Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. (HS-LS4-2),(HS-LS4-3) (SEP 1, 4)
- The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS-LS4-3) (SEP 1, 4)

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 env ironment's limited supply of the resources that individuals need in order to surv iv e 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, 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***
    - Explore research in current technologies in stem cells including cutting edge technology/regenerative medicine (**9.4.12.TL.2:** Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data. **9.4.12.CI.1:** Demonstrate the ability to reflect, analyze, and use creative skills and ideas). Use BLAST bioinformatics data to diagnose a genetic disorder
    - Research and debate pros and cons for genetically modified foods and or organisms within our food production system for the United States of America (**9.4.12.CT.1**: Identify problem-solving strategies used in the development of an innovative product or practice, **9.4.12.CT.2**
  - ***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 develop the skills to independently analyze genetic databases, apply gene manipulation techniques, and acquire biotechnology skills, enabling them to critically evaluate genetic information, contribute to scientific research, and make informed decisions regarding personal, societal, and ethical implications of biotechnology.

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
- 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*	*Essential Questions*

Bacteria serve as a versatile and widely used model organism in biotechnology research. *EU 2* Genetic modification has become a prevalent practice in various industries, including agriculture, due to its benefits and applications. *EU 3* Biotechnology is a dynamic field that continuously evolves with new techniques, technologies, and experimental protocols.	• What are the societal implications of genetically modified organisms (GMOs), and how can biotechnology strategies be employed to identify GMO products while addressing controversies? • How does the expanding knowledge of genetics create opportunities for new careers, and in what ways does it underscore the importance of effective communication skills in ethical decision-making? • How does biotechnology research utilize bacteria as a preferred host, and what techniques are involved in handling and culturing bacteria in a laboratory?
<u>Knowledge</u> *Students will know . . .* *EU1* • the proper technique for handling and culturing bacteria. (LS1.A) (SEP 1, 2, 3, 4) • restriction enzymes recognize specific short sequences of DNA. (LS1.A) (SEP 1, 2, 3, 4) • exogenous genes can be inserted using restriction enzymes. (LS1.A) (SEP 1, 2, 3, 4) *EU2* • the varying viewpoints in regards to GMOs. (LS4.B) (LS1.A) (SEP 1, 2, 3, 4) • the wide variety of ways that GMOs impact our society, including but not limited to: medicine, pharmacology, textiles, agriculture, and research. (LS1.A) (SEP 1, 2, 3, 4) • the ways to scientifically identify whether or not an organism has been genetically modified. (LS1.A) (SEP 1, 2, 3, 4)	*<u>Skills</u>* *Students will be able to. . .* *EU1* • use sterile techniques to successfully culture, work with and dispose of bacteria. (LS1.A) (SEP 1, 2, 3, 4) • model the use of restriction enzymes to cut DNA. (LS1.A) (SEP 1, 2, 3, 4) • perform a lab that utilizes restriction enzymes to cut DNA. (LS1.A) (SEP 1, 2, 3, 4) *EU2* • perform a lab to identify inserted genes. (LS4.B) (LS1.A) (SEP 1, 2, 3, 4) • interpret the vast amount of data available through these resources. (LS4.B) (LS1.A) (SEP 1, 2, 3, 4) • authentically research and apply this information to laboratory exercises. (LS4.B) (LS1.A) (SEP 1, 2, 3, 4) • input short sequences of DNA from unknown origin into various databases in order to identify sequence(s). (LS4.B) (LS1.A) (SEP 1, 2, 3, 4)

EU3 ● the various databases such as, but not limited to: BLAST, OMIM, NCBI. (LS4.B) (LS1.A) (SEP 1, 2, 3, 4) ● the emerging understanding within the biotechnology field requires the development of new research tools and techniques, including CRISPR, microarray, BLAST, etc. (LS4.B) (LS1.A) (SEP 1, 2, 3, 4)	● input short sequences of DNA from known origins into various databases for comparison to other groups and/or species. (LS4.B) (LS1.A) (SEP 1, 2, 3, 4) ● perform lab activities using this new technology. (LS4.B) (LS1.A) (SEP 1, 2, 3, 4) *EU3* ● formulate a hypothetical problem that can be solved using new and emerging technologies. (LS4.B) (LS1.A) (SEP 1, 2, 3, 4) ● discern different viewpoints from authentic resources (LS4.B) (LS1.A) (SEP 1, 2, 3, 4) ● form an evidence based opinion. (LS4.B) (LS1.A) (SEP 1, 2, 3, 4)
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: Ectolife: The World's First Artificial Womb Facility
Link: https://www.youtube.com/watch?v=O2RIvJ1U7RE

GOAL: Students will understand how groundbreaking scientific research conducted by scientists internationally have impacted the field of genetics and could impact the future of humankind and beyond.

1. Activity 1: Introduction to Groundbreaking Scientific Research (A) **(EU1, EU2, EU3)**
    a. Provide an overview of major scientific breakthroughs in genetics and their impact on the field.
    b. Engage students in a class discussion about the significance of these breakthroughs.
    c. Assign readings or multimedia resources for students to explore specific groundbreaking studies.

2. Activity 2: Exploring the Impact of Scientific Research (M, T) **(EU1, EU2, EU3)**
    a. Divide students into small groups and assign each group a specific groundbreaking study to investigate.
    b. In their groups, students analyze the study's methodology, results, and implications.
    c. Each group presents their findings to the class, highlighting the impact of the research on the field of genetics.
    d. Facilitate a class discussion to identify common themes and connections between the studies.

3. Activity 3: Ethical Considerations and Implications (M, T) **(EU2, EU3)**
    a. Introduce ethical considerations related to groundbreaking research in genetics.
    b. Engage students in a debate or discussion, allowing them to explore the potential benefits and risks associated with these advancements.
    c. Assign case studies or scenarios where students must make ethical decisions based on the research's implications.
    d. Encourage students to critically analyze the consequences of these decisions on individuals and society.

4. Activity 4: Interdisciplinary Connections and 21st Century Life & Career Connections (M, T) **(EU1, EU2, EU3)**
    a. Incorporate technology by having students research and create multimedia presentations on interdisciplinary connections related to genetics.

b. Assign projects that explore how genetics intersects with fields such as medicine, agriculture, environmental science, and bioengineering.
c. Have students present their projects to the class, highlighting the relevance of genetics in various disciplines.

5. Activity 5: Future Implications and Beyond (M, T) **(EU3)**
    a. Introduce emerging trends and future possibilities in genetics research, such as gene editing, personalized medicine, and synthetic biology.
    b. Assign students to research and present on a specific trend, focusing on its potential impact on humankind and beyond.
    c. Encourage critical thinking by facilitating a class discussion on the ethical, social, and scientific considerations of these future implications.

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. Students create a multimedia presentation, research paper, or exhibition showcasing the impact of groundbreaking scientific research on the field of genetics and its future implications.
    c. Incorporate reflective prompts to encourage students to analyze their own perspectives and insights gained throughout the learning process.

Interdisciplinary Connections:
Language Arts: Analyze and discuss scientific research articles, focusing on effective communication of complex genetic concepts. **(EU1, EU2, EU3)**
Write persuasive essays or argumentative speeches addressing the ethical considerations and implications of groundbreaking genetic research. **(EU1, EU2, EU3)**
Social Studies: Explore the historical context of major scientific breakthroughs in genetics, considering the societal impact and cultural perspectives of the time. Investigate the global implications of genetic research, including its influence on policies, regulations, and international collaborations. Engage in debates or discussions on the ethical considerations and implications of genetic research, such as privacy, consent, and genetic engineering. Examine ethical frameworks and principles that guide decision-making in genetics, including discussions on distributive justice and genetic equity. **(EU1, EU2, EU3)**
Mathematics: Use statistical analysis to evaluate the significance and validity of research findings presented in scientific papers. Explore mathematical modeling and simulations used in genetics research, such as population genetics and inheritance patterns. **(EU2, EU3)**

Supporting Instructional Framework:
- Instruction of bacteria/yeast plating techniques and dilutions - A **(EU1)**
- Presentation of restriction enzymes, their origin and use in genetics - A **(EU1)**

- Microbiology Techniques, Introductory Lab, such as Edvotek Agar Art: Creating Masterpieces with Microbes Lab Kit or equivalent introductory lab (i.e. culturing, swabbing, and aseptic techniques) – A, M **(EU1)**
- Study in Antibiotic Resistance (labs/activities - link provides one example) - A, M, T **(EU1, EU2, EU3)**
- Soil Microbes Lab, Studying Antibiotic Resistance - A, M, T **(EU1, EU2, EU3)**
- Serial Dilution Lab that demonstrates how to create dilution(s) and use proper plating techniques – A, M, T **(EU1)**
- pGLO (or any equivalent transformation lab) – A, M, T **(EU1, EU3)**
- Carolina – Advanced Conjugation Lab – A, M, T **(EU1, EU3)**
- Carolina Biological - GMO Lab or Edvotek #962 – Identification of Genetically Modified Foods using PCR– A, M, T **(EU1, EU2, EU3)**
- BLAST search Lab (Bioinformatics) - (NCBI/OMIM resources)/Computer exercises that demonstrate comparative bioinformatics showing interspecies homology – A, M, T **(EU3)**
- DNA Fingerprinting (lab and/or worksheets) link provides example, many versions available – A, M, T **(EU1, EU2, EU3)**
- Edvotek #957 - DNA Damage and Repair Lab – A, M, T **(EU1, EU2, EU3)**
- Edvotek #271 – AIDS Kit 1: Simulation of HIV Detection by ELISA test – A, M, T **(EU3)**
- Wards Science – DNA Detectives (Restriction Enzymes and/or equivalent lab) – A, M, T **(EU1, EU2, EU3)**
- Recombinant Paper Plasmids Lab – Recombinant DNA and Biotechnology by Helen Kreuzer and Adrianne Massey (book, link provides information for resource) – A, M **(EU1, EU2, EU3)**
- Restriction Analysis Challenge - Recombinant DNA and Biotechnology by Helen Kreuzer and Adrianne Massey (book, link provides information for resource) – A, M, T **(EU1, EU2, EU3)**
- Restriction Enzyme Site Mapping Activity – M, T **(EU1, EU2, EU3)**
- DNA Fingerprinting Lab - A, M, T **(EU1, EU2, EU3)**

- Presentation of CRISPR technology, origin and use in genetics - A **(EU1, EU2, EU3)**
- CRISPR research project – A, M, T **(EU1, EU2, EU3)**
- Gene Editing Lab, using CRISPR - A, M, T **(EU1, EU2, EU3)**
- CRISPR Lab - A, M, T **(EU1, EU2, EU3)**
- Edvotek #135 - Using CRISPR to Treat Cystic Fibrosis - A, M, T **(EU1, EU2, EU3)**

- Discussion review of Single Nucleotide Polymorphisms and their role in DNA fingerprinting and genealogy - A **(EU3)**
- Edvotek #123 - Nucleic Acid Testing for COVID-19 - A, M, T **(EU1, EU3)**
- Edvotek #315 – In Search of the Sickle Cell Gene (Southern Blot) Lab – A, M, T **(EU1, EU2, EU3)**
- Carolina - PTC Taster: Using SNP to Predict Bitter Tasting Ability - A, M, T **(EU1, EU2, EU3)**
- Carolina - Mitochondrial DNA Polymorphisms in Human Evolution - A, M, T **(EU1, EU2, EU3)**
- Edvotek #332 Mitochondrial DNA Analysis Using PCR - A, M, T **(EU1, EU2, EU3)**
- Analysis of D1S80 VNTR Lab - A, M, T **(EU1, EU2, EU3)**
- The origin of humankind - Haplogroup activity - A, M, T **(EU2, EU3)**

- Review of various genetic modification techniques and present uses - A **(EU2, EU3)**
- GMO crops/organisms (articles/research/class discussions) – A, M, T **(EU2, EU3)**
- Research Paper/Journal articles – A, M, T **(EU1, EU2, EU3)**
- Video - The Island (class discussion) – A, M **(EU2, EU3)**
- Video – GATTACA (class discussion) – A, M **(EU2, EU3)**
- Video – Store Wars – A, M **(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)*
- *Petri dishes*

- *Sterile swabs/inoculating loops*
- *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.