

Pascack Valley Regional High School District

**Pascack Hills High School, Montvale, New Jersey
Pascack Valley High School, Hillsdale, New Jersey**

Course Name: Research in Molecular Genetics I

Born On: August, 2026
Board Approval: 8/24/26

New Jersey Curricular Mandates for Science Instruction

Disabled & LGBT:

18A:35-4.35 - History of disabled and LGBT persons included in middle and high school curriculum. 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.

Diversity, Equity, and Inclusion (DEI):

C.18A:35-4.36a - Curriculum to include instruction on diversity and inclusion. 1. a. Beginning in the 2021-2022 school year, each school district 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. b. The instruction shall: (1) highlight and promote diversity, including economic diversity, equity, inclusion, tolerance, and belonging in connection with gender and sexual orientation, race and ethnicity, disabilities, and religious tolerance; (2) examine the impact that unconscious bias and economic disparities have at both an individual level and on society as a whole; and (3) encourage safe, welcoming, and inclusive environments for all students regardless of race or ethnicity, sexual and gender identities, mental and physical disabilities, and religious beliefs. c. The Commissioner of Education shall provide school districts with sample learning activities and resources designed to promote diversity and inclusion.

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.

Climate Change:

2026 NJSLS-Science: Earth's climate is now changing faster than at any point in the history of modern civilization, primarily as a result of human activities. Global climate change has already resulted in a wide range of impacts across New Jersey and in many sectors of its economy. The addition of academic standards that focus on climate change is important so that all students will have a basic understanding of the climate system, including the natural and human-caused factors that affect it. The underpinnings of climate change span across physical, life, as well as Earth and space sciences. The goal is for students to understand climate science as a way to inform decisions that improve quality of life for themselves, their community, and globally and to know how engineering solutions can allow us to mitigate impacts, adapt practices, and build resilient systems.

Dissection Law

N.J.S.A. 18A:35-4.25 and N.J.S.A. 18A:35-4.24 authorizes parents or guardians to assert the right of their children to refuse to dissect, vivisect, incubate, capture or otherwise harm or destroy animals or any parts thereof as part of a course of instruction.

Honors Research in Molecular Genetics		
Unit Title	Approx # of weeks	Months
Waksman Molecular Biology	Approx. 10 Weeks	September - November
Bioinformatics	Approx. 10 weeks	November - January
Exploring Science Research & Developing a Research Proposal	Approx. 16 weeks	February - June

Honors Research in Molecular Genetics I		
Unit 1: Waksman Molecular Biology Unit		
Related Phenomena: Plants that survive in extreme environments like deserts, swamps, or contaminated water, Conserved genes and new variants of genes (like in Covid-19), Making crops more resistant to climate change or other related phenomena can be used to generate student interest and relevance to their world.		
Pacing: <i>Approximately 10 weeks</i>		
New Jersey Student Learning Standards (NJSL)		
HS-LS1-1: Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life. HS-LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. HS-LS3-1: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. HS-LS3-3: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. HS-LS4-1: Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions. HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems. HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs.		
Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Asking Questions and Defining Problems - Ask questions that arise from examining models, scientific literature, observations, or theories to clarify relationships and guide investigations. - Analyze complex real-world problems by specifying qualitative and quantitative criteria and constraints for successful solutions. Developing and Using Models - Develop, revise, and use models based on evidence to illustrate, explain, predict, and communicate relationships among biological systems and engineering solutions.	LS1.A: Structure and Function - Systems of specialized cells within organisms carry out the essential functions of life. - All cells contain genetic information in the form of DNA molecules. Genes are regions of DNA that contain the instructions for producing proteins, which carry out most cellular functions. LS1.B: Growth and Development of Organisms - Multicellular organisms maintain homeostasis through interacting feedback mechanisms that regulate internal conditions and coordinate the activities of cells, tissues, and organ systems. LS3.A: Inheritance of Traits	Patterns - Patterns observed in data can be used to identify relationships, develop scientific explanations, make predictions, and generate new research questions. Cause and Effect - Empirical evidence is required to distinguish between cause and correlation and to support explanations of biological phenomena and engineering solutions. Scale, Proportion, and Quantity - Biological systems can be investigated at multiple levels of organization—from molecules and cells to organisms, populations, and

Planning and Carrying Out Investigations - Plan and conduct investigations individually and collaboratively to produce data that serve as the basis for evidence while considering appropriate controls, variables, and safety procedures. - Evaluate and refine the design of investigations to improve the quality, reliability, and validity of collected data. Analyzing and Interpreting Data - Analyze and interpret data using graphical, statistical, and computational tools to identify patterns, evaluate evidence, and draw scientifically supported conclusions. Using Mathematics and Computational Thinking - Apply mathematical concepts, statistical analysis, computational tools, and modeling techniques to analyze data, evaluate evidence, and support scientific explanations. Constructing Explanations and Designing Solutions - Construct explanations based on valid and reliable evidence obtained from investigations, models, theories, simulations, peer review, and other scientific sources.	- Chromosomes contain genes that encode the instructions for producing proteins and determining inherited traits. - Although all cells contain the same DNA, differences in gene expression result in specialized cell functions. LS3.B: Variation of Traits - Genetic variation results from meiosis, mutations, sexual reproduction, and interactions between genes and the environment. - Environmental factors can influence gene expression and contribute to phenotypic variation. LS4.B: Natural Selection - Natural selection occurs because individuals within a population vary in inherited traits, and those variations affect survival and reproductive success under specific environmental conditions. LS4.C: Adaptation - Adaptation results from natural selection acting on heritable variation over many generations, leading to populations that are better suited to their environments. ESS3.D: Global Climate Change - Scientific evidence indicates that current climate change is occurring primarily as a result of human activities. Climate models and geoscience data are used	ecosystems—and quantitative relationships help explain phenomena across these scales. Systems and System Models - Models are used to represent biological, environmental, and engineered systems and to examine interactions among components within and between systems. Energy and Matter - Energy and matter flow through biological and environmental systems, providing a framework for understanding cellular processes, organism function, and ecosystem interactions. Structure and Function - The structure of biological molecules, cells, organisms, and engineered systems determines their function and influences system performance. Stability and Change - Feedback mechanisms, environmental conditions, evolutionary processes, and engineering design contribute to the stability or change of biological and environmental systems over time.
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- Design, evaluate, and refine solutions to complex real-world problems using scientific knowledge, engineering principles, and evidence-based reasoning. Engaging in Argument from Evidence - Evaluate scientific claims, competing explanations, and engineering solutions using empirical evidence and logical reasoning. - Defend conclusions and proposed investigations using scientific evidence and appropriate reasoning. Obtaining, Evaluating, and Communicating Information - Critically evaluate scientific information obtained from multiple credible sources. - Communicate scientific ideas, research findings, experimental procedures, and evidence clearly and accurately through written, oral, visual, and digital formats.	to understand past changes and predict future impacts on Earth's systems. ETS1.A: Defining and Delimiting Engineering Problems - Successful engineering solutions are developed by clearly identifying criteria and constraints, including scientific, societal, environmental, and economic considerations. ETS1.B: Developing Possible Solutions - Complex engineering problems can be divided into smaller, manageable components. Multiple solutions should be developed, tested, and evaluated using scientific evidence and established design criteria. ETS1.C: Optimizing the Design Solution - Engineering solutions are improved through iterative testing, analysis, modeling, and refinement to optimize performance while balancing trade-offs among competing criteria and constraints.		
Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
What does it mean to do “authentic” scientific research?	Student will be able to: Utilize duckweed as an ecologically	DNA scissors (Recombinant DNA and Biotechnology,	Content Quizzes that accompany

• How do scientists design experiments to answer specific biological questions? • How can scientists investigate the functioning genome of a species? • Why is reproducibility important in scientific investigations? • How does collaboration enhance scientific discovery? • How do genes determine the traits and functions of living organisms? • What can we learn about an organism by analyzing its DNA? • How do mutations in DNA affect protein function and organism traits? • In what ways do model organisms help us understand human biology?	significant organism in bioremediation and an alternative fuel source. • Investigate how to use duckweed to reduce the effects of climate change • Use various biotechnology assays to isolate unknown DNA sequences. • Evaluate data generated from a cDNA library • Employ underlying principles of DNA sequencing and how it can be used to investigate an organism.	ASM Press) • DNA goes to the races (Recombinant DNA and Biotechnology, ASM Press) • Paper plasmids (Recombinant DNA and Biotechnology, ASM Press) • Paper PCR (Recombinant DNA and Biotechnology, ASM Press) • DNA sequencing terminator (Recombinant DNA and Biotechnology, ASM Press) • A mix up at the hospital (Recombinant DNA and Biotechnology, ASM Press) • Case of the bloody knife (Recombinant DNA and Biotechnology, ASM Press) • Lecture Notes, Activities and videos provided by the Rutgers Waksman Institute of Microbiology https://wssp.rutgers.edu/lecture-notes-students-2024 and resources within	each “Chapter” from the Waksman Student Scholars Program • Student progress on introductory DNA Activities (e.g. DNA scissors, DNA goes the races, etc.) • Electrophoresis Analysis of PCR and Restriction Digest • Completion of Clone Summary Sheet
Interdisciplinary Connections	<u>ELA</u> • RI.CR.11–12.1. Accurately cite a range of thorough textual evidence and make relevant connections to strongly support a comprehensive analysis of multiple aspects of what an informational text says explicitly and inferentially, as well as interpretations of the text. • RI.MF.11–12.6. Synthesize complex information across multiple sources and formats to develop ideas, resolve conflicting information, or develop an		

	interpretation that goes beyond explicit text information (e.g., express a personal point of view, new interpretation of the concept). • W.IW.11–12.2. Write informative/explanatory texts (including the narration of historical events, scientific procedures/experiments, or technical processes) to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content. • W.WR.11–12.5. 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. • SL.PI.11–12.4. Present information, findings and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. Mathematics (practices) • MP.2 – Reason abstractly and quantitatively. • MP.4 – Model with mathematics. • MP.5 – Use appropriate tools strategically. • MP.8 – Look for and express regularity in repeated reasoning. Visual & Performing Arts • 1.3A.12acc.Cr2a: Organize and develop artistic ideas and work by experimenting with, refining, and applying visual, conceptual, and compositional strategies to create a completed work. • 1.3A.12acc.Pr5b: Evaluate and refine artistic and technical work through analysis, interpretation, and practice in preparation for presentation or performance.
Career Readiness, Life Literacies, and Key Skills	• 9.2.12.CAP.1: Analyze personal skills, interests, and abilities to determine how they align with career and postsecondary opportunities. • 9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them including educational training requirements, costs, loans, and debt repayment. • 9.2.12.CAP.7: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest. • 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas. • 9.4.12.CC.1: Demonstrate leadership and collaborative skills when working to solve problems and accomplish goals. • 9.4.12.IML.6: Use appropriate communication and data visualization tools to convey complex information and solve real-world problems using information gathered from multiple sources.
Computer Science and Design Thinking	• 8.1.12.DA.5: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.

	● 8.1.12.DA.6: Create and refine computational models to better represent relationships among different elements of data collected from a phenomenon or process. ● 8.1.12.CS.1: Plan and develop computational solutions that use appropriate algorithms, data structures, and abstractions to solve complex problems. ● 8.2.12.ED.1: Apply a design thinking process to solve a real-world problem by identifying the problem, generating possible solutions, testing ideas, and refining the solution based on feedback.		
Modifications			
Multi-Lingual Learners	Students with Special Needs	At-Risk	Gifted and Talented
● Pre-teach critical terms (e.g., <i>cDNA</i>, <i>PCR</i>, <i>domain</i>) using: Word walls, Visual diagrams of molecular processes, dual-language glossaries ● Connect academic language to hands-on tasks (e.g., showing what “pipetting” or “ligation” looks like) ● Provide written AND visual protocols (flowcharts, illustrated steps) ● Provide examples of scientific writing and lab reports, annotated with explanations of structure and language	● Break down complex procedures into clear, step-by-step instructions ● Provide visuals, flowcharts, and infographics for lab protocols and bioinformatics steps ● Use graphic organizers for writing lab reports or summarizing gene data ● Offer pre-recorded demonstrations and written instructions for home reference ● Modify the length or complexity of written assignments, but retain core scientific goals ● Provide structured lab roles to reduce anxiety and clarify expectations	● Emphasize a growth mindset: "Everyone can be a scientist." ● Keep consistent structures and routines in lab work ● Offer clear timelines and visual calendars for long-term projects ● Let students choose genes, project formats, or partners when possible ● Offer real-world context (e.g., “How this gene might relate to crop science or medicine”) ● Pair with peer mentors or lab partners who can model persistence and curiosity ● Offer goal-setting worksheets or progress trackers ● Build in small “wins” with feedback checkpoints	● Encourage independent exploration of related topics, such as: Advanced bioinformatics tools (e.g., phylogenetic tree construction, protein modeling) ● Explore cutting-edge research articles about duckweed genomics or synthetic biology ● Assign G&T students as lab group leaders, responsible for guiding peers through protocols or data analysis ● Encourage them to mentor those needing support in molecular techniques ● Allow self-paced modules for deeper dives or extended projects

			Offer summer research internships, science fairs, or competitions related to WSSP topics
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Honors Research in Molecular Genetics I		
Unit 2: Bioinformatics		
Related Phenomena: How did scientists identify genes in woolly mammoths? Why can some people digest milk as adults and others can't? Why are some genes conserved, while others are not? How do new variants of genes arise? (e.g. Covid-19)		
Pacing: 10 weeks		
New Jersey Student Learning Standards (NJSLS)		
<i>HS-LS1-1: Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life.</i> <i>HS-LS1-6: Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine to form amino acids and other carbon-based molecules.</i> <i>HS-LS3-1: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits.</i> <i>HS-LS3-2: Make and defend a claim based on evidence that inheritable genetic variations may result from new genetic combinations, replication errors, or environmental factors.</i> <i>HS-LS3-3: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.</i> <i>HS-LS4-1: Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.</i> <i>HS-LS4-2: Construct an explanation based on evidence that evolution results from heritable variation, competition, and differential survival.</i> <i>HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions.</i> <i>HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems.</i> <i>HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs.</i>		
Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Asking Questions and Defining Problems Ask questions that arise from analyzing scientific data, evaluating evidence, and	LS1.B: Growth and Development of Organisms Feedback mechanisms maintain homeostasis by regulating internal conditions	Patterns Patterns identified through biological data, DNA sequences, statistical analyses, and computational models can be used

interpreting research findings to guide future investigations and engineering solutions. Developing and Using Models - Develop, revise, and use models and simulations to represent biological systems, analyze complex data, evaluate proposed solutions, and predict outcomes. Planning and Carrying Out Investigations - Evaluate and refine investigations based on the quality, reliability, and validity of collected data. - Refine experimental procedures and research designs based on evidence obtained from data analysis. Analyzing and Interpreting Data - Analyze and interpret data using graphical, statistical, computational, and bioinformatics tools to identify patterns, evaluate evidence, and draw scientifically supported conclusions. Using Mathematics and Computational Thinking - Apply mathematical concepts, statistical analyses, computational models, and bioinformatics tools to analyze biological data, evaluate evidence, and support scientific explanations. Constructing Explanations and Designing Solutions - Construct evidence-based explanations using valid and reliable scientific data	within organisms. Scientific investigations provide evidence for understanding how biological systems respond to internal and external changes. PS1.B: Chemical Reactions - Chemical systems can be optimized by changing conditions such as concentration, temperature, or pressure to influence reaction rates and equilibrium. Scientific principles can be applied to improve the design and efficiency of chemical systems. ESS3.C: Human Impacts on Earth Systems - Scientists and engineers can develop technologies that reduce pollution, conserve natural resources, restore ecosystems, and minimize environmental degradation while balancing societal needs. ETS1.A: Defining and Delimiting Engineering Problems - Successful engineering solutions are developed by clearly defining problems and identifying criteria and constraints, including scientific, environmental,	to explain phenomena, make predictions, and generate new scientific questions. Cause and Effect - Empirical evidence is required to distinguish between cause and correlation and to evaluate scientific explanations, engineering solutions, and biological relationships. Scale, Proportion, and Quantity - Quantitative relationships, statistical analyses, and computational models are used to investigate biological systems across molecular, cellular, organismal, and ecosystem scales. Systems and System Models - Models, simulations, and computational tools are used to represent complex biological and engineered systems, analyze interactions among components, and predict system behavior. Energy and Matter - The movement and conservation of energy and matter within biological, chemical, and environmental systems provide evidence for explaining system behavior and evaluating changes over time. Structure and Function
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obtained through investigations, models, simulations, and scientific literature. - Evaluate, refine, and optimize engineering solutions using scientific principles, computational models, and evidence-based reasoning. Engaging in Argument from Evidence - Critically evaluate scientific claims, competing explanations, and engineering solutions using empirical evidence, statistical analysis, and logical reasoning. - Defend scientific conclusions and proposed solutions using evidence gathered through authentic research. Obtaining, Evaluating, and Communicating Information - Critically evaluate scientific information from multiple credible sources. - Communicate scientific findings, research conclusions, and engineering solutions clearly and accurately through written reports, scientific posters, oral presentations, and digital media appropriate for scientific and public audiences.			
societal, economic, and ethical considerations. ETS1.B: Developing Possible Solutions - Complex engineering problems can be divided into smaller, manageable components. Multiple solutions should be developed, modeled, tested, and evaluated using scientific evidence and established design criteria. ETS1.C: Optimizing the Design Solution - Engineering solutions are continually refined through iterative testing, analysis, modeling, and evaluation to improve performance while balancing competing criteria and constraints.			
- The structure of biological molecules, organisms, engineered systems, and technological designs determines their function, performance, and effectiveness. Stability and Change - Biological, chemical, environmental, and engineered systems may remain stable or undergo change as a result of feedback mechanisms, environmental influences, and the continual refinement of scientific and engineering solutions.			
Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
How does the sequence of DNA influence the characteristics of an organism?	Student will be able to: Navigate various search engines to	Review Chapters, Slides and Videos pertaining to DNA Sequence Analysis Program (DSAP) provided by the Waksman	Completion of the analysis of 3 Practice Sequences (PC1-PC3) reviewed by the teacher(s) and Rutgers staff.

• How can we use computational tools to identify and compare genes across different species? • How do scientists use bioinformatics to analyze and interpret large sets of genetic data? • Why is it important to validate and curate DNA sequence data in scientific research? • How does protein function differ in relation to the developmental stages of an organism? • What can DNA similarities and differences between species tell us about evolutionary relationships?	investigate a DNA sequence • Identify the function of a novel DNA sequence. • Describe how a DNA sequence relates to the function of a gene • Interpret data to understand the purpose of various DNA sequences • Compare the unknown DNA sequence identified to other known sequences to identify evolutionary relationships	Institute of Microbiology https://wssp.rutgers.edu/research (Password is provided for instructors by the WSSP) • Use DNA Sequence Analysis Program (DSAP) to analyze Example Clones https://benzer.rutgers.edu/DSAP/Projects/2025WSSP/login.php • Use DNA Sequence Analysis Program (DSAP) to analyze Unknown Clones https://benzer.rutgers.edu/DSAP/Projects/2025WSSP/login.php	• Complete the analysis of the novel sequence for publication in NCBI • Completion of post-survey provided by Rutgers University
Interdisciplinary Connections	ELA • RI.CR.11–12.1. Accurately cite a range of thorough textual evidence and make relevant connections to strongly support a comprehensive analysis of multiple aspects of what an informational text says explicitly and inferentially, as well as interpretations of the text. • RI.MF.11–12.6. Synthesize complex information across multiple sources and formats to develop ideas, resolve conflicting information, or develop an interpretation that goes beyond explicit text information (e.g., express a personal point of view, new interpretation of the concept). • W.IW.11–12.2. Write informative/explanatory texts (including the narration of historical events, scientific procedures/experiments, or technical processes) to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content. • W.WR.11–12.5. 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.		

	● SL.PI.11–12.4. Present information, findings and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. Mathematics (practices) ● MP.2. Reason abstractly and quantitatively. ● MP.4. Model with mathematics. ● MP.5. Use appropriate tools strategically. ● MP.8. Look for and express regularity in repeated reasoning. Visual & Performing Arts ● 1.3A.12acc.Cr2a. Organize and develop artistic ideas and work by experimenting with, refining, and applying visual, conceptual, and compositional strategies to create a completed work. ● 1.3A.12acc.Pr6a Convey meaning through the presentation of artistic work, considering venue, audience, and presentation methods.		
Career Readiness, Life Literacies, and Key Skills	● 9.2.12.CAP.1 Analyze personal skills, interests, and abilities to determine how they align with career and postsecondary opportunities. ● 9.2.12.CAP.4 Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them including educational training requirements, costs, loans, and debt repayment. ● 9.2.12.CAP.7 Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest. ● 9.4.12.CI.1 Demonstrate the ability to reflect, analyze, and use creative skills and ideas. ● 9.4.12.CC.1 Demonstrate leadership and collaborative skills when working to solve problems and accomplish goals. ● 9.4.12.IML.6 Use appropriate communication and data visualization tools to convey complex information and solve real-world problems using information gathered from multiple sources.		
Computer Science and Design Thinking	● 8.1.12.DA.5 Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. ● 8.1.12.DA.6 Create and refine computational models to better represent relationships among different elements of data collected from a phenomenon or process. ● 8.1.12.CS.1 Plan and develop computational solutions that use appropriate algorithms, data structures, and abstractions to solve complex problems. ● 8.2.12.ED.1 Apply a design thinking process to identify a real-world problem, generate possible solutions, test ideas, and refine the solution based on feedback.		
Modifications			
Multi-Lingual Learners	Students with Special Needs	At-Risk	Gifted and Talented
● Introduce essential technical terms (e.g., gene, sequence, annotation, algorithm) before diving into activities. ● Use visuals, diagrams, and	● Present content in multiple formats: visual (videos, diagrams), auditory (recorded	● Establish strong, positive relationships to create a safe and trusting environment. ● Help students see	● Allow students to move ahead if they master basic bioinformatics skills quickly ● Connect bioinformatics to mathematics (e.g., probability in

bilingual glossaries to reinforce understanding. • Provide sentence frames or word banks for scientific writing and discussion. • Incorporate diagrams of DNA, proteins, and bioinformatics workflows. • Use videos and animations to demonstrate complex processes like sequence alignment or gene function. • Pair or group MLLs with peers for peer support and language modeling. • Use bioinformatics tools with multilingual interfaces when available. • Provide corrective feedback sensitively and encourage iterative learning.	explanations), and tactile (models). • Provide tiered tasks with varying levels of complexity or scaffolding. • Use visual step-by-step guides for procedures like BLAST searches or sequence annotations. • Break bioinformatics workflows into smaller steps. • Assign peer buddies or small, supportive groups for collaborative tasks. • Use frequent check-ins to support organization and task completion. • Celebrate small successes to build confidence in challenging work.	themselves as capable scientists or researchers—emphasize inclusion and potential. • Connect bioinformatics to real-world problems (e.g., genetics and health, environmental sustainability). • Provide access to tutorials, re-teaching videos, and peer coaching. • Allow flexible pacing, including after-school or asynchronous work time for students juggling outside responsibilities. • Provide models and examples for each part of the project (e.g., example BLAST results or reports). • Provide frequent formative feedback and low-stakes practice opportunities. • Integrate hands-on or tech-based tools to keep lessons dynamic and interactive. • Provide a checklist with visuals showing each step (copying the sequence, running BLAST, interpreting results)	mutation rates), computer science (e.g., coding algorithms), or design thinking (e.g., creating user-friendly data visualization tools). • Provide primary literature to analyze or discuss during seminar-style conversations. • Offer opportunities to go deeper into areas such as: molecular evolution and phylogenetics • Have advanced students serve as peer mentors or “team leads” during collaborative tasks. • Connect students with university mentors, Waksman alumni, or professional researchers
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Honors Research in Molecular Genetics I

Unit 3: Exploring Science Research & Developing a Research Proposal

Related Phenomena: Various biology-related phenomena can be explored using laboratory investigations, research articles and case studies.

Some example phenomena may include:

- **“Despite identical genomes, monozygotic twins often show differences in disease susceptibility, behavior, and gene expression.”**
→ What role do epigenetic modifications and environmental factors play in phenotypic variation?
- **“CRISPR gene editing efficiency varies significantly between cell types and delivery methods.”**
→ What cellular or molecular factors influence the success of gene-editing technologies?
- **“Some bacterial strains survive high concentrations of antibiotics without possessing known resistance genes.”**
→ How might persister cells, biofilms, or gene regulation contribute to non-genetic antibiotic resistance?
- **“Microplastic exposure alters gene expression and reproduction in aquatic organisms, even at low concentrations.”**
→ What molecular mechanisms underlie biological responses to emerging environmental pollutants?
- **“Plants exposed to specific wavelengths of light exhibit differential expression of genes involved in growth and stress response.”**
→ How do light quality and photoreceptor signaling pathways regulate gene networks in plants?
- **“Mitochondrial dysfunction in neurons is associated with neurodegenerative diseases, but the exact causal relationships remain unclear.”**
→ Can targeted manipulation of mitochondrial genes or function help clarify their role in disease progression?
- **“The gut microbiome composition influences not only digestion but also mood and cognitive performance in humans and animal models.”**
→ What microbial metabolites interact with host signaling pathways in the brain-gut axis?
- **“Exposure to endocrine-disrupting chemicals leads to transgenerational effects in animal models.”**
→ *What epigenetic mechanisms mediate inherited changes in gene expression caused by environmental toxins?*

Pacing: 16 weeks

New Jersey Student Learning Standards (NJSLS)

- **HS-LS1-1:** Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.
- **HS-LS1-3:** Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
- **HS-LS3-1:** Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
- **HS-LS3-2:** Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.
- **HS-LS4-2:** Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
- **HS-LS4-5:** Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
- **HS-ESS3-5:** Analyze geoscience data and results from global climate models to make an evidence-based forecast of climate change

impacts.		
Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Patterns - Patterns observed in DNA sequences, biological data, statistical analyses, and computational models can be used to identify relationships, explain biological phenomena, make predictions, and generate new scientific questions. Cause and Effect - Empirical evidence is required to distinguish between cause and correlation and to evaluate scientific explanations, engineering solutions, and biological relationships. Scale, Proportion, and Quantity - Quantitative relationships, statistical analyses, and computational models are used to investigate biological systems across molecular, cellular, organismal, and ecosystem scales. Systems and System Models - Models, simulations, and computational tools are used to represent complex biological, chemical, environmental, and engineered systems, analyze	LS1.A: Structure and Function - DNA contains the instructions for producing proteins that carry out the essential functions of cells. The relationship between structure and function at the molecular level provides the foundation for understanding biological processes and designing scientific investigations. LS1.B: Growth and Development of Organisms - Feedback mechanisms maintain homeostasis and regulate the internal environment of organisms. Understanding these mechanisms helps scientists design investigations and explain biological responses to changing conditions. LS3.A: Inheritance of Traits - Chromosomes contain genes that encode the instructions for producing proteins and determining inherited characteristics. Patterns of inheritance provide the basis for investigating biological questions and developing research hypotheses. LS3.B: Variation of Traits - Genetic variation results from mutations, meiosis, sexual reproduction, and environmental influences. These sources of variation provide opportunities for scientific investigation and explain differences among organisms. LS4.B: Natural Selection	Patterns - Patterns observed in scientific data, biological systems, and published research can be used to identify relationships, develop hypotheses, make predictions, and guide future investigations. Cause and Effect - Empirical evidence is required to distinguish between cause and correlation and to explain biological phenomena, evaluate scientific claims, and support engineering solutions. Scale, Proportion, and Quantity - Biological systems can be investigated at multiple organizational levels, from molecules and cells to organisms, populations, ecosystems, and global systems. Quantitative relationships help explain processes across these scales. Systems and System Models

interactions among components, and predict system behavior. Energy and Matter - The movement and conservation of energy and matter within biological, chemical, and environmental systems provide evidence for explaining system behavior, evaluating change, and supporting scientific predictions. Structure and Function - The structure of biological molecules, organisms, engineered systems, and technological designs determines their function, performance, and effectiveness. Stability and Change - Biological, chemical, environmental, and engineered systems may remain stable or undergo change as a result of feedback mechanisms, environmental influences, and the continual refinement of scientific and engineering solutions.	- Natural selection occurs because inherited variation influences survival and reproductive success under changing environmental conditions. Evidence from research can be used to explain evolutionary change. LS4.C: Adaptation - Adaptation results from natural selection acting on heritable variation over many generations, leading to populations better suited to their environments. ESS3.D: Global Climate Change - Scientific evidence demonstrates that current climate change is occurring primarily as a result of human activities. Climate models and geoscience data can be used to investigate impacts and evaluate potential solutions. ETS1.A: Defining and Delimiting Engineering Problems - Successful engineering solutions begin with clearly defining a problem and identifying criteria and constraints, including scientific, environmental, societal, ethical, and economic considerations. ETS1.B: Developing Possible Solutions - Complex engineering problems can be divided into manageable components. Multiple solutions should be developed, tested, and evaluated using scientific evidence and established design criteria. ETS1.C: Optimizing the Design Solution	- Models are used to represent biological, environmental, and engineered systems and to examine interactions among components, evaluate system behavior, and predict outcomes. Energy and Matter - Energy and matter are conserved as they move through biological, chemical, and environmental systems, providing a framework for explaining cellular processes, organism function, ecosystem interactions, and engineering solutions. Structure and Function - The structure of biological molecules, organisms, and engineered systems determines their function and influences the effectiveness of scientific investigations and technological solutions. Stability and Change - Biological and environmental systems may remain stable or undergo change as a result of feedback mechanisms,
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		Engineering solutions are improved through iterative testing, analysis, modeling, and refinement to maximize effectiveness while balancing competing criteria and constraints.	environmental influences, evolutionary processes, and the continual refinement of scientific and engineering solutions.
Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
- How can scientific research contribute to solving global and local challenges? - How do advancements in science and technology shape our understanding of the world—and ourselves? - How do my interests and questions connect to real scientific problems? - How do scientists develop meaningful research questions that lead to new discoveries? - What makes a scientific investigation reliable, valid, and ethical? - How can we use data and outcomes from previous experiments to create and refine a research protocol?	Student will be able to: - Identify a topic of interest through conducting a literature review. - Design and execute independent or team-based investigations. - Formulate a clear, testable, and original research question(s). - Develop a hypothesis grounded in peer-reviewed research. - Design a valid, ethical, and feasible experimental procedure grounded in peer-reviewed research.	Literature Review Topic Exploration using the “Topic Exploration Wizard” - Investigate and research the observable effects of a specific phenomena/ on living organisms. (Review of images of phenomena and article analysis to develop research questions). - Discuss articles and case studies with peers to determine the relationship between the phenomena/variable and molecular mechanisms using specific known mechanisms present in the case studies and articles. - Review the guidelines of posing scientific questions and designing scientific investigations. - Develop a scientific question, testable hypothesis and hypothetical experiment to investigate the impact of a specific phenomena or variable on	- Research proposal - Background literature summary - Midpoint data presentation - Revised experiment plan (if needed) (Use Science Buddies Rubrics)

• What factors must be considered when designing experiments that involve living organisms, including humans? • How do genetic and environmental factors studied in model organisms help us understand complex human diseases and global issues? • What ethical principles must guide research involving human subjects and animal models? • How can data collection methods impact the accuracy and reliability of scientific results? • What statistical tools and analytical techniques help scientists interpret complex data and draw meaningful conclusions? • How can visualization and modeling of data improve our understanding of biological phenomena and support hypothesis testing? • In what ways can bias or error be introduced during data collection	• Evaluate the use of model organisms in the lab. • Compare the care and use of different model organisms and when they are used. • Create a research plan aligned with science fair or related program criteria. • Present and justify their research plan to peers and instructors for feedback.	molecular mechanisms of organisms. • Identify a model organism or system that would be needed to test the hypothesis. • Develop / modify protocols to appropriately test the hypothesis. • Regular lab check-ins and mentoring	
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and analysis, and how can researchers minimize these risks? In what ways do scientists communicate their findings, and why is that important?			
Interdisciplinary Connections	<u>ELA</u> RI.CR.11–12.1 Accurately cite a range of thorough textual evidence and make relevant connections to strongly support a comprehensive analysis of multiple aspects of what an informational text says explicitly and inferentially, as well as interpretations of the text. RI.MF.11–12.6 Synthesize complex information across multiple sources and formats to develop ideas, resolve conflicting information, or develop an interpretation that goes beyond explicit text information (e.g., express a personal point of view, new interpretation of the concept). W.WR.11–12.5 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. W.IW.11–12.2 Write informative/explanatory texts (including the narration of historical events, scientific procedures/experiments, or technical processes) to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content. SL.PI.11–12.4 Present information, findings and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. <u>Mathematics</u> MP.2 Reason abstractly and quantitatively. MP.4 Model with mathematics. MP.5 Use appropriate tools strategically. HS.S-ID.1 Represent data with plots on the real number line (dot plots, histograms, and box plots). HS.S-ID.6 Use statistics appropriate to the shape of the data distribution to compare center and spread of two or more different data sets and interpret differences in context. <u>Health & Physical Education</u> 2.1.12.HP.5 Research current and emerging health issues and how they are influenced by genetics, environments, and personal behaviors. 2.1.12.PGD.5 Investigate current issues related to genetics, reproductive technologies, and bioethics. <u>Visual & Performing Arts</u> 1.3A.12acc.Cr2a Organize and develop artistic ideas and work by experimenting with, refining, and applying visual, conceptual, and compositional strategies to create a completed work. 1.3A.12acc.Pr5b Evaluate and refine artistic and technical work through analysis, interpretation, and practice in preparation for presentation or performance.		

Career Readiness, Life Literacies, and Key Skills	● 9.2.12.CAP.1 Analyze personal skills, interests, and abilities to determine how they align with career and postsecondary opportunities. ● 9.2.12.CAP.4 Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them including educational training requirements, costs, loans, and debt repayment. ● 9.2.12.CAP.5 Assess and modify a personal plan to support current interests and postsecondary plans. ● 9.2.12.CAP.6 Identify transferable skills in career choices and design alternative career plans based on those skills. ● 9.4.12.CI.1 Demonstrate the ability to reflect, analyze, and use creative skills and ideas. ● 9.4.12.CI.3 Investigate new challenges and opportunities for personal growth, advancement, and transition. ● 9.4.12.CT.2 Develop multiple solutions to a problem and evaluate which is the most effective. ● 9.4.12.IML.5 Evaluate, synthesize, and apply information on the ethical and legal use of technology. ● 9.4.12.IML.6 Use information from multiple sources to analyze a real-world problem and propose a solution.		
Computer Science and Design Thinking	● 8.1.12.DA.1 Create interactive data visualizations using software and tools to help others better understand real-world phenomena. ● 8.1.12.DA.3 Create, evaluate, and refine computational models and visualizations using data to support scientific reasoning and decision making. ● 8.1.12.DA.6 Create and refine computational models to better represent relationships among different elements of data collected from a phenomenon or process. ● 8.1.12.CS.1 Plan and develop computational solutions that use appropriate algorithms, data structures, and abstractions to solve complex problems. ● 8.2.12.ED.1 Apply a design thinking process to identify a real-world problem, generate possible solutions, test ideas, and refine the solution based on feedback. ● 8.2.12.ED.2 Develop and test multiple prototype solutions to solve an authentic problem using an iterative design process.		
Modifications			
Multi-Lingual Learners	Students with Special Needs	At-Risk	Gifted and Talented
● Provide diagrams, flowcharts, and labeled images of experimental setups. ● Use graphic organizers (e.g., cause/effect charts, hypothesis vs. results tables) to help organize ideas. ● Visuals help bridge language gaps and clarify abstract concepts. ● Break down complex instructions into	● Break down experiments into smaller, clear steps. ● Use simple, direct language paired with visuals or demonstrations. ● Provide written and verbal instructions. ● Use checklists or task cards to guide progress. ● Offer hands-on materials or tactile models for students	● Foster a positive classroom culture where mistakes are valued as learning. ● Connect lessons to students' interests, backgrounds, and real-life experiences. ● Provide consistent encouragement and recognize effort. ● Offer choices in topics, formats, or group/individual work. ● Use small groups or peer mentoring to build skills and confidence. ● Teach and model effective teamwork and communication skills.	● Challenge students to design multi-variable experiments or novel bioinformatics pipelines. ● Assign tasks requiring critical evaluation of conflicting data or ethical implications. ● Support participation in science fairs, competitions, or publication of findings. ● Connect students with mentors or scientists in the field. ● Explore ethical, social, or philosophical questions raised by genetic data.

smaller, manageable steps. • Use sentence frames or starters (e.g., “I predict that...”, “The data shows...”). • Provide bilingual glossaries or translated materials if possible. • Emphasize “learning by doing” through experiments, models, and simulations. • Use videos, animations, and interactive tools to demonstrate scientific processes.	with sensory needs. • Use videos or simulations as alternatives to physical experiments. • Give extended time for completing experiments and data recording. • Allow breaks during longer tasks. • Provide opportunities to repeat steps or practice skills. • Incorporate pictures, diagrams, flowcharts, and labeled tools.	• Highlight how scientific skills relate to jobs and daily life. • Invite guest speakers or organize field trips to increase motivation. • Offer after-school tutoring, study sessions, or access to resource centers. • Encourage use of school counseling or mentoring programs to address socio-emotional needs.	• Link bioinformatics to fields like computer science, math modeling, or health sciences.
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Professional Resources

- 2026 New Jersey Student Learning Standards for Science – <https://www.nj.gov/education/standards/science/2026/>
- New Jersey Student Learning Standards (All Content Areas) – <https://www.nj.gov/education/standards/>
- New Jersey Department of Education Climate Change Resources – <https://www.nj.gov/education/climate/>
- Rutgers Waksman Student Scholars Program – <https://wssp.rutgers.edu/>
- Rutgers Waksman Student Scholars Program Lecture Notes – <https://wssp.rutgers.edu/lecture-notes-students-2024>
- Rutgers Waksman Student Scholars Program DNA Sequence Analysis Program (DSAP) – <https://benzer.rutgers.edu/DSAP/>
- Rutgers Waksman Student Scholars Program Resources – <https://wssp.rutgers.edu/resources/>
- American Society for Microbiology (ASM) – <https://asm.org/>
- ASM Press—Recombinant DNA and Biotechnology – <https://asm.org/books>
- National Center for Biotechnology Information (NCBI) – <https://www.ncbi.nlm.nih.gov/>
- NCBI Gene Database – <https://www.ncbi.nlm.nih.gov/gene>
- NCBI BLAST – <https://blast.ncbi.nlm.nih.gov/>
- NCBI GenBank – <https://www.ncbi.nlm.nih.gov/genbank/>
- PubMed – <https://pubmed.ncbi.nlm.nih.gov/>
- National Library of Medicine – <https://www.nlm.nih.gov/>
- National Institutes of Health – <https://www.nih.gov/>
- National Human Genome Research Institute – <https://www.genome.gov/>
- MedlinePlus Genetics – <https://medlineplus.gov/genetics/>

- DNA Learning Center (Cold Spring Harbor Laboratory) – <https://dnalc.cshl.edu/>
- HHMI BioInteractive – <https://www.biointeractive.org/>
- OpenStax Biology 2e – <https://openstax.org/details/books/biology-2e>
- Khan Academy Biology – <https://www.khanacademy.org/science/biology>
- ExploreLearning Gizmos – <https://www.explorelearning.com/>
- BioInteractive Virtual Labs – <https://www.biointeractive.org/classroom-resources>
- University of Utah Learn.Genetics – <https://learn.genetics.utah.edu/>
- European Bioinformatics Institute (EMBL-EBI) – <https://www.ebi.ac.uk/>
- UniProt Protein Knowledgebase – <https://www.uniprot.org/>
- Protein Data Bank (RCSB PDB) – <https://www.rcsb.org/>
- DNA Subway (CyVerse) – <https://dnasubway.cyverse.org/>
- DNA from the Beginning – <https://www.dnafb.org/>
- National Center for Case Study Teaching in Science – <https://sciencecases.lib.buffalo.edu/>
- Science Buddies – <https://www.sciencebuddies.org/>
- Google Scholar – <https://scholar.google.com/>
- Nature Education Scitable – <https://www.nature.com/scitable/>
- Centers for Disease Control and Prevention (CDC) – <https://www.cdc.gov/>
- World Health Organization (WHO) – <https://www.who.int/>
- United States Department of Agriculture (USDA) Plant Research – <https://www.ars.usda.gov/>
- Duckweed Forum – <https://www.ruduckweed.org/>
- The Arabidopsis Information Resource (TAIR) – <https://www.arabidopsis.org/>
- NCBI Sequence Read Archive – <https://www.ncbi.nlm.nih.gov/sra>
- BLAST Video Tutorials (NCBI) – <https://www.ncbi.nlm.nih.gov/books/NBK153387/>
- NCBI Genome Data Viewer – <https://www.ncbi.nlm.nih.gov/genome/gdv/>
- U.S. Bureau of Labor Statistics Occupational Outlook Handbook – <https://www.bls.gov/ooh/>
- O*NET OnLine – <https://www.onetonline.org/>
- CareerOneStop – <https://www.careeronestop.org/>
- ExploreHealthCareers.org – <https://explorehealthcareers.org/>
- New Jersey Career Assistance Navigator (NJCAN) – <https://portal.njcis.intocareers.org/>
- New Jersey Department of Labor and Workforce Development – <https://www.nj.gov/labor/>