

Saving the Mountain Lion - Teacher Materials

Unit 4

Biology



The Curriculum and Instruction Department at New Visions for Public Schools develops free, full-course materials for all areas of high school science, math, ELA, and social studies, for use across our network of 80 New York City schools and beyond.



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Unit 4 Saving the Mountain Lion

Genetics and Variation

Performance Expectations

HS-LS3-2, HS-LS1-8, HS-LS1-4, HS-LS4-3, HS-LS3-3

Time

22-24 days

How can we save the mountain lion?

Students investigate different populations of mountain lions by looking at microsatellite data, and apply concepts of mitosis, meiosis and cause and effect to figure out that the mountain lion in Connecticut came from South Dakota, seeking genetic variation. They apply what they are learning about the mountain lion to the make and defend a claim relating to a solution implemented to increase genetic diversity of the population of mountain lions.

Unit Opening

Mountain Lion Populations 5E

Sexual Reproduction 3E (optional)

Genetic Variation 5E

Engineering Gene Flow 5E

Unit Closing

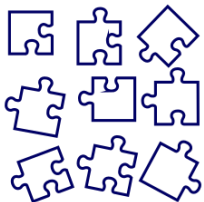
Anchor Phenomenon



5E Lessons connect learning to the performance task



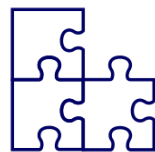
Performance Task



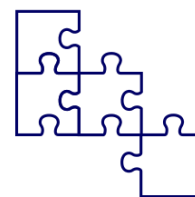
A mountain lion was hit by a car on a highway in Connecticut, right outside NYC. How can we figure out where the mountain lion came from and why it was there?



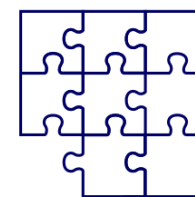
How can we figure out where the Connecticut Cat came from?



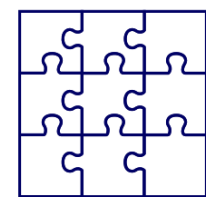
How can we understand the abnormalities seen in the Florida mountain lion population?



Why is it advantageous for a mountain lion to seek variation?



How can humans solve the mountain lion population isolation problem?



What causes a lack of genetic variation in a population?, Why is genetic diversity a problem for some species, and how can we evaluate conservation solutions for isolated populations?

Unit Introduction

How do we make science education meaningful and relevant to our students? High school biology courses are traditionally filled with lectures and cookbook labs, memorizing vocabulary, and an occasional research report. New science education standards (NGSS/NYSSLS) require a more engaging, accessible vision of science teaching and learning to help all students learn about the natural world and become scientifically literate citizens.

The three-dimensional, phenomenon-driven materials in this unit support students in engaging in the authentic practices of science. Students construct meaning about the natural world through modeling, investigations, labs and experiments. As students have opportunities to manipulate the physical tools of science, they also engage in productive struggle that can be resolved through evaluating claims using evidence and engaging in consensus building discussions. The materials support teachers in becoming skillful facilitators of student sense-making and deepen teachers' understanding of how to teach science in an interactive way that is driven by students' questions and ideas.

In Unit 4, students learn about a mountain lion that had walked from South Dakota to Connecticut, got hit by a car on the Merritt Parkway, and died. Why was this mountain lion in Connecticut, where big cats are rare? The backbone of this unit is a data set of genetic variation information of mountain lions. The real-life data was provided through a collaboration with a content expert, Dr. Anthony Caragiulo, a big cat expert from the American Museum of Natural History. Additionally, unit 4 was co-designed with Dr. Dave Randle, an Assistant Director of Curriculum and Instruction, and a faculty member at the Richard Gilder Graduate School, The American Museum of Natural History.

Through an iterative analysis of the genetic data set, students learn about the impact of reduced ranges (due to human-caused habitat destruction) has on mountain lion genetics and overall health. They figure out that variation exists across living things, and that this variation comes from our genes. Students explain that traits are expressed through proteins that are coded for in genes, and that variation can be due to a number of causes including mutations during meiosis, along with environmental influences on gene expression.

Students also figure out that genetic variation is essential for species survival, as a requirement for natural selection and adaptation to changing environments. Finally they use what they have learned about the mountain lion to evaluate the efficacy of a solution designed to increase genetic diversity in mountain lion populations.

Unit Coherence

In Unit 4, the overall question around the causes and benefits of genetic variation is intended to motivate student engagement across the unit. It is our intention that from the students' perspective, there is a clear and explicit unit storyline that guides the sequence of activities. Rather than one long continuous unit, we have chosen to use an instructional model to develop three coherent learning sequences within Unit 4. Each sequence builds towards figuring out something that contributes to explaining the overall unit-level question about what is happening with mountain lion populations, and how to evaluate conservation solutions for megafauna suffering from fragmented populations. The phenomena, the instructional model, and the routines embedded throughout the sequences of lessons are all used in service of coherence across Unit 4.

One additional note - this unit was also designed to support students with a NYSSLS Performance Expectation that addresses human reproduction. This PE is not in the NGSS. The way we have attended to this is to provide an optional "3E" after the first 5E instructional sequence that supports students with that PE. If

teachers are ONLY using this unit to meet the NGSS PEs, and if students have already had sufficient NGSS experiences across K-8, this 3E can be skipped, and it will not undermine the coherence of the unit storyline.

Phenomenon-Driven Instruction

Phenomena are a key part of instruction in *A Framework for K-12 Science Education* and the NGSS. As in the work of scientists, students should be encouraged to move from observable phenomena to generalizable explanations of the natural world. Too often, traditional science instruction has started with generalizable principles, sidelining the lived experience and intuitions that all young people bring to school. In this unit (and all New Visions units) there are two kinds of phenomena: anchor phenomena and investigative phenomena.

Anchor Phenomenon	Investigative Phenomena
• One per unit; drives the learning of the unit • Attention-grabbing and relevant • Does not have to be phenomenal	• One per 5E sequence (three in this unit *) • Presented in the Engage phase of each 5E

* NOTE - this unit has an additional “3E” that is optional (only Engage, Explore and Explain), and uses the same investigative phenomena as the 3rd 5E.

Anchor Phenomenon

To support coherence, students are prompted to figure out one overarching, real-world question over the course of the unit. The anchor phenomenon question is revisited across the unit, and this question motivates the investigations conducted in each of the 5E instructional sequences. A good anchor phenomenon should be attention-grabbing and relevant to students but also thought-provoking, comprehensible, and connected to the science learning goals. It needs to be observable to students through firsthand experiences or through someone else’s experiences, such as through a video or secondary data. If a teacher feels the anchor phenomenon will not be familiar or accessible to all students, we suggest relating it to similar, more familiar phenomena. It is important to notice that the phenomenon question anchoring the unit is different from the more generalized and abstracted science question for the unit. This difference is part of what helps make the unit more student-centered, rather than teacher-centered.

Investigative Phenomena

Based on the Anchor Phenomenon and three-dimensional learning goals for students for the unit, each 5E instructional sequence has a related investigative phenomenon, typically presented in the Engage phase. This phenomenon brings students together around a shared puzzle or experience that frames the learning for that 5E sequence. Similar to the anchor phenomenon question, the questions about the investigative phenomena are intended to be specific and contextualized, rather than the traditional content questions teachers use as their lesson aims. They present what is being figured out; therefore, the scientific concepts that are in the learning goal cannot be part of the wording of the question!

Solving Problems

One of the major NGSS shifts is integrating engineering into science instruction. Defining problems and developing solutions are critical components of engaging in addressing significant global and social problems within an NGSS-designed high school science course. After being presented with the unit anchor phenomena, students are naturally inclined to want to do something about it - and thus students' investigations across a unit are also motivated by the desire to solve the related problem. This engineering thread is intertwined with the anchor phenomenon as the science figured out is useful in arguing for a causal explanation of the phenomenon *and* figuring out a solution.

Storyline and Pacing Guide

Unit Opening

A mountain lion was hit by a car on a highway in Connecticut, right outside NYC. How can we figure out where the mountain lion came from and why it was there?

Performance Expectations

Anchor Phenomenon

A mountain lion was hit by a car on a highway outside NYC. How did it get there, and what can this tell us about saving mountain lions?

Time
2 days

Student Questions

These questions motivate the unit storyline.

- Where did the mountain lion come from?
- How did it get to Connecticut?
- Why would a male mountain lion stray so far from home?
- How can we figure out where the mountain lion came from?

What Students Do

Students read a text and watch a video in order to think about why the Connecticut mountain lion was so far away from its home. After telling the story of the mountain lion, students generate a driving question board.

Student Ideas

These ideas are revisited throughout the unit storyline.

- Mountain lions have historically had a huge range across North America.
- Their range has gotten smaller, and this is somehow related to them getting hit by a car.

Students are now curious to know where the Connecticut cat came from and why it was wandering around where there are no other mountain lions! Students will analyze genetic data to figure out where it originated from.

Mountain Lion Populations 5E

How can we figure out where the Connecticut Cat came from?

Performance Expectations
HS-LS3-2

Investigative Phenomenon
A male mountain lion was killed by a car on a parkway in Connecticut. Students need to figure out where it came from, how it got there, and why it would roam so far from its original home.

Time
5 days

Student Questions

These questions motivate this 5E sequence and the unit storyline.

- How did the mountain lion get to Connecticut?
- Why did he come to Connecticut?
- Would other mountain lions be showing up now, too?
- Where are the relatives of this mountain lion?

What Students Do

Students determine where the Connecticut Cat came from using genetic data from five different populations of mountain lions in North America. They then try to determine why a male mountain lion would stray so far. Determining the population that's most closely related to the mountain lion who died requires analysis of genetic data using statistical methods. The same data will also be used to determine the frequency of certain alleles within a population, which leads to calculations of genetic diversity.

Student Ideas

Students figure out these ideas in this 5E sequence.

- The mountain lions in South Dakota are very similar, genetically, to the one found in Connecticut
- The Connecticut Cat must have come all the way from South Dakota

Students apply what they have learned during this investigation to develop a model at different scales, based on evidence, that represents the cause behind the migration of the Connecticut cat.

Have students identify which categories/questions they have not figured out yet. Students should share out these questions, and document new questions that arise based on what they have been learning, which can be added to the Driving Question Board.

Sexual Reproduction 3E (optional)

How can we understand the abnormalities seen in the Florida mountain lion population?

Performance Expectations
HS-LS1-8

Investigative Phenomenon
Florida panthers, a population of mountain lions, possessed a set of strange traits.

Time
3 days

Student Questions	What Students Do	Student Ideas
<i>These questions motivate this 5E sequence and the unit storyline.</i> - How do mammals (like humans and mountain lions) sexually reproduce? - How do the structures of the reproductive system support internal fertilization and development? - How do abnormal traits impact sexual reproduction and the continuation of the species?	In this 5E students use models of the human reproductive system to closely investigate the structure and function of its parts. Students generate a sequence chart to help them understand how abnormalities in the Florida mountain lion population may negatively impact their ability to reproduce.	<i>Students figure out these ideas in this 5E sequence.</i> - All mammals reproduce sexually with internal fertilization & development - The reproductive structures of the male and female reveal their function in reproduction (including the production of gametes, fertilization, and development of the fetus in the female) - Hormones regulate sexual reproduction in both males and females - Abnormalities in the reproductive system (or in other body systems that interactive with the reproductive system) may reduce the probability of successful fertilization or the growth and development of the fetus

Students apply what they have learned during this investigation to make sense of how abnormalities in structure may impact the functioning of the reproductive system.

Have students identify which questions they generated during the Engage phase they have not figured out yet. Questions about whether abnormalities are caused by mutations or another cause. Students should share out these questions, and document new questions that arise based on what they have been learning, which can be added to the Driving Question Board.

Genetic Variation 5E

Why is it advantageous for a mountain lion to seek variation?

Performance Expectations
HS-LS1-4, HS-LS4-3,
HS-LS3-2

Investigative Phenomenon
Florida panthers, a population of mountain lions, possessed a set of strange traits.

Time
6 days

Student Questions

These questions motivate this 5E sequence and the unit storyline.

- Why do the Florida mountain lions have abnormal traits?
- How and where do mutations occur?
- Why are mutations only expressed in some cells of the body?
- Why do mutations increase in frequency in small populations?

What Students Do

Students notice that Florida mountain lions have a high frequency of abnormal traits such as kinked tails and low sperm counts. Students investigate the genetic data on this population to uncover patterns on homozygosity and heterozygosity of allele pairs. Then, students explore more about the origin of the abnormal traits and how they increase in frequency due to inbreeding. Finally, students consider the case of the Chernobyl dogs and how their circumstances contributed to their genetically unique populations..

Student Ideas

Students figure out these ideas in this 5E sequence.

- Florida mountain lions have a high frequency of homozygous alleles and inbreeding
- Mutations are errors during replication; mutations that occur in sex cells can be passed onto offspring
- Mutations can happen randomly, and can be caused by mutagens in the environment
- After fertilization, mitosis (cell division) occurs as an embryo grows; creating identical cells
- Early in embryonic development cells differentiate, so that only some genes are expressed in each cell depending on the type of cell
- In small populations inbreeding occurs because there few individuals to mate with
- Inbreeding increases the frequency of often deleterious mutations in a population

Students apply what they learned during this investigation to develop a model based on evidence to represent the cause of disadvantageous traits in mountain lions.

Have students identify which categories/questions they have not addressed yet. One question category should relate to questions about how to increase diversity in small populations like the Florida mountain lions. Tell students that in the next sequence of lessons, they will investigate these questions.

Engineering Gene Flow 5E

How can humans solve the mountain lion population isolation problem?

Performance Expectations
HS-LS3-2, HS-LS3-3,
HS-LS4-3

Investigative Phenomenon
The introduction of Texas mountain lions into the Florida panther population led to an increase in genetic diversity.

Time
5 days

Student Questions	What Students Do	Student Ideas
<i>These questions motivate this 5E sequence and the unit storyline.</i> - How can humans solve the mountain lion problem of decreasing range sizes and populations? - How does sexual reproduction increase the variation of alleles and traits? - Why is it important to have a variety of individuals to mate with?	Students notice that the genetic diversity in the Florida mountain lions increased after the 1995 introduction of 8 female mountain lions from a population of lions in Texas. Students investigate a model of cellular level processes of sexual reproduction (meiosis) and observe how new genetic combinations in offspring result from sexual reproduction. Then, students model breeding in populations with varying degrees of genetic diversity and use ideas surfaced from the investigations to model what occurred after the introduction of Texas mountain lions to the Florida Panther population and make a claim about whether the intervention increased genetic diversity of the Florida Panthers.	<i>Students figure out these ideas in this 5E sequence.</i> - Exchange of DNA between paired homologous chromosomes (one from each parent) occurs during the first stage of egg and sperm cell development (meiosis). This process results in new combinations of alleles in the gametes (egg or sperm) formed. This is called crossing over. - Half of the new chromosomes randomly move to opposite sides of cells before they split into new cells. This is called random assortment and results in new genetic combinations. - We saw an increase in genetic diversity in the Florida panther population after the Texas mountain lions were introduced because that increased the genetic diversity of the cats mating and that led to more observed heterozygosity in offspring. - Variation is good for offspring: meiosis leads to variation. - During development it's all mitosis, so sexual reproduction is your one shot at variation! - Environmental factors also lead to variation in gene expression.

After students figure out the reason behind the Connecticut Cat's long migration from the genetic, individual, population, and species levels across the unit, they are encouraged in the Unit Closing to apply what they learned to evaluate a solution designed to increase genetic diversity in mountain lion populations.

Unit Closing

What causes a lack of genetic variation in a population?, Why is genetic diversity a problem for some species, and how can we evaluate conservation solutions for isolated populations?

Performance Expectations
HS-LS4-3, HS-LS3-2

Anchor Phenomenon
A mountain lion was hit by a car on a highway outside NYC. How did it get there, and what can this tell us about saving mountain lions?

Time
1-3 days

Student Questions	What Students Do	Student Ideas
<i>These questions are addressed in the performance task.</i> - What explains why populations of large animals have a problem with genetic diversity? - How does low genetic diversity impact species? - How can we address low genetic diversity in different population's genetic diversity?	Students are introduced to the solution of wildlife corridors to increase mountain lion genetic diversity. Based on the investigations and learning throughout the unit, they analyze the potential impacts of different wildlife corridors in order to generate and defend a claim in support of one corridor.	<i>These ideas were developed throughout the unit storyline.</i> - Mountain lions seek genetic variation to reproduce, and when that variation is limited, will go outside their normal range to find it. - Based on the nature of science, we can predict that other populations of organisms will be governed by the same scientific principles that we observed in the mountain lion populations. - During sexual reproduction a cellular process called meiosis occurs and multiple phases of the process lead to recombination of genes from each parents' gametes. - The more genetic diversity there is within a population, the more likely it is that mating results in new genetic combinations in offspring. - Genetic variation is required for natural selection. - Beneficial traits (including behavioral traits) are adaptations that can increase in a population due to differential survival and reproduction. - Humans can be the cause of the struggle some species are experiencing with limited genetic diversity, and can <i>also</i> provide solutions to help organisms that are struggling with genetic variation.

Based on the investigations and learning throughout the unit, students conduct a statistical analysis of genetic data and in order to make and defend a claim about which wildlife corridor would best address the lack of variation in Mountain Lion populations.

Unit Standards

This unit is designed to meet Next Generation Science Standards Performance Expectations. Since this unit is part of a full-year Biology course, the design includes intentional foregrounding of a limited number of Crosscutting Concepts (CCCs) and Science and Engineering Practices (SEPs). Further, since an aspect of NGSS design is connections to Common Core Math and ELA standards, these connections are highlighted in this section.

Performance Expectations

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.

Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.

Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.

In NYS the entire PE has been edited as follows: 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, (3) mutations caused by environmental factors and/or (4) genetic engineering. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs including the relevant processes in meiosis and advances in biotechnology.] [Assessment Boundary: Assessment does not include recalling the specific details of the phases of meiosis or the biochemical mechanisms of the specific phases in the process.]

HS-LS1-8

Clarification Statement:

Assessment Boundary:

This PE, added by NYS, is not in the NGSS: Use models to illustrate how human reproduction and development maintains continuity of life. [Clarification Statement: Emphasis is on structures and function of human reproductive systems, interactions with other human body systems, embryonic development, and influences of environmental factors on development.] [Assessment Boundary: Assessment does not include the details of hormonal regulation or stages of embryonic development.]

HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

Clarification Statement: None

Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.

In NYS the entire PE has been edited as follows: Use a model to illustrate cellular division (mitosis) and differentiation. [Clarification Statement: Emphasis should be on the outcomes of mitotic division and cell differentiation on growth and development of complex organisms and possible implications for abnormal cell division (cancer) and stem cell research.] [Assessment Boundary: Assessment does not include specific gene control mechanisms or recalling the specific steps of mitosis.]

HS-LS4-3 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.

Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.

HS-LS3-3

Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.

Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.

Unit Standards

This unit is designed to meet Next Generation Science Standards Performance Expectations. Since this unit is part of a full-year Biology course, the design includes intentional foregrounding of a limited number of Crosscutting Concepts (CCCs) and Science and Engineering Practices (SEPs). Further, since an aspect of NGSS design is connections to Common Core Math and ELA standards, these connections are highlighted in this section.

Three-Dimensional Learning Goals in This Unit

Given the breadth of three-dimensional standards for high school biology, Unit 4 builds on the ideas developed in Units 2 and 3 related to evolution by natural selection and genetics, and focuses primarily on ideas related to the causes and benefits of genetic variation. These ideas fall mostly within Core Idea LS3 of the NGSS/NYSLS, Heredity: Inheritance and Variation of Traits. Disciplinary Core Ideas within LS1.B: Growth and Development of Organisms, and LS4.B Natural Selection and LS4.C: Adaptation are also addressed in this unit. The use of disciplinary core ideas from LS4.B Natural Selection and LS4.C: Adaptation draw heavily from students' earlier work with these components in Unit 2.

In Unit 4, the second element of LS4.C (Adaptation also means that the distribution of traits in a population can change when conditions change) is **not** assessed, even though it is a part of HS-LS4-3, a performance expectation found in this unit. Evidence for student use of this element is found in Unit 2. Additionally, to address NYS-specific standards, ideas related to sexual reproduction are also part of the Unit 4 storyline.

Similar to Unit 1, this unit draws heavily on the SEP of Developing and Using Models. Students build on their use of modeling to focus on a new SEP, Analyzing and Interpreting Data. That is not to say that students will not engage in other SEPs throughout the lessons, particularly the practice of Engaging In Argument from Evidence; however, it is important to foreground and be explicit about a limited number of practices with enough duration to see how students develop their understanding and ability to use this practice. This is important for both student and teacher learning! The foregrounded CCC for this unit is Patterns, which fits well with our selected SEP. As students deepen their understanding of the content to understand why genetic diversity is important for species survival, they learn how to use multiple lines of evidence to make causal claims based on empirical data at different scales, and strengthen explanatory models. Scaffolding across the unit supports students' three-dimensional learning and will help shift classrooms to become more NGSS-aligned spaces.

Three Dimensions in Unit 4

This chart is a high-level summary of the standards for Unit 4. For more detail about specific elements, see the section on Assessment later in this document.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models	LS1.A Structure and Function	Patterns
Analyzing and Interpreting Data	LS1.B Growth and Development of Organisms	Cause and Effect
Engaging in Argument from Evidence	LS3.B Variation of Traits	Scale, Proportion, and Quantity
	LS4.B Natural Selection	Systems and Systems Models
	LS4.C Adaptation	

Building on Middle School

High school science teaching necessarily builds on student learning from middle school. It is helpful to consider the middle school standards in order to enact a unit that builds on students' prior experiences. As we are in the middle of a multi-year transition, however, it is also critical to keep in mind that not all students will have experienced an NGSS-designed unit when they come to high school, so the process of building on middle school learning may be particularly complex for years to come. The following sections detail the ways in which this unit builds on middle school standards across the three dimensions.

Science and Engineering Practices from Middle School

Developing and Using Models

- Students in middle school have experience developing models based on evidence, using models to make predictions and evaluating models to evaluate their limitations. The use of modeling in this unit at the high school level builds on these experiences as students have to develop models at different scales and revise their models to show relationships between systems and components of a system.

Analyzing and Interpreting Data

- Students in middle school have previous experience using graphical displays, such as graphs and charts, to identify relationships and to distinguish between causal and correlational relationships. This unit builds on this practice, providing students with multiple opportunities to engage with complex visual representations of data and using concepts of statistics and probability in order to evaluate claims of causal relationships.

Engaging in Argument from Evidence

- In middle school, students have previous experience constructing arguments supported by evidence and reasoning, as well as experience comparing and critiquing each others' arguments; in high school, they develop a deeper understanding of how to evaluate the strength of evidence for different claims, and use evidence to develop and defend claims. This unit builds on the practice of Engaging in Argument from Evidence through scaffolded speaking and writing experiences.

Disciplinary Core Ideas from Middle School

LS4.B Natural Selection

- In middle school, students learn that natural and artificial selection results in the increase in advantageous traits in a population. In high schools, students look at additional ways in which traits increase in a population, including genetic drift and gene flow. In this unit, students engage in multiple opportunities to closely examine genetic diversity in different populations and the processes that may lead to specific traits dominating in a population.

LS3.B Variation in Traits

- Students in middle school learn that Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other and that mutations are a source of genetic variation. In this unit, students learn that meiosis during sexual reproduction generates new combinations of alleles, and that variation can also arise from the variation of the expression traits, based on the environment.

Crosscutting Concepts from Middle School

Patterns

This unit builds on the following aspects of Patterns in middle school.

- Middle school students learn that patterns in data can be identified in graphs and images, and that these patterns can be used to identify cause and effect relationships. Students in middle school also learn that macroscopic patterns observed are related to what is happening at the microscopic level, which will be important in helping them understand and identify causal relationships in this unit.

Cause and Effect

This unit builds on the following aspects of Cause and Effect in middle school.

- Students in middle school learn that relationships may be causal or correlational and that correlation does not always imply causation. This unit builds on this understanding by engaging students in multiple opportunities to evaluate possible causal relationships using empirical evidence. In evaluating claims throughout the unit, students are supported in differentiating between causation and correlation in order to identify the best supported claim.

Scale, Proportion, and Quantity

This unit builds on the following aspects of Scale, Proportion, and Quantity in middle school.

- Students in middle school that scientific relationships can be represented through the use of algebraic expressions and equations. This unit builds on the use of this understanding as students use algebraic thinking to examine and better understand scientific data and concepts; and to predict the impact of changing one variable on another.

Assessment

Performance expectations (PEs) in the NGSS describe what students should know and be able to do. Unit 4 targets a bundle of one PE taken from the first core idea in high school life science (HS-LS1), *From Molecules to Organisms: Structures and Processes*; that standard is HS-LS1-4. One PE is taken from the fourth core idea in high school life science (HS-LS4), *Biological Evolution: Unity and Diversity*; that standard is HS-LS4-3. Two PEs are taken from the third core idea in high school life science (HS-LS3), *Heredity: Inheritance and Variation of Traits*; those standards are HS-LS3-2 and HS-LS3-3. Additionally, an optional 3E sequence is used to target the NYSSLS PE, HS-LS1-8, which is not a part of the NGSS. This PE bundle informs the types of three-dimensional tasks in which students engage across the unit. Each sequence of lessons within the unit targets elements from one or more of the performance expectations for the unit, and the teacher has

opportunities to collect evidence of student learning around these elements within that learning sequence. The unit-level Performance Task only targets a subset of three-dimensional learning goals informed by the bundled PEs for the unit. All other evidence of learning related to the other dimensions/elements in the PEs can be found within the instructional sequences. It is important to note that Unit 4 does not address the third element of LS4.C Adaptation (LS4.C(3)). Evidence for student use of this element is found in Unit 2.

The **Teacher Materials** for each 5E instructional sequence includes a matrix that lists which student artifacts can provide evidence of student learning for each of three-dimensional learning goals from that sequence. Each 5E addresses the integration of the three dimensions across the activities. Please keep in mind that Explore/Explain phases in the matrix should be looked at together, as a continuous experience to assess the foregrounded three-dimensional learning goals across the two phases.

This unit was designed to support teachers in tracking student progress across the three dimensions, not for mastery within individual days of instruction. The targeted disciplinary core ideas (DCIs) listed below will be developed throughout the unit. While all of the science and engineering practices (SEPs) may be utilized across the unit, the target SEPs for the unit are listed below. Similarly, many crosscutting concepts (CCCs) may be useful in making sense of the phenomena in this unit, however the foregrounded, targeted CCCs are listed below.

The following [Science and Engineering Practices](#), [Disciplinary Core Ideas](#), and [Crosscutting Concepts](#) are assessed throughout the unit:

	Mountain Lion Populations 5E	Sexual Reproduction 3E (optional)	Genetic Variation 5E	Engineering Gene Flow 5E
Developing and Using Models	✓	✓	✓	✓
Analyzing and Interpreting Data	✓		✓	✓
Engaging in Argument from Evidence	✓		✓	✓
LS1.A Structure and Function		✓		
LS1.B Growth and Development of Organisms		✓	✓	
LS3.B Variation of Traits	✓		✓	✓
LS4.B Natural Selection	✓		✓	✓

	Mountain Lion Populations 5E	Sexual Reproduction 3E (optional)	Genetic Variation 5E	Engineering Gene Flow 5E
LS4.C Adaptation			✓	✓
Patterns	✓		✓	✓
Cause and Effect	✓		✓	✓
Scale, Proportion, and Quantity				✓
Systems and Systems Models		✓		

At the end of the unit, teachers will have evidence in student work (tasks) related to the elements listed in this table and can therefore make claims at the end of this unit related to student proficiency for all three performance expectations.

To support assessment throughout the unit, rubrics have been included in the **Student Materials** to support the Evaluate phase in every 5E instructional sequence. Teachers should customize these rubrics to support their schools' grading systems. Rubrics address both individual reflection, peer review, and the teacher's feedback. The Unit 4 Performance Task also includes a rubric, and the task can be considered a final summative assessment for the unit - we have not included a traditional "unit test" in our materials. Teachers may opt to create their final exam using their states' previous exam questions, however we believe that the formative assessment tasks embedded in the materials (such as the Looks and Listen For notes, the Explore phase summaries, and the modeling done in the Evaluate phases), along with the Performance Task can serve as sufficient evidence of what students know and can do.

Common Core State Standards (Mathematics)

Standards for Mathematical Practice

MP3 Construct viable arguments and critique the reasoning of others.	Mathematically proficient students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They are able to analyze situations by breaking them into cases, and can recognize and use counterexamples. They justify their conclusions, communicate them to others, and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose. Mathematically proficient students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in an argument—explain what it is. Elementary students can construct arguments using concrete referents such as objects, drawings, diagrams, and actions. Such arguments can make sense and be correct, even though they are not generalized or made formal until later grades. Later, students learn to determine
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domains to which an argument applies. Students at all grades can listen or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments.

MP6
Attend to
precision.

Mathematically proficient students try to communicate precisely to others. They try to use clear definitions in discussion with others and in their own reasoning. They state the meaning of the symbols they choose, including using the equal sign consistently and appropriately. They are careful about specifying units of measure, and labeling axes to clarify the correspondence with quantities in a problem. They calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the problem context. In the elementary grades, students give carefully formulated explanations to each other. By the time they reach high school they have learned to examine claims and make explicit use of definitions.

Common Core State Standards (ELA/Literacy)

Speaking and Listening Standards

- SL.9-10.1 Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.
- SL.9-10.4 Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

Reading Standards for Literacy in Science and Technical Subjects

- RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
- RST.9-10.2 Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
- RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- RST.9-10.9 Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects

- WHST.9-10.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Implementing Unit 4

This unit is designed to be the fourth unit of the Biology course. We do not recommend spending more than two months on this unit, as our field testing showed that six to eight weeks is the maximum amount of time students can stay engaged with the unit-level anchor phenomenon.

Within the unit, we also suggest spending no more than two weeks on each 5E instructional sequence. It is important to trust that ideas will build over time. Part of learning to teach NGSS-designed curriculum is getting comfortable with moving on, even if not every student “gets it,” with the knowledge that there are additional opportunities to revisit particular standards. See the Assessment section below for guidance on providing multiple opportunities for assessment throughout the unit.

The first time enacting any unit with students may take longer than anticipated, particularly if the pedagogical approach is significantly different from what a teacher is used to. A teacher may want to skip entire lessons or activities, or revert to more traditional approaches when it seems like time is running out. We often ask teachers to think about the best way to modify recipes. Just like when using a recipe for the first time, it’s a good idea to stay as true to the materials as possible before making modifications or substitutions! As teachers become more familiar and comfortable with the instructional model, the embedded routines, and three-dimensional teaching overall, the desire to skip things will dissipate. Teachers using our curriculum over time have noticed that they are able to move a bit quicker through this and other NGSS-designed units every year!

Routines

The table below summarizes the routines embedded in this unit. The number indicates the number of times a given routine appears in a lesson.

	Unit Opening	Mountain Lion Populations 5E	Sexual Reproduction 3E (optional)	Genetic Variation 5E	Engineering Gene Flow 5E	Unit Closing
Class Consensus Discussion		1		1	1	
Consensus Building Share		1	1			
Domino Discover			1	1	1	
Idea Carousel				1		
Questions Only			1			
Read-Generate-Sort-Solve		1		1	1	

	Unit Opening	Mountain Lion Populations 5E	Sexual Reproduction 3E (optional)	Genetic Variation 5E	Engineering Gene Flow 5E	Unit Closing
Rumors		1		1	1	
Think-Talk-Open Exchange					1	
Think-Talk-Open Exchange + Buzzwords			1			

Literacy Strategies

The table below summarizes the literacy strategies embedded in this unit. The number indicates the number of times a given strategy appears in a lesson.

	Unit Opening	Mountain Lion Populations 5E	Sexual Reproduction 3E (optional)	Genetic Variation 5E	Engineering Gene Flow 5E	Unit Closing
Concept Mapping				1		
Sequence Chart			1			
Text Annotation	1	1		1	1	

Videos in this Unit

Lesson	Video Title	Source	Technical Notes	Permissions Notes
Unit Opening	Mountain Lions in California	https://www.youtube.com/watch?v=GLvRuSjSYgo	NA	NA
Mountain Lion Populations 5E	Sample Size Explained	https://www.youtube.com/watch?v=Uyd_Fk9cDjA	NA	NA

Lesson	Video Title	Source	Technical Notes	Permissions Notes
Mountain Lion Populations 5E	Cheetahs 101 Nat Geo Wild	https://www.youtube.com/watch?v=N7e_IDDojas	NA	NA
Genetic Variation 5E	Mitosis	https://www.youtube.com/watch?v=f-lDPgEfAHI	NA	NA
Engineering Gene Flow 5E	Meiosis	https://www.youtube.com/watch?v=rB_8dTuh73c	NA	NA

Lab Materials in this Unit

Lesson	Lab	Materials needed (per group)
Mountain Lion Populations 5E	Mountain Lion Genotype Data Investigation Lab minutes: 45 minutes	
Sexual Reproduction 3E (optional)	Sexual Reproduction 3E Explore Sexual Reproduction Models Investigation Lab minutes: 30 minutes	
Genetic Variation 5E	Mountain Lion Genetic Diversity Investigation Lab minutes: 45 minutes	
Engineering Gene Flow 5E	Increasing Genetic Variation Investigation Lab minutes: 60 minutes	☐ 2 paper bags ☐ 10 colored marbles for each of the following colors: red; blue; yellow; and green

Other Materials in this Unit

Lesson	Materials needed
Unit Opening	☐ Post-it notes ☐ chart paper or digital access
Mountain Lion Populations 5E	☐ Confidence Calculator ☐ Cheetahs: On the Brink of Extinction, Again National Geographic Society
Sexual Reproduction 3E (optional)	☐ <i>Sexual Reproduction Models</i> ☐ <i>Sexual Reproduction Models</i> ☐ <i>Sexual Reproduction Female Sequence Chart Cards</i> ☐ <i>Sexual Reproduction Male Sequence Chart Cards</i>
Genetic Variation 5E	☐ Mountain Lion Genetic Diversity Calculator ☐ Observed and Expected Heterozygosity (optional) ☐ Mutations ☐ Differentiation ☐ CK-12 Reading Causes of Mutations ☐ CK-12 Reading Causes of Mutations Advanced ☐ CK-12 Reading Sources of Genetic Variation Advanced ☐ Are Contaminants Silencing Our Genes? (optional) ☐ computer access
Engineering Gene Flow 5E	

Lesson	Materials needed
	☐ Post it notes ☐ Mountain Lion Genetic Diversity Calculator ☐ Observed and Expected Heterozygosity (optional) ☐ What causes a sea turtle to be born male or female? ☐ Temperature-Dependent Sex Determination Visual ☐ Temperature-Dependent Sex Determination Unraveled: An Interview with Dr. Alex Lolavar (optional) ☐ Sex Determination: More Complicated Than You Thought
Unit Closing	☐ Driving Question Board