Project-Based Inquiry Science: Genetics
Storyline

Targeted Performance Expectations:
· MS-LS1-4 · MS-LS1-5 · MS-LS2-1 · MS-LS2-4 · MS-LS2-5 · MS-LS3-1 · MS-LS3-2 · MS-LS4-4 · MS-LS4-5 · MS-LS4-6 · MS–ETS1–1 · MS–ETS1–2 · MS–ETS1–3 · MS–ETS1–4

Genetics: What's the Big Question?
How Can Knowledge of Genetics Help Feed the World?

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices
In the *Introduction* to *Genetics*, students read a short history of agriculture and the how plants have been changed to meet the needs of humans as a food source. To begin thinking about *How can knowledge of genetics help feed the world?*, they analyze several food labels comparing ingredients. They identify the most common grains and discuss the importance of grains in their diets. Students read a letter from a girl in the Philippines describing the importance of rice in their lives and some of the problems with sufficient supply. A letter from Rice for a Better World Institute (RBWI) asks students to join them in developing a new variety for the farmers which is nutritious, grows in droughts and is pest resistant. Students document and make public their ideas and understanding about rice, rice production, what scientists do to develop new plants and the main problems farmers have in growing rice as they create the *Project Board*, including questions they would like to investigate to help address the *Big Challenge* and answer the *Big Question*. **Disciplinary Core Ideas:** **ETS1.A: Defining and Delimiting Engineering Problems** · The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)	**Obtaining, Evaluating, and Communicating Information** (gain information from food labels, a personal and a corporate letter) **Asking Questions and Defining Problems** (students create the *Project Board* and add what they think they know and questions they would like to investigate)

Genetics: Learning Set 1
What Is Rice?

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices	Crosscutting Concepts
Introduction to *Learning Set 1*: In *Learning Set 1*, students explore rice as a plant with nutritional value for humans.	**Obtaining, Evaluating, and Communicating Information** (read a letter and discuss ideas about what they know about rice) **Asking Questions and Defining Problems** (students create the *Project Board* and add what they think they know and questions they would like to investigate)	Unit Level: **Structure and Function**
Section 1.1: Students read a letter from RBWI asking them to compare rice plants and identify the differences and similarities between them, then develop questions they would like answered to learn more about how rice is grown.		

Section 1.2: To emphasize and support students developing understanding of where and how rice is grown, they create a labeled diagram of rice to use as a model. They locate major rice producing regions in the world using maps and use a data chart to compare consumption of rice by country. Combining their new knowledge they *Update the Project Board* using evidence from their reading.	**Analyzing and Interpreting Data** (create graphs from data charts) **Obtaining, Evaluating, and Communicating Information** (analyze information from text and data charts.) **Developing and Using Models** (create a diagram to use as a model of a rice plant)	Unit Level: **Structure and Function**
Section 1.3: Students gather data about the inherited traits of the members of their group. They analyze and compare the variation in their groups and the class. They recognize that humans, as well as other organisms and rice, share similar traits, but also have many differences. Groups create statements backed by evidence about which of the tested traits are more common in humans. **Disciplinary Core Ideas:** **LS3.B: Variation of Traits** · In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. 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. (MS-LS3-2)	**Analyzing and Interpreting Data** (analyze their data from the trait inventory) **Obtaining, Evaluating, and Communicating Information** (gather information about which traits are the most common and share their thoughts with the class) **Engage in Argument from Evidence** (determine which traits are more common based on the evidence from their data)	Section Level: **Patterns**
Section 1.4: The class works in small groups, then as a whole to develop a precise and accurate estimation of the variations in five different rice varieties. They record measurements, calculate averages and ratios then graph the results. Building on their knowledge of variations in organisms, students classify the five different grains. **Disciplinary Core Ideas:** **LS3.B: Variation of Traits** · In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. 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. (MS-LS3-2)	**Analyzing and Interpreting Data** (analyze data from investigations, create a graph) **Planning and Carrying Out Investigations** (investigate the variations in length and width of five rice varieties) **Using Mathematical and Computational Thinking** (measure, record, calculate averages and ratios, then graph the data of five rice varieties)	Section Level: **Patterns**
Section 1.5: Students increase academic vocabulary by reading informational text and increasing their knowledge about how the starch in rice is formed. They begin to formulate ideas about the nutritional value of rice as they *Update the Project Board* with new learning.	**Obtaining, Evaluating, and Communicating Information** (gather information about the nutritional value of rice)	Unit Level: **Structure and Function** Section Level: **Energy and Matter** **Systems and System Models**

Back to the Big Challenge: As they return to the *Learning Set* question, *What is Rice?*, students now have a better understanding of the variations in rice types and the nutritional importance of the starch for humans. Students revisit the request of RBWI and begin to select the traits they believe most desirable in the new and better rice. Small groups create their list and share it with the class as they update the criteria for the challenge. **Disciplinary Core Ideas:** **ETS1.B: Developing Possible Solutions** · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) · Models of all kinds are important for testing solutions. (MS-ETS1-4)	**Asking Questions and Defining Problems** (update the criteria of the better rice and add new questions which will help address the *Big Question*)	Unit Level: **Structure and Function**

Genetics: Learning Set 2
How Are Traits Passed Down From Generation to Generation?

Storyline (with Disciplinary Core Ideas and Science Content)	**Science and Engineering Practices**	**Crosscutting Concepts**
Introduction to *Learning Set 2*: In *Learning Set 2*, students explore how genetic traits are passed from generation to generation in organisms.	**Developing and Using Models** (create a model of a rice plant)	Unit Level: **Structure and Function** Section Level: **Cause and Effect** **Patterns**
Section 2.1: Students build a Reez-ot with randomly selected characteristics found in rice to use as a model for their investigations. Paired letters are used determine how each trait will appear in the Reez-ot. They compare their Reez-ot to others in the class and begin to see that the traits an organism has depend on the combination of traits that the organism has inherited. Students also begin to see how some traits are dominant and some are recessive. They *Update the Project Board* with new learning.		
Section 2.2: Students dissect a flower and study its reproductive parts. Through observation and reading, they discover the process of pollination combines traits passed on through the male and female parts of a flower, which results in the development of seeds. They discuss how knowing that rice plants are self-pollinating will help them cross varieties of rice plants as they create their better rice. **Disciplinary Core Ideas:** **LS1.B: Growth and Development of Organisms** · Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. (MS-LS1-4) · Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (secondary to MS-LS3-2)	**Obtaining, Evaluating, and Communicating Information** (gather information about the reproductive parts of flowers and the process of pollination)	Unit Level: **Structure and Function** Section Level: **Cause and Effect**

Section 2.3: Students read about Gregor Mendel's historic experiment, which explains how pea plants inherit their traits. They discover the two factors for each trait, usually one dominant and one recessive. They develop academic vocabulary as they read about the mechanism of gene transfer. Students apply this to the letter code of their Reez-ot model and connect the information to the creating a better rice challenge. The class updates the *Project Board* with their new knowledge siting evidence from the reading. *More to Learn:* Students read about incomplete dominance and co-dominance, and connect this to their Reeze-ot models and the rice challenge. **Disciplinary Core Ideas:** **LS3.A: Inheritance of Traits** · Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (MS-LS3-1) · Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2)	**Obtaining, Evaluating, and Communicating Information** (reading supports the developing scientific explanation of how genetic traits are passed from generation to generation)	Unit Level: **Structure and Function** Section Level: **Cause and Effect** **Patterns**
Section 2.4: Students are introduced to Punnett squares, and use them to determine the possible genotypes and phenotypes of several crosses. They estimate the probable number of offspring with each genotype. They complete Punnett squares for two generations of rice plants, and learn that recessive traits may be expressed in organisms whose parents did not express the traits. Students transfer this knowledge of genetics to how it will help them develop the better rice plant with the desired traits. **Disciplinary Core Ideas:** **LS3.B: Variation of Traits** · In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. 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. (MS-LS3-2)	**Analyzing and Interpreting Data** (Use Punnett square to determine probable outcomes of offspring) **Using Mathematical and Computational Thinking** (Calculate probability of genetic outcomes through the use of Punnett squares) **Developing and Using Models** (model genetic crosses using Punnett squares)	Unit Level: **Structure and Function** Section Level: **Cause and Effect** **Patterns**

Section 2.5: Based on a request from rice farmers, students design a procedure to produce a hybrid rice variety with specific traits. They develop a method which will reveal which traits are recessive and which traits are dominant in the rice they will be crossing. They use what they know about how rice plants reproduce to design procedures for pollinating the plants using Punnett squares to support their recommendation. Groups share their plans with their peers and come to consensus as a class with a final plan to send to the Philippine Rice Farmers Cooperative. **Disciplinary Core Ideas:** **LS3.B: Variation of Traits** · In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. 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. (MS-LS3-2)	**Planning and Carrying Out Investigations** (plan a procedure to cross rice varieties for specific traits) **Using Mathematical and Computation Thinking** (develop a procedure to determine dominate and recessive traits in rice varieties)	Unit Level: **Structure and Function** Section Level: **Cause and Effect** **Patterns**
Section 2.6: Students analyze the results of the field test provided by the farmers. They determine which allele (white or red grains) is dominant or recessive. They use Punnett squares to calculate the percent of each genotype and phenotypes of offspring in the first and second generations of hybrids and create posters to share their results with the class. As students come to consensus with a recommendation about how to produce rice with the desired traits they begin to deepen their knowledge and skills related to completing the *Big Question*. Students *Update the Project Board* with new learning about how traits are passed from generation to generation. **Disciplinary Core Ideas:** **LS3.B: Variation of Traits** · In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. 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. (MS-LS3-2)	**Analyzing and Interpreting Data** (use Punnett square to determine probable outcomes of offspring) **Using Mathematical and Computational Thinking** (calculate probability of genetic outcomes through the use of Punnett squares)	Section Level: **Cause and Effect** **Patterns** **Scale, Proportion, and Quantity**
Section 2.7: Students develop their understanding about diversity in offspring as they combine random chromosomes of two Reeze-ot parents. They use the new set of chromosomes for the offspring to build models of the next generation of Reeze-ots. They compare the genotypes and phenotypes of the offspring Reeze-ots to the genotypes and phenotypes of other offspring Reeze-ots and of the parents. Students build their knowledge of variation in offspring from generation to generation as they prepare to address the *Big Question.* **Disciplinary Core Ideas:** **LS3.B: Variation of Traits** · In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. 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. (MS-LS3-2)	**Analyzing and Interpreting Data** (analyze the genetic transfer of traits from generation to generation) **Developing and Using Models** (model genetic crosses using Punnett squares and build a phenotypic model of offspring from a random cross)	Section Level: **Cause and Effect** **Patterns** **Scale, Proportion, and Quantity**

Section 2.8: Students read a case study about cystic fibrosis. They deepen their knowledge of genetic transfer by learning how recessive alleles can be passed by parents who do not have the disease, but can produce a child with the disease. Students complete a Punnett square where each parent carries a single cystic fibrosis allele, developing a sense of the probabilities of children inheriting the disease when their parents carry the recessive alleles. Students *Update the Project Board* with how this new knowledge will help them address the *Big Question*. **Disciplinary Core Ideas:** **LS3.B: Variation of Traits** · In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. 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. (MS-LS3-2) · In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. (MS-LS3-1)	**Obtaining, Evaluating, and Communicating Information** (reading supports student's developing scientific knowledge about genes, chromosomes and genetic transfer of traits)	Section Level: **Cause and Effect Patterns**
Back to the Big Challenge: Students begin to address the *Big Challenge* by using what they know about how dominant and recessive alleles are inherited to figure out how to produce a hybrid with the desired phenotype. They create three recommendations for farmers about how to create the desired rice with supporting evidence from their readings and Punnett squares. Students update the criteria and constraints for the challenge and as a class come to consensus with their recommendations. **Disciplinary Core Ideas:** **ETS1.B: Developing Possible Solutions** · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) · Models of all kinds are important for testing solutions. (MS-ETS1-4)	**Engage in Argument from Evidence** (create recommendations using supporting evidence from reading and investigations)	Section Level: **Cause and Effect Patterns**

Genetics: Learning Set 3
How Do Traits and the Environment Interact?

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices	Crosscutting Concepts
Introduction to *Learning Set 3*: Students investigate how the environment and organisms interact and how organisms can change over time based on changes in the environment.	**Analyzing and Interpreting Data** (analyze data from a simulation showing the effects of the environment on a population) **Developing and Using Models** (use a simulation to model changes in frequencies of a trait in a population) **Using Mathematical and Computational Thinking** (calculate frequencies of a characteristic in an organism over time) **Constructing Explanations** (construct a scientific explanation about how the environment affects the traits of an organism in a population)	Unit Level: **Stability and Change** Section Level: **Cause and Effect** **Patterns** **Scale, Proportion, and Quantity**
Section 3.1: Students design a model to investigate how selection pressure affects the frequencies of specific traits in populations. They simulate environmental factors to calculate changes in the frequencies of traits. Finally, they construct explanations for how selection pressures change frequencies of traits in populations using evidence from their investigation. They connect their experience to see how people or factors in the environment can put pressure on traits in a population. **Disciplinary Core Ideas:** **LS4.B: Natural Selection** · Natural selection leads to the predominance of certain traits in a population, and the suppression of others. (MS-LS4-4) · In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring. (MS-LS4-5)		Unit Level: **Stability and Change** Section Level: **Cause and Effect** **Patterns** **Scale, Proportion, and Quantity**
Section 3.2: Students use photographs to observe adaptations of animals to their environments. They connect their observations to help understand how adaptations help an organism survive. They use NetLogo to simulate how different hunting strategies by birds put different selection pressures on a bug population. Students connect and expand this experience to consider how they could stop bugs from eating their rice. **Disciplinary Core Ideas:** **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** · Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4) **LS4.C: Adaptation** · Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (MS-LS4-6)	**Developing and Using Models** (use a simulation to model changes in frequencies of a trait in a population) **Using Mathematical and Computational Thinking** (calculate frequencies of a characteristic in an organism over time) **Constructing Explanations** (construct an explanation about how the environment affects the traits of an organism in a population) **Analyze and Interpret Data** (compare graphs and data to analyze selection pressure on a bug population)	Unit Level: **Stability and Change** Section Level: **Cause and Effect** **Patterns** **Scale, Proportion, and Quantity**

Section 3.3: Students delve deeper into selection pressure and transfer of traits by reading about Charles Darwin's study of animals on the Galapagos Islands. They build academic vocabulary as they gain an understanding of the evidence for environmental selection pressures on an organism. They read how Darwin built on his observations in the Islands with what he knew from fossils to develop his theory of natural selection. As they read about natural selection, they develop an understanding of how this process leads to evolution and how individuals with the best traits for an environment live to reproduce. *More to Learn:* Students continue to develop understanding of how the fossil record supports the evidence for evolution. **Disciplinary Core Ideas:** **LS4.A: Evidence of Common Ancestry and Diversity** · The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (MS-LS4-1) **LS4.B: Natural Selection** · Natural selection leads to the predominance of certain traits in a population, and the suppression of others. (MS-LS4-4)	**Obtaining, Evaluating, and Communicating Information** (reading supports development of scientific knowledge and the building of academic vocabulary)	Unit Level: **Stability and Change** **Structure and Function** Section Level: **Cause and Effect** **Patterns**
Section 3.4: Students simulate the feeding behavior of birds with variations in beak design. They simulate a drought on two islands in which only one type of food is available on each island, and use the simulation to determine which beak design would survive. **Disciplinary Core Ideas:** **LS4.C: Adaptation** · Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (MS-LS4-6)	**Developing and Using Models** (simulate the feeding behavior of birds with various beak designs) **Analyzing and Interpreting Data** (analyze data to determine how selection pressure works on birds with variations in beak design) **Planning and Carrying Out Investigations** (carry out an investigation to determine how beak variation effects the survival of birds when the environment changes) **Using Mathematical and Computational Thinking** (calculate the relationship between beak design, food gathering, and potential survival of a bird)	Unit Level: **Stability and Change** **Structure and Function** Section Level: **Cause and Effect** **Patterns**

Section 3.5: Students design a field experiment to determine whether farmers should plant only drought-resistant rice plants or a combination of drought-resistant and normal rice plants. They combine what they know about changing environments, selection pressures and transfer of genetic traits to make predictions about the outcome of the experiment. Groups share their plans with the class, and then work to consensus as they develop a final plan to send to the Philippine Rice Farmers Cooperative. **Disciplinary Core Ideas:** **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** · Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)	**Planning and Carrying Out Investigations** (prepare a "best" procedure by using science knowledge and evidence from investigations to design an experiment)	Unit Level: **Stability and Change** Section Level: **Cause and Effect**
Section 3.6: Students read a letter from the Philippine Rice Farmers Cooperative with the results of their field experiments. They gain experience in analyzing the results to see that a trait can be an advantage in some environments, but a disadvantage in other environments. They move toward addressing the *Big Question* as they create and share explanations of the results, determining that diversity in the rice will help to protect the crops from changes in the environment. **Disciplinary Core Ideas:** **LS4.B: Natural Selection** · In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring. (MS-LS4-5)	**Analyzing and Interpreting Data** (analyze the data from field trials of breeding rice varieties) **Engaging in Argument from Evidence** (develop a statement with scientific evidence to support a claim about the impact of the environment on rice production) **Create and Explanation** (develop a statement with scientific evidence to support a claim about the impact of the environment on rice production) **Obtaining, Evaluating, and Communicating Information** (case study provides information about the results of monoculture practices)	Unit Level: **Stability and Change** Section Level: **Cause and Effect** **Scale, Proportion, and Quantity**
Section 3.7: Students develop academic vocabulary as they read about how humans have used artificial selection to develop breeds of dogs and varieties of plants to accomplish various goals. They deepen their understanding of how a population can change as traits are passed from generation to another and the risks and benefits of using artificial selection. They consider how they can apply what they have learned to the *Big Question*. **Disciplinary Core Ideas:** **LS4.B: Natural Selection** · In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring. (MS-LS4-5)	**Obtaining, Evaluating, and Communicating Information** (reading supports development of scientific knowledge and the building of academic vocabulary)	Section Level: **Cause and Effect**

Section 3.8: Students use a simulation to breed birds with desirable traits, learning that it can take many generations to create the individuals they desire. They plan their breeding program by analyzing the possible traits and genotypes of the birds, and then breed the birds with the desired traits. The simulation provides students with experience selecting traits and breeding organisms as they get ready to answer the *Big Question*. **Disciplinary Core Ideas:** **LS3.A: Inheritance of Traits** · Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2) **LS3.B: Variation of Traits** · In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. 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. (MS-LS3-2) **LS4.B: Natural Selection** · In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring. (MS-LS4-5)	**Developing and Using Models** (use computer software to simulate the breeding of birds for the desired traits) **Analyzing and Interpreting Data** (analyze data from breeding simulation to determine best possible crosses for desired offspring) **Planning and Carrying Out Investigations** (use computer software to simulate the breeding of birds for the desired traits) **Using Mathematics and Computational Thinking** (determine the best method to use when breeding birds for the desired traits)	Unit Level: **Stability and Change** Section Level: **Cause and Effect** **Scale, Proportion, and Quantity**
Back to the Big Challenge: Students use what they have learned about how traits interact with the environment to revise their recommendations about developing a more productive and nutritious rice varieties. They consider the *Big Challenge* and how they can select the traits they want in rice plants to produce the better rice. They share their revised recommendations with the class and come to consensus with a plan taking into account the desired traits, environmental factors, and the constraints of the challenge. **Disciplinary Core Ideas:** **ETS1.B: Developing Possible Solutions** · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) · Models of all kinds are important for testing solutions. (MS-ETS1-4)	**Engaging in Argument from Evidence** (use data and scientific reading to establish an explanation to support a breeding plan for better rice) **Constructing Explanations** (use data and scientific reading to establish an explanation for a breeding plan)	Unit Level: **Stability and Change** Section Level: **Cause and Effect**

Genetics: Learning Set 4
How Do Cells Grow and Reproduce?

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices	Crosscutting Concepts
Introduction to *Learning Set 4*: Students expand their knowledge and connect the concepts from earlier sections to understand genes, chromosomes and the transfer of genetic traits.	**Obtaining, Evaluating, and Communicating Information** (view a video to gain information about cell division) **Developing and Using Models** (develop a diagram to act as a model of cell division)	Unit Level: **Stability and Change** **Structure and Function** Section Level: **Cause and Effect** **Patterns**
Section 4.1: Students watch a video of a cell dividing and observe what happens to the chromosomes in the cell. They sketch their observations and use their diagrams as a model to identify the arrangements of chromosomes in the cell. They gain understanding of how genetic material is transferred from parent to daughter cells in definite patterns and *Update the Project Board* with new knowledge. **Disciplinary Core Ideas:** **LS3.A: Inheritance of Traits** · Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (MS-LS3-1)		
Section 4.2: After viewing a video, students use microscopes to observe cells from the tips of onion roots in different stages of cell division. They watch an animation of cell division, comparing the steps illustrated in the animation to the steps they identified in their observations. From this analysis, they learn that the chromosomes of a cell are duplicated during cell division. Students discuss their observations with their groups and then design a kinetic simulation of cell division connecting what they learn to help answer the *Big Question*. **Disciplinary Core Ideas:** **LS3.A: Inheritance of Traits** · Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (MS-LS3-1)	**Obtaining, Evaluating, and Communicating Information** (view a video, prepared slides and an animation to gain understanding of cell division) **Developing and Using Models** (build a kinetic modes to simulate the process of cell division)	Unit Level: **Structure and Function** Section Level: **Patterns** **Systems and System Models**

Section 4.3: Students gain academic vocabulary as they read about cell division that will help them understand how genetic information is carried by cells during reproduction and answer the *Big Question*. They learn the phases of mitosis connecting their understanding of cell division from earlier *Learning Sets*. They also learn how errors in mitosis can lead to cancer, and *Update the Project Board* with new knowledge about variations within the genetic code. *More to Learn:* Students deepen their knowledge about how organisms can reproduce asexually. **Disciplinary Core Ideas:** **LS3.A: Inheritance of Traits** · Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (MS-LS3-1)	**Obtaining, Evaluating, and Communicating Information** (reading supports development of scientific knowledge and the building of academic vocabulary on cell reproduction)	Unit Level: **Stability and Change** **Structure and Function** Section Level: **Cause and Effect** **Systems and System Models**
Section 4.4: Students explore why there is so much variation among organisms. They observe a video of how zygotes are produced from male and female sex cells adding to their knowledge of the transfer of genetic material and population variation. Students read about sexual reproduction and use their observations and the reading to construct and revise explanations on what causes variation among organisms. They share and review their group's ideas with the class and come to an agreement on an explanation. *More to Learn:* Students add to their knowledge of errors in the transfer of the genetic code. **Disciplinary Core Ideas:** **LS3.B: Variation of Traits** · In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. 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. (MS-LS3-2)	**Obtaining, Evaluating, and Communicating Information** (reading supports development of scientific knowledge and the building of academic vocabulary on meiosis and population variation) **Developing and Using Models** (use diagrams to help develop understanding of cell division) **Constructing Explanations** (develop a statement with supporting evidence to explain the variation in organisms that reproduce sexually)	Unit Level: **Stability and Change** **Structure and Function** Section Level: **Cause and Effect** **Patterns**
Section 4.5: Students read about DNA and its structure as the basis of genetic information, the history of DNA research, and about how knowledge of DNA has changed scientists' understanding of genetics. Students begin to think about how they can use their understanding of DNA to develop the better rice variety as they answer the *Big Question*. *More to Learn*: Students deepen their understanding about genetic engineering, reinforcing the science they have learned with examples of real-world applications. **Disciplinary Core Ideas:** **LS3.B: Variation of Traits** · In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. 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. (MS-LS3-2)	**Obtaining, Evaluating, and Communicating Information** (reading supports development of scientific knowledge and the building of academic vocabulary about DNA)	Section Level: **Cause and Effect** **Scale, Proportion, and Quantity**

Back to the Big Challenge: Students determine what genes a rice plant would need in order meet the criteria of the *Big Challenge*. They construct recommendations to RBWI explaining how the traits they chose for their rice plants meet the criteria and constraints of the challenge. After discussing their recommendations with the class, they revise their recommendations and agree on a final recommendation from the class. **Disciplinary Core Ideas:** **ETS1.B: Developing Possible Solutions** · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) · Models of all kinds are important for testing solutions. (MS-ETS1-4)	**Constructing Explanations** (use evidence from reading and investigations to create recommendations about how to produce a better rice variety)	Unit Level: **Stability and Change** Section Level: **Patterns** **Cause and Effect**

Genetics: Address the Big Challenge
Make Recommendations About Developing a New Rice Plant That Will Produce More Rice and More Nutritious Rice

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices	Crosscutting Concepts
Students create and revise their final recommendations to RBWI. They describe what types of rice are important to grow, what types of crosses scientists should make, and what procedures farmers should use. Students share their recommendations with the class and answer questions, supporting their claims with evidence and science knowledge. **Disciplinary Core Ideas:** **ETS1.B: Developing Possible Solutions** · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) · Models of all kinds are important for testing solutions. (MS-ETS1-4) **ETS1.C: Optimizing the Design Solution** · Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3) · The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)	**Constructing Explanations** (use evidence from reading and investigations to create recommendations about how to produce a better rice variety) **Engaging in Argument from Evidence** (use evidence from reading and investigations to create recommendations about how to produce a better rice variety. Share their ideas with the class)	Section Level: **Cause and Effect** **Scale, Proportion, and Quantity**

Genetics: Answer the Big Question ***How Can Knowledge of Genetics Help Feed the World?***		
Storyline (with Disciplinary Core Ideas and Science Content)	**Science and Engineering Practices**	**Crosscutting Concepts**
Students bring together their scientific learning and experiences to develop a proposal on how genetics can help feed the world. They select possible ways the knowledge of genetics, select a specific food, describe ways to change it for better and how scientist should be careful about making the genetic changes. Students identify advantages and disadvantages to their proposal and communicate their proposals to the class. **Disciplinary Core Ideas:** **ETS1.B: Developing Possible Solutions** · A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) · Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) · Models of all kinds are important for testing solutions. (MS-ETS1-4) **ETS1.C: Optimizing the Design Solution** · Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3) · The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)	**Constructing Explanations** (use evidence from reading and investigations to create a proposal about how to feed the world using genetics) **Engaging in Argument from Evidence** (use evidence from reading and investigations to create recommendations about how to use the knowledge of genetics to improve the food quality for the world)	Unit Level: **Stability and Change** Section Level: **Cause and Effect**