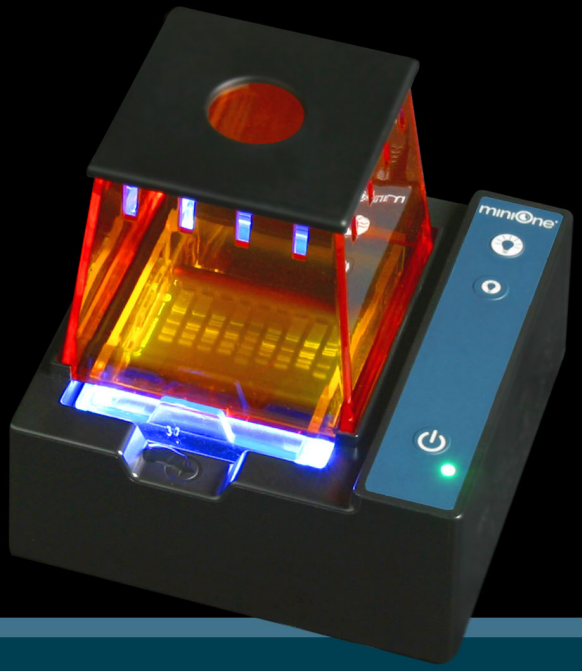
miniOne® SYSTEMS

LEARNING SCIENCE by DOING SCIENCE

Engaging Students Through Inquiry-Based Instruction



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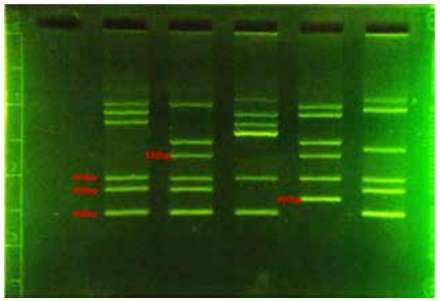
NEXT GENERATION SCIENCE STANDARDS

Alignment of **MiniOne® MiniLabs** to the Next Generation Science Standards

The **MiniOne® Electrophoresis System** provides students with the tools needed to learn Next Generation Science Standards (NGSS) through hands-on application of biotechnology principles.

Gel electrophoresis is the key technology used in DNA fingerprinting, a method whereby technicians are able to analyze DNA taken from multiple tissue samples and determine if they came from the same person, from two closely related individuals, or from two different, unrelated individuals. For example, DNA fingerprinting is commonly used for paternity testing and in forensic science to identify crime scene victims or suspects. Gel electrophoresis is also used in biomedical research to identify genetic variations in DNA samples of people suffering from particular diseases.



Horizontal banding patterns created by five separate DNA samples using gel electrophoresis.

Gel electrophoresis essentially works by using an electrical field to separate DNA fragments from one another based on their size. This creates a banding pattern in which clumps (bands) of the smallest fragments move the furthest from the start point and bands of the largest fragments remain closest to the start point, with bands of intermediary-sized fragments spread between. Since the fragments are cut from known regions of a chromosome, the resulting banding pattern can be compared to known reference samples, or to those from other individuals, in order to analyze and make meaning of the results. Gel electrophoresis can also be used to separate and identify *proteins* based on their size and electrical charge.

Gel Electrophoresis & The Disciplinary Core Ideas of NGSS

A complete understanding of gel electrophoresis involves learning principles of genetics, macromolecular structure of proteins and nucleic acids (DNA and RNA), how restriction enzymes are used to cut chromosomes into variously sized DNA fragments based on nucleotide sequence, and how those fragments interact with an electrical charge. It also involves an understanding how electrical fields work and the need for a buffer to conduct the electrical charge and to stabilize pH within the system. Thus, teaching students how gel electrophoresis works involves teaching them principles of biology, chemistry and physics, thereby emphasizing the truly integrative nature of science.

The following disciplinary Core Ideas (DCI's) are implicit in understanding gel electrophoresis technology. Depending on the grade level, teachers can scale up or scale down the complexity of the student learning expectations.

Disciplinary Core Ideas (DCIs)

DCI Category	GRADE 3-5	GRADE 6-8	GRADE 9-12
PS1.A Structure of Matter	Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means.	Matter is composed of atoms and molecules.	The sub-atomic structural model and interactions between electric charges at the atomic scale can be used to explain the structure and interactions of matter.
LS1.A: Structure and Function			All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.
LS1.B Growth and Development of Organisms		Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring.	
LS1.C Organization for Matter and Energy Flow in Organisms			The hydrocarbon backbones of sugars produced through photosynthesis are used to make amino acids and other molecules that can be assembled into proteins or DNA.

DCI Category	GRADE 3-5	GRADE 6-8	GRADE 9-12
LS3.A Inheritance of Traits	Many characteristics of organisms are inherited from their parents.	Genes chiefly regulate a specific protein, which affect an individual's 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. Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited.	Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.
LS3.B Variation of Traits	Different organisms vary in how they look and function because they have different inherited information.	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.	DNA carries instructions for forming species' characteristics. Each cell in an organism has the same genetic content, but genes expressed by cells can differ.
PS2.B Types of interaction	The effect of unbalanced forces on an object results in a change of motion. Patterns of motion can be used to predict future motion. Some forces act through contact, some forces act even when the objects are not in contact.	Forces that act at a distance involve fields that can be mapped by their relative strength and effect on an object.	Forces at a distance are explained by fields that can transfer energy and can be described in terms of the arrangement and properties of the interacting objects and the distance between them. These forces can be used to describe the relationship between electrical and magnetic fields. Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

PS - Physical Science / LS - Life Science *These standards have been taken word for word or paraphrased from the NGSS Document*

In addition to the life science and physical science DCIs embedded in learning about gel electrophoresis, the *Science, Technology, Society and the Environment* standards are highly relevant to using the MiniOne® System and MiniLabs. While not technically part of the DCIs, the *Science, Technology, Society and the Environment* standards are most easily grouped with them and are outlined below.

Science, Technology, Society and the Environment

Standard Category	GRADE 3-5	GRADE 6-8	GRADE 9-12
Interdependence of Science, Engineering and Technology	Science and technology support each other. Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies.	Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems. Science and technology drive each other forward.	Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.

MiniOne® and the Science & Engineering Practices of NGSS

Science and Engineering Practices (SEPs) are the second dimension of NGSS and are arguably the most important as they involve teaching students *how* to do science and engineering by applying critical thinking skills to solve problems using methodical approaches. In addition to coaching students on the use of SEPs, it is important to provide students with time for reflection in order to promote metacognition as well.

The structure of a lesson is highly dependent on which SEP(s) the instructor wishes students to practice. All **MiniOne® MiniLabs** start with a real-world phenomenon to stimulate student practice of one or more SEPs by engaging natural student curiosity. See the *MiniOne® MiniLab Alignment to NGSS* section for details about the phenomenon and SEP(s) central to each **MiniOne® MiniLab**.

MiniOne® and the Crosscutting Concepts of NGSS

The third and final dimension of NGSS are the Crosscutting concepts (CCs). Crosscutting concepts are “big ideas” that emphasize the interdisciplinary nature of science. They are recurring themes that help students identify commonalities within the natural world, thereby helping students build on prior learning and develop efficient methods for approaching new questions and problems. Crosscutting concepts are easily emphasized during instruction of gel electrophoresis and are also embedded in **MiniOne® MiniLabs**. See the *MiniOne® MiniLab Alignment to NGSS* section for details about the crosscutting concepts central to each **MiniOne® MiniLab**.

MiniOne® MiniLab Alignment to NGSS

MiniOne® MiniLabs meet all three dimensions of the NGSS for various standards in grades 3-12, as outlined below. Teachers can use **MiniOne® MiniLabs** independently to practice a few target standards, or embed them in a complete unit of learning that involves a more comprehensive set of standards. For example, **MiniOne® MiniLabs** make great "elaborate" activities in a 5E lesson plan, a unit planning strategies recommended in NGSS.

Overview of Alignment of MiniOne® MiniLabs to NGSS

MiniLab	DCIs	SEPs	CCs
M3002 Gel Loading Practice MiniLab	• Interdependence of Science, Engineering and Technology	• Using Mathematics and Computational Thinking	• Scale, Proportion, and Quantity
M3001 Electrophoresis 101 MiniLab	• PS2.B Types of Interaction • Interdependence of Science, Engineering and Technology	• Analyzing and Interpreting Data • Using Mathematics and Computational Thinking	• Scale, Proportion, and Quantity • Energy and Matter
M3003 Fingerprinting MiniLab	• LS1.A Structure and Function • LS1.B Growth and Development of Organisms • LS3.A Inheritance of Traits • LS3.B Variation of Traits • Interdependence of Science, Engineering and Technology	• Analyzing and Interpreting Data	• Patterns
M3003 PTC Genetics MiniLab	• LS1.A Structure and Function • LS1.B Growth and Development of Organisms • LS3.A Inheritance of Traits • LS3.B Variation of Traits • Interdependence of Science, Engineering and Technology	• Analyzing and Interpreting Data	• Patterns
M3005 CSI Forensics MiniLab	• LS1.A Structure and Function • LS1.B Growth and Development of Organisms • LS3.A Inheritance of Traits • LS3.B Variation of Traits • Interdependence of Science, Engineering and Technology	• Analyzing and Interpreting Data	• Patterns

MiniLab	DCIs	SEPs	CCs
M3006 Forensic Science: Foodborne Outbreak Investigation MiniLab	• PS1.A Structure of Matter • LS1.A: Structure and Function • LS1.C Organization for Matter and Energy Flow in Organisms • LS3.A Inheritance of Traits • LS3.B Variation of Traits • Interdependence of Science, Engineering and Technology	• Analyzing and Interpreting Data • Planning and Carrying Out Investigations • Engaging in Argument from Evidence • Constructing Explanations	• Patterns • Cause and Effect: Mechanisms and Explanations

Detailed Alignment of MiniOne® MiniLabs to NGSS

M3002 Gel Loading Practice MiniLab	
Phenomenon	How do scientists measure and dispense very small volumes?
Grade Level	This lab teaches students how to use a micropipette and requires a mathematical understanding of decimals. It is appropriate for grades 4-12.
DCIs	**Interdependence of Science, Engineering and Technology** In grades 3-5: Tools and instruments are used to answer scientific questions.
SEPs	**Using Mathematics and Computational Thinking** In grades 3-5: Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems.
CCs	**Scale, Proportion, and Quantity** In grades 3-5: Students use standard units to measure and describe physical quantities such as weight, time, temperature, and volume.

Detailed Alignment of MiniOne® MiniLabs to NGSS

M3001 Electrophoresis 101 MiniLab	
Phenomenon	How can electricity be used to separate mixtures of macromolecules?
Grade Level	This lab introduces students to gel electrophoresis principles. It involves advanced data analysis and mathematics skills, including a mathematical understanding of standard curves. Learning basic gel electrophoresis principles is appropriate for grades 4-12; however, student worksheets for this lab, which include the standard curve component, are appropriate for grades 9-12.
DCIs	**PS2.B Types of Interaction** In grades 3-5: The effect of unbalanced forces on an object results in a change of motion. Patterns of motion can be used to predict future motion. Some forces act through contact, some forces act even when the objects are not in contact In grades 6-8: Forces that act at a distance involve fields that can be mapped by their relative strength and effect on an object. In grades 9-12: Forces at a distance are explained by fields that can transfer energy and can be described in terms of the arrangement and properties of the interacting objects and the distance between them. These forces can be used to describe the relationship between electrical and magnetic fields. **Interdependence of Science, Engineering and Technology** In grades 3-5: Tools and instruments are used to answer scientific questions. In grades 6-8: Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems. In grades 9-12: Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.
SEPs	**Analyzing and Interpreting Data** In grades 3-5 • Introduce quantitative approaches to collecting data and conducting multiple trials of qualitative observations. • Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. • Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. In grades 6-8 • Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships. • Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships. In grades 9-12: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

M3001 Electrophoresis 101 MiniLab	
SEPs	**Using Mathematics and Computational Thinking** In grades 3-5 • Extend quantitative measurements to a variety of physical properties and use computation and mathematics to analyze data. • Organize simple data sets to reveal patterns that suggest relationships. • Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems. In grades 6-8 • Use mathematical representations to describe and/or support scientific conclusions and design solutions. • Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems. In grades 9-12 • Use algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems.
CCs	**Scale, Proportion, and Quantity** In grades 3-5: Students use standard units to measure and describe physical quantities such as weight, time, temperature, and volume. **Energy and Matter** In grades 3-5: Students learn matter is made of particles and energy can be transferred in various ways and between objects. In grades 6-8: Students learn within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). In grades 9-12: Students can describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system. It only moves between one place and another place, between objects and/or fields, or between systems.

Detailed Alignment of MiniOne® MiniLabs to NGSS

M3004 DNA Fingerprinting MiniLab	
Phenomenon	How can we use DNA samples to determine paternity?
Grade Level	This lab introduces students to basic gel electrophoresis principles and paternity testing. It involves intermediate data analysis and introductory knowledge of genetics principles. It is appropriate for grades 4-12. The student worksheets are appropriate for grades 9-12, but students in grades 4-8 could use them with additional teacher support.
DCIs	**LS1.A Structure and Function** In grades 9-12: All cells contain genetic information in the form of DNA molecules. **LS1.B Growth and Development of Organisms** In grades 6-8: Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. **LS3.A Inheritance of Traits** In grades 3-5: Many characteristics of organisms are inherited from their parents. In grades 6-8: • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. • Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. In grades 9-12: Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. **LS3.B Variation of Traits** In grades 3-5: Different organisms vary in how they look and function because they have different inherited information. In grades 6-8: 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. In grades 9-12: DNA carries instructions for forming species' characteristics. Each cell in an organism has the same genetic content, but genes expressed by cells can differ. **Interdependence of Science, Engineering and Technology** In grades 3-5: Tools and instruments are used to answer scientific questions.

	In grades 6-8: Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems. In grades 9-12: Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.
SEPs	**Analyzing and Interpreting Data** In grades 3-5 • Introduce quantitative approaches to collecting data. • Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. In grades 6-8: Analyze and interpret data to provide evidence for phenomena. In grades 9-12: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
CCs	**Patterns** In grades 3-5: Students identify similarities and differences in order to sort and classify natural objects and designed products. In grades 6-8: Students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data. In grades 9-12: Students observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena. They use mathematical representations to identify certain patterns and analyze patterns of performance in order to reengineer and improve a designed system.

Detailed Alignment of MiniOne® MiniLabs to NGSS

M3003 PTC Genetics MiniLab	
Phenomenon	How is it possible for an individual to have a trait that no one else in his or her family has?
Grade Level	This lab teaches students how to use gel electrophoresis to identify target genes and introduces them to restriction enzyme digestion. It requires an advanced understanding of genetics principles and is appropriate for grades 9-12. It could also be used to help illustrate basic genetics principles to grades 6-8 with modifications to simplify it.
DCIs	**LS1.A Structure and Function** In grades 9-12: All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. **LS1.B Growth and Development of Organisms** In grades 6-8: Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. **LS3.A Inheritance of Traits** In grades 6-8: • Genes chiefly regulate a specific protein, which affect an individual's 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. • Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. In grades 9-12: Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. **LS3.B Variation of Traits** In grades 6-8: 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. In grades 9-12: DNA carries instructions for forming species' characteristics. Each cell in an organism has the same genetic content, but genes expressed by cells can differ. **Interdependence of Science, Engineering and Technology** In grades 6-8: Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems. In grades 9-12: Science and engineering complement each other in the cycle known as research and development (R&D).

M3003 PTC Genetics MiniLab	
SEPs	**Analyzing and Interpreting Data** In grades 6-8 • Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships. • Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships. • Analyze and interpret data to provide evidence for phenomena. • Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible. In grades 9-12 • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.
CCs	**Patterns** In grades 6-8: Students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data. In grades 9-12: Students observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena. They use mathematical representations to identify certain patterns and analyze patterns of performance in order to reengineer and improve a designed system.

Detailed Alignment of MiniOne® MiniLabs to NGSS

M3005 CSI Forensics MiniLab	
Phenomenon	How can a hair sample be matched to an individual? How can fingerprints be matched to an individual? How can a DNA sample be matched to an individual?
Grade Level	This lab introduces students to fingerprint and hair analysis, and to DNA fingerprinting using gel electrophoresis. It involves intermediate data analysis and introductory knowledge of genetics principles, and is appropriate for grades 4-12. The student worksheets are appropriate for grades 6-12, but students in grades 4-5 could use them with additional teacher support.
DCIs	**LS1.A Structure and Function** In grades 9-12: All cells contain genetic information in the form of DNA molecules. **LS1.B Growth and Development of Organisms** In grades 6-8: Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. **LS3.A Inheritance of Traits** In grades 3-5: Many characteristics of organisms are inherited from their parents. In grades 6-8: • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. • 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. • Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. In grades 9-12: Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. **LS3.B Variation of Traits** In grades 3-5: Different organisms vary in how they look and function because they have different inherited information. In grades 6-8: 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. In grades 9-12: DNA carries instructions for forming species' characteristics. Each cell in an organism has the same genetic content, but genes expressed by cells can differ. **Interdependence of Science, Engineering and Technology** In grades 3-5: Tools and instruments are used to answer scientific questions. In grades 6-8: Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems.

SEPs	**Analyzing and Interpreting Data** In grades 3-5 • Introduce quantitative approaches to collecting data. • Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. • Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. In grades 6-8 • Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships. • Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships. • Analyze and interpret data to provide evidence for phenomena. • Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible. In grades 9-12 • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.
CCs	**Patterns** In grades 3-5: Students identify similarities and differences in order to sort and classify natural objects and designed products. In grades 6-8: Students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data. In grades 9-12: Students observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena. They use mathematical representations to identify certain patterns and analyze patterns of performance in order to reengineer and improve a designed system.

M3006 Forensic Science: Foodborne Outbreak Investigation MiniLab	
Phenomenon	How do epidemiologists trace the source of a foodborne illness outbreak? How can gel electrophoresis be used to identify a fragment of a target gene?
Grade Level	This lab provides students an opportunity to practice using gel electrophoresis to identify a targeted gene and to use advanced data analysis and experimental design skills to solve a real-world problem. It requires an advanced understanding of genetics principles and a basic understanding of polymerase chain reaction (PCR) technology. It is appropriate for grades 9-12; however, students in grades 6-8 could do this lab with modifications to simplify it.
DCIs	**PS1.A Structure of Matter** In grades 6-8: Matter is composed of atoms and molecules. In grades 9-12: The sub-atomic structural model and interactions between electric charges at the atomic scale can be used to explain the structure and interactions of matter. **LS1.A: Structure and Function** In grades 9-12: All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. **LS1.C Organization for Matter and Energy Flow in Organisms.** In grades 9-12: The hydrocarbon backbones of sugars produced through photosynthesis are used to make amino acids and other molecules that can be assembled into proteins or DNA. **LS3.A Inheritance of Traits.** In grades 6-8: Genes are located in the chromosomes of cells, with each chromosome pair (in sexually reproducing organisms) containing two variants of each of many distinct genes. In grades 9-12: Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. **LS3.B Variation of Traits.** In grades 9-12: DNA carries instructions for forming species' characteristics. Each cell in an organism has the same genetic content, but genes expressed by cells can differ. **Interdependence of Science, Engineering and Technology** In grades 6-8: Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems.

SEPs	**Analyzing and Interpreting Data** In grades 6-8 • Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships. • Distinguish between causal and correlational relationships in data. • Analyze and interpret data to provide evidence for phenomena. • Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials). • Analyze and interpret data to determine similarities and differences in findings. In grades 9-12 • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data. **Planning and Carrying Out Investigations** In grades 6-8 • Plan and carry out investigations that use multiple variables and provide evidence to support explanations or solutions. • Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. • Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of the investigation. • Collect data to produce data to serve as the basis for evidence to answer scientific questions under a range of conditions. In grades 9-12 • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. • Select appropriate tools to collect, record, analyze, and evaluate data.

SEPs	**Engaging in Argument from Evidence** In grades 6-8 • Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail. • Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. In grades 9-12 • Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. • Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations). **Constructing Explanations** In grades 6-8 • Construct explanations and design solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real- world phenomena, examples, or events. • Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. In grades 9-12 • Construct explanations and design solutions that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

CCs	**Patterns** In grades 6-8: Students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data. In grades 9-12: Students observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena. They recognize classifications or explanations used at one scale may not be useful or need revision using a different scale; thus requiring improved investigations and experiments. They use mathematical representations to identify certain patterns and analyze patterns of performance in order to reengineer and improve a designed system. **Cause and Effect: Mechanisms and Explanations** In grades 6-8: Students classify relationships as causal or correlational, and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. In grades 9-12: Students understand that empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.