Project-Based Inquiry Science: Air Quality
Storyline

Targeted Performance Expectations:
· MS–PS1–1 · MS–PS1–2 · MS–PS1–5 · MS–LS2–4 · MS–ESS2–5 · MS–ESS3–3 · MS–ESS3–4 · MS–ETS1–4

Air Quality: What's the Big Question?
How Can You Improve Air Quality in Your Community?

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices	Crosscutting Concepts
In the *Introduction* to *Air Quality*, students read a parable about the changes in a town due to increased air pollution from human activity. To begin thinking about the *Big Question: How can you improve the air quality in your community?* they view several pictures illustrating a human activity and determine the effects on air quality. They identify if the activity makes the air better or worse and determine the source of pollution if present. They share their initial ideas in their small group and then *Communicate* their thoughts with the class. Finally, they take an "air walk" to look for evidence of air quality in their community. They begin by predicting what they expect to see and then recording their observations, identifying sources, effects and potential solutions. They document and make public their ideas and understanding about air quality as they create the *Project Board*, including questions they would like to investigate to help answer the *Big Question*.	**Obtaining, Evaluating, and Communicating Information** (an air walk provides students with observations which they evaluate and communicate to others) **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: **Cause and Effect** Section Level: **Stability and Change**

Air Quality: Learning Set 1
What Is Air?

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 the properties of air and develop an understanding of air as matter.	**Developing and Using Models** (create a sketch of what they think air looks like under a powerful magnifying lens) **Obtaining, Evaluating, and Communicating Information** (discuss thoughts with others and revise their ideas, update the *Project Board*)	Section Level: **Patterns** **Systems and System Models**
Section 1.1: Beginning with *Section 1.1*, students create sketches that act as models to illustrate their understanding of what air would look like if they could see it through a powerful magnifying tool. They use their models to compare clean with dirty air as they share their ideas with their small groups and the class. They look for patterns in others' ideas and *Update the Project Board* with new ideas, thoughts and questions.		
Section 1.2: To emphasize and support students developing understanding of air as matter, students observe three demonstrations to determine if air takes up space. In each demonstration students predict what they think will happen and then record their observations. Combining the demonstrations with a reading about volume, they create a statement using evidence from their observations that air takes up space and has volume.	**Analyzing and Interpreting Data** (record observations during demonstrations) **Construct Explanations** (make predictions about expectations in the demonstrations, create explanations for observed results) **Obtaining, Evaluating, and Communicating Information** (evaluate their observations of the demonstrations and revise their ideas)	Unit Level: **Cause and Effect** Section Level: **System and System Models**

Section 1.3: Students continue to investigate the properties of air as they answer the question: Does air have mass? This characteristic of all matter will help them define their understanding of the nature of air. Drawing from their developing model, students predict the outcome for the demonstrations, record their observations, compare their observations with others and come to a consensus on whether air has mass. In small groups, they create a statement using evidence from sections *1.1* and *1.2* to determine whether air is matter, they share their explanation with the class and then update the *Project Board* with their new knowledge, their claim and evidence about air being matter, and more questions.	**Analyzing and Interpreting Data** (analyze data from investigations, create a graph) **Obtaining, Evaluating, and Communicating Information** (read about matter and share ideas with others) **Constructing Explanations** (create an explanation about the arrangement of particles in the three states of matter) **Planning and Carrying Out Investigations** (develop a simulation to illustrate particle movement at various temperatures) **Developing and Using Models** (develop a simulation to illustrate particle arrangement in the three states of matter)	Unit Level: **Cause and Effect** Section Level: **System and System Models**
Section 1.4: With the consensus that air is matter, students explore the three common states of matter, solid, liquid and gas. In a short read they are introduced to the concepts of atoms, elements and molecules, and how the changes of state occur when energy is added to or removed from a system. Students examine diagrams which model the arrangement of particles in the three common states and revisit their early sketches of air, identifying how their models are similar to or different from the models in the reading. They then revise their models to represent what their current understanding. In their small groups, students develop and then run a simulation using students as particles to illustrate the difference between the three states of matter and discuss the accuracy of this model with their peers. A short read recaps the characteristics of matter at the atomic level to aide student understanding. In a *More to Learn* investigation, students explore the connection between input of energy and the changes of state of water. They analyze their data with a graph. **Disciplinary Core Ideas:** **PS1.A: Structure and Properties of Matter** · Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4) · In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (MS-PS1-4) · The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (MS-PS1-4)	**Analyzing and Interpreting Data** (analyze data from investigations, create a graph) **Obtaining, Evaluating, and Communicating Information** (read about matter and share ideas with others) **Constructing Explanations** (create an explanation about the arrangement of particles in the three states of matter) **Planning and Carrying out Investigations** (develop a simulation to illustrate particle movement at various temperatures) **Developing and Using Models** (develop a simulation to illustrate particle arrangement in the three states of matter)	Unit Level: **Cause and Effect** **Energy and Matter** Section Level: **Stability and Change** **Systems and System Models**

Back to the Big Question: As they return to the section's *Big Question, What is Air?* and prepare to answer the Unit's *Big Question*, students now apply their understanding of air as matter, the three common states of matter, and the connection between energy and the changes of states. Students update their earlier sketch of air under a powerful magnifying tool. They share their current model in their small group and with the class. Then revise their explanations that air is matter. They share and revise their explanations in a short discussion and then update the *Project Board*. **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) · Models of all kinds are important for testing solutions. (MS-ETS1-4)	**Engaging in Argument from Evidence** (students defend their statements about air as matter, drawing from evidence) **Constructing Explanations and Designing Solutions** (using evidence from investigations, observations and reading to create a scientific explanation about the motion of particles in the three states of matter) **Asking Questions and Defining Problems** (update the *Project Board* with new questions for investigation to help address the *Big Challenge*) **Developing and Using Models** (revise their early sketches of air based on their current understanding using the models to motivate discussion and synthesize evidence from demonstrations)	Unit Level: **Cause and Effect** **Energy and Matter** Section Level: **Stability and Change** **Systems and System Models**

Air Quality: Learning Set 2
What Is in Air?

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 the substances that make up air an develop an explanation that air is a mixture of gases.	**Asking Questions** (formulate questions to answer which will help come to agreement about the composition of air) **Using Mathematics and Computational Thinking** (create a pie chart to predict the percent composition of the substances in air) **Analyzing and Interpreting Data** (interpret observations of a demonstration)	Unit Level: **Cause and Effect** Section Level: **Scale, Proportion, and Quantity**
Section 2.1: Using the common understanding that air is the same as oxygen, students watch a demonstration of fire in air and in pure oxygen. They reflect on the differences and use this as evidence that air must be different from pure oxygen. Then, students create a pie chart to represent their current thinking about the composition of air and predict the relative amounts of different substances within air. They share their graphs with the class and discuss similarities and differences in the current graphs. They add their current ideas and questions to investigate about the components of air and whether the mixture is homogenous or heterogenous to the *Project Board*.		
Section 2.2: Students begin by identifying the number of different substances in air and the relative quantity of each as they use a model of air where one colored sphere represents on percent of a sample and each color represents one substance. Through the model students are able to calculate and describe the type and percentage of substances in air and identify that air is a heterogenous mixture.	**Developing and Using Models** (use a model of representative sampling to determine the percent of several gases in the atmosphere) **Analyzing and Interpreting Data** (collect data and analyze the percent composition of the gases in the atmosphere	Section Level: **Scale, Proportion, and Quantity** **Systems and System Models**

Section 2.3: Students build on their description of air from the previous model and obtain additional information by reading about the scientific explorations of Joseph Priestly as he investigated air and its components. They read about the main components of air, oxygen, carbon dioxide, and nitrogen as well as argon, in text and diagrams representing atoms, molecules and compounds. Students also read about air as a solution. They compare their current ideas with earlier predictions, and as a class update the *Project Board.* **Disciplinary Core Ideas:** **PS1.A: Structure and Properties of Matter** · Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)	**Obtaining, Evaluating and Communicating Information** (reading supports the developing scientific explanation of air as a solution) **Asking Questions** (formulate questions to help address the *Big Question* and learn more about air)	Section Level: **Systems and System Models**
Section 2.4: Students are introduced to the atomic model kit. They learn that there are two ways to build molecules - stable and unstable. Stable molecules have filled holes and no empty "grey rods". They mess about with the kits, using the atomic models to build many stable molecules with the "red (oxygen), blue (nitrogen) and silver (argon) spheres" and record the models they build, labeling each atom. They observe the differences among the atoms and the molecules they can build with each atom, following the rules for stability and note that all the atoms are different, include argon, which has no holes. Students read about chemical formulas as one way to represent molecules.Next, they build oxygen and nitrogen molecules, using the appropriate atoms and making sure the molecules are stable. This time they include the sketch and the molecular formula for each molecule. Students then analyze the data they have collected and reflect on the differences between the molecules. In the third investigation, students use the atomic modeling materials to build unstable molecules. They analyze their data and begin to make conjectures about stable and unstable molecules. They read about the analogs of the model materials and then connect their ideas about stable and unstable molecules to pollutants in air. Using evidence from the model building and readings, students create claims and update the *Project Board.* **Disciplinary Core Ideas:** **PS1.A: Structure and Properties of Matter** · Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)	**Developing and Using Models** (use models to observe phenomenon that are too small to see, model molecules to build stable molecules, oxygen and nitrogen molecules, and three new molecules using N, O, and Ar) **Analyzing and Interpreting Data** (collect data to support the phenomenon of stable vs. non-stable molecules) **Constructing Explanations** (use evidence to make a statement about the stable and unstable atoms and molecules of oxygen, nitrogen, and argon)	Section Level: **Systems and System Models**

Section 2.5: Students used the model materials to see that atoms "bond" to make molecules. Now students obtain additional information through reading to answer the question, what causes atoms to join together? Using a timeline, students read about how the atomic theory has changed over time, in light of changes in ways to collect evidence. Students learn academic terms for ideas they have investigated in the models as well as being introduced to atoms being composed of subatomic particles. Students investigate electrical charges to experience and better understand a force holding atoms together. They read additional information about atomic bonding, linking these ideas to the atomic model components they have been using to build molecules. They then update their claims, including using academic language and their "science knowledge" from the reading, and add them to the *Project Board*. In a *More to Learn*, students are introduced to the organization of the periodic table of elements. **Disciplinary Core Ideas:** **PS1.A: Structure and Properties of Matter** · Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)	**Obtaining, Evaluating, and Communicating Information** (reading supports the developing scientific explanation of atomic structure and bonding) **Asking Questions** (formulate questions to help address the *Big Question* and learn more about the atomic theory) **Developing and Using Models** (use models to observe phenomenon that are too small to see and illustrate molecular structure)	Unit Level: **Cause and Effect** Section Level: **Systems and System Models**
Section 2.6: Students are introduced to particulate matter as a part of air, a product of combustion, and a pollutant through a demonstration in which a match is burnt. They read about the formation of particulate matter and the structure of molecules of soot. They obtain additional information about physical and chemical changes and the need of fuel in combustion. They then build models of carbon dioxide and water molecules, using carbon, hydrogen and oxygen "atoms" from the model kit. For each molecule, students use the chemical formula to identify the number of atoms in each molecule and diagram the model. They make connections to stable molecules by identifying that both carbon dioxide and water are stable and why, based on the rules of the models. They update the *Project Board* with their current knowledge about combustion, air pollution and molecular stability and updated academic knowledge. **Disciplinary Core Ideas:** **PS1.A: Structure and Properties of Matter** · Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1) · The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (MS-PS1-4)	**Obtaining, Evaluating, and Communicating Information** (reading supports the developing scientific explanation of atomic structure and bonding) **Asking Questions** (formulate questions to help address the *Big Question* and learn more about the atomic theory) **Developing and Using Models** (use models to observe phenomenon that are too small to see and illustrate molecular structure)	Unit Level: **Cause and Effect** Section Level: **Systems and System Models**

Section 2.7: In small groups, students investigate the answer to the question, How much pollution is combustion causing in your community? by building a particulate matter collector and negotiating, based on their predictions, where they think they should hang the collector to gather evidence to answer the question. After 48 hours, they record and analyze the data. Each small group prepares a presentation to explain their investigation, including why they chose their location, how their results compared with expectations, and what the results mean related to air pollution in general and air pollution in their community. In a *More To Learn* students obtain information about the role of water vapor in Earth's atmosphere. **Disciplinary Core Ideas:** **ESS3.C: Human Impacts on Earth Systems** · Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)	**Planning and Carrying Out Investigations** (build a pollution catcher and determine the location for testing) **Analyzing and Interpreting Data** (analyze the particulates found on the pollution catcher) **Constructing Explanations** (describe how the particulate matter analysis relates to air pollution in the community)	Unit Level: **Cause and Effect** Section Level: **Patterns** **Scale, Proportion, and Quantity**
Back to the Big Question: *Answering the Big Question* requires students to determine the causes and effects of air quality in their community. Pulling together what they have learned from the Learning Set, students update their initial drawings to include oxygen, argon, nitrogen, carbon dioxide and water molecule representations. They share the sketches with their small group and the class. Using this information, small groups revise the explanation from *Learning Set 1* about what is air. They use evidence and scientific knowledge to support the new explanation and write a statement that connects the evidence and the claim. Groups share their explanation with the class and then revise based on what they learn from other groups. Students revisit the pictures of human activity from *Learning Set 1* and revise, if necessary, their initial ideas about which ones cause pollution and which ones do not. **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) · Models of all kinds are important for testing solutions. (MS-ETS1-4)	**Constructing Explanations** (update their explanation about air using evidence from observations, models and science knowledge) **Systems and System Models** (use sketches as models to represent the components of the atmosphere)	Unit Level: **Cause and Effect** Section Level: **Systems and System Models**

Air Quality: Learning Set 3
What Are Pollutants, and How Do They Get Into Air?

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices	Crosscutting Concepts
Introduction to *Learning Set 3*: Students have investigated the nature of air as a gas and explored particulates as pollution. They build on this knowledge adding other kinds of pollution and their sources.	**Analyzing and Interpreting Data** (data from a dilution activity is analyzed to demonstrate percent concentration, ppm, ppb) **Obtaining, Evaluating, and Communicating Information** (reading supports the developing scientific explanation for concentration and dilution) **Asking Questions** (formulate questions to help address the *Big Question* and learn more about the sources of air pollution)	Section Level: **Scale, Proportion, and Quantity** **Systems and System Models**
Section 3.1: Students read a play, *The Sickening Six*, in which they learn, through the performance, about six common air pollutants (particulate matter, carbon monoxide, mercury, ozone, nitrogen monoxide, sulfur dioxide), how they get into the air and the health problems they create. To scaffold their developing understanding and provide a tool for later learning, they keep track of what they are learning about each pollutant as the play is performed. Drawing from their information sheet, students identify characteristics of the six pollutants, which were caused by combustion, which are elements and compounds and relative concentration of the pollutants. Students share their answers with the class through a discussion and update the *Project Board*. To begin to understand how pollutants are measured, students read about units of concentration and the limits of pollutants allowed by the EPA. Critical to answering the *Big Question*, students need to understand concentration of pollutants. Students explore concentration and dilution through three activities, analyze the data from each and share it with the class. They use this information to update the *Project Board*. **Disciplinary Core Ideas:** **ESS3.C: Human Impacts on Earth Systems** · Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)		
Section 3.2: Students know that pollution lowers air quality. By reading the case study of Los Angeles' pollution, they begin to identify sources and effects of combustion from automobiles interacting with geography on air quality. They begin by making predictions about what causes air pollution in LA and then sharing their ideas in their small groups. They read the case study, documenting the sources and effects of pollution on a table similar to one used in *Learning Set 1*. Finally, they share their ideas with the class. **Disciplinary Core Ideas:** **ESS3.C: Human Impacts on Earth Systems** · Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)	**Obtaining, Evaluating, and Communicating Information** (reading supports the developing scientific explanation for the causes of air pollution)	Unit Level: **Cause and Effect** Section Level: **Scale, Proportion, and Quantity**

Section 3.3: Delving deeper into combustion, students explore how pollutants form during combustion. In doing this, they link their understanding of chemical changes to the reactions in an internal combustion engine and the products of combustion they have built models for in *Learning Set 2*. The reading also supports students making appropriate connections between the previous models built, the atomic structure of the molecules and their stability. Students focus on various representations of the combustion equation. They begin with the "equation" represented in a sentence. Then they transfer the words into symbols for each molecule, reactants and products. Students use these representations to see the connection between reactants and products and are introduced to the Law of Conservation of Matter. Students then build models for the reactants and products of combustion. They begin by using the product molecules for carbon dioxide and water that they built in *Learning Set 2* and add the molecule reactants to create model "equations" for carbon dioxide and water. Through a scaffolded process, students read about balancing chemical equations and then the combustion equation. Using this information, students build models for reactants and products of combustion molecules and discuss how the model representations help them to see the need for balancing equations and how the law of conservation of matter requires that the reactants and products need to be balanced in the models. Students add their ideas and evidence to the *Project Board*. **Disciplinary Core Ideas:** **PS1.B: Chemical Reactions** · Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3),(MS-PS1-5) · The total number of each type of atom is conserved, and thus the mass does not change. (MS-PS1-5)	**Obtaining, Evaluating, and Communicating Information** (reading about the pollutants formed from combustion, read about balanced chemical equations) **Developing and Using Models** (build molecular models of the reactants and products of combustion; build models to learn about balancing equations and the law of conservation of matter) **Using Mathematical and Computational Thinking** (use coefficients to balance chemical equations)	Unit Level: **Cause and Effect** Section Level: **Systems and System Models**
Section 3.4: Students read about what causes poor air quality in Los Angeles paying particular attention to the causes of smog and ozone. Using text and diagrams, students read about the sources and effects of these two pollutants and the cycles of reactions that are driven by the sun's energy. Students also connect ozone to stable/unstable molecules and recognize O_3 as an unstable molecule. **Disciplinary Core Ideas:** **PS1.B: Chemical Reactions** · Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3),(MS-PS1-5)	**Obtaining, Evaluating and Communicating Information** (reading supports the scientific knowledge of smog formation)	Unit Level: **Cause and Effect**

Section 3.5: Students now explore the interactions among air quality and geography, weather, and climate. Applying and deepening their knowledge of Los Angeles air quality, students make comparisons to a similarly large city with different geography, weather and climate, New York City. Students watch a demonstration of convection currents, sketching and labeling a drawing to show the motion of the fluids. They apply their sketched models to the areas in Los Angeles and New York City and how convection currents in these areas affect air quality. They then re-watch the video and check their labels and direction of motion to the video labels, checking for understanding of the interactions. Knowledge of inversions is also critical for explaining air quality in Los Angeles and students watch a video of an inversion again labeling and sketching. As they rewatch the video they check for understanding and match the model to the geography and climate of Los Angeles. Linking the experiences of *Learning Set 1,* 2, and *3* students prepare a scientific explanation for the causes of poor air quality in Los Angeles. They use evidence from their investigations and science readings to support their explanation, share their claims and evidence with the class and update the *Project Board*. In the *More To Learn*, students' develop deeper understanding of density as a property of matter and how it is measured. **Disciplinary Core Ideas:** **ESS2.D: Weather and Climate** · Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. (MS-ESS2-6) **ESS3.C: Human Impacts on Earth Systems** · Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)	**Constructing Explanations** (construct an explanation about the causes of poor air quality in Los Angeles) **Developing and Using Models** (convection and inversion models are used to increase understanding of scientific concepts) **Analyzing and Interpreting Data** (observe and analyze data from demonstrations)	Unit Level: **Cause and Effect** Section Level: **Patterns** **Systems and Systems Models**

Back to the Big Question: Students now elaborate on their understanding of the factors that affect air quality by applying their current understanding of the factors to a new city, Denver. Also a large city but with different climate and geography than Los Angeles or New York City. Using the ideas from *Learning Set 3*, they observe patterns of wind across the U.S., weather information and the mechanisms of geography from the region to predict the air quality of Denver. They seek trends in the data and examples of interactions among systems, and compare the data from Los Angeles to create an explanation about what effects air quality in Denver and share their ideas with the class. To address the *Big Question*, they begin to explore the population, climate, geography and sources of pollution in their own community to develop ideas about local air quality and update the *Project Board* with evidence linked to new knowledge. **Disciplinary Core Ideas:** **ESS3.C: Human Impacts on Earth Systems** · Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3) **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) · Models of all kinds are important for testing solutions. (MS-ETS1-4)	**Analyzing and Interpreting Data** (maps and data trends are used to create predictions) **Engaging in Argument from Evidence** (develop a prediction about the air quality of Denver based on evidence from several data sources) **Constructing Explanations** (use evidence to explain how geography, climate and other factors contribute to air pollution)	Unit Level: **Cause and Effect** Section Level: **Patterns**
Air Quality: Learning Set 4 ***How Does Air Pollution Affect Other Regions?***		
Storyline (with Disciplinary Core Ideas and Science Content)	**Science and Engineering Practices**	**Crosscutting Concepts**
Introduction to *Learning Set 4*: Students have investigated and synthesized their explanations for how air pollutants are formed and how geography, weather and other factors contribute to air quality, using Los Angeles, New York City, and Denver as case studies. In *Learning Set 4* they investigate a new form of air pollution, acid rain, its sources, environmental harm, dispersion and mitigation through a case study of the Adirondack region of New York state.	**Obtaining, Evaluating, and Communicating Information** (case study provides information about the geographical features and climate trends of the Adirondacks) **Analyzing and Interpreting Data** (data from maps and charts are used to create predictions) **Constructing Explanations** (use evidence to explain how geography, climate and other factors contribute to air pollution in the Adirondacks)	Unit Level: **Cause and Effect** Section Level: **Patterns**

Section 4.1: Expanding their knowledge of the sources and effects of air quality in Los Angeles and their community, students use data from a case study to identify the factors that contribute to poor air quality in the Adirondacks mountain region of New York state. They outline the differences between Los Angeles and Adirondacks relates to population and climate, recognizing that the factors must be different in the Adirondacks than in Los Angeles. Again, students create source/effects/solutions tables to help them organize the information from the case study and then use the current table and previous tables to compare data among cases. Students use maps to compare geography and its effect on air quality between the two regions and continue to explore ideas about sources of pollutants in the mountains compared to large cities. They discuss the effects of climate in small groups. They then share their current ideas, create tentative explanations in small groups, and update the *Project Board* as a class. **Disciplinary Core Ideas:** **LS2.A: Interdependent Relationships in Ecosystems** · Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1) **ESS3.C: Human Impacts on Earth Systems** · Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)	**Obtaining, Evaluating, and Communicating Information** (case study provides information about the geographical features and climate trends of the Adirondacks) **Analyzing and Interpreting Data** (data from maps and charts are used to create predictions) **Constructing Explanations** (use evidence to explain how geography, climate and other factors contribute to air pollution in the Adirondacks)	Unit Level: **Cause and Effect** Section Level: **Patterns**
Section 4.2: Having analyzed wind and geological maps and data tables students revise their ideas about how air pollution reached the Adirondacks and the nature of the pollution. They revisit the Sickening Sick, take a virtual trip of a coal power plant and explore the chemical reactions of coal combustion. Small groups formulate a scientific explanation for the source of the pollution in the Adirondacks using evidence from their reading and data to support their claim. After discussion, reflection and revision the class develops the best explanation so far, adds the new knowledge to the *Project Board* and new questions to investigate, which will resolve disagreements among students and complete the explanation. **Disciplinary Core Ideas:** **PS1.B: Chemical Reactions** · Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3),(MS-PS1-5) **ESS3.C: Human Impacts on Earth Systems** · Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3) · Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MSESS3-3),(MS-ESS3-4)	**Obtaining, Evaluating, and Communicating Information** (reading provides information about the wind patterns and the location of coal burning plants in the region) **Analyzing and Interpreting Data** (data from maps and charts are used to create predictions) **Constructing Explanations** (use evidence to explain how geography, climate and other factors contribute to air pollution in the Adirondacks)	Unit Level: **Cause and Effect** Section Level: **Patterns**

Section 4.3: To better understand the source of the acid rain in the Adirondacks, students begin by modeling the secondary pollutants SO_x and NO_x. As they build their models, they sketch and record atomic structure and bonding. They identify whether these molecules are stable and then build SO_3. Students recognize that by the rules used in the modeling activities, SO_3 is stable yet they are told that this is one of the limitations of this modeling activity, in fact, SO_3 is not stable and is highly corrosive. Students compare climates of Adirondack mountains to LA and read that the climate is a critical factor in determining what bonds with the unstable NOx and SOx. Through text and diagrams, students see the relationship between NOx and SOx as these molecules bond with water (H_2O) forming weak and strong acids. **Disciplinary Core Ideas:** **PS1.B: Chemical Reactions** · Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3),(MS-PS1-5)	**Developing and Using Models** (build modes to describe the formation of acid rain) **Obtaining, Communicating, Evaluating Information** (through text and diagrams develop understand of climate and its effect on air pollution	Unit Level: **Cause and Effect**
Section 4.4: Building on their understanding of acid rain developed in *Section 4.3*, students now investigate through reading what acid rain is and what acids are. Drawing from previous investigations on atomic charges, students make connections to the subatomic particles and charges to define acidity. They then read about the causes and damaging effects of acid rain. **Disciplinary Core Ideas:** **ESS3.C: Human Impacts on Earth Systems** · Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)	**Obtaining, Evaluating, and Communicating Information** (read about acid rain and the damage it causes)	Unit Level: **Cause and Effect**
Section 4.5: Using tools of scientists, students measure the acidity of several solutions. They quantify their results and apply the pH scale readings to the pH of the acid rain in the Adirondacks. They link this data with what they know to update the *Project Board* about the formation of acid rain and it's potential harm to the environment.	**Analyzing and Interpreting Data** (data from an investigation is used to compare the pH of known solutions to a sample of acid rain) **Carrying Out Investigations** (measuring the acidity of solutions)	Unit Level: **Cause and Effect** Section Level: **Scale, Proportion, and Quantity**

Section 4.6: Using four separate investigations, students work in small groups to investigate the effects of acid rain on natural and man-made materials, lake water, plant growth, stone and metal structures. When they have completed their investigations, each group provides their explanations to the other groups. Exploration A - Lake Bottoms - students watch a video and collect data from the investigation shown to explain the interaction between acid rain and the lake bottom composition of Adirondack lakes using evidence collected from the video. Exploration B - Plant Growth - students watch a video showing plant growth differences between plants watered with neutral pH water and acidic water. They explain the effects of acidic water on plant growth supporting their explanation with evidence from the video. Exploration C - Sandstone and Marble - students watch a video demonstrating the differences in effect of acid rain (acidic water) on sandstone and marble. As they learn more about the composition of rocks in the Adirondack region they can explain the cause and effect relationships between acid rain and rocks in the region using evidence from the video data. Exploration D - Metal - students observe the changes acids can cause to metals and create an explanation for the interaction between acid rain and man-made objects in the region relying on evidence from the video. The *More to Learn* reading supports students in identifying the patterns of metals and non-metals on the Periodic Table. **Disciplinary Core Ideas:** **PS1.B: Chemical Reactions** · Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3),(MS-PS1-5) **LS2.A: Interdependent Relationships in Ecosystems** · Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1) **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.D: Biodiversity and Humans** · Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary to MS-LS2-5)	**Analyzing and Interpreting Data** (data from investigations is used to develop claims about the effects of acid rain) **Constructing Explanations** (use evidence from reading and investigations to create explanations relating the effects of acid rain on various materials)	Unit Level: **Cause and Effect**

Section 4.7: Student groups build on their learning from the previous sections to revise, share and refine their four explanations from *Section 4.6*. Through presentations and discussions, students combine their scientific knowledge to create one claim about the sources of air pollution in the Adirondacks and one claim about the effects of the air pollution. After discussion, further revision and refinement the class comes to consensus on the explanations and updates the *Project Board* with what they have learned using supporting evidence. Through reading the *More to Learn*, students identify ways that air pollutants contribute to global climate change. **Disciplinary Core Ideas:** **ESS3.C: Human Impacts on Earth Systems** · Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3) **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) · Models of all kinds are important for testing solutions. (MS-ETS1-4)	**Obtaining, Evaluating and Communicating Information** (revision, communication and refining of explanations result in the preparation of posters which illustrate scientific information) **Constructing Explanations** (discussion and revision of small group explanations results in a classroom consensus on scientific learning) **Engage in Argument from Evidence** (scientific knowledge is placed on the *Project Board* which explains the source and effects of air pollution in the Adirondacks)	Unit Level: **Cause and Effect**
Back to the Big Question: Students are asked to answer the *Big Question, how can we improve air quality in our community?* They have explained the sources of various air pollutants and their effects on various materials in the environment. Now student groups begin to investigate the effects of acid rain in their community through two investigations. First, they measure the pH of three soil samples from their community using a given procedure. They link these pH readings to their recorded observations of the number of organisms at each site. In the second investigation, students measure the pH buffering capacity of the soil samples. They extend their knowledge through a reading on buffering capacity in the Adirondack region. Working in teams, students identify the effects or potential effects of acid rain in their community and propose potential solutions for acid rain. They add their current recommendations to the *Project Board*. **Disciplinary Core Ideas:** **ESS3.C: Human Impacts on Earth Systems** · Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3) **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) · Models of all kinds are important for testing solutions. (MS-ETS1-4)	**Analyzing and Interpreting Data** (data from soil analysis is used to determine how soils can neutralize acid rain) **Planning and Carrying Out Investigations** (collect data on the effects of various soil samples on acid rain) **Constructing Explanations** (explain what happens to soil that cannot neutralize, discuss whether acid rain is an air-quality problem or a water-quality problem) **Engaging in Argument from Evidence** (use evidence to justify their answer of how big a problem acid rain is in their community)	Unit Level: **Cause and Effect**

Air Quality: Learning Set 5 How Can Air Quality Be Improved?		
Storyline (with Disciplinary Core Ideas and Science Content)	**Science and Engineering Practices**	**Crosscutting Concepts**
Section 5.1: To prepare for answering *Big Question,* students read about how people have worked to enact federal and local laws to reduce air pollutants. They read more about how the EPA is charged with enforcing laws (Clean Air Act), starting in 1970, which require communities to clean up pollutants that already exist and reduce emissions of pollutants within their community. Students add information to the *Project Board*. **Disciplinary Core Ideas:** **ESS3.C: Human Impacts on Earth Systems** · Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3) · Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4)	**Asking Questions** (students create questions, which will help develop good recommendations about reducing air pollution in their community) **Obtaining, Communicating, and Evaluating Information** (students obtain information about federal and local laws to reduce air pollutants and about the EPA)	Unit Level: **Cause and Effect**
Section 5.2: Students expand their scientific knowledge by exploring methods used to remove pollutants from the air. They gather data on the effects of a catalyst reducing the activation energy of a reaction, and transfer their learning to how cars use this method to produce cleaner exhaust. They use their knowledge of balanced equations to analyze catalyzed combustion reactions. **Disciplinary Core Ideas:** **PS1.B: Chemical Reactions** · Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3),(MS-PS1-5)	**Obtaining, Evaluating, and Communicating Information** (reading increases science knowledge of the concepts of catalysts and activation energy)	Unit Level: **Cause and Effect**
Section 5.3: Students explore more methods to improve air quality. They create a procedure to separate a mixture into its components using the physical properties of the materials. They use their knowledge of density, size, magnetism, electrical charge, and solutions to develop and carry out their plan. Students transfer their experience to ideas about improving air quality and explore safe standards of concentration for various common pollutants. **Disciplinary Core Ideas:** **PS1.B: Chemical Reactions** · Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3),(MS-PS1-5)	**Planning and Carrying out Investigations** (develop a procedure for separating a mixture of various materials)	Unit Level: **Cause and Effect**

Section 5.4: Students increase their scientific knowledge about methods used to improve air quality as they move towards answering the *Big Question: How can we improve air quality in our community?* They explore fuel alternatives for cars and alternate sources of energy for communities. The class updates the *Project Board* with what they have learned about reducing pollutants in the air by either removing pollutants already in the air or generating fewer pollutants. **Disciplinary Core Ideas:** **ESS3.C: Human Impacts on Earth Systems** · Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4)	**Obtaining, Evaluating, and Communicating Information** (reading increases science knowledge of the concepts of alternative energy and fuels)	Unit Level: **Cause and Effect**
Section 5.5: Students return to their study of Los Angeles air quality to examine the role of pollution from cars and how it has changed. They examine a pollution time scale, data charts and graphs to uncover trends in the air quality over time. They combine data about population growth, changes in health levels and environmental regulations and legislation to analyze the improvement of Los Angeles air quality since the 1940s. They discuss what else could be done to improve air quality in this region as they develop their answer to the *Big Question*. **Disciplinary Core Ideas:** **ESS3.C: Human Impacts on Earth Systems** · Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4)	**Obtaining, Evaluating, and Communicating Information** (academic reading increases science knowledge of the concepts of alternative energy and fuels) **Analyzing and Interpreting Data** (compare charts, graphs, and diagrams to uncover trends in air quality) **Using Mathematical and Computation Thinking** (examine graphs, charts and time lines to look for trends)	Unit Level: **Cause and Effect**
Section 5.6: Students increase their scientific knowledge through an academic read about coal fired plant regulation aimed at reducing combustion pollutants and emissions in the eastern region of the U.S. They examine a time line of federal regulations aimed at reducing emissions over the past five decades and analyze changes in air quality as a result of these regulations. They propose a possible law to improve air quality and determine how it would affect the community. A *More to Learn* provides scientific information about indoor pollutants as an environmental concern. **Disciplinary Core Ideas:** **ESS3.C: Human Impacts on Earth Systems** · Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4)	**Obtaining, Evaluating, and Communicating Information** (reading increases science knowledge of how air quality can be improved)	Unit Level: **Cause and Effect**

Air Quality: Answer the Big Question How Can You Improve Air Quality in Your Community?	
Storyline (with Disciplinary Core Ideas and Science Content)	**Science and Engineering Practices**
Students bring together their scientific learning and experiences to develop a collaborative plan for improving air quality in their community. They select a specific air quality problem and address how to minimize the pollutants presence in the air. Student groups combine information and apply what they have learned about climate, population growth, geography and industry to develop their recommendation. Groups create a poster to communicate their recommendation with supporting evidence and science information to the class. Students take into account the cost, ease and effectiveness of each recommendation as they defend their ideas. **Disciplinary Core Ideas:** **ESS3.C: Human Impacts on Earth Systems** · Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3) **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) · Models of all kinds are important for testing solutions. (MS-ETS1-4)	**Engaging in Argument from Evidence** (students create a recommendation for improving air quality in the community using evidence from science knowledge and investigation to support the recommendation)