5th Grade – Topic Model - Bundle 1
Physical and Chemical Changes

This is the first bundle of the Fifth Grade Topic Model. Each bundle has connections to the other bundles in the course, as shown in the Course Flowchart.

Bundle 1 Question: This bundle is assembled to address the question "How much does air weigh?"

Summary
The bundle organizes performance expectations with a focus on helping students begin to understand the conservation of matter and its particulate nature. Instruction developed from this bundle should always maintain the three-dimensional nature of the standards, and is not limited to the practices and concepts directly linked with any of the bundle performance expectations.

Connections between bundle DCIs
The idea that matter of any type can be subdivided into particles that are too small to see (PS1.A as in 5-PS1-1) connects to the idea that the amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish (PS1.A as in 5-PS1-2). The total weight of substances also does not change no matter what reaction or change in properties occurs (PS1.B as in 5-PS1-2).

Change in properties connects to the idea that when two or more different substances are mixed, a new substance with different properties may be formed (PS1.B as in 5-PS1-4). Measurements of a variety of properties can be used to identify materials (PS1.A as in 5-PS1-3), including the new ones that may be formed when two or more substances are mixed.

The engineering design idea that different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints (ETS1.C as in 3-5-ETS1-3) could connect to multiple science concepts, such as that when two or more different substances are mixed, a new substance with different properties may be formed (PS1.B as in 5-PS1-4), and that measurements of a variety of properties can be used to identify materials (PS1.A as in 5-PS1-3). Students can be challenged to create a new substance with particular properties (i.e., given criteria). In order to test the solution, measurements of the properties need to be taken to determine that the new substance with the desired properties has been created.

Bundle Science and Engineering Practices
Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the practices of developing and using models (5-PS1-1); planning and carrying out investigations (5-PS1-3, 5-PS1-4, and 3-5-ETS1-3); and using mathematics and computational thinking (5-PS1-2). Many other practice elements can be used in instruction.

Bundle Crosscutting Concepts
Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the crosscutting concepts of Cause and Effect (5-PS1-4) and Scale, Proportion, and Quantity (5-PS1-1, 5-PS1-2, and 5-PS1-3). Many other crosscutting concepts elements can be used in instruction.

All instruction should be three-dimensional.

Performance Expectations	5-PS1-1. **Develop a model to describe that matter is made of particles too small to be seen.** [Clarification Statement: Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] [*Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.*] 5-PS1-2. **Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.** [Clarification Statement: Examples of reactions or changes could include phase changes, dissolving, and mixing that form new substances.] [*Assessment Boundary: Assessment does not include distinguishing mass and weight.*] 5-PS1-3. **Make observations and measurements to identify materials based on their properties.** [Clarification Statement: Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.] [*Assessment Boundary: Assessment does not include density or distinguishing mass and weight.*] 5-PS1-4. **Conduct an investigation to determine whether the mixing of two or more substances results in new substances.** 3-5-ETS1-3. **Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.**
Example Phenomena	Mixing baking soda and vinegar makes a lot of foam. You can smell food cooking from across a room.
Additional Practices Building to the PEs	**Asking Questions and Defining Problems** • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. Students could *ask questions* [about what] ***measurements can be used to identify materials***. 5-PS1-3 **Developing and Using Models** • Develop and/or use models to describe and/or predict phenomena. Students could *use a model to predict* [whether] ***when two different substances are mixed, a new substance*** [will] ***be formed.*** 5-PS1-4 **Planning and Carrying Out Investigations** • Evaluate appropriate methods and/or tools for collecting data. Students could *evaluate appropriate methods and tools for collecting data* [on the relationship between] ***a change in properties of substances*** [and the] ***total weight of the substances***. 5-PS1-2 **Analyzing and Interpreting Data** • Represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships. Students could *use graphical displays to represent data* [from] ***mixing two different substances*** *to reveal patterns in* [the resulting] ***properties*** [of the substances]. 5-PS1-4

Additional Practices Building to the PEs (Continued)	**Using Mathematical and Computational Thinking** • Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems. Students could *measure* ***a variety of properties to identify materials***. 5-PS1-3 **Constructing Explanations and Designing Solutions** • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. Students could *use evidence to construct or support an explanation* [that] ***the amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish***. 5-PS1-2 **Engaging in Argument from Evidence** • Respectfully provide and receive critiques from peers about a proposed procedure, explanation or model by citing relevant evidence and posing specific questions. Students could *respectfully provide critiques to peers about a model* [that describes that] ***gases are made from particles that are too small to see and are moving freely around in space*** *by citing relevant evidence and posing specific questions*. 5-PS1-1 **Obtaining, Evaluating and Communicating Information** • Communicate scientific and/or technical information orally and/or in written formats, including various forms of media and may include tables, diagrams, and charts. Students could *orally communicate* [the] *scientific information* [that] ***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***. 5-PS1-1
Additional Crosscutting Concepts Building to the PEs	**Cause and Effect** • Events that occur together with regularity might or might not be a cause and effect relationship. Students could describe that *there might or might not be a cause and effect relationship* [between] ***matter changing form*** *and* [changing color]. 5-PS1-2 **Energy and Matter** • Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. Students could describe that *matter flows and cycles can be tracked in terms of the weight of the substances* ***when matter changes form, even when it seems to vanish***. 5-PS1-2 **Stability and Change** • Some systems appear stable, but over long periods of time will eventually change. Students could obtain information about *systems* [in which] ***air can*** [seem to only] ***affect objects*** *over long periods of time*. 5-PS1-1

Additional Connections to Nature of Science .	**Science Knowledge Is Based on Empirical Evidence** • Science uses tools and technologies to make accurate measurements and observations. Students could describe how they used *tools and technologies to make accurate measurements and observations* [of what happens] ***when two different substances are mixed***. 5-PS1-4 **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Science explanations describe the mechanisms for natural events. Students could describe that *science explanations describe the mechanisms for natural events;* [for example,] ***the inflation and shape of a balloon*** [can be explained by the fact] ***that gases are made from matter particles that are too small to see and are moving freely around in space***. 5-PS1-1

5-PS1-1 Matter and Its Interactions

Students who demonstrate understanding can:

5-PS1-1. **Develop a model to describe that matter is made of particles too small to be seen.** [Clarification Statement: Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] [*Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models
Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.

- Use models to describe phenomena.

Disciplinary Core Ideas

PS1.A: Structure and Properties 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. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects.

Crosscutting Concepts

Scale, Proportion, and Quantity

- Natural objects exist from the very small to the immensely large.

Observable features of the student performance by the end of the grade:			
1	Components of the model		
	a	Students develop a model to describe* a phenomenon that includes the idea that matter is made of particles too small to be seen. In the model, students identify the relevant components for the phenomenon, including:	
		i.	Bulk matter (macroscopic observable matter; e.g., as sugar, air, water).
		ii.	Particles of matter that are too small to be seen.
2	Relationships		
	a	In the model, students identify and describe* relevant relationships between components, including the relationships between:	
		i.	Bulk matter and tiny particles that cannot be seen (e.g., tiny particles of matter that cannot be seen make up bulk matter).
		ii.	The behavior of a collection of many tiny particles of matter and observable phenomena involving bulk matter (e.g., an expanding balloon, evaporating liquids, substances that dissolve in a solvent, effects of wind).
3	Connections		
	a	Students use the model to describe* how matter composed of tiny particles too small to be seen can account for observable phenomena (e.g., air inflating a basketball, ice melting into water).	

5-PS1-2 Matter and Its Interactions

Students who demonstrate understanding can:

5-PS1-2. **Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.** [Clarification Statement: Examples of reactions or changes could include phase changes, dissolving, and mixing that form new substances.] [*Assessment Boundary: Assessment does not include distinguishing mass and weight.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Using Mathematics and Computational Thinking

Mathematical and computational thinking in 3–5 builds on K–2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions.

- Measure and graph quantities such as weight to address scientific and engineering questions and problems.

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

- The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish.

PS1.B: Chemical Reactions

- No matter what reaction or change in properties occurs, the total weight of the substances does not change. (Boundary: Mass and weight are not distinguished at this grade level.)

Crosscutting Concepts

Scale, Proportion, and Quantity

- Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.

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Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes consistent patterns in natural systems.

Observable features of the student performance by the end of the grade:		
1	Representation	
	a	Students measure and graph the given quantities using standard units, including:
		i. The weight of substances before they are heated, cooled, or mixed.
		ii. The weight of substances, including any new substances produced by a reaction, after they are heated, cooled, or mixed.
2	Mathematical/computational analysis	
	a	Students measure and/or calculate the difference between the total weight of the substances (using standard units) before and after they are heated, cooled, and/or mixed.
	b	Students describe* the changes in properties they observe during and/or after heating, cooling, or mixing substances.
	c	Students use their measurements and calculations to describe* that the total weights of the substances did not change, regardless of the reaction or changes in properties that were observed.
	d	Students use measurements and descriptions* of weight, as well as the assumption of consistent patterns in natural systems, to describe* evidence to address scientific questions about the conservation of the amount of matter, including the idea that the total weight of matter is conserved after heating, cooling, or mixing substances.

5-PS1-3 Matter and Its Interactions

Students who demonstrate understanding can:

5-PS1-3. **Make observations and measurements to identify materials based on their properties.** [Clarification Statement: Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.] [*Assessment Boundary: Assessment does not include density or distinguishing mass and weight.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.	**PS1.A: Structure and Properties of Matter** • Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.)	**Scale, Proportion, and Quantity** • Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.

Observable features of the student performance by the end of the grade:			
1	Identifying the phenomenon under investigation		
	a	From the given investigation plan, students identify the phenomenon under investigation, which includes the observable and measurable properties of materials.	
	b	Students identify the purpose of the investigation, which includes collecting data to serve as the basis for evidence for an explanation about the idea that materials can be identified based on their observable and measurable properties.	
2	Identifying the evidence to address the purpose of the investigation		
	a	From the given investigation plan, students describe* the evidence from data (e.g., qualitative observations and measurements) that will be collected, including:	
		i.	Properties of materials that can be used to identify those materials (e.g., color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility).
	b	Students describe* how the observations and measurements will provide the data necessary to address the purpose of the investigation.	
3	Planning the investigation		
	a	From the given plan investigation plan, students describe* how the data will be collected. Examples could include:	
		i.	Quantitative measures of properties, in standard units (e.g., grams, liters).
		ii.	Observations of properties such as color, conductivity, and reflectivity.
		iii.	Determination of conductors vs. nonconductors and magnetic vs. nonmagnetic materials.
	b	Students describe* how the observations and measurements they make will allow them to identify materials based on their properties.	
4	Collecting the data		
	a	Students collect and record data, according to the given investigation plan.	

5-PS1-4 Matter and Its Interactions

Students who demonstrate understanding can:

5-PS1-4. Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.	**PS1.B: Chemical Reactions** • When two or more different substances are mixed, a new substance with different properties may be formed.	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change.

Observable features of the student performance by the end of the grade:			
1	Identifying the phenomenon under investigation		
	a	From the given investigation plan, students describe* the phenomenon under investigation, which includes the mixing of two or more substances.	
	b	Students identify the purpose of the investigation, which includes providing evidence for whether new substances are formed by mixing two or more substances, based on the properties of the resulting substance.	
2	Identifying the evidence to address the purpose of the investigation		
	a	From the given investigation plan, students describe* the evidence from data that will be collected, including:	
		i.	Quantitative (e.g., weight) and qualitative properties (e.g., state of matter, color, texture, odor) of the substances to be mixed.
		ii.	Quantitative and qualitative properties of the resulting substances.
	b	Students describe* how the collected data can serve as evidence for whether the mixing of the two or more tested substances results in one or more new substances.	
3	Planning the investigation		
	a	From the given investigation plan, students describe* how the data will be collected, including:	
		i.	How quantitative and qualitative properties of the two or more substances to be mixed will be determined and measured.
		ii.	How quantitative and qualitative properties of the substances that resulted from the mixture of the two or more substances will be determined and measured.
		iii.	Number of trials for the investigation.
		iv.	How variables will be controlled to ensure a fair test (e.g., the temperature at which the substances are mixed, the number of substances mixed together in each trial).
4	Collecting the data		
	a	According to the investigation plan, students collaboratively collect and record data, including data about the substances before and after mixing.	

3-5-ETS1-3 Engineering Design

Students who demonstrate understanding can:

3-5-ETS1-3. **Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.**

The performance expectation above was developed using the following elements from the NRC document *A Framework for K- 12 Science Education*:

Science and Engineering Practices

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.

- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.

Disciplinary Core Ideas

ETS1.B: Developing Possible Solutions

- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.

ETS1.C: Optimizing the Design Solution

- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.

Crosscutting Concepts

Observable features of the student performance by the end of the grade:			
1	Identifying the purpose of the investigation		
	a	Students describe* the purpose of the investigation, which includes finding possible failure points or difficulties to identify aspects of a model or prototype that can be improved.	
2	Identifying the evidence to be address the purpose of the investigation		
	a	Students describe* the evidence to be collected, including:	
		i.	How well the model/prototype performs against the given criteria and constraints.
		ii.	Specific aspects of the prototype or model that do not meet one or more of the criteria or constraints (i.e., failure points or difficulties).
		iii.	Aspects of the model/prototype that can be improved to better meet the criteria and constraints.
	b	Students describe* how the evidence is relevant to the purpose of the investigation.	
3	Planning the investigation		
	a	Students create a plan for the investigation that describes* different tests for each aspect of the criteria and constraints. For each aspect, students describe*:	
		i.	The specific criterion or constraint to be used.
		ii.	What is to be changed in each trial (the independent variable).
		iii.	The outcome (dependent variable) that will be measured to determine success.
		iv.	What tools and methods are to be used for collecting data.
		v.	What is to be kept the same from trial to trial to ensure a fair test.
4	Collecting the data		
	a	Students carry out the investigation, collecting and recording data according to the developed plan.	