Middle School Phenomenon Model Course 2 – Bundle 4
Organization of Living Things

This is the fourth bundle of the Middle School Phenomenon Model Course 2. Each bundle has connections to the other bundles in the course, as shown in the Course Flowchart.

Bundle 4 Question: This bundle is assembled to address the question "why are bones so hard?"

Summary
The bundle organizes performance expectations with a focus on helping students build understanding of cells and how they work together in particular body functions. Instruction developed from this bundle should always maintain the three-dimensional nature of the standards, and recognize that instruction is not limited to the practices and concepts directly linked with any of the bundle performance expectations.

Connections between bundle DCIs
All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular) (LS1.A as in MS-LS1-1). Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell (LS1.A as in MS-LS1-2). In multicellular organisms, the body is a system of multiple interacting subsystems, which are groups of cells that work together to form tissues and organs that are specialized for particular body functions (LS1.A as in MS-LS1-3).

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 (MS-LS1-2), conducting investigations (MS-LS1-1), and engaging in argument (MS-LS1-3). 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 Scale, Proportion, and Quantity (MS-LS1-1), Systems and System Models (MS-LS1-3), and Structure and Function (MS-LS1-2). Many other crosscutting concept elements can be used in instruction.

All instruction should be three-dimensional.

Performance Expectations	MS-LS1-1. **Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.** [Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living cells, and understanding that living things may be made of one cell or many and varied cells.] MS-LS1-2. **Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.** [Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.] [Assessment Boundary: Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts.]

Performance Expectations (Continued)	MS-LS1-3. **Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.** [Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.] [Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.]
Example Phenomena	When I swab inside my cheek and look at it through a microscope, I can see cells. Tomatoes on the vine split open after a big rainstorm.
Additional Practices Building to the PEs	**Asking Questions and Defining Problems** • Ask questions that require sufficient and appropriate empirical evidence to answer. Students could *ask questions about how* ***tissues and organs are specialized for particular body functions***, [ensuring that their questions] *require sufficient and appropriate empirical evidence to answer.* MS-LS1-3 **Developing and Using Models** • Develop a model to describe unobservable mechanisms. Students could *develop a model to describe* [that] ***body subsystems are groups of cells that work together to form tissues and organs***. MS-LS1-3 **Planning and Carrying Out Investigations** • 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. Students could *collaboratively plan a* [hypothetical] *investigation* [to determine whether] ***all living things are made up of cells*** *and in the plan,* students could *identify independent and dependent variables and controls and how many data would be needed to support a claim*. MS-LS1-2 **Analyzing and Interpreting Data** • 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). Students could *consider limitations of data analysis, including measurement error*, [when determining whether] ***cells are the smallest unit that can be said to be alive***. MS-LS1-1 **Using Mathematical and Computational Thinking** • Apply mathematical representations to describe and/or support scientific conclusions and design solutions Students could *apply mathematic representations to describe* [the relationship between the] ***numbers and types of cells in an organism***. MS-LS1-1

	Constructing Explanations and Designing Solutions • Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. Students could *apply scientific reasoning to show why the evidence* [that] ***the cell membrane forms the boundary that controls what enters and leaves the cell is adequate for the explanation***. MS-LS1-2 **Engaging in Argument from Evidence** • Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretation of facts. Students could *compare and critique two arguments that* ***cells are the smallest unit that can be said to be alive****, and analyze whether the arguments emphasize similar or different evidence and/or interpretation of facts*. MS-LS1-1 **Obtaining, Evaluating, and Communicating Information** • Communicate scientific and/or technical information in writing and/or through oral presentations. Students could *communicate scientific information through oral presentations* [about how] ***within cells, special structures are responsible for particular functions***. MS-LS1-2
Additional Crosscutting Concepts Building to the PEs	**Patterns** • Macroscopic patterns are related to the nature of microscopic and atomic-level structure. Students could ask questions about how *macroscopic patterns are related to the nature of microscopic and atomic-level* structure ***in multicellular organisms,*** [where] ***groups of cells work together to form tissues and organs that are specialized for particular body functions***. MS-LS1-3 **Systems and System Models** • Models are limited in that they only represent certain aspects of the system under study. Students could construct an argument that *models are limited in that they only represent certain aspects of the system under study, [using as evidence a model of]* ***special structures within cells that are responsible for particular functions***. MS-LS1-2 **Stability and Change** • Small changes in one part of a system might cause large changes in another part. Students could construct an argument that *small changes in one part of a* ***multicellular organism*** *might cause large changes in another part* ***of the organism*** [because] ***the body is a system of multiple interacting subsystems***. MS-LS1-3
Additional Connections to Nature of Science	**Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Theories are explanations for observable phenomena. Students could obtain and communicate information about how *theories are explanations for observable phenomena*, [including that] ***all living things are made up of cells***. MS-LS1-1 **Science Addresses Questions About the Natural and Material World** • Scientific knowledge is constrained by human capacity, technology, and materials. Students could construct an argument for how *scientific knowledge is constrained by human capacity and technology*, [using as evidence the scientific knowledge that] ***all living things are made up of cells***. MS-LS1-1

MS-LS1-1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

MS-LS1-1. **Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.** [Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells.]

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 in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.

- Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation.

Disciplinary Core Ideas

LS1.A: Structure and Function

- All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).

Crosscutting Concepts

Scale, Proportion, and Quantity

- Phenomena that can be observed at one scale may not be observable at another scale.

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Connections to Engineering, Technology and Applications of Science

Interdependence of Science, Engineering, and Technology

- 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.

Observable features of the student performance by the end of the course:		
1	Identifying the phenomenon under investigation	
	a	From the given investigation plan, students identify and describe* the phenomenon under investigation, which includes the idea that living things are made up of cells.
	b	Students identify and describe* the purpose of the investigation, which includes providing evidence for the following ideas: that all living things are made of cells (either one cell or many different numbers and types of cells) and that the cell is the smallest unit that can be said to be alive.
2	Identifying the evidence to address the purpose of the investigation	
	a	From the given investigation plan, students describe* the data that will be collected and the evidence to be derived from the data, including:
		i. The presence or absence of cells in living and nonliving things.
		ii. The presence or absence of any part of a living thing that is not made up of cells.
		iii. The presence or absence of cells in a variety of organisms, including unicellular and multicellular organisms.
		iv. Different types of cells within one multicellular organism.
	b	Students describe* how the evidence collected will be relevant to the purpose of the investigation.
3	Planning the investigation	
	a	From the given investigation plan, students describe* how the tools and methods included in the experimental design will provide the evidence necessary to address the purpose of the investigation, including that due to their small-scale size, cells are unable to be seen with the unaided eye and require engineered magnification devices to be seen.
	b	Students describe* how the tools used in the investigation are an example of how science depends on engineering advances.
4	Collecting the data	
	a	According to the given investigation plan, students collect and record data on the cellular composition of living organisms.

	b	Students identify the tools used for observation at different magnifications and describe* that different tools are required to observe phenomena related to cells at different scales.
	c	Students evaluate the data they collect to determine whether the resulting evidence meets the goals of the investigation, including cellular composition as a distinguishing feature of living things.

MS-LS1-2 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

MS-LS1-2. **Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.** [Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.] [*Assessment Boundary: Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts.*]

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 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena.

Disciplinary Core Ideas

LS1.A: Structure and Function

- Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.

Crosscutting Concepts

Structure and Function

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.

Observable features of the student performance by the end of the course:		
1	Components of the model	
	a	To make sense of a phenomenon, students develop a model in which they identify the parts (i.e., components; e.g., nucleus, chloroplasts, cell wall, mitochondria, cell membrane, the function of a cell as a whole) of cells relevant for the given phenomenon.
2	Relationships	
	a	In the model, students describe* the relationships between components, including:
		i. The particular functions of parts of cells in terms of their contributions to overall cellular functions (e.g., chloroplasts' involvement in photosynthesis and energy production, mitochondria's involvement in cellular respiration).
		ii. The structure of the cell membrane or cell wall and its relationship to the function of the organelles and the whole cell.
3	Connections	
	a	Students use the model to describe* a causal account for the phenomenon, including how different parts of a cell contribute to how the cell functions as a whole, both separately and together with other structures. Students include how components, separately and together, contribute to:
		i. Maintaining a cell's internal processes, for which it needs energy.
		ii. Maintaining the structure of the cell and controlling what enters and leaves the cell.
		iii. Functioning together as parts of a system that determines cellular function.
	b	Students use the model to identify key differences between plant and animal cells based on structure and function, including:
		i. Plant cells have a cell wall in addition to a cell membrane, whereas animal cells have only a cell membrane. Plants use cell walls to provide structure to the plant.
		ii. Plant cells contain organelles called chloroplasts, while animal cells do not. Chloroplasts allow plants to make the food they need to live using photosynthesis.

MS-LS1-3 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

MS-LS1-3. **Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.** [Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.] [*Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.*]

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

Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

- Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon.

Disciplinary Core Ideas

LS1.A: Structure and Function

- In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.

Crosscutting Concepts

Systems and System Models

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

Connections to Nature of Science

Science is a Human Endeavor

- Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.

Observable features of the student performance by the end of the course:			
1	Supported claims		
	a	Students make a claim to be supported, related to a given explanation or model of a phenomenon. In the claim, students include the idea that the body is a system of interacting subsystems composed of groups of cells.	
2	Identifying scientific evidence		
	a	Students identify and describe* the given evidence that supports the claim (e.g., evidence from data and scientific literature), including evidence that:	
		i.	Specialized groups of cells work together to form tissues (e.g., evidence from data about the kinds of cells found in different tissues, such as nervous, muscular, and epithelial, and their functions).
		ii.	Specialized tissues comprise each organ, enabling the specific organ functions to be carried out (e.g., the heart contains muscle, connective, and epithelial tissues that allow the heart to receive and pump blood).
		iii.	Different organs can work together as subsystems to form organ systems that carry out complex functions (e.g., the heart and blood vessels work together as the circulatory system to transport blood and materials throughout the body).
		iv.	The body contains organs and organ systems that interact with each other to carry out all necessary functions for survival and growth of the organism (e.g., the digestive, respiratory, and circulatory systems are involved in the breakdown and transport of food and the transport of oxygen throughout the body to cells, where the molecules can be used for energy, growth, and repair).
3	Evaluating and critiquing the evidence		
	a	Students evaluate the evidence and identify the strengths and weaknesses of the evidence, including:	
		i.	Types of sources.

		ii. Sufficiency, including validity and reliability, of the evidence to make and defend the claim.
		iii. Any alternative interpretations of the evidence and why the evidence supports the student's claim, as opposed to any other claims.
4	Reasoning and synthesis	
	a	Students use reasoning to connect the appropriate evidence to the claim. Students describe* the following chain of reasoning in their argumentation:
		i. Every scale (e.g., cells, tissues, organs, organ systems) of body function is composed of systems of interacting components.
		ii. Organs are composed of interacting tissues. Each tissue is made up of specialized cells. These interactions at the cellular and tissue levels enable the organs to carry out specific functions.
		iii. A body is a system of specialized organs that interact with each other and their subsystems to carry out the functions necessary for life.
	b	Students use oral or written arguments to support or refute an explanation or model of a phenomenon.