Middle School Topics Model Course 1-Bundle 1
Body Systems

This is the first bundle of the Middle School Topics Model Course 1. 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 of "How do the structures of organisms enable life's functions?"

Summary
The bundle organizes performance expectations with a focus on helping students begin to understand how the structures of organisms enable life's functions. Instruction developed from this bundle should always maintain the three-dimensional nature of the standards, but 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 can be composed of one single cell or many different numbers and types of cells (LS1.A as in MS-LS1-1). This concept is expanded with the idea of special structures within cells that are responsible for particular functions (LS1.A as in MS-LS1-2). The concept of cells connects to the concept of body systems with the idea that 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 (LS1.A as in MS-LS1-3). This concept of subsystems connects to the idea of the nervous system, which is made up of specialized nerve cells (LS1.D as in MS-LS1-8).

The concept that the more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful (ETS1.A as in MS-ETS1-1) could connect to concepts of the cell membrane (LS1.A as in MS-LS1-2) or how sense receptors respond to different inputs (LS1.D as in MS-LS1-8). Connections could be made through an engineering design task such as defining the criteria and constraints for designing prosthetic limbs for amputees. Alternatively, students could be asked to consider the role of nerve cells in skin grafts for burn victims, and to consider that role in identifying the criteria and constraints with which to evaluate two similar processes for grafting skin.

Bundle Science and Engineering Practices
Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the practices of defining a design problem (MS-ETS1-1), developing and using a model (MS-LS1-2), conducting an investigation (MS-LS1-1), engaging in argumentation (MS-LS1-3), and obtaining, evaluating, and communicating information (MS-LS1-8). 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 (MS-LS1-8), Scale, Proportion, and Quantity (MS-LS1-1), Systems and System Models (MS-LS1-3), Structure and Function (MS-LS1-2), and Influence of Science, Engineering, and Technology on Society and the Natural World (MS-ETS1-1) Many other crosscutting concept elements can be used in instruction.

All instruction should be three-dimensional.

Version 1 - published June 2016

Performance Expectations MS-LS1-3 and MS-LS1-8 are partially assessable	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.] **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.] MS-LS1-8 **Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.** [Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.] MS-ETS1-1 **Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**
Example Phenomena	Muscle tissue, fat, blood, and bone are all very different from one another. We can remember things that happened in the past.
Additional Practices Building to the PEs	**Asking Questions and Defining Problems** • Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. Students could *ask questions that arise from careful observation to clarify* [whether] ***cells are the smallest unit that can be said to be alive***. MS-LS1-1 **Developing and Using Models** • Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales. Students could *use a model to generate data* [for how] ***an organism may consist of one single cell or many different numbers and types of cells***. MS-LS1-1

Additional Practices Building to the PEs (Continued)	**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 *plan an investigation and in the design: identify the 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* [for how] ***special structures within cells are responsible for particular functions***. HS-LS1-2 **Analyzing and Interpreting Data** • Distinguish between causal and correlational relationships in data. Students could *distinguish between causal and correlational relationships in data* [for how] ***in multicellular organisms, groups of cells work together to form tissues and organs that are specialized for particular body functions***. MS-LS1-3 **Using Mathematical and Computational Thinking** • Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems. Students could *apply mathematical concepts and/or processes* [to determine the rate at which] ***each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain***. MS-LS1-8 **Constructing Explanations and Designing Solutions** • Construct an explanation using models or representations. Students could *construct an explanation using models or representations* [for how] ***in multicellular organisms, the body is a system of multiple interacting subsystems***. MS-LS1-3 **Engaging in Argument from Evidence** • Respectfully provide and receive critiques about one's explanations, procedures, models and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail. Students could *respectfully receive critiques about their explanations by citing relevant evidence and responding to questions* [about how] ***special structures within cells are responsible for particular functions***. HS-LS1-2 **Obtaining, Evaluating, and Communicating Information** • Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings. Students could *integrate qualitative scientific information to clarify claims* [for how] ***in multicellular organisms, the body is a system of multiple interacting subsystems and these subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions***. MS-LS1-3

Version 1 - published June 2016

Additional Crosscutting Concepts Leading to PE	**Cause and Effect** • Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. Students could ask questions about *causal* [versus] *correlational relationships* [for how] ***each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain and how these signals are then processed in the brain, resulting in immediate behaviors or memories***. MS-LS1-8 **Systems and System Models** • Models are limited in that they only represent certain aspects of the system under study. Students could analyze how a *model* of ***multicellular organisms*** [as] ***systems of multiple interacting subsystems*** *is limited in that the model only represents certain aspects of the* **organisms**. MS-LS1-3 **Stability and Change** • Small changes in one part of a system might cause large changes in another part. Students could plan and conduct an investigation to gather data about how *small changes in one part of* ***a cell*** *(e.g.,* ***the cell membrane****) might cause large changes in another part* of ***the cell***. MS-LS1-2
Additional Connections to Nature of Science	**Scientific Investigations Use a Variety of Methods (SEP):** • Science investigations use a variety of methods and tools to make measurements and observations. Students could obtain and evaluate information about how *science investigations use a variety of methods and tools to make measurements and observations* [for how] ***each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain and how these signals are then processed in the brain, resulting in immediate behaviors or memories***. MS-LS1-8 **Science is a Way of Knowing (CCC):** • Science is a way of knowing used by many people, not just scientists. Students could construct an argument from evidence for how *science is a way of knowing used by many people, not just scientists* [to learn about how] ***groups of cells work together to form tissues and organs that are specialized for particular body functions***. MS-LS1-3

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.

- -

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.

MS-LS1-8 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

MS-LS1-8. **Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.** [*Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.*]

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

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 6-8 builds on K-5 experiences and progresses to evaluating the merit and validity of ideas and methods.

- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.

Disciplinary Core Ideas

LS1.D: Information Processing

- Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.

Crosscutting Concepts

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural systems.

Observable features of the student performance by the end of the course:			
1	Obtaining information		
	a	Students gather and synthesize information from at least two sources (e.g., text, media, visual displays, data) about a phenomenon that includes the relationship between sensory receptors and the storage and usage of sensory information by organisms. Students gather information about:	
		i.	Different types of sensory receptors and the types of inputs to which they respond (e.g., electromagnetic, mechanical, chemical stimuli).
		ii.	Sensory information transmission along nerve cells from receptors to the brain.
		iii.	Sensory information processing by the brain as:
			1. Memories (i.e., stored information).
			2. Immediate behavioral responses (i.e., immediate use).
	b	Students gather sufficient information to provide evidence that illustrates the causal relationships between information received by sensory receptors and behavior, both immediate and over longer time scales (e.g., a loud noise processed via auditory receptors may cause an animal to startle immediately or may be encoded as a memory, which can later be used to help the animal react appropriately in similar situations).	
2	Evaluating information		
	a	Students evaluate the information based on:	
		i.	The credibility, accuracy, and possible bias of each publication and the methods used to generate and collect the evidence.
		ii.	The ability of the information to provide evidence that supports or does not support the idea that sensory receptors send signals to the brain, resulting in immediate behavioral changes or stored memories.
		iii.	Whether the information is sufficient to allow prediction of the response of an organism to different stimuli based on cause and effect relationships between the responses of sensory receptors and behavioral responses.

MS-ETS1-1 Engineering Design

Students who demonstrate understanding can:

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

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

Asking Questions and Defining Problems

Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.

- Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.

Disciplinary Core Ideas

ETS1.A: Defining and Delimiting Engineering Problems

- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.

Crosscutting Concepts

Influence of Science, Engineering, and Technology on Society and the Natural World

- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
- The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.

Observable features of the student performance by the end of the course:			
1	Identifying the problem to be solved		
	a	Students describe* a problem that can be solved through the development of an object, tool, process, or system.	
2	Defining the process or system boundaries and the components of the process or system		
	a	Students identify the system in which the problem is embedded, including the major components and relationships in the system and its boundaries, to clarify what is and is not part of the problem. In their definition of the system, students include:	
		i.	Which individuals or groups need this problem to be solved.
		ii.	The needs that must be met by solving the problem.
		iii.	Scientific issues that are relevant to the problem.
		iv.	Potential societal and environmental impacts of solutions.
		v.	The relative importance of the various issues and components of the process or system.
3	Defining criteria and constraints		
	a	Students define criteria that must be taken into account in the solution that:	
		i.	Meet the needs of the individuals or groups who may be affected by the problem (including defining who will be the target of the solution).
		ii.	Enable comparisons among different solutions, including quantitative considerations when appropriate.
	b	Students define constraints that must be taken into account in the solution, including:	
		i.	Time, materials, and costs.
		ii.	Scientific or other issues that are relevant to the problem.
		iii.	Needs and desires of the individuals or groups involved that may limit acceptable solutions.
		iv.	Safety considerations.
		v.	Potential effect(s) on other individuals or groups.
		vi.	Potential negative environmental effects of possible solutions or failure to solve the problem.