Addressing the Crosscutting Concepts

Crosscutting concepts are unifying ideas that apply across all disciplines of science. A crosscutting concept connects topics where the same unifying concept underpins the content. The crosscutting statements in the NGSS documentation are provided as bulleted points. These points have been used to produce relevant, meaningful crosscutting statements for each chapter. The activities to which the statements apply are identified in the chapter introductions as previously described.

For the most part, we have based the crosscutting statements for each chapter on the points linked specifically to performance expectations (**PE** in the tables below), so the list is not exhaustive and we have identified others not incorporated into performance expectations. These are summarized in the tables below and opposite. The teacher's notes for each chapter also identify the performance expectations incorporating each CCC point. Each crosscutting concept below is accompanied by a progression statement, taken directly from the NGSS document.

CCC **P**

1. Patterns

Progression in grades 9-12
"In grades 9-12, students observe pattens in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena. They recognize that classifications or explanations used at one scale may not be useful or may need revision using a different scale, thus requiring improved investigations and experiments. They use mathematical representations to identify certain patterns and analyze patterns of performance in order to reengineer and improve a designed system".

Crossing cutting statement(s)	DCI	Applies to PE#	Activity number
Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.	LS4.A	HS-LS4-1	216-225
	LS4-B	HS-LS4-3	232-234

CCC **CE**

2. Cause and effect

Progression in grades 9-12
"In grades 9-12, students understand that empirical evidence is required to differentiate between cause and correlations and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller-scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects".

Crossing cutting statement(s)	DCI	Applies to PE#	Activity number
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	LS2.A		120-123, 131
	LS2.D	HS-LS2-8	171-172, 174, 176-177
	LS3.A	HS-LS3-1	183, 185-187
	LS3.B	HS-LS3-1	191, 211
		HS-LS3-2	198-202, 205
	LS4.B	HS-LS4-2	232-234
	LS4.C	HS-LS4-4	232-234
		HS-LS4-5	240-242
	LS4.D ETS1.B	HS-LS4-6	249, 251-253

CCC **SPQ**

3. Scale, proportion and quantity

Progression in grades 9-12
"In grades 9-12, students understand that the significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. They recognize that patterns observable at one scale many not be observable or exist at other scales and that some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Students use orders of magnitude to understand how a model at one scale relates to a model at another scale. They use algebraic thinking to examine scientific data and predict the effect of a change in one variable on another (e.g. linear growth vs exponential growth)".

Crossing cutting statement(s)	DCI	Applies to PE#	Activity number
The significance of a phenomenon depends on the scale, proportion, and quantity at which it occurs.	LS2.A	HS-LS2-1	114, 120, 124, 125
			117
Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.	LS2.A	HS-LS2-2	128, 131
	LS2.C	HS-LS2-2	155
Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another.	LS3.B	HS-LS3-2	195
			206, 209, 211-212

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CCC **SSM**

4. Systems and system models

Progression in grades 9-12
"In grades 9-12 ,students investigate or analyze a system by defining its boundaries and initial conditions, as well as its inputs and outputs. They use models (e.g. physical, mathematical, computer models) to simulate the flow of energy, matter, and interactions within and between systems at different scales. They also use models and simulations to predict the behavior of a system and recognize that these predictions have limited precision and reliability due to the assumptions and approximations inherent to the models. They also design systems to do specific tasks".

Crossing cutting statement(s)	DCI	Applies to PE#	Activity number
Models (e.g. physical, mathematical, computer models) can simulate systems and interactions- including energy, matter, and information flows- within and between systems at different scales.	LS1.A	HS-LS1-2	57-61
			48
	LS1.B	HS-LS1-4	88, 91
			84-86
	LS2.B	HS-LS2-5	147-150
			138-139, 143

CCC **EM**

5. Energy and matter

Progression in grades 9-12
"In grades 9-12, students learn that the total amount of energy and matter in closed systems is conserved. They can describe changes of energy and matter ina system in terms of energy and matter flows into, out of, and within that system. They also learn that energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between system. Energy drives the cycling of matter within and between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved".

Crossing cutting statement(s)	DCI	Applies to PE#	Activity number
Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.	LS1.C	HS-LS1-5	98, 100-103
		HS-LS1-6	104
	LS2.B		138
Energy cannot be created or destroyed- it only moves between one place and another place, between objects, and/or fields, and between systems.	LS1.C	HS-LS1-7	98, 100, 103, 106-107
	LS2.B Also relates to PS3.D	HS-LS2-4	135, 139, 142, 143
Energy drives the cycling of matter within and between systems.	LS2.B	HS-LS2-3	136, 145-151

CCC **SF**

6. Structure and function

Progression in grades 9-12
"In grades 9-12, students investigate systems by examining the properties of different materials, the structures of different components, and their interconnections to reveal a system's function and/or solve a problem. They infer the functions and properties of natural and designed objects and systems from their overall structure, the way their components are shaped and used, and the molecular substructures of their various materials".

Crossing cutting statement(s)	DCI	Applies to PE#	Activity number
The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of their various materials.	LS1.A		32-36, 38, 42-44
			48
	LS1.C		100, 103
Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of the different components, and connections of components to reveal their function and/or solve a problem.	LS1.A	HS-LS1-1	46-52, 54

CCC **SC**

7. Stability and change

Progression in grades 9-12
"In grades 9-12, students understand that much of science deals with constructing explanations of how things change and how they remain stable. They quantify and model changes in systems over short or very periods of time. They see that some changes are irreversible and that negative feedback can stabilize a system, while positive feedback can destabilize it. They recognize that systems can be designed for more or less stability".

Crossing cutting statement(s)	DCI	Applies to PE#	Activity number
Feedback (negative or positive) can stablilize or destabilize a system.	LS1.A	HS-LS1-3	65-68, 70-71, 73-79
Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changed is irreversible.	LS2.C		155-158, 164, 166

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Addressing the Science and Engineering Practices

Science and Engineering Practices (SEPs) for NGSS are overlapping and interconnected practices that students should know and understand. While this student book cannot provide wet lab practical experiences, we have provided numerous opportunities to prepare students for those experiences and develop and refine their skills in planning investigations and analyzing and evaluating data. There are also many opportunities for students to participate in collaboration and discourse. SEPs are supported throughout the book, beginning with an introductory chapter covering basic computational, analytical, and design skills, to a variety of activities focusing on the development of specific skills within the framework of the DCIs.

The SEP statements in the NGSS documentation are provided as bulleted points. These points have been used to produce relevant, meaningful statements for each chapter. The activities to which the statements apply are identified in the chapter introductions as previously described. For the most part, we have based these SEP statements on the points linked specifically to performance expectations, so the list is not exhaustive and we have identified others not incorporated into performance expectations. These are summarized in the tables following. The teacher's notes for each chapter also identify the performance expectations incorporating each SEP point. Each SEP below is accompanied by a progression statement, taken directly from the NGSS document.

PRACTICES

PRACTICE 1: Asking questions and defining problems

"Asking questions and defining problems in 9-12 builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations."

	DCI	Applies to PE#	Activity number
Most activities in the student edition incorporate aspects of this SEP.			
Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.			1, 3
Ask questions that arise from examining models or a theory, to clarify and/or seek additional information about relationships.	LS3.A	HS-LS3-1	182, 183, 185-186*

*ERRATUM: SEP tabs missing from the chapter "Inheritance of Traits" (first printing only). The SEPs are identified in the introduction.

PRACTICES

PRACTICE 2: Developing and using models

"Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s)."

	DCI	Applies to PE#	Activity number
Develop, revise, and or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	LS1.A	HS-LS1-2	29, 32-33, 57-61
			67-68, 70-71
	LS1.B	HS-LS1-4	91-93
	LS1.C	HS-LS1-5	100, 109 140
		HS-LS1-7	106-107, 109
			99
	LS2.A		121, 128-129
	LS2.C		156
	LS2.B	HS-LS2-5	148, 150
	LS3.A		187
	LS3.B		194, 197, 199
	LS4.A		217, 223,
	LS4.B		236, 239
Develop/and or use a model (including mathematical and computational), to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.	LS1.B		86

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PRACTICES

PRACTICE 3: Planning and carrying out investigations

"Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual mathematical, physical, and empirical models".

	DCI	Applies to PE#	Activity number
Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions for problems. Consider possible confounding variables or effects and evaluate the investigations' design to ensure variables are controlled.			4, 12
	LS1.A		39-40, 71
Select appropriate tools to collect, record, analyze and evaluate data.			9, 10-11, 13, 31
Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.			11, 28
Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g. number of trials, cost, risk, time), and refine the design accordingly.	LS1.A	HS-LS1-3	76, 79
	LS1.C		101, 108
	LS2.A		130

PRACTICES

PRACTICE 4: Analyzing and interpreting data

"Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data."

	DCI	Applies to PE#	Activity number
Analyze data using tools, technologies, and/or models (e.g. computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution			16-17, 19-22
	LS1.A		79
	LS4.B		241
Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.			18-19, 23-25
	LS3.B	HS-LS3-3	206-211
	LS4.B		229, 232-234

PRACTICES

PRACTICE 5: Using mathematics and computational thinking

"Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and non-linear functions, including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions."

	DCI	Applies to PE#	Activity number
Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims or explanations.			5, 23-25,
	LS1.A		39-40, 56, 77
	LS2.A	HS-LS2-1	124, 128-131
	LS2.B	HS-LS2-4	142-144, 150
	LS2.C		155-157, 160
		HS-LS2-2	227
Create and/or revise a computational model or simulation of a phenomenon, designed device, process or system.	LS4.D	HS-LS4-6	251-252
Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units.			5-7, 14
Apply techniques of algebra and functions to represent and solve scientific and engineering problems.			8, 18

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PRACTICES

PRACTICE 6: Constructing explanations and designing solutions

"Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories".

	DCI	Applies to PE#	Activity number
Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including student's own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.			20, 28
	LS1.A	HS-LS1-1	49-50
	LS1.C	HS-LS1-6	104-109
	LS2.A		122
	LS2.B	HS-LS2-3	136
	LS4.B	HS-LS4-2	232-234
		HS-LS4-4	232-234
	LS4.C	HS-LS4-4	231-234
Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	LS2.C ETS-1	HS-LS2-7	161, 165, 167
	LS4.D	HS-LS4-6	251-253, 256
Apply scientific reasoning, principles, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.	LS1.C		102

PRACTICES

PRACTICE 7: Engaging in argument from evidence

"Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science."

	DCI	Applies to PE#	Activity number
Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.			28
	LS3.B	HS-LS3-2	193, 198-201, 204-205
Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	LS2.C	HS-LS2-6	159-160, 163, 166
	LS2.D	HS-LS2-8	172, 174-178
	LS4.A		218-221
	LS4.B	HS-LS4-5	232-234, 241

PRACTICES

PRACTICE 8: Obtaining, evaluating, and communicating information

"Obtaining, evaluating, and communicating information in 9-12 builds on K-8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs."

	DCI	Applies to PE#	Activity number
Evaluate the validity and reliability of, and/or synthesize, multiple claims, methods, and/or designs that appear in scientific and technical texts,or media reports, verifying the data where possible.			1, 28
	LS1.B		86
Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e. orally, graphically, textually, mathematically).	LS4.A	HS-LS4-1	217, 222-225

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Course Guides by DCI and by Topic

Guides summarizing the location of content for programs by DCI (below) or topic (opposite).

NGSS HS-LS PROGRAM BY DISCIPLINARY CORE IDEA	PERFORMANCE EXPECTATION	CHAPTER IN STUDENT EDITION
HS-LS1 FROM MOLECULES TO ORGANISMS: STRUCTURES & PROCESSES		
LS1.A: Structure and Function		
• Specialized cells perform the essential functions of life. • All cells contain genetic information as DNA. Genes are regions of DNA that code for proteins, which carry out most of the work in cells. • Multicellular organisms have a hierarchical organization.	HS-LS1-1 HS-LS1-1, HS-LS3-1 HS-LS1-2	Cell Specialization and Organization
• Feedback mechanisms maintain a living system's internal conditions.	HS-LS1-3	Feedback Mechanisms
LS1.B: Growth and Development of Organisms		
• In multicellular organisms, cells grow and divide by mitosis. Cell division and differentiation produce and maintain organisms.	HS-LS1-4	Growth and Development
LS1.C: Organization for Matter and Energy Flow in Organisms		
• Photosynthesis and the fate of glucose. • Cellular respiration and energy transfer. Energy for maintaining metabolism.	HS-LS1-5, HS-LS1-6, HS-LS1-7	Energy in Living Systems
HS-LS2 ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS		
LS2.A: Interdependent Relationships in Ecosystems		
• Carrying capacity and the influence of resource availability on populations.	HS-LS2-1, HS-LS2-2	Interdependence in Ecosystems
LS2.B: Cycles of Matter and Energy Transfer in Ecosystems		
• Photosynthesis and respiration provide most of the energy for life's processes. • Food webs and the (in)efficiency of energy transfers. • Photosynthesis and respiration are important in the carbon cycle.	HS-LS2-3 HS-LS2-4 HS-LS2-5	Energy Flow and Nutrient Cycles
LS2.C: Ecosystem Dynamics, Functioning, and Resilience		
• Functioning ecosystems: interactions and ecosystem resilience. • Anthropogenic changes and their effects on populations and ecosystems.	HS-LS2-2, HS-LS2-6 HS-LS2-7	The Dynamic Ecosystem
LS2.D: Social Interaction and Group Behavior		
• Survival benefits of group behavior.	HS-LS2-8	Social Behavior
PS3.D: Energy in Chemical Processes		
• Photosynthesis is the main way that solar energy is captured and stored on Earth.	2° to HS-LS2-5	Energy in Living Systems
HS-LS3 HEREDITY: INHERITANCE AND VARIATION OF TRAITS		
LS3.A: Inheritance of Traits		
• Chromosomes, genes, and the regulation of gene expression.	HS-LS3-1	Inheritance of Traits
LS3.B: Variation of Traits		
• Meiosis and mutation as sources of genetic variation. • The effect of environment on the expression of traits.	HS-LS3-2 HS-LS3-2, HS-LS3-3	Variation of Traits
HS-LS4 BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY		
LS4.A: Evidence of Common Ancestry and Diversity		
• Evidence of evolution comes from biochemistry, anatomy, and embryology.	HS-LS4-1	Evidence for Evolution
LS4.B: Natural Selection		
• Natural selection: The differential survival and reproduction of favorable phenotypes.	HS-LS4-2, HS-LS4-3	Natural Selection and Adaptation
LS4.C: Adaptation		
• Adaptation as a consequence of natural selection. Speciation and extinction.	HS-LS4-2 – HS-LS4-6	Natural Selection and Adaptation
LS4.D: Biodiversity		
• Biodiversity is increased by speciation and decreased by extinction. • Humans depend on biodiversity and sustaining it is essential.	2° to HS-LS2-7 2° to HS-LS2-7, HS-LS4-6	Biodiversity
ETS1.B: Developing Possible Solutions		
• A range of constraints need to be considered in developing solutions to problems. • Physcial models and computer simulations can assist in finding the best solution.	2° to HS-LS2-7 2° to HS-LS4-6	Biodiversity

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NGSS HS-LS PROGRAM BY COMBINED TOPIC	PERFORMANCE EXPECTATION	CHAPTER IN STUDENT EDITION
HS STRUCTURE AND FUNCTION		
LS1.A: Structure and Function		
• Specialized cells perform the essential functions of life. • All cells contain genetic information as DNA. Genes are regions of DNA that code for proteins, which carry out most of the work in cells. • Multicellular organisms have a hierarchical organization.	HS-LS1-1 HS-LS1-1, HS-LS3-1 HS-LS1-2	Cell Specialization and Organization
• Feedback mechanisms maintain a living system's internal conditions.	HS-LS1-3	Feedback Mechanisms
HS MATTER AND ENERGY IN ORGANISMS AND ECOSYSTEMS		
LS1.C: Organization for Matter and Energy Flow in Organisms		
• Photosynthesis and the fate of glucose. • Cellular respiration and energy transfer. Energy for maintaining metabolism.	HS-LS1-5, HS-LS1-6, HS-LS1-7	Energy in Living Systems
LS2.B: Cycles of Matter and Energy Transfer in Ecosystems		
• Photosynthesis and respiration provide most of the energy for life's processes. • Food webs and the (in)efficiency of energy transfers. • Photosynthesis and respiration are important in the carbon cycle.	HS-LS2-3 HS-LS2-4 HS-LS2-5	Energy Flow and Nutrient Cycles
PS3.D: Energy in Chemical Processes		
• Photosynthesis is the main way that solar energy is captured and stored on Earth.	2° to HS-LS2-5	Energy in Living Systems
HS INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS		
LS2.A: Interdependent Relationships in Ecosystems		
• Carrying capacity and the influence of resource availability on populations.	HS-LS2-1, HS-LS2-2	Interdependence in Ecosystems
LS2.C: Ecosystem Dynamics, Functioning, and Resilience		
• Functioning ecosystems: interactions and ecosystem resilience. • Anthropogenic changes and their effects on populations and ecosystems.	HS-LS2-2, HS-LS2-6 HS-LS2-7	The Dynamic Ecosystem
LS2.D: Social Interaction and Group Behavior		
• Survival benefits of group behavior.	HS-LS2-8	Social Behavior
LS4.C: Adaptation		
• Environmental change contributes to the emergence, expansion, or decline of species.	HS-LS4-6	The Dynamic Ecosystem
LS4.D: Biodiversity and Humans		
• Biodiversity is increased by speciation and decreased by extinction. • Humans depend on biodiversity and sustaining it is essential.	2° to HS-LS2-7 2° to HS-LS2-7, HS-LS4-6	Biodiversity
ETS1.B: Developing Possible Solutions		
• A range of constraints need to be considered in developing solutions to problems. • Physcial models and computer simulations can assist in finding the best solution.	2° to HS-LS2-7 & HS-LS4-6 2° to HS-LS4-6	The Dynamic Ecosystem
HS INHERITANCE AND VARIATION OF TRAITS		
LS1.A: Structure and Function		
• All cells contain genetic information as DNA. Genes code for proteins.	2° to HS-LS3-1, HS-LS1-1	Cell Specialization and Organization
LS1.B: Growth and Development of Organisms		
• Cell growth and division by mitosis. Cellular differentiation.	HS-LS1-4	Growth and Development
LS3.A: Inheritance of Traits		
• Chromosomes, genes, and the regulation of gene expression.	HS-LS3-1	Inheritance of Traits
LS3.B: Variation of Traits		
• Meiosis and mutation produce genetic variation. Effect of environment.	HS-LS3-2, HS-LS3-3	Variation of Traits
HS NATURAL SELECTION AND EVOLUTION		
LS4.A: Evidence of Common Ancestry and Diversity		
• Evidence of evolution comes from biochemistry, anatomy, and embryology.	HS-LS4-1	Evidence for Evolution
LS4.B: Natural Selection		
• Natural selection: The differential survival and reproduction of favorable phenotypes.	HS-LS4-2, HS-LS4-3	Natural Selection and Adaptation
LS4.C: Adaptation		
• Adaptation as a consequence of natural selection. Speciation and extinction.	HS-LS4-2 – HS-LS4-5	Natural Selection and Adaptation

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