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. Each crosscutting concept below is accompanied by a progression statement, taken directly from the NGSS document.

CCC **P**

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
The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.	ESS1.A	HS-ESS1-1	17, 20-22
Empirical evidence is needed to identify patterns.	ESS1.C	HS-ESS1-5	49-50, 53

CCC **CE**

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.			8
	ESS1.B		31-32, 34-35, 42-44
	ESS2.A	HS-ESS2-4	65, 68-70
	ESS2.D	HS-ESS2-4	91-94
	ESS3.A	HS-ESS3-1	107-109, 120
	ESS3.B	HS-ESS3-1	125-127, 130

CCC **SSM**

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 can simulate systems and interactions- including energy, matter, and information flows- within and between systems at different scales.			1-2
When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.	ESS3.D	HS-ESS3-6	146-149

CCC **SF**

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.	ESS2.C	HS-ESS2-5	81-87

ISBN: 978-1-927309-50-6

CCC

SPQ 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".

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.	ESS1.A	HS-ESS1-1	17, 20-22
	ESS3.B		125, 127
Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.	ESS1.A		13, 16-19
Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another.	ESS1.B	HS-ESS1-4	38-41, 43

CCC

EM 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
Energy cannot be created or destroyed - only moved between one place and another place, between objects and/or fields, or between systems.			4
	ESS1.A	HS-ESS1-2	14
In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	ESS1.A	HS-ESS1-3	17-22
Energy drives the cycling of matter within and between systems.	ESS2.A	HS-ESS2-3	59, 61
	ESS2.B	HS-ESS2-3	74-75
	ESS2.C		82-83
The total amount of energy in a closed system is conserved.	ESS2.D	HS-ESS2-6	99
			91

CCC

SC 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
Much of science deals with constructing explanations of how things change and how they remain stable.	ESS1.C	HS-ESS1-6	49-53
	ESS2.D		92, 94
		HS-ESS2-7	95-98
	ESS2.E	HS-ESS2-7	95-98, 101-102
Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changed is irreversible.	ESS2.A	HS-ESS2-1	62, 66-70
	ESS2.B	HS-ESS2-1	75-77, 80
	ESS2.C	HS-ESS3-3	135, 142, 145
	ESS3.D	HS-ESS3-5	147-149
Feedback (negative or positive) can stablilize or destabilize a system.	ESS2.A	HS-ESS2-2	63-64, 66
	ESS2.D	HS-ESS2-2	91, 100
	ESS2.C	HS-ESS3.4	134-136, 138-142

ISBN: 978-1-927309-50-6

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.

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, 6

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.	ESS1.A		1-2, 4
		HS-ESS1-1	17-19, 22, 25
			14-15
			13, 21
	ESS1.B		27, 42-44
	ESS2.A	HS-ESS2-1	61-62, 66-67
		HS-ESS2-3	59-60
		HS-ESS2-4	63-64, 68-70
	ESS2.B	HS-ESS2-1	77, 79-80
		HS-ESS2-3	74-76, 79
	ESS2.C		81-86
	ESS2.D		68-70
		HS-ESS2-4	91, 94, 105
		HS-ESS2-6	99,105
			92, 94

ISBN: 978-1-927309-50-6

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 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.			10-11
	ESS2.A		65
	ESS2.C	HS-ESS2-5	85-86
	ESS2.D		92
Select appropriate tools to collect, record, analyze and evaluate data.			11
Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.			11

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.			8-11
	ESS2.A	HS-ESS2-2	65, 68-70
	ESS2.D	HS-ESS2-2	95, 97
	ESS2.E		97
	ESS3.D	HS-ESS3-5	148, 155
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.			10

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.			3, 5, 7
	ESS1.B	HS-ESS1-4	35-43, 47
	ESS3.D	HS-ESS3-6	148, 155
Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units.			3, 5
Create a computational model or simulation of a phenomenon, designed device, process, or system.	ESS3.C	HS-ESS3-3	145

ISBN: 978-1-927309-50-6

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.			9, 11
	ESS1.A	HS-ESS1-2	14-15
	ESS2.C		87, 90
	ESS2.D		92
	ESS3.A	HS-ESS3-1	107-110
	ESS3.B	HS-ESS3-1	125-127
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.	ESS1.C		58
		HS-ESS1-6	49-53
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.	ESS3-A		110, 112-113, 116-120
	ESS3-A		128
	ESS3-C	HS-ESS3-4	135-137, 140-142

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.			9
Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	ESS1.C	HS-ESS1-5	49-50, 53
			51-52
	ESS2.D		94
	ESS2.E	HS-ESS2-7	96-98, 101-102
Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).	ESS3.A	HS-ESS3-2	110, 112-114, 116-120, 123
	ESS3.D		152

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.			11
	ESS3.B		131
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).	ESS1.A	HS-ESS1-3	20-22

ISBN: 978-1-927309-50-6

Course Guides by DCI and by Topic

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

NGSS HS-ESS PROGRAM BY DISCIPLINARY CORE IDEA	PERFORMANCE EXPECTATION	CHAPTER IN STUDENT EDITION
HS-ESS1 EARTH'S PLACE IN THE UNIVERSE		
ESS1.A: The Universe and Its Stars		
• The Sun is changing and will burn out. • Stars can be studied using their light spectra and brightness. • The Big Bang is supported by many different lines of evidence. • Elements are produced by nucleosynthesis.	HS-ESS1-1 HS-ESS1-2, HS-ESS1-3 HS-ESS1-2 HS-ESS1-2, HS-ESS1-3	The Universe and Its Stars
ESS1.B: Earth and the Solar System		
• Kepler's laws describe common features of the motions of orbiting objects.	HS-ESS1-4	Earth and the Solar System
ESS1.C: The History of Planet Earth		
• Continental rocks are older than rocks of the ocean floor. • Extraterrestrial objects can provide information about Earth's history.	HS-ESS1-5 HS-ESS1-6	The History of Planet Earth
HS-ESS2 EARTH'S SYSTEMS		
ESS2.A: Earth Materials and Systems		
• Earth's systems cause feedback effects. • Empirical evidence lead to a model of the Earth's structure. • The geological record shows changes to global and regional climates.	HS-ESS2-1, HS-ESS2-2 HS-ESS2-3 HS-ESS2-4	Earth Materials and Systems
ESS2.B: Plate Tectonics and Large-Scale Interactions		
• Radioactive decay provides the heat that drives mantle convection. • Plate tectonics explains the movements of the Earth's surface.	HS-ESS2-3 HS-ESS2-1	Plate Tectonics
ESS2.C: The Role of Water in Earth's Surface Processes		
• Water is central to Earth's dynamics.	HS-ESS2-5	The Role of Water in Earth's Surface Processes
ESS2.D: Weather and Climate		
• Earth's climate is driven by the Sun. • Organisms caused change in the early atmosphere. • Human activity has affected climate.	HS-ESS2-2, HS-ESS2-4 HS-ESS2-6, HS-ESS2-7 HS-ESS2-4, HS-ESS2-6	Weather, Climate and Biogeology
ESS2.E: Biogeology		
• The Earth's surface and the life that exists on it coevolve.	HS-ESS2-7	Weather, Climate and Biogeology
HS-ESS3 EARTH AND HUMAN ACTIVITY		
ESS3.A: Natural Resources		
• Resource availability has guided development of human societies. • Resource extraction and use has costs, risks, and benefits.	HS-ESS3-1 HS-ESS3-2	Natural Resources
ESS3.B: Natural Hazards		
• Natural hazards have shaped human history.	HS-ESS3-1	Natural Hazards
ESS3.C: Human Impacts on Earth Systems		
• Natural resources must be managed responsibly. • New technologies can contribute to sustainability.	HS-ESS3-3 HS-ESS3-4	Human Impacts on Earth Systems
ESS3.D: Global Climate Change		
• Humans have the ability to manage their impact on the Earth. • Studies and simulations provide information about Earth's systems.	HS-ESS3-5 HS-ESS3-6	Global Climate Change

ISBN: 978-1-927309-50-6

NGSS HS-ESS PROGRAM BY TOPIC	PERFORMANCE EXPECTATION	CHAPTER IN STUDENT EDITION
HS SPACE SYSTEMS		
ESS1.A: The Universe and Its Stars		
• The Sun is changing and will burn out. • Stars can be studied using their light spectra and brightness. • The Big Bang is supported by many different lines of evidence. • Elements are produced by nucleosynthesis.	HS-ESS1-1 HS-ESS1-2, HS-ESS1-3 HS-ESS1-2 HS-ESS1-2, HS-ESS1-3	The Universe and Its Stars
ESS1.B: Earth and the Solar System		
• Kepler's laws describe common features of the motions of orbiting objects.	HS-ESS1-4	Earth and the Solar System
HS HISTORY OF EARTH		
ESS1.C: The History of Planet Earth		
• Continental rocks are older than rocks of the ocean floor. • Extraterrestrial objects can provide information about Earth's history.	HS-ESS1-5 HS-ESS1-6	The History of Planet Earth
ESS2.A: Earth Materials and Systems		
• Earth's systems cause feedback effects.	HS-ESS2-1, HS-ESS2-2	Earth Materials and Systems
ESS2.B: Plate Tectonics and Large-Scale Interactions		
• Plate tectonics explains the movements of the Earth's surface.	HS-ESS2-1	Plate Tectonics
HS EARTH'S SYSTEMS		
ESS2.A: Earth Materials and Systems		
• Earth's systems cause feedback effects. • Empirical evidence lead to a model of the Earth's structure.	HS-ESS2-2 HS-ESS2-3	Earth Materials and Systems
ESS2.B: Plate Tectonics and Large-Scale Interactions		
• Radioactive decay provides the heat that drives mantle convection.	HS-ESS2-3	Plate Tectonics
ESS2.C: The Role of Water in Earth's Surface Processes		
• Water is central to Earth's dynamics.	HS-ESS2-5	The Role of Water in Earth's Surface Processes
ESS2.D: Weather and Climate		
• Earth's climate is driven by the Sun. • Organisms caused change in the early atmosphere. • Human activity has affected climate.	HS-ESS2-2 HS-ESS2-6, HS-ESS2-7 HS-ESS2-6	Weather, Climate and Biogeology
ESS2.E: Biogeology		
• The Earth's surface and the life that exists on it coevolve.	HS-ESS2-7	Weather, Climate and Biogeology
HS WEATHER AND CLIMATE		
ESS2.A: Earth Materials and Systems		
• The geological record shows changes to global and regional climates.	HS-ESS2-4	Earth Materials and Systems
ESS2.D: Weather and Climate		
• Earth's climate is driven by the Sun.	HS-ESS2-4	Weather, Climate and Biogeology
ESS3.D: Global Climate Change		
• Humans have the ability to manage their impact on the Earth.	HS-ESS3-5	Global Climate Change
HS HUMAN SUSTAINABILITY		
ESS3.A: Natural Resources		
• Resource availability has guided development of human societies. • Resource extraction and use has costs, risks, and benefits.	HS-ESS3-1 HS-ESS3-2	Natural Resources
ESS3.B: Natural Hazards		
• Natural hazards have shaped human history.	HS-ESS3-1	Natural Hazards
ESS3.C: Human Impacts on Earth Systems		
• Natural resources must be managed responsibly. • New technologies can contribute to sustainability.	HS-ESS3-3 HS-ESS3-4	Human Impacts on Earth Systems
ESS3.D: Global Climate Change		
• Studies and simulations provide information about Earth's systems.	HS-ESS3-6	Global Climate Change

ISBN: 978-1-927309-50-6

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