The Three Dimensions of the Next Generation Science Standards (NGSS)

Scientific and Engineering Practices

1. Asking questions (for science) and defining problems (for engineering)

A basic practice of the *scientist* is the ability to formulate empirically answerable questions about phenomena to establish what is already know, and to determine what questions have yet to be satisfactorily answered.

Engineering begins with a problem that needs to be solved, such as "How can we reduce the nation's dependence on fossil fuels?" or "What can be done to reduce a particular disease?" or "How can we improve the fuel efficiency of automobiles?"

2. Developing and using models

Science often involves the construction and use of models and simulations to help develop explanations about natural phenomena.

Engineering makes use of models and simulations to analyze systems to identify flaw that might occur or to test possible solutions to a new problem.

3. Planning and carrying out investigations

A major practice of *scientists* is planning and carrying out systematic scientific investigations that require identifying variables and clarifying what counts as data.

Engineering investigations are conducted to gain data essential for specifying criteria or parameters and to test proposed designs.

4. Analyzing and interpreting data

Scientific investigations produce data that must be analyzed to derive meaning. *Scientists* use a range of tools to identify significant features and patterns in the data.

Engineering investigations include analysis of data collected in the tests of designs. This allows comparison of different solutions and determines how well each meets specific design criteria.

5. Using mathematics and computational thinking

In *science*, mathematics and computation are fundamental tools for representing physical variables and their relationships.

In *engineering*, mathematical and computational representations of established relationships and principles are an integral part of the design process.

6. Constructing explanations (for science) and designing solutions (for engineering)

The goal of *science* is the construction of theories that provide explanatory accounts of the material world.

The goal of *engineering* design is a systematic approach to solving engineering problems that is based on scientific knowledge and models of the material world.

7. Engaging in argument from evidence

In *science*, reasoning and argument are essential for clarifying strengths and weaknesses of a line of evidence and for identifying the best explanation for a natural phenomenon.

In *engineering*, reasoning and arguments are essential for finding the best solution to a problem. Engineers collaborate with their peers throughout the design process.

8. Obtaining, evaluating, and communicating information

Science cannot advance if scientists are unable to communicate their findings clearly and persuasively or learn about the findings of others.

Engineering cannot produce new or improved technologies if the advantages of their designs are not communicated clearly and persuasively.

Crosscutting Concepts

1. Patterns
Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

2. Cause and Effect: Mechanism and Explanation
Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain new contexts.

3. Scale, Proportion, and Quantity
In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

4. Systems and System Models
Defining the system under study – specifying its boundaries and making explicit a model of that system – provides tools for understanding and testing ideas that are applicable throughout science and engineering.

5. Energy and Matter: Flows, Cycles, and Conservation
Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

6. Structure and Function
The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

7. Stability and Change
For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of the system are critical elements of study.

J. Spiegel, San Diego County Office of Education. Adapted from the National Research Council. (2012). A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.

Disciplinary Core Ideas

Physical Sciences

PS1—MATTER AND ITS INTERACTIONS: *How can one explain the structure, properties, and interactions of matter?*

- **PS1.A: STRUCTURES AND PROPERTIES OF MATTER:** *How do particles combine to form the variety of matter one observes?*
- **PS1.B: CHEMICAL REACTIONS:** *How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?*
- **PS1.C: NUCLEAR PROCESSES:** *What forces hold nuclei together and mediate nuclear processes?*

PS2—MOTION AND STABILITY: FORCES AND INTERACTIONS: *How can one explain and predict interactions between objects and within systems of objects?*

- **PS2.A: FORCES AND MOTION** *How can one predict an object's continued motion, changes in motion, or stability?*
- **PS2.B: TYPES OF INTERACTIONS:** *What underlying forces explain the variety of interactions observed?*
- **PS2.C: STABILITY AND INSTABILITY IN PHYSICAL SYSTEMS:** *Why are some physical systems more stable than others?*

PS3—ENERGY: *How is energy transferred and conserved?*

- **PS3.A: DEFINITIONS OF ENERGY:** *What is energy?*
- **PS3.B: CONSERVATION OF ENERGY AND ENERGY TRANSFER:** *What is meant by conservation of energy? How is energy transferred between objects or systems?*
- **PS3.C: RELATIONSHIP BETWEEN ENERGY AND FORCES:** *How are forces related to energy?*
- **PS3.D: ENERGY IN CHEMICAL PROCESSES AND EVERYDAY LIFE:** *How do food and fuel provide energy? If energy is conserved, why do people say it is produced or used?*

PS4—WAVES AND THEIR APPLICATIONS IN TECHNOLOGIES FOR INFORMATION TRANSFER: *How are waves used to transfer energy and information?*

- **PS4.A: WAVE PROPERTIES:** *What are the characteristic properties and behaviors of waves?*
- **PS4.B: ELECTROMAGNETIC RADIATION:** *What is light? How can one explain the varied effects that involve light? What other forms of electromagnetic radiation are there?*
- **PS4.C: INFORMATION TECHNOLOGIES AND INSTRUMENTATION:** *How are instruments that transmit and detect waves used to extend human senses?*

Life Sciences

LS1—FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES: *How do organisms live, grow, respond to their environment, and reproduce?*

- **LS1.A: STRUCTURE AND FUNCTION:** *How do the structures of organisms enable life's functions?*
- **LS1.B: GROWTH AND DEVELOPMENT OF ORGANISMS:** *How do organisms grow and develop?*
- **LS1.C: ORGANIZATION FOR MATTER AND ENERGY FLOW IN ORGANISMS:** *How do organisms obtain and use the matter and energy they need to live and grow?*
- **LS1.D: INFORMATION PROCESSING:** *How do organisms detect, process, and use information about the environment?*

LS2—ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS: *How and why do organisms interact with their environment and what are the effects of these interactions?*

- **LS2.A: INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS:** *How do organisms interact with the living and nonliving environments to obtain matter and energy?*
- **LS2.B: CYCLES OF MATTER AND ENERGY TRANSFER IN ECOSYSTEMS:** *How do matter and energy move through an ecosystem?*
- **LS2.C: ECOSYSTEM DYNAMICS, FUNCTIONING, AND RESILIENCE:** *What happens to ecosystems when the environment changes?*
- **LS2.D: SOCIAL INTERACTIONS AND GROUP BEHAVIOR:** *How do organisms interact in groups so as to benefit individuals?*

LS3—HEREDITY: INHERITANCE AND VARIATION OF TRAITS: *How are characteristics of one generation passed to the next? How can individuals of the same species and even siblings have different characteristics?*

- **LS3.A: INHERITANCE OF TRAITS:** *How are the characteristics of one generation related to the previous generation?*
- **LS3.B: VARIATION OF TRAITS:** *Why do individuals of the same species vary in how they look, function, and behave?*

LS4—BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY: *How can there be so many similarities among organisms yet so many different kinds of plants, animals, and microorganisms? How does biodiversity affect humans?*

- **LS4.A: EVIDENCE OF COMMON ANCESTRY AND DIVERSITY:** *What evidence shows that different species are related?*
- **LS4.B: NATURAL SELECTION:** *How does genetic variation among organisms affect survival and reproduction?*
- **LS4.C: ADAPTATION:** *How does genetic variation among organisms affect survival and reproduction?*
- **LS4.D: BIODIVERSITY AND HUMANS:** *Why do individuals of the same species vary in how they look, function, and behave?*

Earth and Space Science

ESS1— EARTH'S PLACE IN THE UNIVERSE: *What is the universe, and what is Earth's place in it?*

- **ESS1.A: THE UNIVERSE AND ITS STARS:** *What is the universe, and what goes on in stars?*
- **ESS1.B: EARTH AND THE SOLAR SYSTEM:** *What are the predictable patterns caused by Earth's movement in the solar system?*
- **ESS1.C: THE HISTORY OF PLANET EARTH:** *How do people reconstruct and date events in Earth's planetary history?*

ESS2—EARTH'S SYSTEMS: *How and why is Earth constantly changing?*

- **ESS2.A: EARTH MATERIALS AND SYSTEMS:** *How do Earth's major systems interact?*
- **ESS2.B: PLATE TECTONICS AND LARGE-SCALE SYSTEM INTERACTIONS:** *Why do the continents move, and what causes earthquakes and volcanoes?*
- **ESS2.C: THE ROLES OF WATER IN EARTH'S SURFACE PROCESSES:** *How do the properties and movements of water shape Earth's surface and affect its systems?*
- **ESS2.D: WEATHER AND CLIMATE**: *What regulates weather and climate?*
- **ESS2.E: BIOGEOLOGY:** *How do living organisms alter Earth's processes and structures*?

ESS3—EARTH AND HUMAN ACTIVITY: *How do Earth's surface processes and human activities affect each other?*

- **ESS3.A: NATURAL RESOURCES:** *How do humans depend on Earth's resources?*
- **ESS3.B: NATURAL HAZARDS:** *How do natural hazards affect individuals and societies?*
- **ESS3.C: HUMAN IMPACTS ON EARTH SYSTEMS:** *How do humans change the planet?*
- **ESS3.D: GLOBAL CLIMATE CHANGE:** *How do people model and predict the effects of human activities on Earth's climate?*

Engineering, Technology, and Applications of Science

ETS1: ENGINEERING DESIGN: *How do engineers solve problems?*

- **ETS1.A: DEFINING AND DELIMITING AN ENGINEERING PROBLEM:** *What is a design for? What are the criteria and constraints of a successful solution?*
- **ETS1.B: DEVELOPING POSSIBLE SOLUTIONS:** *What is the process for developing potential design solutions?*
- **ETS1.C: OPTIMIZING THE DESIGN SOLUTION:** *How can the various proposed design solutions be compared and improved?*

ETS2: LINKS AMONG ENGINEERING, TECHNOLOGY, SCIENCE, AND SOCIETY: *How are engineering, technology, science, and society interconnected?*

- **ETS2.A: INTERDEPENDENCE OF SCIENCE, ENGINEERING, AND TECHNOLOGY:** *What are the relationships among science, engineering, and technology?*
- **ETS2.B: INFLUENCE OF ENGINEERING, TECHNOLOGY, AND SCIENCE ON SOCIETY AND THE NATURAL WORLD:** *How do science, engineering, and the technologies that result from them affect the ways in which people live? How do they affect the natural world?*

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