Appendix E – Progressions Within the Next Generation Science Standards

Following the vision of *A Framework for K-12 Science Education*, the NGSS are intended to increase coherence in K-12 science education. The following excerpt from the *Framework* explains the approach in more detail:

"First, it is built on the notion of learning as a developmental progression. It is designed to help children continually build on and revise their knowledge and abilities, starting from their curiosity about what they see around them and their initial conceptions about how the world works. The goal is to guide their knowledge toward a more scientifically based and coherent view of the natural sciences and engineering, as well as of the ways in which they are pursued and their results can be used.

Second, the framework focuses on a limited number of core ideas in science and engineering both within and across the disciplines. The committee made this choice in order to avoid the shallow coverage of a large number of topics and to allow more time for teachers and students to explore each idea in greater depth. Reduction of the sheer sum of details to be mastered is intended to give time for students to engage in scientific investigations and argumentation and to achieve depth of understanding of the core ideas presented. Delimiting what is to be learned about each core idea within each grade band also helps clarify what is most important to spend time on, and avoid the proliferation of detail to be learned with no conceptual grounding.

Third, the framework emphasizes that learning about science and engineering involves integration of the knowledge of scientific explanations (i.e., content knowledge) and the practices needed to engage in scientific inquiry and engineering design. Thus the framework seeks to illustrate how knowledge and practice must be intertwined in designing learning experiences in K-12 science education." - NRC Framework for K-12 Science Education, 1-3

Disciplinary Core Idea Progression

The *Framework* does indicate the progression of disciplinary core ideas by describing grade band endpoints for each disciplinary core idea. The progressions have been summarized to the NGSS in the following documents. They describe the content that occurs at each grade band. Some of the sub-ideas within the disciplinary core ideas overlap significantly. Readers will notice there is not always a clear divide between those ideas, so several progressions divided among more than one sub-idea. The purpose of these diagrams is to briefly describe the content at each grade band for each disciplinary core idea across K-12. This progression is for reference only. The full progressions can be seen in the *Framework*. In addition, the NGSS show the integration of the three dimensions. This document in no way endorses separating the disciplinary core ideas from the other two dimensions.

(1) Identify your grade(s) level "span". (2) Read the contents of the "box" that coincides with a "standard" that you "should" be addressing in a course or courses that you presently teach. (3) Annotate each item in the box with an abbreviation for the course that you teach where this item "should" be presented. (4) Use a "+" to indicate if you presently address this item or a "-" if you do not.

Earth Space Science Progression

INCREASING SOPHISTICATION OF STUDENT THINKING

{Standard}	K-2	3-5	6-8	9-12 {Band}
ESS1.A The universe and its stars	Patterns of movement of the sun, moon and stars as seen from Earth can be observed, described and predicted	Stars range greatly in size and distance from Earth and this can explain their relative brightness	The Big Bang describes the origin of the universe; the Earth is part of one galaxy among many	a) Light spectra are used to describe characteristics of stars; b) The sun will burn out over a life span of about 10 billion years; c) Stars and galaxies are abundant in the universe; d) The development of technologies has provided the observable astronomical data that are the empirical evidence of the Big Bang theory
ESS1.B Earth and the solar system		The Earth's orbit and rotation, and the orbit of the moon around the Earth cause observed patterns of movement of celestial objects as seen from Earth	The solar system can be modeled to predict tides, eclipses and the apparent motion of planets seen in the sky from Earth. The Earth's tilt cause seasons	a) Kepler's laws describe common features of the motions of orbiting objects; b) Ice ages and other gradual climatic changes are caused by gradual changes in Earth's orbit and changes in Earth's axial tilt APES, +
ESS1.C The history of planet Earth	Some events on Earth occur in cycles while some are discrete events, any of which can occur over varying time scales	Earth has changed over time; the history of local landscapes can be inferred. Certain features can be used to order events that have occurred in a landscape	Rock strata and the fossil record can be used as evidence to organize the relative occurrence of major historical events in Earth's history	Radioactive-decay lifetimes and isotopic content can be used to fix the scale of geologic time; the rock record resulting from tectonic and other geoscience processes as well as objects from the solar system can provide evidence of Earth's early history and the relative ages of major geologic formations
ESS2.A Earth materials and systems	The materials and resources found in association with landforms provide homes for plants and animals	Four major Earth systems interact to affect materials and processes on Earth's surface	Energy flows and matter cycles within and among Earth's systems, including the sun and Earth's interior as primary energy sources; Plate tectonics is one result of these processes	Feedback effects exist within and among Earth's systems; APES, +
ESS2.B Plate tectonics and large-scale system interactions	Wind and water carry natural materials that influence landforms and what can live in a location	Earth's physical features occur in patterns, as do earthquakes and volcanoes; Maps can be used to locate features and predict location of those events	Plate tectonics is the unifying theory that explains movements of rocks at Earth's surface and geological history; Maps are used to display evidence of plate movement	Radioactive decay and residual heat of formation within Earth's interior contribute to thermal convection in the mantle APES, +

	K-2	3-5	6-8	9-12
ESS2.C The roles of water in Earth's surface processes	Water is found in many places and forms on Earth;	The movement of water shapes landforms; Most of Earth's water is in the ocean and much of the Earth's fresh water is in glaciers or underground	Water cycles among land, ocean and atmosphere, and is propelled by sunlight and gravity; Density variations of sea water drive interconnected ocean currents; Water movement causes weathering and erosion, changing landscape features --- Complex interactions determine local weather patterns and influence climate, including the role of the ocean and greenhouse gasses	The planet's dynamics are greatly influenced by water's unique chemical and physical properties APES, +
ESS2.D Weather and climate	Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region and time; People record weather patterns over time	Climate describes patterns of typical weather conditions over different scales and variations; Historical weather patterns can be analyzed to make predictions about future weather		The role of radiation from the sun and its interactions with the atmosphere, ocean and land are the foundation for the global climate system; Some sources of climate change can be determined from geologic evidence; Global climate models are used to predict future changes, including changes influenced by human behavior and natural factors APES, +
ESS2.E Biogeology	Plants and animals depend on the resources in the place they live and can change their local environment --- Humans use natural resources for everything they do	Living things can affect the physical characteristics of their environment; Some rocks and minerals are formed from organisms or their activities	Evolution is shaped by changes in Earth's geological conditions and in turn influences Earth processes and resource availability	The biosphere and Earth's other systems have many interconnections that cause a continual co-evolution of Earth's surface and life on it APES, +
ESS3.A Natural resources		All materials, energy and fuels humans use are derived from natural sources and their use affects the environment; Some resources are renewable over time, others are not	Humans depend on Earth's land, ocean, atmosphere and biosphere for different resources, many of which are limited or not renewable; Resources are distributed unevenly around the planet as a result of past geologic processes	Resource availability has guided the development of human society and use of natural resources has associated costs, risks and benefits APES, +
ESS3.B Natural hazards	In a region, some kinds of severe weather are more likely than others; Forecasts allow communities to prepare	A variety of hazards result from natural processes; humans cannot eliminate hazards but can reduce their impacts	Some natural hazards can be predicted by mapping the history of those in a region and understanding related geological forces	Natural hazards and other geological events have shaped the course of human history at local, regional and global scales; APES, + in turn, human activities contribute to the frequency and intensity of some natural hazards
ESS3.C Human impacts on Earth systems	Things people do can affect the environment but they can make choices to reduce their impacts	Societal activities have had major effects on the land, ocean, atmosphere and even outer space; Students describe things society does to protect Earth's resources and environments	Human activities have altered the biosphere, sometimes damaging it, although changes to environments can have different impacts for different living things; Activities and technologies can be engineered to reduce people's impacts on Earth	Sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources, including the development of technologies and regulations APES, +

ESS3.D Global climate change	N/A	Humans and other organisms will be affected in many different ways if Earth's global mean temperature continues to rise	Human activities affect global warming; Decisions to reduce the impact of global warming depend on understanding climate science, engineering capabilities, and social dynamics	Global climate models used to predict changes continue to be improved, although discoveries about the global climate system are ongoing and continually needed APES, +

Life Science Progression

INCREASING SOPHISTICATION OF STUDENT THINKING

	K-2	3-5	6-8	9-12
LS1.A Structure and function	All organisms have external parts that they use to perform daily functions.	Organisms have both internal and external macroscopic structures that allow for growth, survival, behavior, and reproduction.	All living things are made up of cells. In organisms, cells work together to form tissues and organs that are specialized for particular body functions.	Systems of specialized cells within {HAnP 2,+} organisms help perform essential functions of life, which involve chemical reactions; Any one system in an organism is made up of numerous parts; Feedback mechanisms maintain an organism's internal conditions within certain limits and mediate behaviors.
LS1.B Growth and development of organisms	Organisms have predictable characteristics at different stages of development; Parents and offspring often engage in behaviors that help the offspring survive.	Reproduction is essential to every kind of organism; Organisms have unique and diverse life cycles.	Organisms reproduce sexually or asexually, transferring their genetic information to their offspring (LS3); Plant growth can continue throughout the plant's life through production of plant matter in photosynthesis; An organism's growth is controlled by genetic and environmental factors; Animals engage in behaviors that increase the odds of reproduction.	Growth and division of cells in organisms occurs by mitosis and differentiation for specific cell types; Sexual reproduction involves cell division by meiosis that result in cells with only one member from each chromosome pair in the parent cell. {HAnP 2,+}
LS1.C Organization for matter and energy flow in organisms	Animals obtain food they need from plants or other animals; Plants need water and light.	Food provides animals with the materials and energy they need for body repair, growth, warmth and motion; Plants acquire material for growth chiefly from air, water and process matter and obtain energy from sunlight, which is used to maintain conditions necessary for survival.	Plants use the energy from light to make sugars through photosynthesis; Within individual organisms, food is broken down through a series of chemical reactions that rearrange molecules and release energy.	The hydrocarbon backbones of sugars produced through photosynthesis are used to make amino acids and other molecules that can be assembled into proteins or DNA; Through cellular respiration, matter and energy flow through different organizational levels of an organism as elements are recombined to form different products and transfer energy; Cellular respiration is a key mechanism to release the energy an organism needs. {HAnP 2,+}
LS1.D Information processing	Animals sense and communicate information and respond to inputs with behaviors that help them grow and survive.	Different sense receptors are specialized for particular kinds of information; Animals use their perceptions and memories to guide their actions.	Each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain; The signals are then processed in the brain, resulting in immediate behavior or memories.	The integrated functioning of each distinct region and circuit of the brain, each primarily serving a dedicated function, is needed for successful interpretation of inputs and generation of behaviors in response. {HAnP 2,+}

	K-2	3-5	6-8	9-12
LS2.A Interdependent relationships in ecosystems	Animals use their senses and body parts to get what they need; Organisms depend on their surroundings to obtain the materials they need to grow and survive; Different plants survive better in different settings due to their varied needs.	The food of almost any animal can be traced back to plants; Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants, while decomposers restore some materials back to the soil.	Organisms and populations are dependent on their environmental interactions both with other living things and with nonliving factors, any of which can limit their growth; Competitive, predatory and mutually beneficial interactions vary across ecosystems but the patterns are shared.	Ecosystems have carrying capacities resulting from biotic and abiotic factors; The fundamental tension between resource availability and organism populations affects the abundance of species in any given ecosystem. APES, +
LS2.B Cycles of matter and energy transfer in ecosystems		Matter cycles between the air and soil and among organisms as they live and die.	The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem; Food webs model how matter and energy are transferred between producers, consumers and decomposers as the three groups interact within an ecosystem.	Photosynthesis and cellular respiration provide most of the energy for life processes; Only a fraction of matter consumed at the lower level of a food web is transferred up, resulting in fewer organisms at higher levels; At each link in an ecosystem elements are combined in different ways and matter and energy are conserved; Photosynthesis and cellular respiration are key components of the global carbon cycle. APES, +
LS2.C Ecosystem dynamics, functioning, and resilience	The places where plants and animals live often change, and if they change too much, organisms may die.	When the environment changes some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die.	Ecosystem characteristics vary over time and can lead to shifts in all of its populations; The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.	If a biological or physical disturbance to an ecosystem occurs, including one induced by human activity, the ecosystem may return to its more or less original state or become a very different ecosystem, depending on the complex set of interactions within the ecosystem. APES, +
LS2.D Social interactions and group behavior	Being part of a group helps animals obtain food, defend themselves, and cope with changes.	Groups can be composed in different ways: some are stable, others fluid; some assign specialized tasks to each member, others have all members perform similar functions.	Groups may form based on genetics, proximity or other recognition mechanisms and may dissolve if they no longer meet individuals' needs or if key members are removed; Groups engage in signaling behaviors to maintain their integrity or warn of threats.	Animals, including humans, have a strong drive for social affiliation; Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. APES, +

	K-2	3-5	6-8	9-12
LS3.A Inheritance of traits	Young organisms are very much, but not exactly, like their parents and also resemble other organisms of the same kind.	Different organisms vary in how they look and function because they have different inherited information; the environment also affects the traits that an organism develops.	In sexual reproduction each parent contributes half of the genes acquired by the offspring resulting in variation between parent and offspring; Genes chiefly regulate a specific protein, which affect an individual's traits. --- Genetic information can be altered because of mutations, which may result in beneficial, negative, or no change to proteins in or traits of an organism.	DNA carries instructions for forming species characteristics; Each cell in an organism has the same genetic content, but genes expressed by cells can differ APES, + {HAnP 2,+}
LS3.B Variation of traits				The variation and distribution of traits in a population depend on genetic and environmental factors; Genetic variation can result from mutations caused by environmental factors or errors in DNA replication, or from chromosomes swapping sections during meiosis. APES, +
LS4.A Evidence of common ancestry and diversity	Some living organisms resemble organisms that once lived on Earth.	Fossils provide evidence about the types of organisms and environments that existed long ago.	The fossil record documents the existence, diversity, extinction and change of many life forms and their environments through Earth's history and enables the inference of lines of evolutionary descent.	The ongoing branching that produces multiple lines of descent can be inferred by comparing DNA sequences, amino acid sequences, and anatomical and embryological evidence of different organisms. APES, +
LS4.B Natural selection	NA	Differences in characteristics between individuals of the same species provide advantages in surviving and reproducing.	Natural or artificial selection result in genetic variations that give some individuals an advantage in surviving and reproducing, leading to predominance of certain traits in a population.	Natural selection occurs only if there is variation in the genetic information between organisms in a population and trait variation. APES, +
LS4.C Adaptation	NA	Particular organisms can only survive in particular environments; Changes in an organism's environment are sometimes beneficial and sometimes harmful. --- All organisms obtain living and nonliving resources from their environment.	Species can change over time in response to changes in environmental conditions through adaptation by natural selection acting over generations; Traits that support successful survival and reproduction in the new environment become more common.	Natural selection results from genetic variation of individuals in a species, competition for resources, and proliferation of organisms better able to survive and reproduce; Adaptation means that the distribution of traits in a population, as well as species expansion, emergence or extinction, can change when conditions change. APES, + {HAnP 2,+}
LS4.D Biodiversity and humans	A range of different organisms live in different places.		Biodiversity is the wide range of existing life forms on Earth and includes genetic variation within a species and species variation in different habitats and ecosystem types. --- Changes in biodiversity can influence humans' resources and ecosystem services they rely on.	Biodiversity is increased by formation of new species and reduced by extinction. --- Humans depend on biodiversity but also have adverse impacts on it, including the potential of major extinctions that may be harmful to humans and other organisms; Sustaining biodiversity is essential to supporting life on Earth. APES, +

NEXT GENERATION SCIENCE STANDARDS For States, By States

Physical Science Progression

INCREASING SOPHISTICATION OF STUDENT THINKING

	K-2	3-5	6-8	9-12
PS1.A Structure of matter (includes PS1.C Nuclear processes)	Matter exists as different substances as exhibited by their observable properties. Different properties are suited to different purposes.	Matter exists as particles that are always conserved even if they are too small to see. Measurements of a variety of observable properties can be used to identify particular substances.	The fact that matter is composed of atoms and molecules can be used to explain properties of substances, diversity of materials, states of matter and phase changes.	The sub-atomic structural model and interactions between electric charges at the atomic scale can be used to explain interactions of matter, including chemical reactions and nuclear processes. Repeating patterns of the periodic table reflect patterns of outer electrons. {HAnP 2,+}
PS1.B Chemical reactions	Heating and cooling substances cause changes that are sometimes reversible and sometimes not.	Chemical reactions that occur when two or more substances are mixed can be identified by the emergence of substances with different properties; the total mass remains the same.	Reacting substances rearrange to form different molecules, but the number of atoms is conserved. Some reactions release energy and others absorb energy.	Chemical processes are understood in terms of collisions of molecules, rearrangement of atoms, and changes in binding energy as determined by properties of elements involved. {HAnP 2,+}
PS2.A Forces and motion	Pushes and pulls can have different strengths and directions, and can change the speed or direction of its motion or start or stop it.	The effect of unbalanced forces on an object results in a change of motion. Patterns of motion can be used to predict future motion.	A frame of reference from which motion is described and the role of the mass of an object must be qualitatively accounted for in any change of motion due to the application of a force.	Newton's 2nd law (F=ma) and the conservation of momentum can be used to predict changes in the motion of macroscopic objects.
PS2.B Types of interactions			Forces that act at a distance involve fields that can be mapped by their relative strength and effect on an object.	The effects of forces at a distance at macroscopic and atomic levels can be predicted and can be used to describe the relationship between electrical and magnetic fields. {HAnP 2,+}
PS2.C Stability & instability in physical systems	A change in motion of an object can depend on the effects of multiple forces.	A system's pattern of change, including how a system may appear to be unchanging, is a result of dynamic but balanced processes.	Stable and unstable systems as well as static and dynamic systems can be distinguished. Patterns of change and an understanding of feedback mechanisms are used to predict a system's future.	A system's behavior under a variety of conditions can be explained and predicted based on the cycles and transformations that drive it; some systems can be unpredictable given certain conditions.
PS3.A Definitions of energy	NA	Energy is present in moving objects, sound, light and heat and can be transferred between objects or from place to place. Faster moving objects contain more energy.	Kinetic energy can be distinguished from the various forms of potential energy. Energy changes to and from each type can be tracked through physical or chemical interactions; the relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter.	The total energy within a system is conserved. Energy transfer within and between systems can be described and predicted in terms of interactions of particles or fields. ---------- Systems move toward stable states. {HAnP 2,+}
PS3.B Conservation of energy and energy transfer	Sunlight warms Earth's surface.			

	K-2	3-5	6-8	9-12
PS3.C Relationship between energy and forces	Bigger forces cause bigger changes in an object's motion or shape.	Forces due to contact and forces at a distance transfer energy, which can change an object's motion.	When two objects interact, each one exerts a force on the other, and these forces can transfer energy between them.	Force fields act to reduce energy in the field between objects.
PS3.D Energy in chemical processes and everyday life	Friction warms surfaces.	Energy can be "produced," "used" or "released" by converting stored energy; Plants capture energy from sunlight which can later be used as fuel or food.	Sunlight is captured by plants and used in a reaction to produce sugar molecules, which can be reversed by burning those molecules to release energy. Mechanical efficiency can be increased through reduction of friction.	Photosynthesis is the primary means of capturing radiation from the sun; Physical and chemical processes in an organism account for transport and transfer of energy needed for life; energy cannot be destroyed, it can be converted to less useful forms. {HAnP 2,+} APES, +
PS4.A Wave properties	Waves are regular patterns of motion which can be made in water by disturbing the surface. Sound can make matter vibrate, and vibrating matter can make sound.	Waves of the same type can differ in amplitude and wavelength. The interaction of waves of the same type is affected by the relative phase of the interacting waves.	A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. A sound wave needs a medium through which it is transmitted.	The wavelength and frequency of a wave are related to one another by the speed of the wave, which depends on the type of wave and the medium through which it is passing. The reflection, refraction, and transmission of waves at an interface between two media can be modeled on the basis of these properties. Waves can cause resonance and be used to transmit information. {HAnP 2,+}
PS4.B Electromagnetic radiation	Light travels from place to place; interactions of light with macroscopic objects.	Interactions of light with properties of an object can be described and predicted.	A basic wave model is used to describe how light interacts with objects, including transparent materials.	Both an electromagnetic wave model and a photon model explain features of electromagnetic radiation broadly and describe common applications of electromagnetic radiation. {HAnP 2,+}
PS4.C Information technologies and instrumentation	People use devices and senses to send and receive information.	---------- Devices can encode, send, receive and decode digitized information.	Devices are designed to send and receive information (often digital) based on principles of how waves interact with matter.	A wide variety of technologies use waves to generate and detect signals and store and interpret information.