Unit 3 continues to integrate all three disciplines—life science, physical science, and earth science—but now incorporates some engineering and design components as well. In this unit, students use what they already know about ecosystems to explore how matter cycles and energy flows within them, keeping them healthy and functioning. Students are then able to use these concepts and mimic a natural ecosystem in the design of their own aquaponics system.

The integrated model requires students to access and use a wide range of ideas from prior grades. This content knowledge spans seven different Disciplinary Core Ideas: LS1.C. Organization for Matter and Energy Flow in Organisms, PS3.D: Energy in Chemical Processes and Everyday Life, ESS2.A. Earth’s Materials and Systems, PS1.A. Structure and Properties of Matter, PS1.B. Chemical Reactions, ETS1.B. Developing Possible Solutions, and ETS1.C. Optimizing the Design Solution.

As students explore these core ideas, they build on their skills in the following science and engineering practices: Developing and Using Models, Analyzing and Interpreting Data, and Constructing Explanations and Designing Solutions. In addition to science and engineering practices, students also continue to build on their knowledge of the following crosscutting concepts: Patterns, Energy and Matter, and Stability and Change.

\*This summary is based on information found in the NGSS Framework.

**K-8 Progression of Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts for Unit 3**

|  |  |  |  |
| --- | --- | --- | --- |
| **Disciplinary Core Ideas** | **K-2** | **3-5** | **6-8** |
| **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 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. |
| **PS3.D**  **Energy in Chemical Processes and Everyday Life** | Sunlight warms Earth’s surface. | 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. |
| **ESS2.A**  **Earth’s Materials and Systems** | Wind and water change the shape of the land. | Four major Earth systems interact. Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, organisms, and gravity break rocks, soils, and sediments into smaller pieces and move them around. | 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. |
| **PS1.A. Structure and Properties of Matter** | Matter exists as different substances that have observable different properties. Different properties are suited to different purposes. Objects can be built up from smaller parts. | Because matter exists as particles that are too small to see, matter is always conserved even if it seems to disappear. Measurements of a variety of observable properties can be used to identify particular materials. | The fact that matter is composed of atoms and molecules can be used to explain the properties of substances, diversity of materials, states of matter, phase changes, and conservation of matter. |
| **PS1.B**  **Chemical Reactions** | Heating and cooling substances cause changes that are sometimes reversible and sometimes not. | Chemical reactions that occur when 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. |
| **ETS1.B**  **Developing Possible Solutions** | Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem’s solutions to other people. | Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions.  At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. | A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.  Models of all kinds are important for testing solutions. |
| **ETS1.C**  **Optimizing the Design Solution** | Because there is always more than one possible solution to a problem, it is useful to compare and test designs. | Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. | Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. |

|  |  |  |  |
| --- | --- | --- | --- |
| **Science and Engineering Practices** | **K-2** | **3-5** | **6-8** |
| **Developing and Using Models\*** | Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions.   * Develop and/or use a model to represent amounts, relationships, relative scales (bigger/smaller) and/or patterns in the natural and designed world(s). * Develop a simple model based on evidence to represent a proposed object or tool. | Modeling in 3–5 builds on prior experiences and progresses to building and revising simple models and using models to represent events and design solutions.   * Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. * Develop and/or use models to describe and/or predict phenomena. * Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. * Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system. | Modeling in 6–8 builds on prior 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. * Develop a model to describe unobservable mechanisms. * Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. |
| **Analyzing and Interpreting Data\*** | Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations.   * Compare predictions (based on prior experiences) to what occurred (observable events).   . | Analyzing data in 3-5 builds on prior experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used.   * Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings. * Represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships. | Analyzing data in 6-8 builds on prior experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.   * Analyze and interpret data to determine similarities and differences in findings. |
| **Constructing Explanations\*** | Constructing Explanations in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena.   * Use information from observations (firsthand and from media) to construct an evidence-based account for natural phenomena. | Constructing Explanations in 3-5 builds on prior experiences and progresses to the use of evidence and ideas in constructing explanations that specify variables that describe and predict phenomena.   * Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. | Constructing Explanations in 6-8 builds on prior experiences and progresses to include constructing explanations supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.   * Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) 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. |
| **Designing Solutions\*** | Designing solutions in K-2 builds on prior experiences and progresses to the use of evidence and ideas in designing solutions.   * Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem. | Designing solutions in 3-5 builds on prior experiences and progresses to the use of evidence in designing multiple solutions to design problems.   * Apply scientific ideas to solve design problems. | Designing solutions in 6-8 builds on prior experiences and progresses to include designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.   * Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. |

\*These SEPs are summatively assessed using the Culminating Project.

|  |  |  |  |
| --- | --- | --- | --- |
| **Crosscutting Concepts** | **K-2** | **3-5** | **6-8** |
| **Patterns\*** | Students recognize that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.   * Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. | Students identify similarities and differences in order to sort and classify natural objects and designed products. They identify patterns related to time, including simple rates of change and cycles, and to use these patterns to make predictions.   * Patterns can be used as evidence to support an explanation. | Students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data.   * Macroscopic patterns are related to the nature of microscopic and atomic-level structure. |
| **Energy and Matter\*** | Students observe objects may break into smaller pieces, be put together into larger pieces, or change shapes.   * Objects may break into smaller pieces, be put together into larger pieces, or change shapes. | Students learn matter is made of particles and energy can be transferred in various ways and between objects. Students observe the conservation of matter by tracking matter flows and cycles before and after processes and recognizing the total weight of substances does not change.   * Matter is made of particles. * Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change. This is what is meant by conservation of matter. Matter is transported into, out of, and within systems. * Energy can be transferred in various ways and between objects. | Students learn matter is conserved because atoms are conserved in physical and chemical processes. They also learn that within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.   * Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. * Matter is conserved because atoms are conserved in physical and chemical processes. * The transfer of energy can be tracked as energy flows through a natural system. |
| **Stability and Change\*** | Students observe some things stay the same while other things change, and things may change slowly or rapidly.   * Some things stay the same while other things change. | Students measure change in terms of differences over time, and observe that change may occur at different rates. Students learn some systems appear stable, but over long periods of time they will eventually change.   * Change is measured in terms of differences over time and may occur at different rates. | Students explain stability and change in natural or designed systems by examining changes over time, and considering forces at different scales, including the atomic scale. Students learn changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time.   * Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. |

\*These CCCs are summatively assessed using the Culminating Project.

**Progression of Knowledge from Kindergarten – 8th grade**

LS1.C. Organization for Matter and Energy Flow in Organisms: In Kindergarten – second grade, students make observations to begin to understand the core content of this DCI—what plants and animals need to live and grow and how this is all related. In fifth grade, students explore these relationships a bit deeper by making connections between plants and animals as it relates to matter and energy flow. Students first gather evidence that plants get their matter from air and water, and then use models to describe that this matter also holds energy that plants harvested from the sun. Since animals eat plants, this original energy from the sun is what gives animals the energy they need for everyday life and growth. By the time students get to this seventh grade unit, they already understand the mechanisms at a macroscopic level and thus are well prepared to learn about the detailed underlying mechanisms of photosynthesis and cellular respiration. While in the K-2 band, students are focused on Patterns and Analyzing and Interpreting Data as they begin their exploration with real-life observations, the later grade bands focus entirely on the lens of Energy and Matter as students consider the connections between plants and animals and within an ecosystem as a whole. In line with this shift, students also move towards the science and engineering practices of Developing and Using Models and using evidence as they engage in Constructing Explanations and Engaging in Argument From Evidence.

The following is the progression of the Performance Expectations for this DCI:

|  |  |
| --- | --- |
| **K-LS1-1** | Use observations to describe patterns of what plants and animals (including humans) need to survive. |
| **5-PS3-1** | Use models to describe that energy in animals’ food (used for body repair, growth, motion, and to maintain warmth) was once energy from the sun. |
| **5-LS1-1** | Support an argument that plants get the materials they need for growth chiefly from air and water. |
| **MS-LS1-6** | Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. |
| **MS-LS1-7** | Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. |

PS3.D. Energy in Chemical Processes and Everyday Life: In Kindergarten – second grade, students are not explicitly introduced to this DCI but they do learn that sunlight warms the Earth’s surface, which is an essential foundation for the chemical processes they will explore in later grades. In fourth grade, students first engage in this DCI by learning that the expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use. While this Performance Expectation applies the concept to designed systems, rather than the natural systems in other Performance Expectations, it is an essential understanding for all of them. In fifth grade, students begin this exploration of natural systems by studying photosynthesis without explicit reference to the term; they learn that the energy released from food was once energy from the sun captured in a chemical process. In middle school, students dive deeper, constructing explanations and developing models for both photosynthesis and cellular respiration, explaining all components and interactions involved in these chemical reactions. At all grade bands, students are engaging with the crosscutting concept of Energy Matter, but Science and Engineering practices range from Designing Solutions to Developing and Using Models to Constructing Explanations.

The following is the progression of the Performance Expectations for this DCI:

|  |  |
| --- | --- |
| **4-PS3-4** | Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. |
| **5-PS3-1** | Use models to describe that energy in animals’ food (used for body repair, growth, motion, and to maintain warmth) was once energy from the sun. |
| **MS-LS1-6** | Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. |
| **MS-LS1-7** | Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. |

ESS2.A. Earth’s Materials and Systems: In Kindergarten – second grade, students begin with the basic idea that wind and water can change the shape of the land and use this knowledge to compare solutions that might prevent this from happening. In fourth grade, students build on this knowledge to investigate other factors, such as water, ice, wind, living organisms, and gravity that might also cause weathering and erosion. At both of these grade levels, students have been implicitly engaging with the idea that different earth systems interact in these particular ways. In fifth grade, students explore this idea at a broad level, developing a model that shows an example of the geosphere, biosphere, hydrosphere, and/or atmosphere interacting. This sets the stage for this seventh grade unit in which students learn that all Earth processes are the result of energy flowing and matter cycling within and among the Earth systems that they modeled in fifth grade. In the next unit in this seventh grade curriculum, students will focus on these interactions between Earth systems at different scales to think about how they have shaped Earth’s history and will determine its future.

The following is the progression of the Performance Expectations for this DCI:

|  |  |
| --- | --- |
| **2-ESS2-1** | Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land. |
| **4-ESS2-1** | Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. |
| **5-ESS2-1** | Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. |
| **MS-ESS2-1** | Develop a model to describe the cycling of Earth’s materials and the flow of energy that drives this process. |
| **MS-ESS2-2** | Construct an explanation based on evidence for how geoscience processes have changed Earth’s surface at varying time and spatial scales. |

PS1.A. Structure and Properties of Matter: In Kindergarten - second grade, students begin their initial exploration of matter by beginning to observe and analyze tangible materials and their properties. They also explore how an object made of small pieces can be disassembled and made into a new object, a concept that will be crucial as they begin to think about atoms, molecules, chemical reactions, and conservation of matter in later grade bands. In third-fifth grade, they build on explorations from second grade to identify specific materials based on their properties. They also use experiments to gather evidence of the law of conservation of matter, a schema they started to develop in second grade. At this point, students are moving past observations of matter they can see and towards developing an understanding that matter is made of particles too small to be seen. Thus, by Unit 2 of this seventh grade curriculum, they were able to develop models of unseen particles, such as the atomic composition of various molecules and the movement of particles in different states of matter. In this unit, students delve deeper into chemical reactions, learning how to determine when a chemical reaction has occurred. In a later unit, students will apply this knowledge to the processes that transform natural resources to synthetic materials. Because of the vast number of Performance Expectations related to this DCI, students engage with a large range of science and engineering practices and crosscutting concepts.

The following is the progression of the Performance Expectations for this DCI:

|  |  |
| --- | --- |
| **2-PS1-1** | Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. |
| **2-PS1-2** | Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose. |
| **2-PS1-3** | Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object. |
| **5-PS1-1** | Develop a model to describe that matter is made of particles too small to be seen. |
| **5-PS1-2** | Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved. |
| **5-PS1-3** | Make observations and measurements to identify materials based on their properties. |
| **MS-PS1-1** | Develop models to describe the atomic composition of simple molecules and extended structures. |
| **MS-PS1-2** | Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. |
| **MS-PS1-3** | Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. |
| **MS-PS1-4** | Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. |

PS1.B. Chemical Reactions: In Kindergarten - second grade, students gather evidence to argue that some changes caused by heating or cooling can be reversed and some cannot. In doing so, they begin to experience chemical reactions without knowing that is what they are observing. In fifth grade, students take this a bit further by investigating that when substances are mixed, a new substance with different properties may be formed. At this grade level, students are also beginning to engage with the idea of conservation of matter by gathering evidence that total weight of matter is conserved in any type of change. All of this evidence prepares students for the middle school level in which they are finally asked to explicitly engage with the definition of a chemical reaction. In this seventh grade unit, students learn that in chemical reactions, the atoms that make up the original substances are regrouped into different molecules and these new substances have different properties. They are able to use their investigation skills from 5th grade to again analyze properties of substances, but this time to determine whether a chemical reaction has occurred. Students also model the law of conservation of matter at the atomic level, which builds on the evidence they gathered of this phenomenon in fifth grade and revisits a Performance Expectation from Unit 2. Lastly, students learn that some chemical reactions release energy and others store energy and use this knowledge to design a thermal-absorbing or thermal-releasing device. Again, because of the vast number of Performance Expectations related to this DCI, students engage with a large range of science and engineering practices and crosscutting concepts. You will also notice that this DCI has many parallels to the DCI above—PS1.A. Structure and Properties of Matter—as they are often both identified within a PE.

The following is the progression of the Performance Expectations for this DCI:

|  |  |
| --- | --- |
| **2-PS1-4** | Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot. |
| **5-PS1-2** | Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved. |
| **5-PS1-4** | Conduct an investigation to determine whether the mixing of two or more substances results in new substances. |
|  |  |
| **MS-PS1-2** | Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. |
| **MS-PS1-3** | Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. |
| **MS-PS1-5** | Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. |
| **MS-PS1-6** | Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. |

ETS1.B. Developing Possible Solutions: During Kindergarten through second grade, students begin communicating multiple designs in the form of diagrams and sketches. By third to fifth grade, students move from mere drawings to actually testing out their designs to see how they perform under different conditions. Students then use this data to make improvements. Like in Kindergarten through second grade, there is still the idea that communication of designs with peers is an essential part of the design process. In this seventh grade unit, students move towards more systematic processes to evaluate solutions for how well they meet criteria and constraints. There is also a much greater emphasis on using the data to inform improvements, focusing on the idea that parts of different solutions can be used to make an even better solution. At the different grade levels, students engage in a variety of different science and engineering practices: Developing Models in K-2, Designing Solutions (specifically comparing solutions) in 3-5, and Engaging in Argument From Evidence in 6-8. This is representative of the different practices students are engaging with, described above.

The following is the progression of the Performance Expectations for this DCI:

|  |  |
| --- | --- |
| **K-2-ETS1-2** | Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem. |
| **3-5-ETS1-2** | Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. |
| **MS-ETS1-2** | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |

ETS1.C. Optimizing the Design Solution: In Kindergarten to second grade, students begin to understand that because there are always multiple solutions to a problem, it is useful to compare and test designs. Students in third through fifth grade take this skill and use findings from those tests to determine which solution best meets criteria and constraints that they identified through ETS1.A. In accordance with the progression students follow in middle school for ETS1.B, students in this seventh grade unit move towards developing and testing models, and analyzing data to identify best characteristics that inform a new and better solution. Thus, it makes sense that at all grade levels, students focus on Science and Engineering Practices related to testing and analyzing: Developing and Using Models, Planning and Carrying Out Investigations, and Analyzing and Interpreting Data.

The following is the progression of the Performance Expectations for this DCI:

|  |  |
| --- | --- |
| **K-2-ETS1-3** | Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs |
| **3-5-ETS1-3** | Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved |
| **MS-ETS1-3** | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. |
| **MS-ETS1-4** | Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. |