Middle School Topic Model Course II

Narrative and Rationale: This course model arranges the Performance Expectations (PEs) outlined in the second year of the California Integrated Middle School Model into three different bundles of PEs using a topical arrangement. The disciplinary core ideas (DCIs) of each PE were used in this model to arrange bundles that address the topics of the properties of matter, dynamic interactions within ecosystems, and geologic changes in the Earth. The DCIs build conceptually throughout the year; in particular, the study of properties of matter in Bundle One lays the foundation for a deeper understanding of matter flow in ecosystems and Earth processes in bundles two and three respectively. In addition, engineering design PEs are incorporated in each bundle throughout the year.

Throughout the year, students develop their proficiency in the middle school-level Science and Engineering Practices (SEPs) and Crosscutting Concepts (CCCs), building on a foundation of SEPs and CCCs from Course I in middle school. It is important to note that the SEPs and CCCs described are intended as end-of-instructional unit expectations and not curricular designations. Additional SEPs and CCCs should be used throughout instruction toward each bundle.

Unit 1: What causes changes in matter? **~ 10 weeks**	**Unit 2:** How do organisms and ecosystems interact? **~ 10 weeks**	**Unit 3:** How has the Earth changed? **~ 10 weeks**
MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.[1] **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. **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.* **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. [1] **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-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-LS2-1**. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. **MS-LS2-2**. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. **MS-LS2-3**. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. **MS-LS2-4**. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. **MS-LS2-5**. Evaluate competing design solutions for maintaining biodiversity and ecosystem services. **MS-ETS1-1**. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. **MS-ETS1-2**. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	**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. **MS-ESS2-3**. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. **MS-ESS3-1**. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. **MS-ESS3-2**. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. **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.

[1]. The bundle only includes part of this PE; the PE is not fully assessable in a unit of instruction leading to this bundle.

Version 1 - published September 2016

Middle School Topic Model Course II Flowchart

Bundle 1

To ESS3.A in Bundle 3

PS1.A as found in MS-PS1-1
- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

To ESS2.A in Bundle 3

PS1.A as found in MS-PS1-4
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

PS1.A as found in MS-PS1-2 and MS-PS1-3
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

PS1.B as found in MS-PS1-2, MS-PS1-3, and MS-PS1-5
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

PS1.B as found in MS-PS1-5
- The total number of each type of atom is conserved, and thus the mass does not change.

To ESS2.A in Bundle 3

PS1.B as found in MS-PS1-6
- Some chemical reactions release energy, others store energy.

To ESS2.A in Bundle 3

PS3.A as found in MS-PS1-4
- The term "heat" as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects.
- The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system's material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material.

Bundle 2

PS3.D as found in MS-LS1-6
- The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.

LS1.C as found in MS-LS1-6
- Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

LS2.A as found in MS-LS2-1
- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
- Growth of organisms and population increases are limited by access to resources.

LS2.A as found in MS-LS2-2
- Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.

LS2.B as found in MS-LS2-3
- Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

LS2.C as found in MS-LS2-4
- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

LS2.C as found in MS-LS2-5
- Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.

Bundle 3

ESS1.C as found in MS-ESS2-3
- Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches.

ESS2.A as found in MS-ESS2-1
- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.

ESS2.A as found in MS-ESS2-2
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

ESS2.B as found in MS-ESS2-3
- Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.

ESS2.C as found in MS-ESS2-2
- Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.

ESS3.A as found in MS-ESS3-1
- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

ESS3.B as found in MS-ESS3-2
- Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.

ETS1.B as found in MS-ETS1-4
- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- Models of all kinds are important for testing solutions.

Version 1 - published September 2016

To PS3.D , LS1.C, and LS2.B in Bundle 2

PS3.D as found in MS-LS1-7
- Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.

To PS3.D , LS1.C, and LS2.B in Bundle 2

LS1.C as found in MS-LS1-7
- Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.

ETS1.B as found in MS-PS1-6
- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.

ETS1.B as found in MS-ETS1-3
- 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.

ETS1.C as found in MS-PS1-6 and MS-ETS1-3
- 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 the characteristics may be incorporated into the new design.

ETS1.C as found in MS-PS1-6
- 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.

To ESS3.A in Bundle 3

LS4.D as found in MS-LS2-5
- Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.

ETS1.A as found in MS-ETS1-1
- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.

ETS1.B as found in MS-LS2-5 and MS-ETS1-2
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.

ETS1.C as found in MS-ETS1-4
- 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.