IS4

Integrated Grade Six Instructional Segment 4: Effects of Global Warming on Living Systems

INTEGRATED GRADE SIX INSTRUCTIONAL SEGMENT 4: EFFECTS OF GLOBAL WARMING ON LIVING SYSTEMS

Guiding Questions

- How do human activities affect Earth systems?
- How do we know our global climate is changing?

Performance Expectations

Students who demonstrate understanding can do the following:

MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. [Clarification Statement: Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.]

MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.] [*Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.*]

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]

MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic

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activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]

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.

**The performance expectations marked with an asterisk integrate traditional science content with engineering through a practice or Disciplinary Core Idea.*

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-1] Asking Questions and Defining Problems [SEP-2] Developing and Using Models [SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering) [SEP-7] Engaging in Argument from Evidence [SEP-8] Obtaining, Evaluating, and Communicating Information	LS1.B: Growth and Development of Organisms ESS3.C: Human Impacts on Earth Systems ESS3.D: Global Climate Change ETS1.A: Defining and Delimiting Engineering Problems ETS1.B: Developing Possible Solutions	[CCC-2] Cause and Effect [CCC-4] System and System Models [CCC-5] Energy and Matter: Flows, Cycles, and Conservation [CCC-7] Stability and Change

Highlighted California Environmental Principles and Concepts:

Principle I The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.

Principle II The long-term functioning and health of terrestrial, freshwater, coastal, and marine ecosystems are influenced by their relationships with human societies.

Principle IV The exchange of matter between natural systems and human societies affects the long-term functioning of both.

CA CCSS Math Connections: MP.2, 6RP.1, 6.EE.6, 6.SP.2, 4

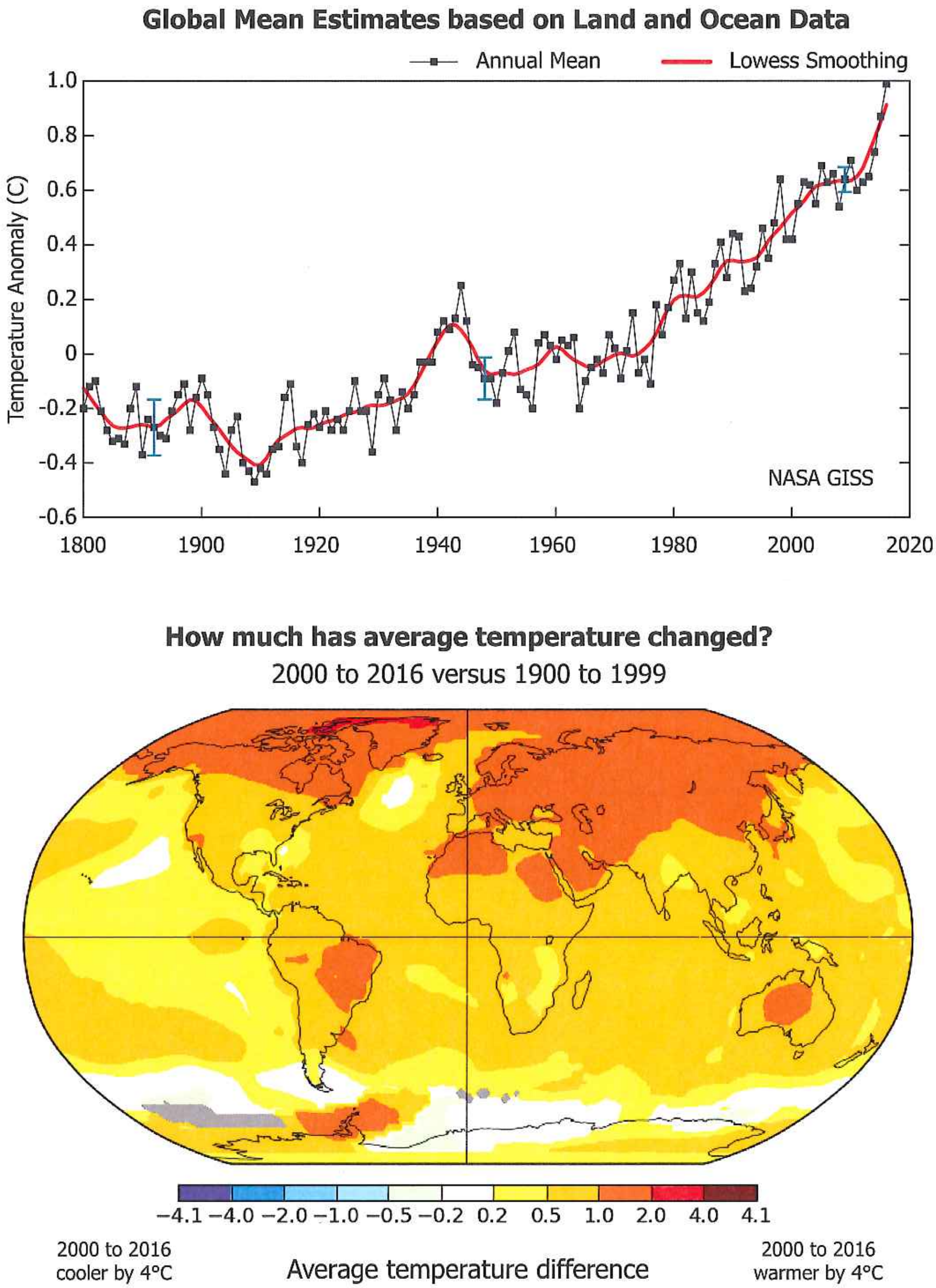
CA CCSS for ELA/Literacy Connections: RI.6.8, RST.6–8.1, 2 WHST.6–8.7, WHST.6–8.8

CA ELD Connections: ELD.PI.6.1, 5, 6a–b, 9, 10, 11a

In this instructional segment, students collect evidence that Earth's climate is changing. At the grade six level, the scope of their understanding is intended to be limited. Students **analyze data [SEP-4]**, recognize **patterns [CCC-1]**, and **ask questions [SEP-1]** about what **causes [CCC-2]** these patterns. Students in the middle grades are not expected to explain why the Earth is warming in much detail—they will develop models explaining the causal mechanisms when they get to high school. The clarification statement for MS-ESS3-5 indicates that emphasis should be placed on the way human activities might influence the climate.

For this instructional segment, the anchoring phenomenon is that the temperature on Earth has warmed over the last 150 years, but the pattern of warming is complex. Students begin to **analyze data [SEP-4]** showing the temperature history over the last century (figure 5.22). While graphs like figure 5.22 are simple enough for students to interpret, scientists also use more sophisticated interactive displays of data that depict how temperatures have changed in space and time. More advanced visualizations allow students to zoom into areas of interest (such as regions within California) and watch the time progression (see California Energy Commission, Cal-Adapt, http://www.cde.ca.gov/ci/sc/cf/ch5.asp#link11). As students see the data depicted in new ways, they should be able to ask more detailed questions. For example, the bottom panel of figure 5.22 shows that the Northern Hemisphere has warmed more than the Southern Hemisphere. Why? The eastern part of South America warmed more than the west. Is that due to deforestation of the Amazon, or does it involve more complex interactions? The lowest temperatures are shortly after 1900. What caused that? Did it affect the whole planet equally? These are the types of **questions [SEP-1]** we want our students to start asking even though they won't have the tools to answer them yet in grade six.

Figure 5.22. Temperature Changes Over Time



Temperature changes over time depicted as a graph of average annual temperatures for the entire globe since 1880 (top) and a map showing changes at different locations, comparing the average from the first portion of the twenty-first century to the twentieth century (bottom). The twenty-first century is warmer than the nineteenth and twentieth centuries. *Source:* NASA 2016

Opportunities for ELA/ELD Connections

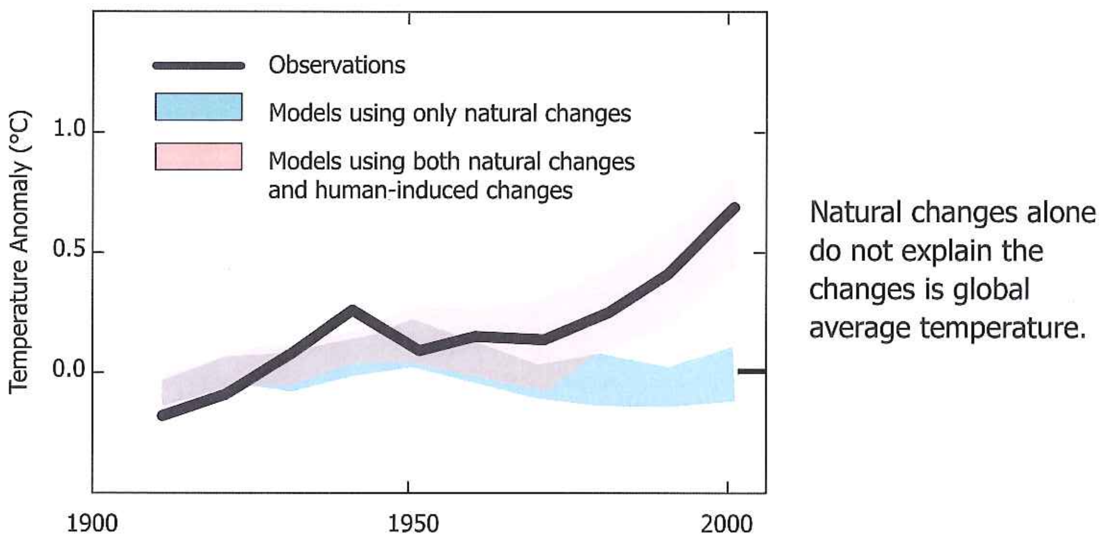
To help data come alive and help students compile it for a particular audience, have them obtain information [SEP-8] about the effect [CCC-2] temperature changes [CCC-7] have on sea level, glaciers, or storm intensity. In groups, or pairs, students research one aspect of the effect of temperature change on sea level, glaciers, or storm intensity using government reports summarizing these changes (such as EPA Climate Change Indicators, National Climate Assessment, or NASA's Climate Effects Web portal). Working in groups, students collaborate on creating a one-page campaign advertisement for an environmental magazine that includes a headline, a picture, and a visual that represents [SEP-8] the data gathered. Have each group present its advertisement to the class as if the class were the editing team of the environmental magazine. To ensure that students who may need it have time to rehearse or practice speaking, have the group decide each member's role, including English learners, so all students understand their part in the presentation.

CA CCSS for ELA/Literacy Standards: RST.6–8.2, 7; WHST.6–8.7, 9; SL.6–8.5
CA ELD Standards: ELD.PI.6–8.9

Causes of Climate Change

Several possible natural mechanisms exist that can cause [CCC-2] climate changes [CCC-7] over human timescale [CCC-3] (tens or hundreds of years), including variations in the Sun's energy output, ocean circulation patterns, atmospheric composition, and volcanic activity (ESS3.D). When ocean currents change their flow patterns [CCC-1], such as during El Niño Southern Oscillation conditions, some global regions become warmer or wetter and others become colder or drier. When scientists make computer simulations that include only these natural changes [CCC-7], they cannot match the temperature changes from the last century (figure 5.23). But there are also changes that are caused by human activity (EP&Cs III, IV). Many aspects of modern society result in the release of carbon dioxide and other greenhouse gases. These include automobiles, power plants or factories that use coal, oil, or gas as an energy source, cement production for buildings and roads, burning forest and agricultural land, and even the raising of livestock whose digestive processes emit methane. Greenhouse gases increase the capacity of Earth to retain energy, so changes in these gases cause changes in Earth's average temperature. Changes in surface or atmospheric reflectivity change the amount of energy from the Sun that enters the planetary system. Icy surfaces, clouds, aerosols, and larger particles in the atmosphere, such as from volcanic ash, reflect sunlight and thereby decrease the amount of solar energy that can enter the weather/climate system. Many surfaces that humans construct (e.g., roads, most buildings, agricultural fields versus natural forests) absorb sunlight and thus increase the energy [CCC-5] in the system [CCC-4]. As students analyze data [SEP-4] about greenhouse gas concentrations in the atmosphere, they observe very similar patterns [CCC-1] in the change in temperature (figure 5.24). In fact, computer models of climate show that human activities are an important part of the cause [CCC-2] of global temperature changes (figure 5.23).

Figure 5.23. Global Climate Outputs

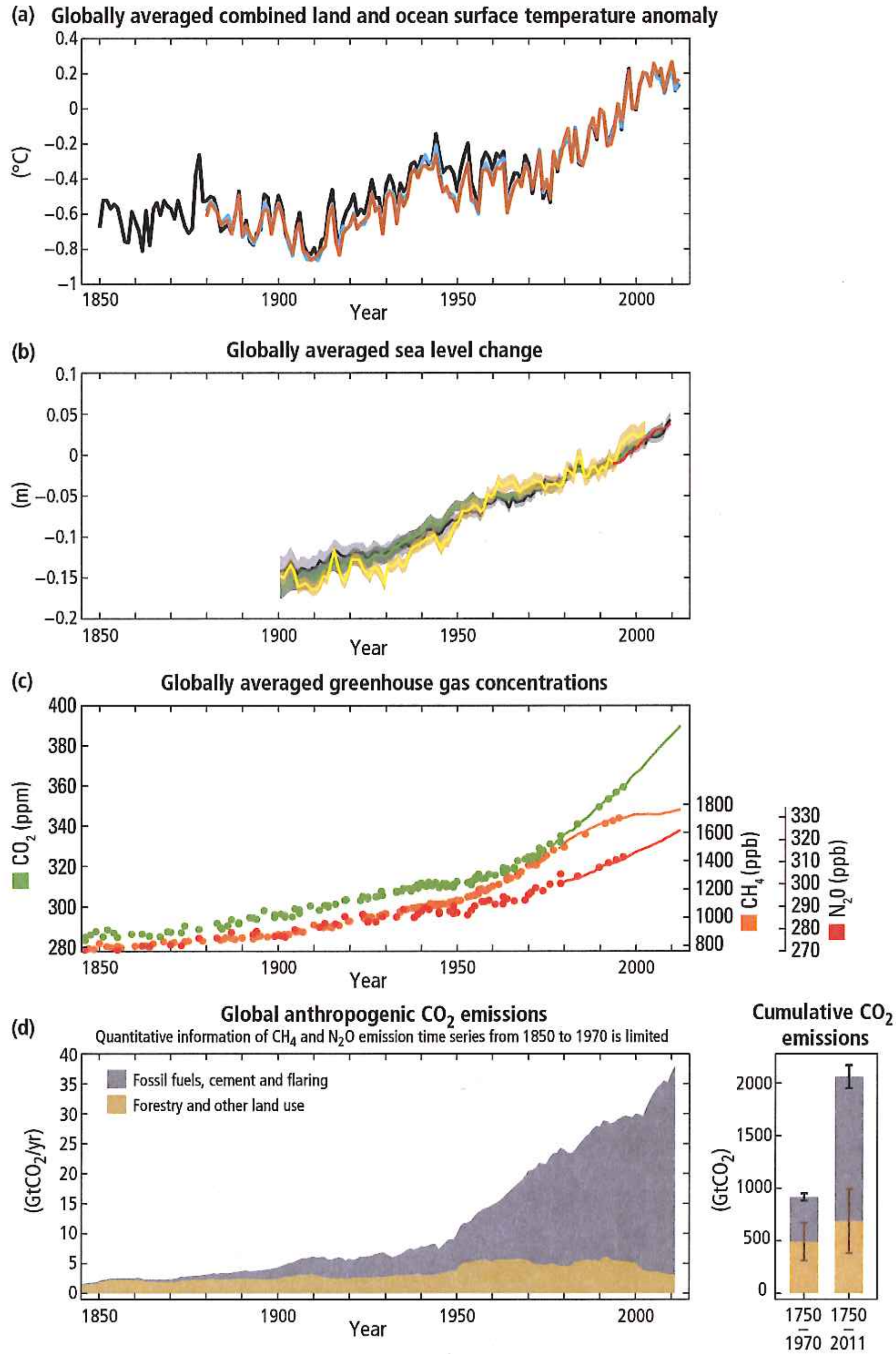


Outputs of different computer models of global climate compared to observations. The colored bands are thick because they represent hundreds of different models created by many different researchers using different assumptions. While the models have slight variations in their output, only models that include human-induced changes can explain the observed temperature record. *Source:* Adapted from figure SPM.4 from *Climate Change 2007: Synthesis Report.* Contribution of Working Groups I, II and III to the *Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, Pachauri, R.K. and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland.

Opportunities for Mathematics Connections

Global average temperature rises as human activity emits more greenhouse gases. This rate of emission depends on two key variables: population growth and energy consumed per person. Students should **construct an argument from evidence [SEP-7]** that connects these population and energy-use ideas to a significant impact on Earth's systems (MS-ESS3-4). To gather evidence for their argument, students **obtain information [SEP-8]** from online resources that list population and energy consumption **patterns [CCC-1]**. Students will use **mathematical thinking [SEP-5]** to create meaningful comparisons between the energy use in different states and countries. For example, energy use per person is an example of a "unit rate" from ratio thinking in mathematics (CA CCSSM 6.RP.2). People in the United States use more than twice as much energy per person than the average European country (U.S. Energy Information Administration 2012), probably because our homes are bigger and spaced further apart. Californians, on average, use less energy per person than nearly every other state in the United States (U.S. Energy Information Administration 2012), partly due to our mild climate and partly due to effective energy efficiency programs. Despite this fact, the average Californian still uses more than 10 times more energy than the average person on the continent of Africa. These comparisons are examples of using ratio language (CA CCSSM 6.RP.1). Many developing countries around the world have growing populations and are rapidly changing their lifestyles to include more energy-intensive tools. They will start consuming energy at rates more like California or even the United States average, which could have a huge impact on global climate and global emissions. Computer **models [SEP-2]** that forecast **changes [CCC-7]** in global climate rely on accurate estimates about energy consumption in the future. In high school, students will use computer simulations to explore the effects of these assumptions (HS-ESS3-5).

Figure 5.24. Global Warming Cause and Effect



Graphs with similar trends and patterns illustrate global warming causes and effects. *Source:* Figure SPM.1 from *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, Pachauri, R.K. and Meyer, L. (eds.)]. IPCC, Geneva, Switzerland.

Impacts of Climate Change on the Biosphere

Organisms have structural and behavioral adaptations that help them succeed and reproduce in their current environment (MS-LS1-4). The climate changes that have already happened affect behaviors of species, especially the timing of migrations, blooming, and maturing of seeds. Computer analyses of business-as-usual climate change scenarios project more dramatic and rapid changes that are likely to have deleterious effects on many organisms (MS-LS1-5).

Each of the integrated courses for the middle grades includes performance expectations that relate to human impacts on the environment. These are generally associated with DCI LS2 (Ecosystems: Interactions, Energy, and Dynamics) and DCI ESS3 (Earth and Human Activity). In addition to the global climate topic highlighted in the previous snapshot, Integrated Grade Six includes MS-ESS3-4, which is focused on designing a method for monitoring and minimizing a human impact on the environment. The following snapshot addresses that performance expectation and has an emphasis on engineering design.

Integrated Grade Six Snapshot 5.4: Monitoring and Minimizing Human Environmental Impacts

Anchoring phenomenon: Monarch butterflies fly long distances every year.

Following their **investigations [SEP-3]** related to climate change, students in Ms. D's class became concerned about the ways that climate change can harm organisms and ecosystems. Monarch populations west of the Rocky Mountains escape winter by flying long distances to California. Ms. D's students live in a coastal town with one of the major California winter nesting areas for monarch butterflies. They were concerned when they learned that climate change was affecting the migration of an organism important to the local community. Ms. D divided her students into three teams (A, B, and C) that each designed a different solution that could help the monarchs.

Students in Team A already volunteered with the local conservation group to protect their public monarch protection area. The scale of the global climate change issue inspired them to think at a broader **scale [CCC-3]** about all the places that the butterflies needed during the summer and on their long journey to Central and Southern California. They decided to gather information about the major threats that the butterflies faced on their long journey and to network with schools on that pathway to collaborate on monitoring the monarch population, identifying local threats to the monarchs (especially related to habitat, food and climate), and developing possible local solutions to those threats (MS-ESS3-3).

Integrated Grade Six Snapshot 5.4: Monitoring and Minimizing Human Environmental Impacts

Investigative problem: How can we get more output from our solar panels?

Students in Team B argued that the monarchs, and many other organisms, needed long-term solutions to climate change, such as switching to renewable energy sources. They **gathered information [SEP-8]** about making electricity from solar photovoltaic cells. Their project integrated physical science and Earth and space science DCIs into designing a solution to a life science problem. The school was in the process of seeking funds to purchase and install some solar modules. Team B started investigating how much extra solar electricity the school could get if the solar cells tracked the Sun during the day rather than remaining stationary, and whether those gains would be worth the cost. They also investigated other issues related to the placement of the solar cells. They created a poster that **explained [SEP-6]** how solar cells are energy conversion devices (PS3.A, B) and included a **model [SEP-2]** of how sunlight travels in straight lines (PS4.B) until it is absorbed by the solar cells, which are most efficient when oriented at a specific angle relative to the incident light rays.

Investigative problem: How can we reduce the amount of energy and water we use?

Students in Team C had learned about a different school in the county that had instituted a successful major energy saving program. They wanted their school to monitor and minimize consumption of electricity and natural gas (MS-ESS3-3). Team C started **analyzing data [SEP-4]** about the school energy sources and consumption, and what resources in the school and community were available for collaboration, especially the local utility company. They were particularly interested in digital devices that could monitor and control consumption of energy. These devices helped the students measure and reduce the per capita energy consumption, which they will discuss again in grade eight (MS-ESS3-4).

Ms. D assisted all three teams, helping them to establish a shared understanding about clearly articulating criteria that could be used to evaluate the success of their project and the constraints that could limit and impede success. In addition to collaborating and sharing within their team, the students also had regular meetings to share across the teams so they could gain insights and feedback from a larger and more diverse group. Ms. D also encouraged the three teams to include in their criteria and constraints the longer-term prospects for each of their projects, and how they could use different communication systems to implement their project and begin to support its sustainability.

The focus in IS4 on monitoring/minimizing human environmental impacts as well as on global climate change, complete the year's science education and reconnect with the systems thinking explored in IS1, especially the emphasis on properties of the whole **system [CCC-4]**. Earth's web of life is a property of the whole system that emerges from the interactions of organisms with each other and with the huge diversity of Earth environments. Similarly, the global climate is a whole-system property that emerges from the interactions of the Earth subsystems, with each other, and with the inflow of sunlight. Human actions can change the Earth system's components and interactions in ways that profoundly alter organisms and climate at local, regional, and global levels. The Integrated Grade Six course can help build a middle grades foundation of science and engineering understandings and practices related to citizenship and sustainability that can grow in depth in the succeeding middle and high school grades. (Two EEI Curriculum units, *Energy: It's Not All the Same to You* http://www.cde.ca.gov/ci/sc/cf/ch5.asp#link12 and *Responding to Environmental Change* http://www.cde.ca.gov/ci/sc/cf/ch5.asp#link13 provide a variety of resources that can support this instruction.)

Grade Seven Preferred Integrated Course Model

This section is meant as a guide for educators on how to approach the teaching of the California Next Generation Science Standards (CA NGSS) in grade seven according to the Integrated Model (see the introduction to this chapter for details regarding different models for grades six, seven, and eight). This section is not meant to be an exhaustive list of what can be taught or how it should be taught.

A primary goal of this section is to provide an example of how to bundle the performance expectations into integrated groups that can effectively guide instruction in four sequential instructional segments (IS). There is no prescription regarding the relative amount of time to be spent on each instructional segment. As shown in figure 5.25, the overarching guiding concept for the entire year is "Natural processes and human activities cause energy to flow and matter to cycle through Earth systems."