The Living Earth: Integrating Biology and Earth Science

The interactions between the biosphere and the rest of Earth's systems influence students every day, from the food that they eat to the air they breathe. In high school, students finally have enough understanding to explain patterns that they identified and asked questions about during their K–8 education. Some of these mechanisms occur in the blink of an eye while others take millions of years to unfold. Despite the extreme variability in scale, students have tools to use evidence, evaluate claims, and develop models to interpret the unseen. Students begin with phenomena and use them to enhance their understanding of core ideas in biological science and Earth and space sciences.

The CA NGSS do not specify which phenomena to explore or the order to address topics because phenomena need to be relevant to the students who live in each community and should flow in an authentic manner. This chapter illustrates one possible set of phenomena that will help students achieve the CA NGSS performance expectations. Many of the phenomena selected illustrate California's Environmental Principles and Concepts (EP&Cs), which are an essential part of the CA NGSS (see chapter 1 of this framework). However, the phenomena chosen for this statewide document will not be ideal for every classroom in a state as large and diverse as California. Teachers are therefore encouraged to select phenomena that will engage their students and use this chapter's examples as inspiration for designing their own instructional sequence. For example, the course could be restructured around contemporary issues of health or ecosystem change faced by a local community.

This example course is divided into instructional segments centered on questions about observations of a specific phenomenon. Different phenomena require different amounts of investigation to explore and understand, so each instructional segment should take a different fraction of the school year. As students achieve the performance expectations within the instructional segment, they uncover DCIs from life science and engineering. Students engage in multiple practices in each instructional segment, not only those explicitly indicated in the performance expectations. Students also focus on one or two CCCs as tools to make sense of their observations and investigations; the CCCs are recurring themes in all disciplines of science and engineering and help tie these seemingly disparate fields together.

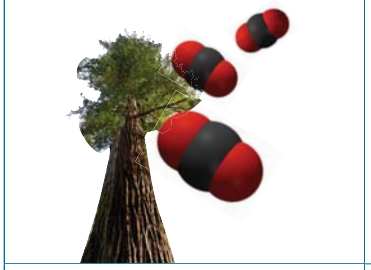
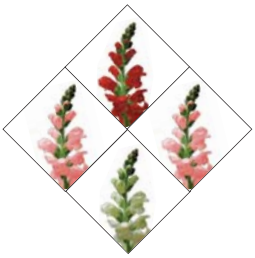
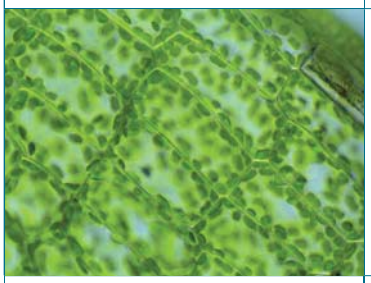
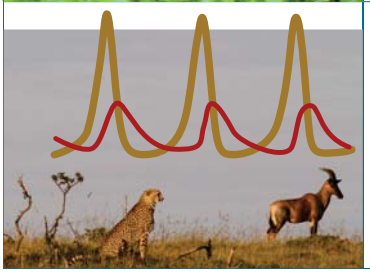
This chapter clarifies the general level of understanding required to meet each performance expectation, but the exact depth of understanding expected of students depends on this course's place in the overall high school sequence. Teachers could modify the content and complexity so that the course serves as a basic freshman introduction to science, serves as a senior capstone that integrates and applies science learning from

all previous science courses, or aligns with the expectations of Advanced Placement or International Baccalaureate curriculum.

Example Course Mapping for an Integrated Life and Earth Science Course

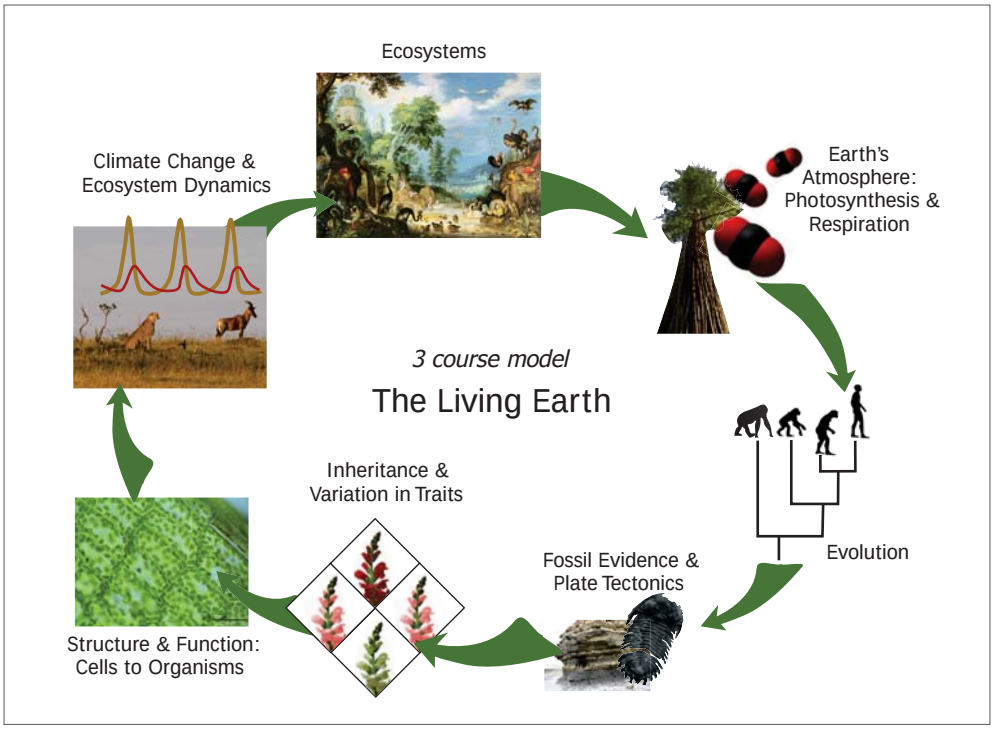
This section presents the life science and selected Earth science CA NGSS performance expectations organized into six embedded instructional segments (table 7.1). The sequence presented here spirals in scale (figure 7.1), starting with ecosystems as a whole (looking at both living and nonliving components), progressing into connections within ecosystems describing the cycling of matter in two important life processes: photosynthesis and respiration while also emphasizing the nonliving parts of these cycles. Then the course moves into evolution (in which evidence is based in both living and nonliving systems) and then links evolution to the study of heredity. From there the course zooms in more (progressing to smaller scales) to what defines characteristics of life from the cell to multicellular organisms. The course ends by coming back full circle to ecosystems and the impacts that humans have on them especially in relationship to climate change. A culminating project for this course should present a synthesis of how life on Earth is dependent on both biotic and abiotic factors.

Table 7.1. Overview of Instructional Segments for High School Three-Course Model Living Earth

	**1 Ecosystem Interactions and Energy** Students use mathematical and computer models to determine the factors that affect the size and diversity of populations in ecosystems, including the availability of resources and interactions between organisms.
	**2 History of Earth's Atmosphere: Photosynthesis and Respiration** Students make a model that links photosynthesis and respiration in organisms to cycles of energy and matter in the Earth system. They gather evidence about the linked history of Earth's biosphere and atmosphere.
	**3 Evidence of Evolution** Students develop a model about how rock layers record evidence of evolution as fossils. Building on their learning from previous grades, they focus on effectively communicating this evidence and relating it to principles of natural selection.
	**4 Inheritance of Traits** Students develop explanations about the specific mechanisms that enable parents to pass traits on to their offspring. They make claims about which processes give rise to variation in deoxyribonucleic acid (DNA) codes and calculate the probability that offspring will inherit traits from their parents.
	**5 Structure, Function, and Growth (from cells to organisms)** Students use models to create explanations of how cells use DNA to construct proteins, build biomass, reproduce, and create complex multicellular organisms. They investigate how these organisms maintain stability.
	**6 Ecosystem Stability & the Response to Climate Change** Students use computer models to investigate how Earth's systems respond to changes, including climate change. They make specific forecasts and design solutions to mitigate the impacts of these changes on the biosphere.

Sources: Savery 1628; adapted from Caulfield 2012; Grant 2010; adapted from Rafandalucia 2016; adapted from Castro 2008; Peters 2007; adapted from d'Alessio 2013

Figure 7.1. Conceptual Flow of Instructional Segments in Example High School Three-Course Model Living Earth



Sources: Savery 1628; adapted from Caulfield 2012; M. d'Alessio using image from Tkgd2007 2008; Grant 2010; adapted from Rafandalucia 2016; adapted from Castro 2008; Peters 2007; adapted from d'Alessio 2013