ARKANSAS

K-12 SCIENCE STANDARDS

EDUCATION FOR A NEW GENERATION

Fundamental Science Content
Biology Integrated

2023

The Arkansas K-12 Science Standards are available here. The standards are three-dimensional, consisting of a Science and Engineering Practice (SEP), a Disciplinary Core Idea (DCI), and a Cross Cutting Concept (CCC). By the end of the grade level, students should be able to demonstrate the full scope of the standard. Example:

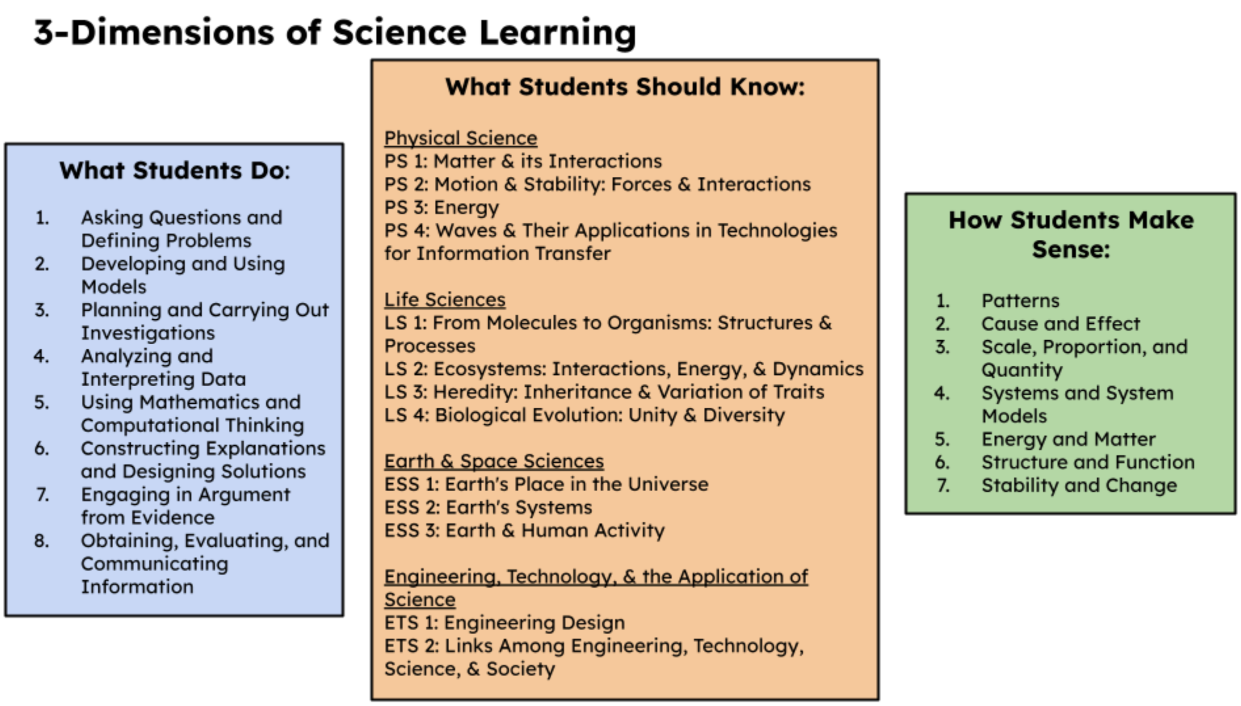
SEP DCI CCC

BI-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

The focus of this document is specifically on the science core ideas in Biology Integrated. In Arkansas K-12 Science Standards, science content is found in the DCI portion of each standard. Three-dimensional learning and assessment best prepares students for success so that students have the opportunity to demonstrate both what they know *and* can do in science. Refer to the full standards document to find the corresponding science and engineering practice and cross cutting concept for each standard. The core ideas are organized into the following domains of science:

- Physical Science
- Life Science
- Earth & Space Science
- Engineering Technology & Applications of Science

Each domain contains core ideas organized into component ideas. By the end of Biology Integrated, students are expected to know the bulleted information under each component idea. Standards that address the bulleted information are included in parentheses and those with an asterisk include an engineering component.



Physical Science

*Asterisks indicate best opportunities to integrate ETS performance expectations into content.

Energy
Energy in Everyday Life
• The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (BI-LS2-5)

Life Science

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ǂIndicates PE's partially addressed in PS-I and fully addressed in Biology- Integrated.

Molecules to Organisms
Structure & Function
• Systems of specialized cells within organisms help them perform the essential functions of life. (BI-LS1-1)
• All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (BI-LS1-1, BI-LS3-1)
• Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (BI-LS1-2)
• Feedback mechanisms (ex. homeostasis) maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (positive feedback) or discourage (negative feedback) what is going on inside the living system. (BI-LS1-3)
Growth & Development
• In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (BI-LS1-4)
Organization for Matter & Energy Flow
• The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (BI-LS1-5ǂ)
• The sugar molecules formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (proteins or DNA), used for example to form new cells. (BI-LS1-6)

• As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (BI-LS1-6) (BI-LS1-7‡)
• As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (BI-LS1-7‡)
Ecosystems
Interdependent Relationships
• Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are limited. This limitation affects the abundance (number of individuals) of species in any given ecosystem. (BI-LS2-1, BI-LS2-2)
• Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. (BI-LS2-8)
Cycles of Matter & Energy Transfer
• Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (BI-LS2-3)
• Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (BI-LS2-4‡)
• Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (BI-LS2-5)
Ecosystem Dynamics
• A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (BI-LS2-2, BI-LS2-6)
• Moreover, Anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (BI-LS2-7*)

Heredity & Variation of Traits
Inheritance of Traits
● Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (BI-LS3-1)
Variation of Traits
● In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (BI-LS3-2)
● Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. (BI-LS3-2, BI-LS3-3)
Biological Evolution
Common Ancestry
● Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. (BI-LS4-1)
Natural Selection
● Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information— that is, trait variation—that leads to differences in performance among individuals. (BI-LS4-2, BI-LS4-3)
● The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (BI-LS4-3)
Adaptation
● Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) an increased number of those organisms that are better able to survive and reproduce in that environment. (BI-LS4-2)
● Adaptation also means that the distribution of traits in a population can change when conditions change. (BI-LS4-3)
● Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific

environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (BI-LS4-3, BI-LS4-4)
• Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. (BI-LS4-5ǂ)
• Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. (BI-LS4-5ǂ) (BI-LS4-6*)
Biodiversity & Humans
• Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (BI-LS4-6*, BI-LS2-7*ǂ)
• Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (BI-LS2-7*ǂ)

Earth & Space Science

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Earth's Place in the Universe
Earth and the Solar System
• Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (BI-ESS2-4)
Earth's Systems
Earth's Materials
• Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (BI-ESS2-2)
• The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (BI-ESS2-4)

Roles of Water in Earth's Processes
● The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (BI-ESS2-5)
Weather and Climate
● The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (BI-ESS2-2, BI-ESS2-4)
● Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (BI-ESS2-4) (BI-ESS2-6)
● Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (BI-ESS2-6) (BI-ESS2-7ǂ)
● Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (BI-ESS3-6)
Biogeology
● The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. (BI-ESS2-7ǂ)
Earth and Human Activity
Natural Resources
● Resource availability has guided the development of human society. (BI-ESS3-1ǂ)
● All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (BI-ESS3-2*ǂ)
Natural Hazards
● Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (BI-ESS3-1ǂ)
Human Impacts on Earth Systems
● The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (BI-ESS3-3)
● Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that prevent ecosystem degradation. (BI-ESS3-4*)
Global Climate Change

• Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (BI-ESS3-5)
• Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (BI-ESS3-6)

Engineering, Technology, and Applications of Science

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Engineering Design
Defining Engineering Problems
• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified and stated in such a way that one can tell if a given design meets them. (BI7-ETS1-1)
• Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may also occur in local communities. (BI7-ETS1-1)
Developing Possible Solutions
• When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (BI-ESS3-2*, BI-ESS3-4*) (BI3-ETS1-3, BI-LS2-7*, BI-LS4-6*) (BI6-ETS1-3)
• Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (BI3-ETS1-4, BI-LS4-6*) (BI7-ETS1-4)
Optimizing the Design Solution
• Criteria may need to be broken down into simpler requirements that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (BI6-ETS1-2)