ARKANSAS

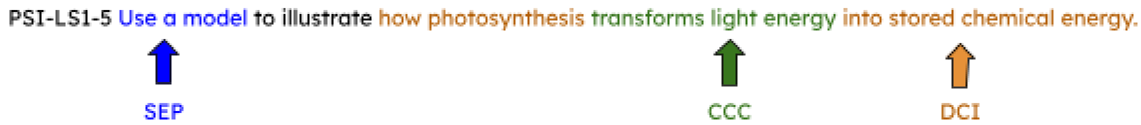
K-12 SCIENCE STANDARDS

EDUCATION FOR A NEW GENERATION

# Fundamental Science Content
# Physical Science Integrated

2023

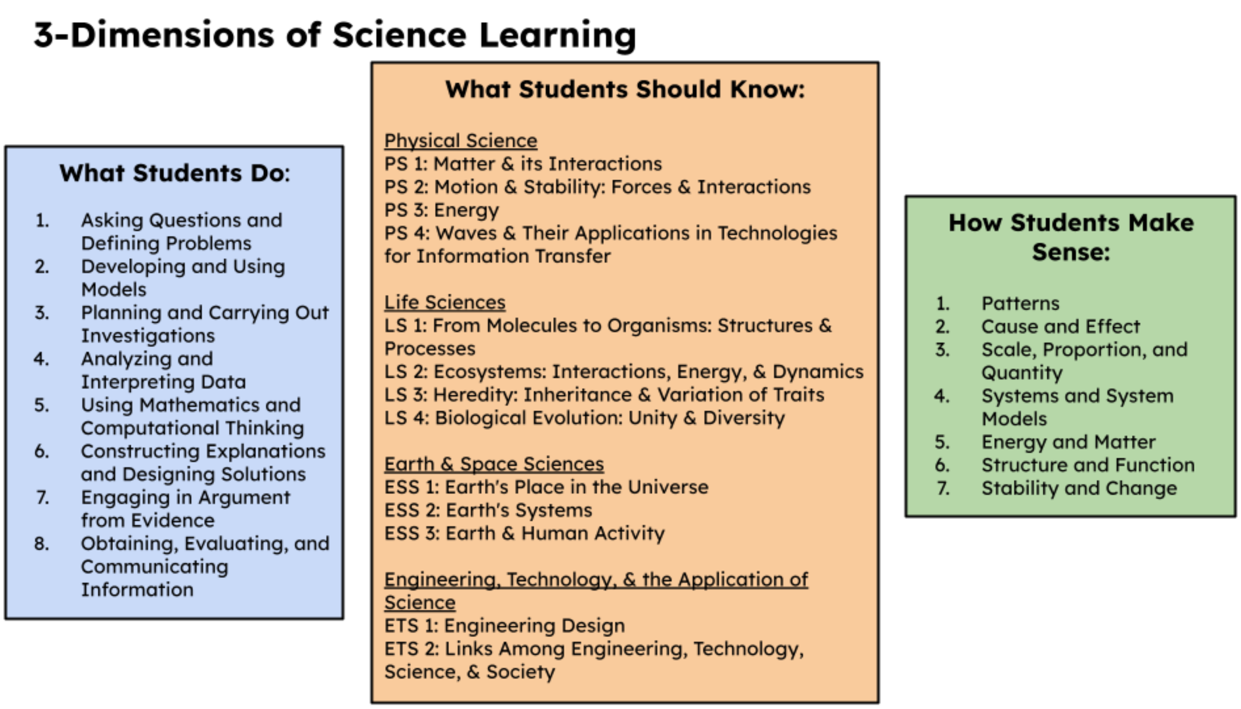
The Arkansas K-12 Science Standards are available here. The standards are three-dimensional, consisting of a Science and Engineering Practice (SEP), a Disciplinary Core Idea (DCI), and a Cross Cutting Concept (CCC). By the end of the grade level, students should be able to demonstrate the full scope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




The focus of this document is specifically on the science core ideas in Physical Science Integrated. In Arkansas K-12 Science Standards, science content is found in the DCI portion of each standard. Three-dimensional learning and assessment best prepare 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 crosscutting 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 Physical Science 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.

† Indicates PE's partially addressed in PS-I and fully addressed in Chemistry- Integrated.

## Matter

*Structure and Properties of Matter*

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (PSI-PS1-1)†
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (PSI-PS1-1,PS-PS1-2)†
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms (e.g., interactions between the nucleus' positive charge and electrons' negative charge). (PSI-PS1-3†,PSI-PS2-6)
- When a set of separated atoms combine to form a stable molecule, energy is released so that the molecule has less energy than the separated atoms. At least this amount of energy has to be put into the molecule to separate it back into its component atoms. (PSI-PS1-4)†

*Chemical Reactions*

- Chemical processes, their rates, and whether or not energy is stored or released (endothermic or exothermic) can be understood based on the collisions of reacting atoms and/or molecules and the rearrangements of atoms into new molecules, with resulting changes in the sum of all bond energies in those molecules that correspond to their changes in kinetic energy. (PSI-PS1-4)†
- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict types of chemical reactions when given the reactants and products. (PSI-PS1-2, PSI-PS1-7)†

## Motion & Stability

*Forces and Motion*

- Newton's second law accurately predicts changes in the motion of macroscopic objects. (PSI-PS2-1)†
- If a system interacts with objects outside itself, the total momentum of an object within a system can change; however, any such change is balanced by changes in the momentum of objects outside the system, thus overall momentum is conserved. (PSI-PS2-3*)

*Types of Interactions*

- Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (PSI-PS2-5)
- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. Coulomb's Law

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| | provides a mathematical model to quantitatively describe and predict these effects. (PSI-PS1-1, PSI-PS1-3†, PSI-PS2-6*) |
| **Energy** | |
| *Definitions of Energy* | |
| • | "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (PSI-PS2-5) |
| • | Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms (e.g., potential to kinetic energy or chemical to thermal energy). (PSI-PS3-1†,PS-PS3-2) |
| • | At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (PSI-PS3-2, PSI-PS3-3*) |
| • | "Mechanical energy" generally refers to some combination of motion and stored energy in an operating machine. "Chemical energy" generally is used to mean the energy that can be released or stored in chemical processes, and "electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. Historically, different units and names were used for the energy present in these different phenomena, and it took some time before the relationships between them were recognized. These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (PSI-PS3-2) |
| *Conservation & Transfer of Energy* | |
| • | Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (PSI-PS3-1†) |
| • | Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (PSI-PS3-1†,PSI-PS3-4) |
| • | Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (PSI-PS3-1†) |
| • | The availability of energy limits what can occur in any system. (PSI-PS3-1†) |
| • | Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, and objects hotter than their surrounding environment cool down). (PSI-PS3-4) |
| *Energy in Everyday Life* | |
| • | Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (PSI-PS3-3*,PSI-PS3-4) |

| **Waves** |
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| *Wave Properties* |
| • The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (PSI-PS4-1†) |
| • Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (PSI-PS4-2) |

**Life Science**

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

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

| **Molecules to Organisms** |
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| *Organization of Matter & Energy Transfer* |
| • The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (PSI-LS1-5ǂ) |
| • As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (PSI-LS1-7ǂ) |
| • 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. (PSI-LS1-7ǂ) |
| **Ecosystems** |
| *Cycles of Matter & Energy Transfer* |
| • 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 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. (PSI-LS2-4ǂ) |
| *Ecosystem Dynamics* |
| • 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. (PSI-LS2-7*ǂ) |
| **Biological Evolution** |
| *Adaptation* |

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| • 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. (PSI-LS4-5‡) |
| • 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. (PSI-LS4-5‡) |
| *Biodiversity & Humans* |
| • Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (PSI-LS2-7*‡) |
| • 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. (PSI-LS2-7*‡) |

## Earth & Space Science

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| **Earth's Place in the Universe** |
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| *The History of Planet Earth* |
| • Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (PSI-ESS1-5) |
| **Earth's Systems** |
| *Earth's Materials* |
| • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (PSI-ESS2-1) |
| *Plate Tectonics* |
| • Plate tectonics is the unifying theory that explains the past and current movements of the rocks at the Earth's surface and provides a framework for understanding its geologic history. (PSI-ESS1-5) |
| *Weather and Climate* |
| • Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (PSI-ESS2-7‡) |
| *Biogeology* |
| • The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause continual coevolution of Earth's surface and the life that exists on it. (PSI-ESS2-7‡) |
| **Earth and Human Activity** |

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| *Natural Resources* |
| • Resource availability has guided the development of human society. (PSI-ESS3-1‡) |
| • 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. (PSI-ESS3-2*‡) |
| *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. (PSI-ESS3-1‡) |

**Engineering, Technology, and Applications of Science**

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| **Engineering Design** |
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| *Defining and Delimiting 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 to the extent possible and stated in such a way that one can tell if a given design meets them. (PSI-PS2-3*, PSI3-ETS1-1, PSI-PS3-3*, PSI6-ETS1-1 )<br>• 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 have manifestations in local communities. (PSI3-ETS1-1, PSI6-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. (PSI4-ETS1-3, PSI-LS2-7*, PSI-ESS3-2*, PSI6-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. (PSI6-ETS1-4) |
| *Optimizing the Design Solution* |
| • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (PSI2-ETS1-2, PSI-PS2-3*, PSI5-ETS1-2, PSI6-ETS1-2) |