

Eco-Schools USA Pathways 9-12 Connection to the National Science Education Standards



A well-educated student is exposed to a well-rounded curriculum. It is the making of connections, conveyed by a rich core curriculum, which ultimately empowers students to develop convictions and reach their full academic and social potential.

U.S. Secretary of Education Arne Duncan

With a number of research studies to support the viability and success of environmental education in schools as well as the tremendous academic benefits and social impacts environmental education provides for students, National Wildlife Federation recognized the need and took charge by becoming the sole host organization for the International Eco-Schools program. Eco-Schools USA is a holistic program. It strives to make environmental awareness and action, **not additional curricula, but an intrinsic part of the life and culture of a school**, including students, teachers, administrative staff, non-teaching staff and parents, as well as the local community. Eco-Schools USA works to extend learning beyond the classroom and develop responsible environmental attitudes and commitments, both at home and in the wider community. Whether you are a teacher, student, administrator or facilities manager, the Eco-Schools USA program can benefit your school and local communities.

National Wildlife Federation has identified eight areas of primary focus or “pathways” to help schools become an Eco-School: Climate Change, Consumption and Waste, Energy, Global Dimensions, Green Hour, School Grounds, Transportation, and Water. The icons that represent each pathway can be seen above. In an effort to demonstrate that Eco-Schools USA can be interwoven through any teacher’s curriculum the pathways have been aligned to the National Science Education Standards from which all states base their state standards. On the following pages each content standard is shown with one or more of Eco-Schools USA’s pathways. These icons denote the pathways that can be targeted when teaching this content standard.

The eight categories of content standards are

- Unifying concepts and processes in science.
- Science as inquiry.
- Physical science.
- Life science.
- Earth and space science.
- Science and technology.
- Science in personal and social perspectives.
- History and nature of science.

The standard for unifying concepts and processes is presented for grades K-12, because the understanding and abilities associated with major conceptual and procedural schemes need to be developed over an entire education, and the unifying concepts and processes transcend disciplinary boundaries. The next seven categories are clustered for grades K-4, 5-8, and 9-12. Those clusters were selected based on a combination of factors, including cognitive development theory, the classroom experience of teachers, organization of schools, and the frameworks of other disciplinary-based standards.



Conceptual and procedural schemes unify science disciplines and provide students with powerful ideas to help them understand the natural world. Because of the underlying principles embodied in this standard, the understandings and abilities described here are repeated in the other content standards.

Unifying concepts and processes include

- Systems, order, and organization.
- Evidence, models, and explanation.
- Change, constancy, and measurement.
- Evolution and equilibrium.
- Form and function.

This standard describes some of the integrative schemes that can bring together students' many experiences in science education across grades K-12. The unifying concepts and processes standard can be the focus of instruction at any grade level but should always be closely linked to outcomes aligned with other content standards. In the early grades, instruction should establish the meaning and use of unifying concepts and processes—for example, what it means to measure and how to use measurement tools. At the upper grades, the standard should facilitate and enhance the learning of scientific concepts and principles by providing students with a big picture of scientific ideas—for example, how measurement is important in all scientific endeavors.

All users and reviewers are reminded that the content described is not a science curriculum. Content is what students should learn. Curriculum is the way content is organized and emphasized; it includes structure, organization, balance, and presentation of the content in the classroom.

National Science Education Standards, (1996)

National Committee on Science Education Standards and Assessment, National Research Council



Content Standard A Science as Inquiry



As a result of activities in grades 9-12, all students should develop

- **Abilities necessary to do scientific inquiry**

- Identify questions that can be answered through scientific investigations.
- Design and conduct a scientific investigation
- Use technology and mathematics to improve investigations and communications.
- Formulate and revise scientific explanations and models using logic and evidence.
- Recognize and analyze alternative explanations and models.
- Communicate and defend a scientific argument.

- **Understanding about scientific inquiry**

- Scientists usually inquire about how physical, living, or designed systems function. Conceptual principles and knowledge guide scientific inquiries. Historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists.
- Scientists conduct investigations for a wide variety of reasons.
- Scientists rely on technology to enhance the gathering and manipulations of data. New techniques and tools provide new evidence to guide inquiry and new methods to gather data, thereby contributing to the advance of science. The accuracy and precision of the data, and therefore the quality of the explorations depends on the technology.
- Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, construction explanations and communication results.
- Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modification; and it must be based on historical and current scientific knowledge.
- Results of scientific inquiry— new knowledge and methods — emerge from different types of investigations and public communication among scientists. In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge. In addition, the methods and procedures that scientists used to obtain evidence must be clearly reported to enhance opportunities for further investigation.

Scientific inquiry is the backbone of a strong science classroom. Beginning from its foundations in kindergarten students are cognitively molded into scientists, becoming science literate young men and women. The pathways provide a haven of opportunities to invite students into inquiry as you, the educator, facilitate student learning utilizing sound inquiry methods and strategies.

Check out NSTA's position statement on [scientific inquiry](#).



Content Standard B Physical Science



As a result of activities in grades 9-12, all students should develop

- **Structure and Properties of Matter**

- Solids, liquids, gases differ in the distances and angles between molecules or atoms and therefore the energy that binds them together. In solids the structure is nearly rigid; in liquids molecules or atoms move around each other but do not move apart; and in gases molecules or atoms move almost independently of each other and are mostly far apart.
- Carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures, including synthetic polymers, oils and the large molecules essential to life

- **Chemical Reactions**

- Chemical reactions occur all around us, for example in health care, cooking, cosmetics, and automobiles. Complex chemical reactions involving carbon-based molecules take place constantly in every cell in our bodies
- Chemical reactions may release or consume energy. Some reactions such as the burning of fossil fuels release large amounts of energy by losing heat and by emitting light. Light can initiate many chemical reactions such as photosynthesis and the evolution of urban smog.
- A large number of important reactions involve the transfer of either electrons or hydrogen ions between reaction ions, molecules, or atoms. In other reactions, chemical bonds are broken by heat or light to form very reactive radicals with electrons ready to form new bonds. Radical reactions control many processes such as the presence of ozone and greenhouse gases in the atmosphere, burning and processing of fossil fuels, the formation of polymers and explosions.
- Chemical reactions can take place in time periods ranging from the few Femtoseconds (10^{-15} seconds) required for an atom to move a fraction of a chemical bond distance to geologic time scales of billions of years. Reaction rates depend on how often the reacting atoms and molecules encounter on another, on the temperature, and on the properties.

- **Motions and Forces**

- Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.
- The electrical force is a universal force that exists between any two charged objects. The strength of the forces is proportional to the charges, and, as with gravitation, inversely proportional to the square of the distance between them.
- Electricity and magnetism are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces, and moving magnets produce electric forces. These effects help students to understand electric motors and generators.

Matter is everywhere. Many of the eight pathways can be addressed when teaching physical science concepts. Within the theme of climate change one can address the energy, water, consumption and waste, and transportation pathways via their *Structures and Properties* and *Chemical Reactions* standard. The concept of change over time is shown to vary based on different variables and can be taught when discussing the length of time chemical reactions take to form and how long they stay in our atmosphere. When teaching *Motions and Forces* this is an opportunity to discuss earth's natural resources and compare and contrast the methods of collecting, transforming, and transmitting electricity to society i.e. solar panels, wind turbines, hydroelectric plants, geothermal, and tidal, nuclear, biomass, and coal fire.



Content Standard B
Physical Science Continued



As a result of activities in grades 9-12, all students should develop

- **Conservation of Energy and the Increase In Disorder**

- The total energy of the universe is constant. Energy can be transferred, but never destroyed. As these transfers occur, the matter involved becomes steadily less ordered.
- All energy can be considered to be either kinetic energy, which is the energy of motion; potential energy, which depends on relative position; energy contained by a field, such as electromagnetic waves.
- Heat consists of random motion and the vibration of atoms, molecules, and ions. The higher the temperature, the greater the atomic or molecular motion.
- Everything tends to become less organized and less orderly over time. Thus, in all energy transfers, the overall effect is that the energy is spread out uniformly. Examples are the transfer of energy from hotter to cooler objects by conduction, radiation, or convection and the warming of our surroundings when we burn fuels.

- **Interactions of Energy and Matter**

- Waves, including sound and seismic waves, waves on water, and light waves have energy and can transfer energy when they interact with matter.
- Electromagnetic waves result when a charged object is accelerated or decelerated. Electromagnetic waves include radio waves, microwaves, infrared radiation, x-rays, and gamma rays. The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength.
- Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to the amounts. These wavelengths can be used to identify the substance.
- In some materials, such as metals, electrons flow easily, whereas in insulating materials such as glass they can hardly flow at all. Semiconducting materials have intermediate behavior. At low temperatures some materials become superconductors and offer no resistance to the flow of electrons.

By discussing how alternative energy generators work one can address the *Conservation of Energy and the Increase in Disorder* standard in addition utilizing our *Eco-Schools Climate Change Connections* curriculum one can address the standard, *Interactions of Energy and Matter* as the curriculum deals with remote sensing satellite observations, what they gather and what can be learned from those observations in regards to climate change. Often times lessons can be modified or completed outside-take some time and see what accommodations you can make.



Content Standard C Life Science



As a result of their activities in grades 9-12, all students should develop understanding of

- **The Interdependence of Organisms**

- The atoms and molecules on the earth cycle among the living and nonliving components of the biosphere.
- Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers.
- Organisms both cooperate and compete in ecosystems. The Interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds of thousands of years.
- Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms.
- Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors in threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.

- **Matter, Energy, and Organization in Living Systems**

- The energy for life primarily derives from the sun. Plants capture energy by absorbing light and using it to form strong chemical bonds between the atoms of carbon-containing molecules.
- The chemical bonds of food molecules contain energy. Energy is released when the bonds of food molecules are broken and new compounds with lower energy bonds are formed. Cells usually store this energy temporarily in phosphate bonds of a small high-energy compound called ATP.
- The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.
- The distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle matter.
- As matter and energy flows through different levels of organization of living systems and between living systems and the physical environment, chemical elements are recombined in different ways. Each recombination results in storage and dissipation of energy into the environment as heat. Matter and energy are conserved in each change.

Spending time outside in your schoolyard's habitat(s) is a great place to apply knowledge related to energy flow, energy transformations, and energy production in living systems. Raising snails, butterflies, ladybugs, walking sticks, trichogramma wasps, earthworms, and frogs along with a plethora of varieties of plants and vegetables will allow you to address several pathways while addressing the many life science standards. Raising beneficial insects and native plants, fruits, and vegetables is a great way for students to apply laboratory and inquiry skills as students investigate plot sites and observe organism's response to external or environmental stimuli, for example how is growth rate of plant X affected by idling traffic versus at another location not affected by idling traffic?



Content Standard C
Life Science Continued



As a result of their activities in grades 9-12, all students should develop understanding of

- **The Behavior of Organisms**

- Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.

Content Standard D
Earth and Space Science



As a result of their activities in grades 9-12, all students should develop understanding of

- **Energy in the Earth System**

- Earth systems have internal and external sources of energy, both of which create heat. The sun is the major source of energy.
- Heating of earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents.
- Global climate is determined by energy transfer from the sun at and near the earth's surface. This energy transfer is influenced by dynamic processes such as cloud cover and the earth's rotation, and static conditions such as the position of mountain ranges and oceans.

- **Geochemical Cycles**

- The earth is a system containing essentially a fixed amount of each stable chemical atom or element. Each element can exist in several different chemical reservoirs. Each element on earth moves among reservoirs in the solid earth, oceans, atmosphere, and organisms as part of geochemical cycles.
- Movement of matter between reservoirs is driven by the earth's internal and external sources of energy. These movements are often accompanied by a change in the physical and chemical properties of matter. Carbon, for example, occurs in carbonate rocks such as limestone, in the atmosphere as carbon dioxide gas, in water as dissolved carbon dioxide, and in all organisms as complex molecules that control the chemistry of life.

Earth and Space science are the foundations to understanding earth as a part of a larger system and as a system itself with many intricate systems within it. Climate change affects the lithosphere, hydrosphere, and the atmosphere-all studied in the **Earth and Space Science** standard. Through this standard the Eco-Schools pathways above can be addressed.

An online earth system's learning experience for teachers can be found at [Teacher's Domain](#).

For classroom resources related to earth and space science and the environment check out this link at [Teacher's Domain](#).

Linking you to the teachers guide on the [GLOBE](#) website will allow you to further explore earth systems learning opportunities for your students.



Content Standard E Science and Technology



climate change



consumption & waste



energy



global dimensions



school grounds



transportation



water

As a result of activities in grades 9-12, all students should develop

- **Abilities of Technological Design**
 - Identify a problem or design an opportunity.
 - Propose designs and choose between alternative solutions.
 - Implement a proposed solution.
 - Evaluate the solution and its consequences.
 - Communicate the problem, process, and solution.
- **Understandings about Science and Technology**
 - Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations. Many scientific investigations require the contributions of individuals from different disciplines, including engineering.
 - Science often advances with the introduction of new technologies. technological problems often results in new scientific knowledge. New technologies often extend the current levels of scientific understanding and introduce new areas of research.
 - Creativity, imagination, and a good knowledge base are all required in the work of science and engineering.
 - Science and technology are pursued for different purposes. Scientific inquiry is driven by the desire to understand the natural world, and technological design is driven by the need to meet human needs and solve human problems.

This standard ties in well with the inquiry method of teaching and is a true science teaching best practice. Eco-Action teams will find they go through this process often as they look for ideas and ways to green their school. Investigating STEM careers and engaging with local community members will demonstrate to students the need for competencies in science and technology. Exploring the evolution of fossil fuel production and alternative energy production along with what's on the horizon in global green technologies will allow students to see the marriage and strength of the science and technology fields, as well as open their eyes to potential career interests.



**Content Standard F
Science in Personal
and Social Perspectives**



As a result of activities in grades 9-12, all students should develop understanding of

- **Population Growth**

- Populations can increase through linear or exponential growth, with effects on resource use and environmental pollution.
- Populations can reach limits to growth. The limitation is not the availability of space, but the number of people in relation to resources and the capacity of earth systems to support human beings.

- **Natural Resources**

- Human populations use resources in the environment in order to maintain and improve their existence. Natural resources have been and will continue to be used to maintain human populations.
- The earth does not have infinite resources; increasing human consumption places severe stress on the natural processes that renew some resources, and it depletes those resources that cannot be renewed.
- Humans use natural systems as resources. Natural systems have the capacity to reuse waste, but that capacity is limited. Natural systems can change to an extent that exceeds the limits of organisms to adapt naturally or humans to adapt technologically.

- **Environmental Quality**

- Natural ecosystems provide an array of basic processes that affect humans. Those processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. Humans are changing many of these basic processes and the changes may be detrimental to humans.
- Materials from human societies affect both physical and chemical cycles of the earth.
- Many factors influence environmental quality. Factors that students might investigate include population growth, resource use, population distribution, overconsumption, the capacity of technology to solve problems, poverty, the role of economic, political, and religious views and different ways humans view the earth.

This is an opportunity to take the science and technology you have taught and make it personal. Allow students to make personal connections by diving into the following questions.

1. How do humans affect the earth globally?
2. How do humans affect the earth nationally?
3. How does my community affect the earth?
4. How do I affect the earth?

Explore environmental social justice issues to help your students make connections; reach out to community members.

For ideas go to **Facing the Future's**, [*Engaging Students Through Global Issues*](#). (free download)



**Content Standard F
Science in Personal
and Social Perspectives
Continued**



As a result of activities in grades 9-12, all students should develop understanding of

- **Natural and Human-Induced Hazards**

- Human activities can enhance potential for hazards. Acquisition of resources, urban growth, and waste disposal can accelerate rates of natural change.
- Some hazards, such as earthquakes, volcanic eruptions, and severe weather, are rapid and spectacular. But there are slow and progressive changes that also result in problems for individuals and societies. For example, change in stream channel position, erosion of bridge foundations, sedimentations in lakes and harbors, coastal erosions, and continuing erosion and wasting of soil and landscapes can all negatively affect society.
- Natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society, as well as cause risks.

- **Science and Technology in Local, National, and Global Challenges**

- Science and technology are essential social enterprises, but alone they can only indicate what can happen, not what should happen. The latter involves human decisions about the use of knowledge.
- Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, and ethics of various science-and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges.
- Progress in science and technology can be affected by social issues and challenges.
- Individuals and society must decide on proposals involving new research and the introduction of new technologies into society. Decisions involve assessment of alternatives, risks, costs, and benefits and consideration of who benefits and who suffers, who pays and gains, and what the risks are and who bears them. Students should understand the appropriateness and value of basic questions - "What can happen?" - "What are the odds?"- and "How do scientists and engineers know what will happen?"
- Humans have a major effect on other species. For example, the influence of humans on other species-and pollution-which changes the chemical composition of air, soil, and water.



Content Standard G
History and Nature of Science



As a result of activities in grades 9-12, all students should develop understanding of

- **Science as a Human Endeavor**

- Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science or engineering can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific question or technological problem. Pursuing science as a career or as a hobby can be both fascinating and intellectually rewarding.
- Scientists are influenced by societal, cultural, and personal beliefs and ways of viewing the world. Science is not separate from society but rather science is a part of society.

- **Nature of Scientific Knowledge**

- Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. The core ideas of science such as the conservation of energy or the laws of motion have been subjected to a wide variety of confirmations and are therefore unlikely to change in the areas in which they have been tested. In areas where data or understanding is incomplete, such as the details of human evolution or questions surrounding global warming, new data may well lead to changes in current ideas or resolve current conflicts. In situations where information is still fragmentary, it is normal for scientific ideas to be incomplete, but this is also where the opportunity for making advances may be greatest.

- **Historical Perspectives**

- Usually, changes in science occur as small modifications in extant knowledge. The daily work of science and engineering results in incremental advances in our understanding of the world and our ability to meet human needs and aspirations. Much can be learned about the internal workings of individual scientists, their daily work, and their efforts to advance scientific knowledge in their area of study.
- The historical perspective of scientific explanations demonstrates how scientific explanations demonstrates how scientific knowledge changes by evolving over time, almost always building on earlier knowledge.

Finally what does it really take to be a scientist, how much money can I make, how much college do I need, and what classes should I focus on in high school? Throughout instruction take opportunities to share, research, and learn about scientist past and present who have contributed to our science understanding. How have theories changed over time and what were the events that led to change in scientific theory? What role did society play? And what impacts did theory change have on society?

Check out, [STEM Careers](#), [Learning about Scientists](#), [Sloan Career Cornerstone Center](#), [How Much Can I Make?](#), [NOVA-Scientist Profiles](#), and [World Famous Canadian Scientist Profiles](#).

