SCIENCE

The *Illinois Learning Standards for Science* were developed using the 1985 State Goals for Science, the National Science Education Standards, various other state and national works, and local education standards contributed by team members.

Science is a creative endeavor of the human mind. It offers a special perspective of the natural world in terms of understanding and interaction. The aim of science education is to develop in learners a rich and full understanding of the inquiry process; the key concepts and principles of life sciences, physical science, and earth and space sciences; and issues of science, technology, and society in historical and contemporary contexts. The National Science Education Standards present these understandings and their interactions with the natural world as eight science content standard categories. The Illinois Learning Standards in Science integrate these categories into a powerful resource for the design and evaluation of science curricula taught in Illinois schools.

The *Illinois Learning Standards for Science* are organized by goals that inform one another and depend upon one another for meaning. Expectations for learners related to the inquiry process are presented in standards addressing the doing of science and elements of technological design. Unifying concepts connect scientific understanding and process and are embedded in standards spanning life science, physical science, and earth and space science. The importance of this knowledge and its application is conveyed in standards describing the conventions and nature of the scientific enterprise and the interplay among science, technology and society in past, present and future contexts.

APPLICATIONS OF LEARNING

Through Applications of Learning, students demonstrate and deepen their understanding of basic knowledge and skills. These applied learning skills cross academic disciplines and reinforce the important learning of the disciplines. The ability to use these skills will greatly influence students' success in school, in the workplace and in the community.

SOLVING PROBLEMS

Recognize and investigate problems; formulate and propose solutions supported by reason and evidence.

Asking questions and seeking answers are at the heart of scientific inquiry. Following the steps of scientific inquiry, students learn how to gather evidence, review and understand their findings, and compare their solutions with those of others. They learn that there can be differing solutions to the same problem, some more useful than others. In the process, they learn and apply scientific principles. They also learn to be objective in deciding whether their solutions meet specifications and perform as desired.

COMMUNICATING

Express and interpret information and ideas.

Scientists must carefully describe their methods and results to a variety of audiences, including other scientists. This requires precise and complete descriptions and the presentation of conclusions supported by evidence. Young science students develop the powers of observation and description. Older students gain the ability to organize and study data, to determine its meaning, to translate their findings into clear understandable language and to compare their results with those of other investigators.

USING TECHNOLOGY

Use appropriate instruments, electronic equipment, computers and networks to access information, process ideas and communicate results.

Technology is invented and improved by the use of scientific principles. In turn, scientists depend on technology in performing experiments, analyzing data and communicating the results. Science students learn to use a range of technologies: instruments, computer hardware and software, on-line services and equipment, primary source data and images, and communication networks. They learn how technology, in turn, is the result of a scientific design process that includes continual refinements and improvements.

WORKING ON TEAMS

Learn and contribute productively as individuals and as members of groups.

The practical application of science requires both individual and group efforts. Individuals bring unique insight and focus to the work of inquiry and problem solving. Working in groups, scientists pose questions, share hypotheses, divide their experimental efforts, and share data and results. Science students have the opportunity to work both ways—as individuals and as members of teams organized to conduct complex investigations and solve problems.

MAKING CONNECTIONS

Recognize and apply connections of important information and ideas within and among learning areas.

Science has many disciplines, all interrelated. Understanding the functioning of living things depends on knowing chemistry; understanding chemistry depends on knowing physics. In the same way, science itself is highly dependent on mathematics—and it also relates strongly to medicine, geography, physical development and health, social trends and issues, and many other topics. Science, at its best, provides knowledge and skills that improve the understanding of virtually all subjects.

STATE GOAL 11: Understand the processes of scientific inquiry and technological design to investigate questions, conduct experiments and solve problems.

Why This Goal Is Important: The inquiry process prepares learners to engage in science and apply methods of technological design. This understanding will enable students to pose questions, use models to enhance understanding, make predictions, gather and work with data, use appropriate measurement methods, analyze results, draw conclusions based on evidence, communicate their methods and results, and think about the implications of scientific research and technological problem solving.

A. Know and apply the concepts, principles and processes of scientific inquiry.

EARLY ELEMENTARY	LATE ELEMENTARY	MIDDLE/JUNIOR HIGH SCHOOL	EARLY HIGH SCHOOL	LATE HIGH SCHOOL
11.A.1a Describe an observed event.	**11.A.2a** Formulate questions on a specific science topic and choose the steps needed to answer the questions.	**11.A.3a** Formulate hypotheses that can be tested by collecting data.	**11.A.4a** Formulate hypotheses referencing prior research and knowledge.	**11.A.5a** Formulate hypotheses referencing prior research and knowledge.
11.A.1b Develop questions on scientific topics.	**11.A.2b** Collect data for investigations using scientific process skills including observing, estimating and measuring.	**11.A.3b** Conduct scientific experiments that control all but one variable.	**11.A.4b** Conduct controlled experiments or simulations to test hypotheses.	**11.A.5b** Design procedures to test the selected hypotheses.
11.A.1c Collect data for investigations using measuring instruments and technologies.	**11.A.2c** Construct charts and visualizations to display data.	**11.A.3c** Collect and record data accurately using consistent measuring and recording techniques and media.	**11.A.4c** Collect, organize and analyze data accurately and precisely.	**11.A.5c** Conduct systematic controlled experiments to test the selected hypotheses.
11.A.1d Record and store data using available technologies.	**11.A.2d** Use data to produce reasonable explanations.	**11.A.3d** Explain the existence of unexpected results in a data set.	**11.A.4d** Apply statistical methods to the data to reach and support conclusions.	**11.A.5d** Apply statistical methods to make predictions and to test the accuracy of results.

11.A.1e Arrange data into logical patterns and describe the patterns.	**11.A.2e** Report and display the results of individual and group investigations.	**11.A.3e** Use data manipulation tools and quantitative (e.g., mean, mode, simple equations) and representational methods (e.g., simulations, image processing) to analyze measurements.	**11.A.4e** Formulate alternative hypotheses to explain unexpected results.	**11.A.5e** Report, display and defend the results of investigations to audiences that may include professionals and technical experts.
11.A.1f Compare observations of individual and group results.		**11.A.3f** Interpret and represent results of analysis to produce findings.	**11.A.4f** Using available technology, report, display and defend to an audience conclusions drawn from investigations.	
		11.A.3g Report and display the process and results of a scientific investigation.		

B. Know and apply the concepts, principles and processes of technological design.

EARLY ELEMENTARY	LATE ELEMENTARY	MIDDLE/JUNIOR HIGH SCHOOL	EARLY HIGH SCHOOL	LATE HIGH SCHOOL
11.B.1a Given a simple design problem, formulate possible solutions.	**11.B.2a** Identify a design problem and propose possible solutions.	**11.B.3a** Identify an actual design problem and establish criteria for determining the success of a solution.	**11.B.4a** Identify a technological design problem inherent in a commonly used product.	**11.B.5a** Identify a design problem that has practical applications and propose possible solutions, considering such constraints as available tools, materials, time and costs.
11.B.1b Design a device that will be useful in solving the problem.	**11.B.2b** Develop a plan, design and procedure to address the problem identifying constraints (e.g., time, materials, technology).	**11.B.3b** Sketch, propose and compare design solutions to the problem considering available materials, tools, cost effectiveness and safety.	**11.B.4b** Propose and compare different solution designs to the design problem based upon given constraints including available tools, materials and time.	**11.B.5b** Select criteria for a successful design solution to the identified problem.
11.B.1c Build the device using the materials and tools provided.	**11.B.2c** Build a prototype of the design using available tools and materials.	**11.B.3c** Select the most appropriate design and build a prototype or simulation.	**11.B.4c** Develop working visualizations of the proposed solution designs (e.g., blueprints, schematics, flowcharts, cad-cam, animations).	**11.B.5c** Build and test different models or simulations of the design solution using suitable materials, tools and technology.
11.B.1d Test the device and record results using given instruments, techniques and measurement methods.	**11.B.2d** Test the prototype using suitable instruments, techniques and quantitative measure-ments to record data.	**11.B.3d** Test the prototype using available materials, instruments and technology and record the data.	**11.B.4d** Determine the criteria upon which the designs will be judged, identify advantages and disadvantages of the designs and select the most promising design.	**11.B.5d** Choose a model and refine its design based on the test results.

11.B.1e Report the design of the device, the test process and the results in solving a given problem.	**11.B.2e** Assess test results and the effectiveness of the design using given criteria and noting possible sources of error.	**11.B.3e** Evaluate the test results based on established criteria, note sources of error and recommend improvements.	**11.B.4e** Develop and test a prototype or simulation of the solution design using available materials, instruments and technology.	**11.B.5e** Apply established criteria to evaluate the suitability, acceptability, benefits, drawbacks and consequences for the tested design solution and recommend modifications and refinements.
	11.B.2f Report test design, test process and test results.	**11.B.3f** Using available technology, report the relative success of the design based on the test results and criteria.	**11.B.4f** Evaluate the test results based on established criteria, note sources of error and recommend improvements.	**11.B.5f** Using available technology, prepare and present findings of the tested design solution to an audience that may include professional and technical experts.
			11.B.4g Using available technology, report to an audience the relative success of the design based on the test results and criteria.	

STATE GOAL 12: Understand the fundamental concepts, principles and interconnections of the life, physical and earth/space sciences.

Why This Goal Is Important: This goal is comprised of key concepts and principles in the life, physical and earth/space sciences that have considerable explanatory and predictive power for scientists and non-scientists alike. These ideas have been thoroughly studied and have stood the test of time. Knowing and being able to apply these concepts, principles and processes help students understand what they observe in nature and through scientific experimentation. A working knowledge of these concepts and principles allows students to relate new subject matter to material previously learned and to create deeper and more meaningful levels of understanding.

A. Know and apply concepts that explain how living things function, adapt and change.

EARLY ELEMENTARY	LATE ELEMENTARY	MIDDLE/JUNIOR HIGH SCHOOL	EARLY HIGH SCHOOL	LATE HIGH SCHOOL
12.A.1a Identify and describe the component parts of living things (e.g., birds have feathers; people have bones, blood, hair, skin) and their major functions.	**12.A.2a** Describe simple life cycles of plants and animals and the similarities and differences in their offspring.	**12.A.3a** Explain how cells function as "building blocks" of organisms and describe the require-ments for cells to live.	**12.A.4a** Explain how genetic combinations produce visible effects and variations among physical features and cellular functions of organisms.	**12.A.5a** Explain changes within cells and organisms in response to stimuli and changing environmental conditions (e.g., homeostasis, dormancy).
12.A.1b Categorize living organisms using a variety of observable features (e.g., size, color, shape, backbone).	**12.A.2b** Categorize features as either inherited or learned (e.g., flower color or eye color is inherited; language is learned).	**12.A.3b** Compare characteristics of organisms produced from a single parent with those of organisms produced by two parents.	**12.A.4b** Describe the structures and organization of cells and tissues that underlie basic life functions including nutrition, respiration, cellular transport, biosynthesis and reproduction.	**12.A.5b** Analyze the transmission of genetic traits, diseases and defects.

		12.A.3c Compare and contrast how different forms and structures reflect different functions (e.g., similarities and differences among animals that fly, walk or swim; structures of plant cells and animal cells).	**12.A.4c** Describe processes by which organisms change over time using evidence from comparative anatomy and physiology, embryology, the fossil record, genetics and biochemistry.	

B. Know and apply concepts that describe how living things interact with each other and with their environment.

EARLY ELEMENTARY	LATE ELEMENTARY	MIDDLE/JUNIOR HIGH SCHOOL	EARLY HIGH SCHOOL	LATE HIGH SCHOOL
12.B.1a Describe and compare characteristics of living things in relationship to their environments.	**12.B.2a** Describe relationships among various organisms in their environments (e.g., predator/prey, parasite/host, food chains and food webs).	**12.B.3a** Identify and classify biotic and abiotic factors in an environment that affect population density, habitat and placement of organisms in an energy pyramid.	**12.B.4a** Compare physical, ecological and behavioral factors that influence interactions and interdependence of organisms.	**12.B.5a** Analyze and explain biodiversity issues and the causes and effects of extinction.
12.B.1b Describe how living things depend on one another for survival.	**12.B.2b** Identify physical features of plants and animals that help them live in different environments (e.g., specialized teeth for eating certain foods, thorns for protection, insulation for cold temperature).	**12.B.3b** Compare and assess features of organisms for their adaptive, competitive and survival potential (e.g., appendages, reproductive rates, camouflage, defensive structures).	**12.B.4b** Simulate and analyze factors that influence the size and stability of populations within ecosystems (e.g., birth rate, death rate, predation, migration patterns).	**12.B.5b** Compare and predict how life forms can adapt to changes in the environment by applying concepts of change and constancy (e.g., variations within a population increase the likelihood of survival under new conditions).

C. Know and apply concepts that describe properties of matter and energy and the interactions between them.

EARLY ELEMENTARY	LATE ELEMENTARY	MIDDLE/JUNIOR HIGH SCHOOL	EARLY HIGH SCHOOL	LATE HIGH SCHOOL
12.C.1a Identify and compare sources of energy (e.g., batteries, the sun).	**12.C.2a** Describe and compare types of energy including light, heat, sound, electrical and mechanical.	**12.C.3a** Explain interactions of energy with matter including changes of state and conservation of mass and energy.	**12.C.4a** Use kinetic theory, wave theory, quantum theory and the laws of thermo-dynamics to explain energy transformations.	**12.C.5a** Analyze reactions (e.g., nuclear reactions, burning of fuel, decomposition of waste) in natural and man-made energy systems.
12.C.1b Compare large-scale physical properties of matter (e.g., size, shape, color, texture, odor).	**12.C.2b** Describe and explain the properties of solids, liquids and gases.	**12.C.3b** Model and describe the chemical and physical characteristics of matter (e.g., atoms, molecules, elements, compounds, mixtures).	**12.C.4b** Analyze and explain the atomic and nuclear structure of matter.	**12.C.5b** Analyze the properties of materials (e.g., mass, boiling point, melting point, hardness) in relation to their physical and/or chemical structures.

D. Know and apply concepts that describe force and motion and the principles that explain them.

EARLY ELEMENTARY	LATE ELEMENTARY	MIDDLE/JUNIOR HIGH SCHOOL	EARLY HIGH SCHOOL	LATE HIGH SCHOOL
12.D.1a Identify examples of motion (e.g., moving in a straight line, vibrating, rotating).	**12.D.2a** Explain constant, variable and periodic motions.	**12.D.3a** Explain and demonstrate how forces affect motion (e.g., action/reaction, equilibrium conditions, free-falling objects).	**12.D.4a** Explain and predict motions in inertial and accelerated frames of reference.	**12.D.5a** Analyze factors that influence the relative motion of an object (e.g., friction, wind shear, cross currents, potential differences).
12.D.1b Identify observable forces in nature (e.g., pushes, pulls, gravity, magnetism).	**12.D.2b** Demonstrate and explain ways that forces cause actions and reactions (e.g., magnets attracting and repelling; objects falling, rolling and bouncing).	**12.D.3b** Explain the factors that affect the gravitational forces on objects (e.g., changes in mass, distance).	**12.D.4b** Describe the effects of electromagnetic and nuclear forces including atomic and molecular bonding, capacitance and nuclear reactions.	**12.D.5b** Analyze the effects of gravitational, electromagnetic and nuclear forces on a physical system.

E. Know and apply concepts that describe the features and processes of the Earth and its resources.

EARLY ELEMENTARY	LATE ELEMENTARY	MIDDLE/JUNIOR HIGH SCHOOL	EARLY HIGH SCHOOL	LATE HIGH SCHOOL
12.E.1a Identify components and describe diverse features of the Earth's land, water and atmospheric systems.	**12.E.2a** Identify and explain natural cycles of the Earth's land, water and atmospheric systems (e.g., rock cycle, water cycle, weather patterns).	**12.E.3a** Analyze and explain large-scale dynamic forces, events and processes that affect the Earth's land, water and atmospheric systems (e.g., jetstream, hurricanes, plate tectonics).	**12.E.4a** Explain how external and internal energy sources drive Earth processes (e.g., solar energy drives weather patterns; internal heat drives plate tectonics).	**12.E.5** Analyze the processes involved in naturally occurring short-term and long-term Earth events (e.g., floods, ice ages, temperature, sea-level fluctuations).
12.E.1b Identify and describe patterns of weather and seasonal change.	**12.E.2b** Describe and explain short-term and long-term interactions of the Earth's components (e.g., earthquakes, types of erosion).	**12.E.3b** Describe interactions between solid earth, oceans, atmosphere and organisms that have resulted in ongoing changes of Earth (e.g., erosion, El Nino).	**12.E.4b** Describe how rock sequences and fossil remains are used to interpret the age and changes in the Earth.	
12.E.1c Identify renewable and nonrenewable natural resources.	**12.E.2c** Identify and classify recyclable materials.	**12.E.3c** Evaluate the biodegradability of renewable and nonrenewable natural resources.		

F. Know and apply concepts that explain the composition and structure of the universe and Earth's place in it.

EARLY ELEMENTARY	LATE ELEMENTARY	MIDDLE/JUNIOR HIGH SCHOOL	EARLY HIGH SCHOOL	LATE HIGH SCHOOL
12.F.1a Identify and describe characteristics of the sun, Earth and moon as familiar objects in the solar system.	**12.F.2a** Identify and explain natural cycles and patterns in the solar system (e.g., order of the planets; moon phases; seasons as related to Earth's tilt, one's latitude, and where Earth is in its yearly orbit around the sun).	**12.F.3a** Simulate, analyze and explain the effects of gravitational force in the solar system (e.g., orbital shape and speed, tides, spherical shape of the planets and moons).	**12.F.4a** Explain theories, past and present, for changes observed in the universe.	**12.F.5a** Compare the processes involved in the life cycle of stars (e.g., gravitational collapse, thermonuclear fusion, nova) and evaluate the supporting evidence.

12.F.1b Identify daily, seasonal and annual patterns related to the Earth's rotation and revolution.	**12.F.2b** Explain the apparent motion of the sun and stars.	**12.F.3b** Describe the organization and physical characteristics of the solar system (e.g., sun, planets, satellites, asteroids, comets).	**12.F.4b** Describe and compare the chemical and physical characteristics of galaxies and objects within galaxies (e.g., pulsars, nebulae, black holes, dark matter, stars).	**12.F.5b** Describe the size and age of the universe and evaluate the supporting evidence (e.g., red-shift, Hubble's constant).
	12.F.2c Identify easily recognizable star patterns (e.g., the Big Dipper, constellations).	**12.F.3c** Compare and contrast the sun as a star with other objects in the Milky Way Galaxy (e.g., nebulae, dust clouds, stars, black holes).		

STATE GOAL 13: Understand the relationships among science, technology and society in historical and contemporary contexts.

Why This Goal Is Important: Understanding the nature and practices of science such as ensuring the validity and replicability of results, building upon the work of others and recognizing risks involved in experimentation gives learners a useful sense of the scientific enterprise. In addition, the relationships among science, technology and society give humans the ability to change and improve their surroundings. Learners who understand this relationship will be able to appreciate the efforts and effects of scientific discovery and applications of technology on their own lives and on the society in which we live.

A. Know and apply the accepted practices of science.

EARLY ELEMENTARY	LATE ELEMENTARY	MIDDLE/JUNIOR HIGH SCHOOL	EARLY HIGH SCHOOL	LATE HIGH SCHOOL
13.A.1a Use basic safety practices (e.g., not tasting materials without permission, "stop/drop/roll").	**13.A.2a** Demonstrate ways to avoid injury when conducting science activities (e.g., wearing goggles, fire extinguisher use).	**13.A.3a** Identify and reduce potential hazards in science activities (e.g., ventilation, handling chemicals).	**13.A.4a** Estimate and suggest ways to reduce the degree of risk involved in science activities.	**13.A.5a** Design procedures and policies to eliminate or reduce risk in potentially hazardous science activities.
13.A.1b Explain why similar results are expected when procedures are done the same way.	**13.A.2b** Explain why similar investigations may not produce similar results.	**13.A.3b** Analyze historical and contemporary cases in which the work of science has been affected by both valid and biased scientific practices.	**13.A.4b** Assess the validity of scientific data by analyzing the results, sample set, sample size, similar previous experimentation, possible misrepresentation of data presented and potential sources of error.	**13.A.5b** Explain criteria that scientists use to evaluate the validity of scientific claims and theories.
13.A.1c Explain how knowledge can be gained by careful observation.	**13.A.2c** Explain why keeping accurate and detailed records is important.	**13.A.3c** Explain what is similar and different about observational and experimental investigations.	**13.A.4c** Describe how scientific knowledge, explanations and technological designs may change with new information over time (e.g., the understanding of DNA, the design of computers).	**13.A.5c** Explain the strengths, weaknesses and uses of research methodologies including observational studies, controlled laboratory experiments, computer modeling and statistical studies.

			13.A.4d Explain how peer review helps to assure the accurate use of data and improves the scientific process.	**13.A.5d** Explain, using a practical example (e.g., cold fusion), why experimental replication and peer review are essential to scientific claims.

B. Know and apply concepts that describe the interaction between science, technology and society.

EARLY ELEMENTARY	LATE ELEMENTARY	MIDDLE/JUNIOR HIGH SCHOOL	EARLY HIGH SCHOOL	LATE HIGH SCHOOL
13.B.1a Explain the uses of common scientific instruments (e.g., ruler, thermometer, balance, probe, computer).	**13.B.2a** Explain how technology is used in science for a variety of purposes (e.g., sample collection, storage and treatment; measurement; data collection, storage and retrieval; communication of information).	**13.B.3a** Identify and explain ways that scientific knowledge and economics drive technological development.	**13.B.4a** Compare and contrast scientific inquiry and technological design as pure and applied sciences.	**13.B.5a** Analyze challenges created by international competition for increases in scientific knowledge and technological capabilities (e.g., patent issues, industrial espionage, technology obsolescence).
13.B.1b Explain how using measuring tools improves the accuracy of estimates.	**13.B.2b** Describe the effects on society of scientific and technological innovations (e.g., antibiotics, steam engine, digital computer).	**13.B.3b** Identify important contributions to science and technology that have been made by individuals and groups from various cultures.	**13.B.4b** Analyze a particular occupation to identify decisions that may be influenced by a knowledge of science.	**13.B.5b** Analyze and describe the processes and effects of scientific and technological breakthroughs.
13.B.1c Describe contributions men and women have made to science and technology.	**13.B.2c** Identify and explain ways that science and technology influence the lives and careers of people.	**13.B.3c** Describe how occupations use scientific and technological knowledge and skills.	**13.B.4c** Analyze ways that resource management and technology can be used to accommodate population trends.	**13.B.5c** Design and conduct an environmental impact study, analyze findings and justify recommendations.
13.B.1d Identify and describe ways that science and technology affect people's everyday lives (e.g., transportation, medicine, agriculture, sanitation, communication occupations).	**13.B.2d** Compare the relative effectiveness of reducing, reusing and recycling in actual situations.	**13.B.3d** Analyze the interaction of resource acquisition, technological development and ecosystem impact (e.g., diamond, coal or gold mining; deforestation).	**13.B.4d** Analyze local examples of resource use, technology use or conservation programs; document findings; and make recommendations for improvements.	**13.B.5d** Analyze the costs, benefits and effects of scientific and technological policies at the local, state, national and global levels (e.g., genetic research, Internet access).
13.B.1e Demonstrate ways to reduce, reuse and recycle materials.	**13.B.2e** Identify and explain ways that technology changes ecosystems (e.g., dams, highways, buildings, communication networks, power plants).	**13.B.3e** Identify advantages and disadvantages of natural resource conservation and management programs.	**13.B.4e** Evaluate claims derived from purported scientific studies used in advertising and marketing strategies.	**13.B.5e** Assess how scientific and technological progress has affected other fields of study, careers and job markets and aspects of everyday life.
	13.B.2f Analyze how specific personal and societal choices that humans make affect local, regional and global ecosystems (e.g., lawn and garden care, mass transit).	**13.B.3f** Apply classroom-developed criteria to determine the effects of policies on local science and technology issues (e.g., energy consumption, landfills, water quality).		