Science Standards: Options For Sears

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The Illinois state science standards for K-12 provide a minimal outline of what is expected in a public school science program. The emphasis is on *minimal.* Compared to most other state standards, the Illinois standards are exceedingly terse. *An eighth grade student could graduate from a complying Illinois school and yet be a science illiterate.*

This document looks at two approaches of how to address this problem. First, the state of California resolved it by instituting a far more useful science standard. Second, a national network of schools has adopted the Core Knowledge curriculum, which provides a clear flight plan for grade school education in science (and other disciplines as well).

Comparing the State Standards

Compared to Illinois' science standards, the California standards provide a much more useful measure of what students are expected to discover in science.

As an example, let's consider how these standards handle the topic of weather : California identifies nine points that grade school children should learn. That isn't at all unreasonable. Moreover, all of those nine points make perfect sense for a grade school curriculum. In stark contrast, all that Illinois says is that "early elementary" students should be able to "identify and describe patterns of weather and seasonal change".

The result is startling when you consider a whole subject area within science. Consider the life sciences: California observes 76 points on the biology of plants and animals and their environments that grade school children should learn somewhere across their nine years in grade school. In reading this list, it is clear that they make perfect sense for a grade school curriculum. But in its standards, Illinois gives only a dozen sentences that are astonishingly vague.

The treatment of the earth sciences is even worse: California notes 55 important ideas that kids should learn in nine years, while Illinois treats this whole broad area with a measly seven lines.

About This Document

Given the shallowness of the Illinois standard, and the allure of the California standard, I wanted to compare the two. In this document I have re-organized the items of the two standards by subject areas and subtopics. The purpose of this format is to allow easy review and comparison of just what the two standards expect students to learn somewhere in their K-8 experiences. These broad subject areas are:

- Physical sciences
- Life sciences
- Earth sciences
- Space sciences
- The history of science
- The nature and practice of science
- Applied science

Within subtopics, items are shown with California first followed by Illinois. And, within states, items are shown by grade level. The California science standard specifies topics by specific grade. To identify California items, I have placed the designated grade letter ("K" through "8") in the first column. The Illinois science standard specifies topics by three ranges, "early elementary", "late elementary" and "middle/junior high". To identify Illinois items, I have placed the designated range ("E", "L" or "J") in the second column.

The wording of individual items is copied verbatim from the two standards, with very few changes made for the sake of clarity, verb tense, and so on. I was tempted to try to merge individual topics, but dismissed that notion because of the difficulty of matching them, and because I wanted to preserve the original flavor and intent of the source documents. I apologize in advance for any errors made during the rather extensive cutting and pasting required.

Readers should also be sure to examine the original source documents. My goal here was simply to review *what* content was to be included. Both the source documents do a much better job in showing *how these topics are developed,* and *how they grow richly upon each other.*

Is More Too Much?

On first glance, this document looks lengthy, in seeming contrast to the trendy educational mantras to avoid "mere facts" and the Orwellian "less is more". But bear in mind that these topics are designed to be covered over nine years. Also note that in many cases, a number of the key facts quickly collapse into one single class topic.

So, is California too much? I tabulated the number of individual bullet points by specified grade level, with these results:

State	Grade or Level	Items
California	K	14
	1	16
	2	25
	3	28
	4	28
	5	36
	6	41
	7	47
	8	53
Illinois	E (early elementary)	32
	L (late elementary)	34
	J (middle/junior high)	28

It is a pleasure to discover that even the rich, content-oriented California standard is *easily attained:* For most of the early grades, California demands <u>less</u> *than one single bullet point per week!* The "heaviest" load in either of these documents is found in California's standards for eighth grade, when 53 line items are noted. Even then, this is an average of *fewer than two items per week,* a goal that is certainly not unreasonable, and offering plenty of time and opportunity for imaginative, hands-on student projects and explorations.

To anyone who thinks that the California standards demand "too much", I would ask two questions: First, how can one fact a week possibly be too much? Second, which of these facts would you not want Sears students to learn?

Applying Content to Create Exciting and Meaningful Units

The California standard places no demands or restraints on how schools or teachers should teach. This allows great flexibility in fashioning interesting and suitable lessons.

Ann Krumplys, a parent on our science committee, mentioned that she would love to see more coverage of <u>flight</u>, a topic she finds exciting and inspiring (as do I). To consider how flexibility and imagination might be achieved in a curriculum that is also content-rich, I took Ann's idea as a challenge!

I found that it was easy to skim through the list of topics in the list and put together a skeleton of content that could be fashioned into a series of lively units on flight. Aviation topics (and the science they require) *might* include such *possibilities* as these:

– how flight works (action and reaction, Bernoulli's law)
– force and motion (the mass of the plane, the resistance of air, momentum, the equivalence of gravity and acceleration)
– building strong skins and engines (chemistry reactions and alloys)
– radar and other avionics (electromagnetism, properties of light)
– dangers to flight (weather)
– energy and heat (engine operation, skin friction, heat conduction and radiation)
– concerns for crew and passengers (the needs of life, air supply and recirculation, accelerations, air and radiation at high altitudes or in space)
– airports (urban land use, noise, pollution, wetlands, other environmental issues)
– key historical topics and persons (Chinese fireworks, Da Vinci, Wright brothers, Goddard, Armstrong)

All of these areas immediately trigger many ideas for hands-on, discovery-learning projects!

Flight is so pervasive as a factor in contemporary society that opportunities for an integrated curriculum would be plentiful as well:

– mythology (Icarus)
– literature (Verne)
– social studies (our country, and the world, unified by flight)
– history (warfare changed by flight)

This is just *one* possible look at *one* topic, flight. Another person's ideas would be different than mine, and there is certainly no need for any class to go through all of these topics.

But I believe the point is demonstrated: lively classroom sessions and rich content can thrive together beautifully!

An Illinois School

What does the California standard mean to us, a committee of a school in Illinois? Simply this: it provides a higher goal, a better goal, for what we can achieve in science.

But can we embrace some or all of the California standard, while still conforming to the Illinois standard? The answer is yes: Since the Illinois standard is so vague and minimal, it can properly be considered a subset of the California standard. An Illinois school can observe the California standard, or even just selected portions of it, and easily meet the Illinois standard. The reverse is not true – if a California school had a science program that was as weak as the Illinois standard, it would be in violation of the California standard.

The California science standard also has an immediate benefit to us: it ensures that correspondingly rich curricula, materials and textbooks will be developed by publishers and available for use in all states, including ours.

I do not believe that the California standard is perfect. For example, California prescribes content items down to specific grade levels. This does address the issue of students moving between schools, a problem in a highly mobile state. However, it complicates the writing of interesting and lively thematic units, since suitable content items might be assigned to more than one grade. Delightfully, we have no such problem. In its introduction, the Illinois standard says, “Specific grade levels are not used to allow schools flexibility in how they structure their education programs.” This is highly desirable.

The California standard also has a few conspicuous gaps. It says nothing about the historical figures in science, for example. And, in a very few cases, the Illinois standard provides better coverage than California’s. In such cases, the omissions could be easily handled through supplemental material.

We enjoy the enviable situation of being free to welcome the rich (but not excessive) content specified by California, and yet have the freedom provided by the looseness of the Illinois standard.

Another Approach: Core Knowledge

It’s dangerously easy to lump educational philosophies into one of two groups: try-as-toast or fun and fuzzy. But this is a false dilemma: there certainly is a valuable place for hands-on discovery learning, and that’s within the context of a content-rich, goal-oriented curriculum. Rich content and active learning can and do co-exist beautifully!

This is precisely the allure of the Core Knowledge movement, which has been adopted by about 1,000 schools nationwide. At its heart is the “Core Knowledge Sequence”, a detailed master curriculum guide. It allows teachers to know exactly what is expected of them and how it fits in with other grade levels, and it tells parents exactly what their kids will be learning about. What a pleasure! I would like to have included the science section of this guide within this document, for comparison to the Illinois and California standards. However, I don’t have access to it in a machine-readable format. To give at least a taste, I have typed up the section headings for science from the Sequence, and this is on the first two pages of the attachment.

The Core Knowledge curriculum specifies an exciting and expansive program, all made available in the form of lively, imaginative, active units, activities and lesson plans. These plans and units are developed by individual teachers and schools, each according to their own interests, skills and community needs. Best of all, the Core Knowledge Foundation hosts conferences and a website so that all teachers in the network can share the units they've developed. Core Knowledge schools use dramatizations, art projects, writing projects, collaborative groups, research projects and other imaginative activities, but always in the content of rich and clearly laid out content streams. For more information about Core Knowledge in general, see their website at www.coreknowledge.org. Sample lessons plan are also on that site.

Options For Sears

The California science standard and the Core Knowledge sequence for science both provide strong models of what elementary school science should cover. The California standard will be supported by textbook publishers. But I am particular enamored of the Core Knowledge approach, which features strong content that is clearly defined, lively, involving, exciting classroom activities, and an active network of teachers sharing units and lessons.

I propose that one or the other of these guidelines be adopted by Sears. Doing so would set us on course to have a truly first rate science program.

Attachments

The remainder of this document consists of two items:

- The first two pages provide a top-level outline of the science portion of the Core Knowledge Sequence

- The remaining 19 pages provide a comparison of the Illinois and California state standards

Core Knowledge: Science

This is the top-level outline of the science portion of the Core Knowledge Sequence, the curriculum used by approximately 1,000 schools. The Sequence is a 8 1/2 x 11 spiral-bound book of approximately 100 pages, and it's available from the Core Knowledge Foundation.

Preschool

- Human characteristics, needs and development
- Animal characteristics, needs and development
- Plant characteristics, needs and growth
- Physical elements (water, air, light)
- Tools

Kindergarten

- Plants and plant growth
- Animals and their need
- Human body - five senses
- Introduction to magnetism
- Seasons and weather
- Taking care of the earth
- Science biographies

First Grade

- Living things and their environments
- Human body - body systems
- Matter
- Properties of matter: measurement
- Introduction to electricity
- Astronomy
- The Earth
- Science biographies

Second Grade

- Cycles in nature (seasons, life cycles, water cycle)
- Insects
- Human body (cells, digestive and excretory systems)
- Magnetism
- Simple machines
- Science biographies

Third Grade

- Introduction to the classification of animals
- Human body (muscular, skeletal and nervous systems, vision and hearing)
- Light and optics
- Sound
- Ecology
- Astronomy
- Science biographies

Fourth Grade

- Human body (circulatory and respiratory systems)
- Chemistry (atoms, matter, elements, solutions)
- Electricity
- Geology: Earth and its changes
- History of Earth
- Meteorology
- Science biographies

Fifth Grade

- Classifying living things
- Cells: structure and processes
- Plant structures and processes
- Life cycles and reproduction
- Human body (endocrine and reproductive systems)
- Chemistry: matter and change
- Science biographies

Sixth Grade

- Physics: mechanical concepts (speed, force, work, energy, power)
- Energy, heat and energy transfer
- Astronomy: gravity, stars and galaxies
- The Forest
- Human body (circulatory, lymphatic, and immune systems)
- Science biographies

Seventh Grade

- Atomic structure
- Chemical bonds and reactions
- Cell division and genetics
- Genetics and evolution
- Weather
- Science biographies

Eighth Grade

- Electricity and magnetism
- Electromagnetic radiation and light
- Sound waves
- Chemistry of food and respiration
- Plate tectonics, earthquakes, and volcanos
- Science biographies

Bear in mind that this list consists merely of the top-level headings from the Core Knowledge Sequence. Consult that complete document for full details on each of these units.

Physical Sciences

CA IL

Matter

K objects can be described in terms of the materials they are made of (clay, cloth, paper, etc.) and their physical properties (color, size, shape, weight, texture, flexibility, attraction to magnets, floating and sinking etc.).
K water can be a liquid or a solid and can be made to change back and forth from one form to the other.
K water left in an open container evaporates (goes into the air), but water in a closed container does not.

1 solids, liquids, and gases have different properties.
1 the properties of substances can change when the substances are mixed, cooled, or heated.

3 matter has three forms: solid, liquid and gas.
3 evaporation and melting are changes that occur when the objects are heated.
3 all matter is made of small particles called atoms, too small to see with our eyes.
3 for many years people thought that earth, wind, fire, and water were the basic elements that made up all matter. All matter is made of the elements that are displayed on the Periodic Table of the elements.

5 when two substances react the reactants form products with properties that are different from the original reactants.
5 all matter, including any living thing, is made of very small particles called atoms. Atoms combine to form molecules.
5 some substances contain molecules made up of only one kind of atom, such as oxygen (O_2) and nitrogen (N_2). Substances containing only one type of atom are called elements.
5 some substances contain only one type of molecule, but these molecules contain more than one type of atom, such as water (H_2O), table salt (NaCl), and carbon dioxide (CO_2). Such substances are called compounds.
5 metals are a group of substances that have shared properties such as electrical and thermal conductivity. Some metals, such as aluminum (Al), iron (Fe), nickel (Ni), copper (Cu), silver (Ag), gold (Au), are pure elements while others, such as steel and brass, are composed of a combination of elemental metals.
5 that the periodic table organizes elements by their chemical properties.
5 scientists have developed instruments that can create images of atoms and molecules showing that they are discrete and often occur in well ordered arrays.
5 scientists use differences in chemicals and physical properties of substances to separate mixtures and use substances such as dyes and acid indicators which can be extracted from natural products such as leaves.

8 Elements have distinct properties and atomic structure. All matter is comprised of one or more of approximately 100 elements
8 the structure of the atom and how it is composed of protons, neutrons and electrons.
8 the states (solid, liquid, gas) of matter depend on molecular motion.
8 in solids the atoms are closely locked in position and can only vibrate, in liquids the atoms and molecules are more loosely connected and can collide with and move past one another, while in gases the atoms or molecules are free to move independently, colliding frequently.

E Compare large-scale physical properties of matter (e.g., size, shape, color, texture, odor).
L Describe and explain the properties of solids, liquids and gases.
J Model and describe the chemical and physical characteristics of matter (e.g., atoms, molecules, elements, compounds, mixtures).

Periodic table

8 The organization of the periodic table is based on the properties of the elements and reflects the structure of atoms
8 how to identify regions corresponding to metals, nonmetals and inert gases.
8 elements are defined by the number of protons in the nucleus, which is called the atomic number. Different isotopes of an element have a different number of neutrons in the nucleus.
8 substances can be classified by their properties, including melting temperature, density, hardness, heat, and electrical conductivity.

8 how to use the periodic table to identify elements in simple compounds

Density and buoyancy

8 All objects experience a buoyant force when immersed in a fluid

8 that density is mass per unit volume and how to calculate the density of substances (regular and irregular solids, and liquids) from measurements of mass and volume.

8 that the buoyant force on an object in a fluid is an upward force equal to the weight of the fluid it has displaced, and know how to apply this principle to predict whether an object will float or sink.

8 how to apply their knowledge of buoyant forces to calculate the densities of solids and liquids from appropriate measurement. Investigation and Experimentation

Reactions

3 when two or more substances are combined a new substance may be formed that can have properties that are different from those of the original materials.

5 When substances react the atoms in the reactants are rearranged in the process of forming products.

5 many different materials can be made from the atoms of a small number of elements.

8 compounds are formed by combining two or more different elements. Compounds have properties that are different from the constituent elements.

8 atoms and molecules form solids by building up repeating patterns such as the crystal structure of NaCl or long chain polymers.

8 Chemical reactions are processes in which atoms are rearranged into different combinations of molecules

8 chemical compounds (the reactants) interact to form products with different chemical properties.

8 the idea of atoms explains the conservation of matter: in chemical reactions the number of atoms stays the same no matter how they are arranged, so their total mass stays the same.

8 chemical reactions usually liberate heat or absorb heat.

8 physical processes include freezing and boiling, in which a material changes form with no chemical reaction.

8 how to determine whether a solution is acidic, basic or neutral.

Electricity and magnetism

4 how to design and build simple series and parallel circuits using components such as wires, batteries, and bulbs.

4 how to build a simple compass and use it to detect magnetic effects, including Earth's magnetic field.

4 that all electric currents produce magnetic effects and how to build a simple electromagnet.

4 the role of electromagnets in the construction of electric motors, electric generators, and simple devices such as doorbells and earphones.

4 electrically charged objects attract or repel each other (as effects of static electricity).

4 magnets have two poles, labeled north and south; like poles repel each other while unlike poles attract each other.

4 electrical energy can be converted to heat, light and motion.

Gravity

8 the role of gravity in forming and maintaining planets, stars and the solar system.

J Explain the factors that affect the gravitational forces on objects (e.g., changes in mass, distance)

Light has a source and travels in a direction

3 sunlight can be blocked to create shadows.

3 light is reflected from mirrors and other surfaces.

3 the color of light striking an object affects how our eyes see it.

3 we see objects when light traveling from an object enters our eye.

7 for an object to be seen, light emitted by or scattered from it must enter the eye.
7 white light is a mixture of many wavelengths (colors), and that retinal cells react differently with different wavelengths.

7 visible light is a small band within a very broad electromagnetic spectrum.
7 that light travels in straight lines except when the medium it travels through changes.
7 how simple lenses are used in a magnifying glass, the eye, camera, telescope, and microscope.

Energy

3 energy comes from the sun to the Earth in the form of light.
3 sources of stored energy take many forms: such as food, fuel, and batteries.
3 machines and living things convert stored energy to motion and heat.
3 energy can be carried from one place to another by waves, such as water waves and sound, by electric current and by moving objects.

6 Sources of energy and materials differ in amounts, distribution, usefulness, and the time for their formation
6 the utility of energy sources is determined by factors that are involved in converting these sources to useful forms and the consequences of the conversion process.

E Identify and compare sources of energy (e.g., batteries, the sun).
L Describe and compare types of energy including light, heat, sound, electrical and mechanical.

Heat (thermal energy)

6 Heat moves in a predictable flow from warmer objects to cooler objects until all objects are at the same temperature
6 energy can be carried from one place to another by heat flow, or by waves including water waves, light and sound, or by moving objects.
6 when fuel is consumed, most of the energy released becomes heat energy.
6 heat flows in solids by conduction (which involves no flow of matter) and in fluids by conduction and also by convection (which involves flow of matter).
6 heat energy is also transferred between objects by radiation; radiation can travel through space.

Force and motion

2 the position of an object can be described by locating it relative to another object or the background.
2 an object's motion can be described by recording the change in its position over time.
2 the way to change how something is moving is to give it a push or a pull. The size of the change is related to the strength, or the amount of "force" of the push or pull.
2 tools and machines are used to apply pushes and pulls (forces) to make things move.
2 objects near the Earth fall to the ground unless something holds them up.
2 magnets can be used to make some objects move without being touched.
2 sound is made by vibrating objects and can be described by its pitch and volume.

8 The velocity of an object is the rate of change of its position
8 position is defined relative to some choice of standard reference point and a set of reference directions.
8 average speed is the total distance traveled divided by the total time elapsed. The speed of an object along the path traveled can vary.
8 how to solve problems involving distance, time, and average speed.
8 that to describe the velocity of an object one must specify both direction and speed.
8 changes in velocity can be changes in speed, direction, or both.
8 how to interpret graphs of position versus time and speed versus time for motion in a single direction.

8 unbalanced forces cause changes in velocity
8 a force has both direction and magnitude.
8 when an object is subject to two or more forces at once the effect is the cumulative effect of all the forces.
8 when the forces on an object are balanced, the motion of the object does not change.
8 how to identify separately two or more forces acting on a single static object, including gravity, elastic forces due to tension or compression in matter, and friction.

8 when the forces on an object are unbalanced the object will change its motion (that is, it will speed up, slow down, or change direction).

8 the greater the mass of an object the more force is needed to achieve the same change in motion.

E Identify examples of motion (e.g., moving in a straight line, vibrating, rotating).

L Explain constant, variable and periodic motions.

E Identify observable forces in nature (e.g., pushes, pulls, gravity, magnetism).

L Demonstrate and explain ways that forces cause actions and reactions (e.g., magnets attracting and repelling; objects falling, rolling and bouncing)

J Explain and demonstrate how forces affect motion (e.g., action / reaction, equilibrium conditions, free-falling objects).

General

J Explain interactions of energy with matter including changes of state and conservation of mass and energy.

Life Sciences

CA IL

Categorizing plants and animals

CA	IL	
K		how to observe and describe similarities and differences in the appearance and behavior of plants and of animals (e.g., seed-bearing plants, birds, fish, insects).
K		stories sometimes give plants and animals attributes they do not really have.
K		how to identify major structures of common plants and animals (e.g., stems, leaves, roots, arms, wings, legs)
2		many characteristics of an organism are inherited from the parents, but others result from the influence of the environment.
	L	Categorize features as either inherited or learned (e.g., flower color or eye color is inherited; language is learned).
	E	Identify and describe the component parts of living things (e.g., birds have feathers; people have bones, blood, hair, skin) and their major functions.
	E	Categorize living organisms using a variety of observable features (e.g., size, color, shape, backbone).

Needs of plants and animals

CA	IL	
1		living things are found almost everywhere in the world. Different plants and animals inhabit different kinds of environments.
1		different plants and animals have external features that help them thrive in different kinds of places.
1		plants and animals both need to take in water, and animals need to take in food. In addition, plants need light.
1		animals eat plants or other animals for food and may also use plants (or even other animals) for shelter and nesting.
1		how to infer what animals eat from the shapes of their teeth (e.g. sharp teeth: eats meat; flat teeth: eats plants).
1		roots are associated with the intake of water and soil nutrients, green leaves with making food from sunlight.
4		plants are the primary source of matter and energy entering most food chains.
4		matter may change forms as it moves through the environment.
4		producers and consumers (herbivores, carnivores, omnivores, and decomposers) are related in food chains and food webs, and may compete with each other for resources in an ecosystem.
4		decomposers, including many fungi, insects, and microorganisms recycle matter from dead plants and animals.

Life cycles and genetics

CA	IL	
2		organisms reproduce offspring of their own kind. The offspring resemble their parents and each other.
2		the sequential stages of life cycles are different for different animals, for example butterflies, frogs, and mice.
2		there is variation among individuals of one kind within a population.
2		the germination, growth, and development of plants can be affected by light, gravity, touch, or environmental stress.
2		in plants flowers and fruits are associated with reproduction.
7		A typical cell of any organism contains genetic instructions that specify its traits. Those traits may be modified by environmental influences
7		how to compare the life cycles and reproduction of sexual and asexual organisms, and that sexual reproduction produces offspring that typically contain half of their genes from each parent.
7		an inherited trait can be determined by one or by many genes.
7		plant and animal cells contain many thousands of different genes, and typically have two copies of every gene. The two copies (or alleles) of the gene may or may not be identical, and one may be dominant in determining the phenotype while the other is recessive.
7		DNA is the genetic material of living organisms, and is located in the chromosomes of each cell.

L Describe simple life cycles of plants and animals and the similarities and differences in their offspring.

J Compare characteristics of organisms produced from a single parent with those of organisms produced by two parents.

Environment and adaptations for survival

3 plants and animals have structures that serve different functions in growth, survival, and reproduction.

3 examples of diverse life forms in different environments, such as oceans, deserts, tundra, forests, grasslands, and wetlands.

3 living things cause changes in the environment where they live; some of these changes are detrimental to the organism or other organisms, whereas others are beneficial.

3 when the environment changes, some plants and animals survive and reproduce, and others die or move to new locations.

3 some kinds of organisms that once lived on Earth have completely disappeared, although they resembled others that are alive today.

4 ecosystems can be characterized in terms of their living and nonliving components.

4 for any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all.

4 many plants depend on animals for pollination and seed dispersal, while animals depend on plants for food and shelter.

4 most microorganisms do not cause disease and many are beneficial.

4 organisms, including humans, can change the physical condition of the environment, and these changes may be beneficial, neutral, or detrimental.

6 Organisms in ecosystems exchange energy and nutrients among themselves and with the physical environment

6 energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs.

6 over time, matter is transferred from one organism to others in the food web, and between organisms and the physical environment.

6 how to identify the biotic and abiotic components of various biomes.

6 populations of organisms can be categorized by the functions they serve in an ecosystem.

6 different kinds of organisms may play similar ecological roles in similar biomes.

6 the number and types of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition.

E Describe and compare characteristics of living things in relationship to their environments.

E Describe how living things depend on one another for survival.

L Describe relationships among various organisms in their environments (e.g., predator / prey, parasite / host, food chains and food webs).

L 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).

J 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).

J Identify and classify biotic and abiotic factors in an environment that affect population density, habitat and placement of organisms in an energy pyramid.

J Compare and assess features of organisms for their adaptive, competitive and survival potential (e.g., appendages, reproductive rates, camouflage, defensive structures).

Structures and their function in living systems

5 many multicellular organisms have specialized structures to support the transport of materials.

5 how blood circulates through the heart chambers, lungs, and body, and how these parts work together to allow exchange of carbon dioxide (CO_2) and oxygen (O_2) in the lungs and tissues.

5 the sequential steps of digestion, and how the teeth and mouth, esophagus, stomach, small intestine, large intestine, and colon are important in the function of the digestive system.

5 the role of the kidney in removing cellular wastes out of blood, which become urine stored in the bladder.

5 how sugar, water, and minerals are transported in a vascular plan.

5 carbon dioxide (CO_2) and energy from sunlight are used by plants to build molecules of sugar for growth and maintenance, and oxygen is released into the air.

5 plant and animal cells break down sugar to obtain energy, forming carbon dioxide (CO_2) and water (respiration).

7 Plants and animals at all levels of organization demonstrate the complementary nature of structure and function

7 plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.

7 organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.

7 how bones and muscles work together to provide a structural framework for movement.

7 how the reproductive organs of the human female and male generate eggs and sperm, and how sexual activity may lead to fertilization and pregnancy.

7 the function of the umbilicus and placenta during pregnancy.

7 the structures and processes by which flowering plants generate pollen and ovules, seeds, and fruit.

7 relate the structures of sense organs (including the eye and ear), to their functions.

Cell biology

7 All living things are composed of cells, from just one to many trillions, whose details usually are visible only through a microscope

7 the way in which cells function is similar in all living organisms.

7 the characteristics that distinguish plant cells from animal cells, including chloroplasts and cell walls.

7 the nucleus is the repository for genetic information in plant and animal cells.

7 mitochondria liberate energy for the work that cells do, and chloroplasts capture sunlight energy for photosynthesis.

7 cells divide to increase their numbers through a process of mitosis, which results in two daughter cells with identical sets of chromosomes. As multicellular organisms develop, their cells differentiate.

J Explain how cells function as “building blocks” of organisms and describe the requirements for cells to live.

Chemistry and Life

8 Principles of chemistry underlie the functioning of biological systems

8 carbon, because of its ability to combine in many ways with itself and other elements, has a central role in the chemistry of living things.

8 living things are made of molecules largely consisting of carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur.

8 living things have many different kinds of molecules including small ones such as water and salt, and very large ones such as carbohydrates, fats, proteins and DNA.

Physical Sciences and Life

7 Physical principles underlie biological structures and functions

7 how to compare joints in the body (wrist, shoulder, thigh) with structures used in machines and simple devices (hinge, ball-and-socket, and sliding joints).

7 how levers confer mechanical advantage and how the application of this principle applies to the muscular-skeletal system.

7 that contractions of the heart generate blood pressure, and that heart valves prevent backflow of blood in the circulatory system.

Evolution

7 Biological evolution accounts for the diversity of species developed through gradual processes over many generations

7 both genetic variation and environmental forces act to cause evolution and diversity of organisms.

7 the reasoning used by Darwin in his conclusions that natural selection is the mechanism of evolution.

7 how independent lines of evidence from geology, fossils, and comparative anatomy provide a basis for the theory of evolution.

7 how to construct a simple branching diagram to classify several living groups of organisms by shared derived characteristics, and that a branching diagram can be expanded to include fossil organisms.

7 extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival.

Earth Sciences

Weather

CA	IL	
K		changes in weather occur from day to day and over seasons, affecting the Earth and its inhabitants.
1		how to use simple tools (e.g., thermometer, wind vane) to measure weather conditions and record changes from day to day and over the seasons.
1		the weather changes from day to day, but trends in temperature or of rain (or snow) tend to be predictable during a season.
1		the sun warms the land, air, and water.
5		uneven heating of the Earth causes air movements (convection currents).
5		the influence of the ocean on weather, and the role of the water cycle in weather.
5		causes and effects of different types of severe weather.
5		how to use weather maps and weather forecasts to predict local weather, and that prediction depends on many changing variables.
5		the Earth's atmosphere exerts a pressure that decreases with distance above the Earth's surface, and is the same in all directions.
	E	Identify and describe patterns of weather and seasonal change.

Water reshapes the land

CA	IL	
4		some changes in the Earth are due to slow processes, such as erosion (weathering, transport, and deposition), and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.
4		natural processes, including freezing / thawing and growth of roots, cause rocks to break down into smaller pieces.
4		moving water erodes landforms, reshaping the land by taking it away in places and depositing it as pebbles, sand, silt, and mud in other places.
5		almost all of the Earth’s water is present as salt water in the oceans which cover most of the Earth’s surface.
5		when liquid water evaporates, it turns into water vapor (invisible) in the air and can reappear as a liquid when cooled, or as a solid if cooled below the freezing point of water.
5		water moves in the air from one place to another in the form of clouds or fog, which are tiny droplets of water or ice, and falls to the Earth as rain, hail, sleet, or snow.
6		that the main agents of erosion are water, wind, ice, plants, and gravity and how the surface features of the Earth result from these agents.
6		water running downhill is the dominant process in shaping the landscape and provide specific examples from different parts of California.
6		rivers and streams are dynamic systems that erode and transport sediment, change their course, and flood their banks in natural and recurring patterns.
6		beaches are dynamic systems in which sand is supplied by rivers and moved along the coast by wave action.

Geology

CA	IL	
K		local land forms (e.g., mountains, rivers, oceans, valleys).
K		how to identify resources from the Earth that are used in everyday life and know that many of them can be conserved.
2		how to compare the physical properties of different kinds of rocks and that rock is composed of different combinations of minerals.
2		smaller rocks come from the breakage and weathering of larger rocks.
2		soil is made partly from weathered rock and partly from organic materials; soils differ in their color, texture, capacity to retain water, and ability to support the growth of many kinds of plants.
2		fossils provide evidence about the plants and animals that lived long ago and that scientists learn about the past history of Earth by studying fossils.

2 rock, water, plants and soil provide many resources including food, fuel, and building materials that humans use.

4 how to differentiate among igneous, sedimentary, and metamorphic rocks by their properties and methods of formation (the rock cycle).
4 how to identify common rock-forming minerals (including quartz, calcite, feldspar, mica, and hornblende) and ore minerals using a table of diagnostic properties.
4 the composition of soils or sand helps to tell the geologic history of a region.

6 natural hazards, including earthquakes, volcanic eruptions, landslides, and floods, change or destroy human and wildlife habitats, damage property, and harm or kill humans.

7 Earth processes today are similar to those that occurred in the past and slow geologic processes have large cumulative effects over long periods of time.
7 Earth and life history are influenced by occasional catastrophic events, such as the impact of an asteroid or major volcanic eruptions.
7 the rock cycle includes the formation of new sediment and rocks. Rocks are often found in layers with the oldest generally on the bottom.
7 evidence from geologic layers and radioactive dating indicate the Earth is approximately 4.6 billion years old, and that life has existed for more than 3 billion years.

Earth’s structure

6 evidence for plate tectonics based on the fit of the continents; location of earthquakes, volcanoes, and midocean ridges; and the distribution of fossils, rock types, and ancient climatic zones.
6 the solid Earth is layered with lithosphere; hot, convecting mantle; and dense, metallic core.
6 lithospheric plates on the scales of continents and oceans move at rates of centimeters per year in response to movements in the mantle.
6 earthquakes are sudden motions along breaks in the crust called faults, and volcanoes/fissures are locations where magma reaches the surface.
6 major geologic events, such as earthquakes, volcanic eruptions, and mountain building result from plate motions.
6 how to explain major features of California geology in terms of plate tectonics (including mountains, faults, volcanoes).
6 how to determine the epicenter of an earthquake and that the effects of an earthquake vary with its size, distance from the epicenter, local geology, and the type of construction involved.

7 how movements of the Earth’s continental and oceanic plates through time, with associated changes in climate and geographical connections, have affected the past and present distribution of organisms.

Earth sciences and life

7 Evidence from rocks allows us to understand the evolution of life on Earth
7 fossils provide important evidence of how life and environmental conditions have changed.
7 how to explain significant developments and extinctions of plant and animal life on the geologic time scale.

Energy in the earth system

6 Many phenomena on the Earth’s surface are affected by the transfer of energy through radiation and convection currents
6 the sun is the major source of energy for phenomena on the Earth’s surface, powering winds, ocean currents, and the water cycle.
6 solar energy reaches Earth through radiation, mostly in the form of visible light.
6 heat from Earth's interior reaches the surface primarily through convection.
6 convection currents distribute heat in the atmosphere and oceans.

Conservation of materials

5 the amount of fresh water, located in rivers, lakes, underground sources, and glaciers, is limited, and its availability can be extended through recycling and decreased use.
5 the origin of water that is used by the local communities.
6 different energy sources and classify them as renewable or nonrenewable .
6 different natural resources, including air, soil, rocks, minerals, petroleum, fresh water, and forests, and classify them as renewable or nonrenewable .

6 natural origin of the materials used to make common objects.

E Identify renewable and nonrenewable natural resources.

General

These Illinois items are so broad and non-specific that I couldn't easily classify them into the other subject areas above.

E Identify components and describe diverse features of the Earth's land, water and atmospheric systems.
L Identify and explain natural cycles of the Earth's land, water and atmospheric systems (e.g., rock cycle, water cycle, weather patterns).
L Describe and explain short-term and long-term interactions of the Earth's components (e.g., earthquakes, types of erosion).
J 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).
J Describe interactions between solid earth, oceans, atmosphere and organisms that have resulted in ongoing changes of Earth (e.g., erosion, El Nino).

Space Sciences

A recent report of the Fordham Foundation provides a valuable point of view:

> "Astronomical knowledge has been exploding over the past few decades. In contrast, K-12 astronomy Standards almost unanimously concentrate 90% or more of their attention to the astronomy of the 17th and 18th centuries. One cannot fault the argument that younger students should be introduced to the solar system first. But too many Standards dismiss almost everything else with a few brief sentences at the grade 9-12 level. And even solar-system astronomy is too often restricted to the seasons, the motions of the planets, and similar subjects. The spectacular discoveries of the past few years—the geology of Mars, the oceans on Titan, the collision of a comet with Jupiter, to name just a few examples—are ignored."

While the California standards are more helpful than the Illinois standards, neither one clearly calls for the the kind of exciting, up-to-date coverage that the Fordham report suggests.

CA IL

Observational Astronomy

3 the patterns of stars stay the same, although they appear to move across the sky nightly, and different stars can be seen at different seasons.
3 changes in the appearance of the moon that occur over a four-week lunar cycle.
3 telescopes magnify the appearance of some distant objects in the sky, including the moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than can be seen by the unaided eye.
3 the Earth is one of several planets that orbit the sun, and the moon orbits the Earth.
3 the position of the sun in the sky changes during the course of the day and from season to season.

E Identify daily, seasonal and annual patterns related to the Earth's rotation and revolution.
L 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).
L Explain the apparent motion of the sun and stars.
L Identify easily recognizable star patterns (e.g., the Big Dipper, constellations).

The Solar System

8 The solar system consists of planets and other bodies that orbit the sun in predictable paths
8 the sun, an average star, is the central and largest body in the solar system and is composed primarily of hydrogen and helium.
8 the solar system includes the Earth, moon, sun, eight other planets and their satellites, and smaller objects such as asteroids and comets.
8 the path of a planet around the sun is due to the gravitational attraction between the sun and the planet
8 the appearance, composition, size, relative position, and motion of objects in the solar system, including the sun, terrestrial and gas giant planets, planetary satellites, comets, and asteroids.
8 astronomical units and light years are used to measure distances of the sun and stars from Earth.

E Identify and describe characteristics of the sun, Earth and moon
J 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).
J Describe the organization and physical characteristics of the solar system (e.g., sun, planets, satellites, asteroids, comets).

Stars, Galaxies, the Universe

J Compare and contrast the sun as a star with other objects in the Milky Way Galaxy (e.g., nebulae, dust clouds, stars, black holes).

Rather strikingly, neither of the state K-8 science standards mention any of these subjects:

- - Stars have different sizes, colors, temperatures, compositions and ages
- - Life cycle of stars
- - Other solar systems, and planets of other stars (what an exciting topic to overlook, especially for a generation raised on movies about space adventures!)
- - Our solar system and all of the visible stars are part of the Milky Way, which is one of many galaxies
- - Unmanned exploration missions to the moon and the planets of the solar system; their history and accomplishments

History of science

Hmmmm. Is it just me, or do these state standards seem awfully lean on this topic? I kind of like the idea that grade school graduates might have a clue as to the identity of Eratothenes, Da Vinci, Galileo, Newton, Copernicus, Darwin, Curie and Einstein. Illinois dismisses the whole of the spirit, life, vitality and accomplishment of the people of science with 11 words, and California doesn't even go that far.

CA	IL	
	E	Describe contributions men and women have made to science and technology.

The Nature and Practice of Science

Both the Illinois and the California state science standards emphasize the importance of giving students a hands-on feel of doing science. As with the other aspects of these standards, it is the California standard that provides more guidance and ideas to curriculum designers and teachers.

CA	IL	

Review existing studies

7		utilize a variety of print and electronic resources (including the World Wide Web) to collect information as evidence as part of a research project.
7		utilize a variety of print sources to collect information as evidence as part of a research project.

Observation and description

K		observe common objects using the five senses.
K		describe the properties of common objects.
K		describe the relative position of objects using one reference (e.g., above or below).
K		communicate observations orally and in drawings.
1		draw pictures that correctly portray at least some features of the thing being described.
1		record observations and data with pictures, numbers, and / or written statements.
1		record observations on a bar graph.
1		describe the relative position of objects using two references (e.g., above and next to, below and left of).
1		make new observations when discrepancies exist between two descriptions of the same object or phenomena.
2		measure length, weight, temperature, and liquid volume with appropriate tools and express measurements in standard and / or non-standard units.
2		write or draw descriptions of a sequence of steps, events, and observations.
2		construct bar graphs to record data using appropriately labeled axes.
2		write or draw descriptions of a sequence of steps, events and observations, and include the use of magnifiers or microscopes to extend senses.
2		follow verbal instructions for a scientific investigation.
3		use numerical data in describing and comparing objects, events and measurements.
4		measure and estimate weight, length, or volume of objects.
4		construct and interpret graphs from measurements.
5		record data using appropriate graphical representation (including charts, graphs, and labeled diagrams), and identify inferences based on those data.
6		read a topographic map and a geologic map for evidence provided on the maps, and construct and interpret a simple scale map.
6		interpret events by sequence and time from natural phenomena (e.g. relative ages of rocks and intrusions).
6		identify changes in natural phenomena over time without manipulating the phenomena (e.g., a tree limb, a grove of trees, a stream, a hillslope).
7		construct scale models, maps and appropriately labeled diagrams to describe scientific knowledge (e.g., motion of Earth's plates and cell structure).
	E	Describe an observed event.
	E	Explain how knowledge can be gained by careful observation
	L	Explain why keeping accurate and detailed records is important
	E	Collect data for investigations using measuring instruments and technologies.

E Record and store data using available technologies.
E Arrange data into logical patterns and describe the patterns.
E Compare observations of individual and group results.

L Collect data for investigations using scientific process skills including observing, estimating and measuring.
L Construct charts and visualizations to display data.

J Collect and record data accurately using consistent measuring and recording techniques and media.

Repeated measurements

3 repeat observations to improve accuracy, and know that the results of similar scientific investigations seldom turn out exactly the same (whether due to unexpected differences in the things being investigated, methods being used, or areas of uncertainty in the observation.).

E Explain why similar results are expected when procedures are done the same way.
L Explain why similar investigations may not produce similar results.

Classification

K compare and sort common objects based on one physical attribute (including color, shape, texture, size, weight).
2 compare and sort common objects based on two or more physical attributes (including color, shape, texture, size, weight).
5 classify objects (e.g., rocks, plant, leaves) based on appropriate criteria.

Hypothesis and Conclusions

2 make predictions based on patterns of observation rather than random guessing.

3 predict the outcome of a simple investigation, and compare the result to the prediction.
3 students will collect data in an investigation and analyze them to develop a logical conclusion

3 differentiate observation from opinion, and know that scientists do not pay much attention to claims about how something works unless the claims are backed up with evidence that can be confirmed.
4 differentiate observation from inference (interpretation), and know that scientists' explanations about what happens in the world come partly from what they observe and partly from what they think about their observations.
4 formulate predictions and justify predictions based on cause and effect relationships.
4 conduct multiple trials to test a prediction and draw conclusions about the relationships between results and predictions.
4 follow a set of written instructions for a scientific investigation.

5 develop a testable question.
5 draw conclusions based on scientific evidence and indicate whether further information is needed to support a specific conclusion.
5 write a report of an investigation that includes tests conducted, data collected or evidence examined, and conclusions drawn

6 develop a hypothesis
6 construct appropriate graphs from data and develop qualitative statements about the relationships between variables.
6 communicate the steps and results from an investigation in written reports and verbal presentations.
6 recognize whether evidence is consistent with a proposed explanation.

7 communicate the logical connection among hypothesis, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence.
7 communicate the steps and results from an investigation in written reports and verbal presentations.

8 evaluate the accuracy and reproducibility of data.

8 recognize the slope of the linear graph as the constant in the relationship y=kx and apply this to interpret graphs constructed from data.
8 construct appropriate graphs from data and develop quantitative statements about the relationships between variables.
8 apply simple mathematical relationships to determine one quantity given the other two (including speed = distance / time, density = mass / volume, force = pressure x area, volume=area x height).
8 distinguish between linear and non-linear relationships on a graph of data.

E Develop questions on scientific topics.

L Formulate questions on a specific science topic and choose the steps needed to answer the questions.
L Use data to produce reasonable explanations.
L Report and display the results of individual and group investigations.

J Formulate hypotheses that can be tested by collecting data.
J Use data manipulation tools and quantitative (e.g., mean, mode, simple equations) and representational methods (e.g., simulations, image processing) to analyze measurements.
J Interpret and represent results of analysis to produce findings.
J Report and display the process and results of a scientific investigation.

Experimental Design and Execution

5 plan and conduct a simple investigation based on a student-developed question, and write instructions others can follow in carrying out the procedure.
5 identify the dependent and controlled variables in an investigation.
5 identify a single independent variable in a scientific investigation and explain what will be learned by collecting data on this variable.

8 plan and conduct a scientific investigation to test a hypothesis.
8 distinguish between variable and controlled parameters in a test.

E Use basic safety practices (e.g., not tasting materials without permission, “stop / drop / roll”).
L Demonstrate ways to avoid injury when conducting science activities (e.g., wearing goggles, fire extinguisher use).

J Conduct scientific experiments that control all but one variable.
J Explain the existence of unexpected results in a data set.

Tools of Science

5 select appropriate tools (e.g., thermometers, meter sticks, balances, and graduated cylinders) and make quantitative observations.

6-7 select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

E Explain the uses of common scientific instruments (e.g., ruler, thermometer, balance, probe, computer).
E Explain how using measuring tools improves the accuracy of estimates.
L 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).

Applied Science

CA IL

Technology and society

California's standard is focused on *science* itself, but Illinois adds a few items regarding the relationship of science and society. Personally, I very much like these three Illinois items, as they help to reinforce the importance of teaching and learning science.

- E Identify and describe ways that science and technology affect people's everyday lives (e.g., transportation, medicine, agriculture, sanitation, communication occupations).
- L Describe the effects on society of scientific and technological innovations (e.g., antibiotics, steam engine, digital computer).
- L Identify and explain ways that science and technology influence the lives and careers of people.

Environmental social issues

Illinois adds a few items regarding environmental social issues. It is very odd that of all the many possible issues in contemporary society in which science plays a core role, only environmental issues are mentioned by the Illinois standard. Even so, this is mercifully refreshing compared to the overdose of environmental polemics masquerading as science in some textbooks.

- E Demonstrate ways to reduce, reuse and recycle materials.
- L Compare the relative effectiveness of reducing, reusing and recycling in actual situations.
- L Identify and explain ways that technology changes ecosystems (e.g., dams, highways, buildings, communication networks, power plants).
- L Analyze how specific personal and societal choices that humans make affect local, regional and global ecosystems (e.g., lawn and garden care, mass transit).
- L Identify and classify recyclable materials.
- J Evaluate the biodegradability of renewable and nonrenewable natural resources.

Industrial Design

Inexplicably and perversely, Illinois includes these time-consuming shop topics in its science standards.

- E Given a simple design problem, formulate possible solutions.
- E Design a device that will be useful in solving the problem.
- E Build the device using the materials and tools provided.
- E Test the device and record results using given instruments, techniques and measurement methods.
- E Report the design of the device, the test process and the results in solving a given problem.

- L Identify a design problem and propose possible solutions.
- L Develop a plan, design and procedure to address the problem identifying constraints (e.g., time, materials, technology).
- L Build a prototype of the design using available tools and materials.
- L Test the prototype using suitable instruments, techniques, quantitative measures to record data.
- L Assess test results and the effectiveness of the design using given criteria and noting possible sources of error.
- L Report test design, test process and test results.

- J Identify an actual design problem and establish criteria for determining the success of a solution.
- J Sketch, propose and compare design solutions to the problem considering available materials, tools, cost effectiveness and safety.
- J Select the most appropriate design and build a prototype or simulation.
- J Test the prototype using available materials, instruments and technology and record the data.
- J Evaluate the test results based on established criteria, note sources of error and recommend improvements.
- J Using available technology, report the relative success of the design based on the test results and criteria.