SCIENCE

# Kansas

| GRADE | SCORES | | TOTAL SCORE |
|---|---|---|---|
| B | Content and Rigor | 5/7 | 7/10 |
| | Clarity and Specificity | 2/3 | |

## REPORT CARD

| | |
|---|---|
| **Content & Rigor** | **5.2** |
| Scientific Inquiry & Methodology | 7 |
| Physical Science | 4 |
| Physics | 6 |
| Chemistry | 4 |
| Earth & Space Science | 3 |
| Life Science | 7 |
| **Clarity & Specificity** | **1.8** |

*Average numerical evaluations*

## Overview

The Kansas science standards vary considerably in quality, both across the sciences and across grade levels. The life science and physics standards are generally clear and rigorous (with caveats). But standards covering chemistry are middling, and those for earth and space science are mediocre at best—in both subjects, much elementary-level material is deferred to high school and much high school-level material is missing. In life science, evolution is sidestepped or ignored until grades 8-12, where a brief but very good treatment appears. In the end, the standards present a decidedly mixed bag.

## Organization of the Standards

The *Kansas Science Education Standards* are divided first into seven "standards" (more commonly denoted as strands): science as inquiry, physical science, life science, earth and space science, science and technology, science in personal and environmental perspectives, and history and nature of science. A series of "benchmarks" is provided for each of the standards at each of four grade bands: K-2, 3-4, 5-7, and 8-12. Further explaining the benchmarks is a list of "indicators" (much like individual standards) and corresponding instructional examples. Teacher notes (which offer further clarification to the standards) are also provided for each benchmark. A single-page overview table presents a handy panoramic view of the whole.

The choice of an 8-12 grade span leads to ambiguity, especially for life science. What part of this material is intended for middle school life science and what part for a high school biology course? The chemistry and physics sections are clearly labeled and presumably intended for the traditional high school courses, though there is a parallel ambiguity inherent in their classification under the 8-12 grade band, which would typically embrace a lower-level physical science course as well.

## Content and Rigor

The Kansas science standards are better than average in most areas. Essential content is present, and the document generally does a satisfactory-to-admirable job of building in complexity through the advancing grade levels. But a few serious gaps exist, and the treatment of earth and space science is disappointing.

### Document(s) Reviewed

► *Kansas Science Education Standards.* August 2007. Accessed from: http://www.ksde.org/LinkClick.aspx?fileticket=YgH0PnTTzS4%3d&tabid=144&mid=8019&forcedownload=true

The silly glossary does the document no favors. Here are a few of the most simplistic and banal examples:

> **Investigation – finding the answer to a question.**
>
> **Properties – a word that describes an object based on direct observations using touch, sight, hearing, taste, smell, and measurement.**
>
> **Structures – parts of the organism that serve different functions in growth, survival, and reproduction.**

## Scientific Inquiry and Methodology

Given Kansas's past flirtations with creationism and attempts to broaden the definition of science to include non-naturalistic explanations, these standards are refreshingly clear, direct, and useful. Up front, they state that "science is restricted to explaining only the natural world using only natural cause." Process and its allied areas are covered in four of the standards: science as inquiry, science and technology, science in personal and environmental perspectives, and history and nature of science. Apart from some vacuity ("people practice science"), the inquiry standards are excellent. History of science receives good attention, with explicit recommendations to tie laboratory work to historical investigations. Helpfully, when considering science in society, one goal is to have students realize that "there are many issues which...go beyond what science can explain, but for which solid scientific literacy is useful."

## Physical Science

The physical science coverage begins in a conventional manner in Kindergarten through second grade, with such items as these:

> **The student…**
>
> **1. observes *properties of objects* and measures or describes those *properties* using age-appropriate tools and materials.**
>
> **2. separates or sorts a group of objects or materials by *properties*.**
>
> **3. compares the properties of solids and liquids.**
>
> **4. describes the position of an object in relation to other objects. (grades K-2; original emphases)**

This conventionality is not surprising, since the Kansas standards are explicitly modeled after the *National Science Education Standards* (NRC, 1996), which are introduced similarly.

These concepts are revisited at the higher grade spans, with increasing depth and detail. Sound, magnetism, and electricity are introduced in third and fourth grades. Plasmas (gas-like states of matter containing electrons and positive ions but overall neutral) are added to the states of matter that students are to understand in grades five through seven, which is a bit puzzling, since the electron is not introduced until much later, in high school chemistry. Numerous other topics are also introduced in this grade span. Missing, however, are such important topics as kinematics (velocity and acceleration are not defined before high school physics) and a decent definition of kinetic and potential energy or of gravity. There is no coverage of light at all. Given these lacunae, and the frequent shallowness of presentation for the subjects that are covered, the overall quality of preparation for student success at the high school level is not what it ought to be.

## High School Physics

The development of kinematics and dynamics in the standards covering grades eight through twelve is perfectly logical, complete though compact, and placed where it belongs, at the beginning of the physics section. It could serve as a model for other states:

> **a. The kinematic (motion) variables: position, velocity, and acceleration can most concisely be described as vectors.**
>
> **b. Velocity describes how position changes and acceleration describes how velocity changes.**
>
> **c. From the definitions of velocity and acceleration, one can derive equations that relate the kinematic variables.**
>
> **d. Acceleration occurs when there is either a change in speed or a change in direction. In the case of uniform circular motion, the acceleration points towards the center of the circle. The magnitude of this acceleration is constant, and is related to the speed of the object and the radius of the circle.**
>
> **e. In the absence of a net force, an object's velocity will not change.**
>
> **f. In the presence of a net force, an object will experience an acceleration which is modeled mathematically by Newton's second law.**
>
> **f. [*sic*] The force that one object exerts on a second object has the same magnitude but opposite direction as the force that the second object exerts on the first. (grades 8-12)**

The treatment of energy is not quite so elegant. But at least there is a systematic attempt to make a formal statement of the first and second laws of thermodynamics. The statement of the first law is correct: "The total internal energy of a substance (the sum of all the kinetic and potential energies of its constituent molecules) will change only if heat is exchanged with the environment or work is done on or by the substance. In any physical interaction, the total energy in the universe is conserved." While the last statement is not really part of the law, the statement is precise and correct. But, as is so often the case, the second law is bungled. It says: "The second law of thermodynamics...states the entropy of the universe is increasing." But that is a *consequence* of the second law, whose two logically equivalent statements are the Clausius statement, "No process is possible in which the *only* event is the transfer of heat from a cooler body to a warmer one," and the Kelvin-Planck statement, "No process is possible in which the only event is the conversion of heat into work." Note that neither of these statements mentions entropy, that magic word that everyone uses but few understand. It seems to be *de rigeur* for science standards to bandy it nonetheless.

The zeroth law is correctly stated but not labeled as such.

### High School Chemistry

The chemistry materials are too thin and skip too many important topics. Among the most important absentees are the full definitions of pH, moles, solution concentration units like molarity and percentages, electronegativity (which leads to polar bonds), Lewis dot structures, the gas law relations, and chemical equilibrium. Redox reactions are mentioned, if too briefly. On the positive side, acid-base chemistry is well covered, even including such refinements as pH and pOH, hydronium ion and hydroxyl ion concentrations, titration, and reaction products. There is also laudable coverage of intermolecular attractions and properties of ionic and molecular (covalent) solids.

### Earth and Space Science

The Kansas standards for earth and space science are particularly problematic. Some important material is covered, but it is only very rarely developed. Topics are simply mentioned or glossed over, giving little confidence that students will learn the critical content they need. Take, for example, the following standard for grades eight through twelve:

> **The rock cycle describes constructive and destructive processes that change the forms of rocks and soil (solid earth). (grades 8-12)**

This mentions the rock cycle but says nothing about the processes and conditions involved except that they are somehow constructive or destructive, and nothing about cycling of materials into different classes of rocks.

In addition, the state provides a list of vocabulary words that students should learn to prepare for the eighth-grade state assessment, and while many of the terms that appear in that list cover critical content—like convergent or divergent plate boundary and atmospheric layers—those topics are either never mentioned or are not well explained elsewhere in the document.

Unfortunately, some material that is entirely suitable for treatment in Kindergarten through seventh grade is inexplicably deferred until grades eight through twelve. A few examples are galaxies, atmospheric pressure, the thermal causes of climate and weather, and the rock cycle. Even at that level, the treatment often is thin and vague (although there is a good exposition of uniformitarianism).

### Life Science

The Kansas standards include most of the essential life science content, including some excellent material on neurons, which is uncommon in state standards. In addition, they present an admirable unit on evolution in grades 8-12, making clear that evolution is "a key theoretical framework for the life sciences" and that the indicators in this unit should be "part of any life sciences course curriculum, including biology, botany, zoology, and microbiology."

Unfortunately, a few notable problems and omissions exist. Mendelian inheritance makes an appearance, but with no mention of phenotype, genotype, genes, or DNA. There is only vague mention of hereditary units, and the standards never cover respiration.

In contrast to the fine treatment in eighth through twelfth grades, the treatment of biological evolution in Kindergarten through seventh grade is ambivalent and some critical material seems pushed to the periphery. In standards for fifth through seventh grades, a "Diversity and Adaptations of Organisms" unit describes how diversity derives from adaptation and that failure to adapt leads to extinction. But there is no discussion of evolution, natural selection, or common-ancestry terminology. Students explore how the shape of beaks can influence what food birds can eat, but there is no mention of Darwin's finches, a classical pillar of

evidence undergirding Darwin's arguments that has been dramatically demonstrated in a dynamic fashion by the modern work of the Grants.

The teacher notes do prompt teachers to use "examples such as Darwin's finches [to] help develop understanding of natural selection over time." So one must suppose that only the pap in the boxed standards part will be used in evaluations, although a teacher might enrich the classroom experience with the genuine concepts found in the teacher notes. The implication is that biological evolution is not part of K-7 standards, but only peripheral to them as a sort of enrichment topic.

Taken together, the Kansas science standards earn a not disreputable five out of seven for content and rigor. (See Appendix A: Methods, Criteria, and Grading Metric.) Given that most of the flaws in the various disciplines involve marginal problems, an overhaul of the earth and space science section would go a long way toward raising the mark.

## Clarity and Specificity

Despite some confusion that derives from the occasional scrambled and illogical presentation of content, the standards are generally clear, well-presented, and as specific as they can be in a grade-span, rather than grade-by-grade, format.

Associated with every indicator and its examples are teacher notes, some of which are both clear and scientifically solid. For example, the following teacher notes are presented for third and fourth grades:

> **The concept of sound is very abstract. To make the connection between vibrations and sounds more concrete, have students listen to, touch, and watch the object (tuning fork, audio speaker, ruler on the edge of the table, etc.) being used to produce the sound/ vibration. Then attempt to connect the controlled experimental sounds with other observed sounds such as jets rattling windows, intercom speakers, class bells, and [with the concept that] all sounds are ultimately the result of vibrations. (grades 3-4)**

The Kansas science standards often hit the target (sometimes with bull's-eyes) but there are misses as well; thus they earn an average score of two out of three for clarity and specificity. (See Appendix A: Methods, Criteria, and Grading Metric.)