SCIENCE

Kentucky

GRADE	SCORES		TOTAL SCORE
D	Content and Rigor	2/7	3/10
	Clarity and Specificity	1/3	

REPORT CARD

Content & Rigor	**2.0**
Scientific Inquiry & Methodology	2
Physical Science	4
Physics	0
Chemistry	0
Earth & Space Science	3
Life Science	3
Clarity & Specificity	**1.1**

Average numerical evaluations

Overview

The Kentucky science standards are lamentable less for their flaws—though they are plenty—than for their failed potential. A scaffold exists for what might have been an effective set of standards. But the documents are so short on details—including some critical content—that the standards fail to provide the backbone for a rigorous K-12 science curriculum.

Organization of the Standards

Kentucky's *Core Academic Standards* document presents grade-specific science standards for grades 4-8 only; grades K-3 (primary elementary) and high school (secondary high school) are presented by grade band. For each grade or grade band, standards are first presented by "big idea," or strand. These big ideas are divided into two categories: "primary enduring knowledge—understandings" (e.g., "most living things need water, food and air, while nonliving things can continue to exist without any requirements") and "primary skills and concepts" (e.g., "describe the basic needs of organisms and explain how these survival needs can be met only in certain environments"). Grade-specific or grade-band standards are then provided for each category.

A second document, titled *Transformations*, is concerned mainly with instructional strategies and adds little or no content to the first one.

Content and Rigor

The Kentucky standards tend to swing between imprecision and silence. In some areas—physics in particular—the content is woefully thin. Even the disciplines that are better stocked are marred by sloppy development, errors, and confusion.

Scientific Inquiry and Methodology

The science process standards are scattered across various "big ideas" within the "primary skills and concepts" category, making it difficult to track what, specifically, students should master at each grade level. Worse still, the single set of process standards presented for Kindergarten through third grade renders it impossible to see how these skills accumulate in an age-appropriate manner over the four-year period—

Document(s) Reviewed

- *Kentucky Core Academic Standards—Science*. 2010. Accessed from: http://www.education.ky.gov/users/otl/POS/POS%20with%20CCS%20for%20public%20review.pdf
- *Kentucky Transformations—Science*. 2006. Accessed from: http://www.education.ky.gov/KDE/Instructional+Resources/Curriculum+Documents+and+Resources/Transformations/

one which is crucial to the development of higher scientific abilities.

Several important topics are vaguely introduced, then not revisited for several grades, if at all. For example, the concept of theory is introduced in seventh grade with only the following "understandings" standard:

> **Investigations are conducted for different reasons, including to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories. (grade 7)**

There is no further mention until the following "understandings" standard from high school life science:

> **In science the term theory is reserved to describe only those ideas that have been well tested through scientific investigation. Scientific theories are judged by how well they fit with other theories, the range of observations they explain, how well they explain observations, and their usefulness in predicting new findings. Scientific theories usually grow slowly through contributions from many investigators. (high school)**

Similarly, the *only* use of hypothesis appears in high school life science as well, with the following "skills and concepts" standard:

> **Distinguish between a scientific law, theory, hypothesis and unsupported supposition/claim. (high school)**

The standards present a complete lack of consistency across disciplines in high school. As noted above, only within the biological sciences is explicit mention made of concepts such as theory and hypothesis. Some disciplines mention the need for accurate record keeping and openness, others do not. Some ask students to examine current ideas and their social impact, some don't. The document at this level lacks cohesion and suggests numerous authors with differing visions. Surely, there is a skill set that all science students at the high school level should be developing, irrespective of the discipline.

On the plus side, there are explicit standards for reading and writing about the sciences. However, one has to read the English language arts standards to discover them.

History receives scant explicit attention beyond an examination of the history of the theory of plate tectonics in high school earth and space science and that of "a variety of accepted scientific laws, theories, and claims" within the biological sciences. Social implications of scientific and technological developments are examined in high school.

Physical Science/High School Physics/High School Chemistry

The physics part of physical science fares poorly. Indeed, the word "physics" doesn't come up in a global search of the entire document. "Similarities in anatomy and molecular chemistry" is the only occurrence of "chemistry," though "chemical" turns up in many appropriate places.

In the intermediate grades, the only mention of magnetism occurs in this standard:

> **Gather information including temperature, magnetism, hardness and mass using appropriate tools to identify physical properties of matter. (grade 4)**

And the only substantive mention of Newton's laws of motion comes in sixth grade, with this statement:

> **At the middle level, qualitative descriptions of the relationship between forces and motion will provide the foundation for quantitative applications of Newton's Laws. (grade 6)**

A clarifying statement adds: "When any force acts on an object, the change in speed or direction depends on the size and direction of the force," which is the truth—but not the whole truth.

These statements are more or less repeated in seventh and eighth grades, with nothing substantive added. In spite of the promise made that these ideas will be "fully developed at the high school level along with the use of models to support evidence of motion in abstract or invisible phenomena such as electromagnetism," the only further mention of Newton's laws at the high school level is this directive: "Investigate Newton's Laws of Motion and Gravitation. Experimentally test inertia and gravitational acceleration."

The chemistry standards are equally weak. In material for sixth grade, for example, we read that "inside a closed system, the temperature increases or decreases as heat energy is added or removed." Of course, this is false if the sample is undergoing a phase change.

At the high school level, we learn that the rate of a chemical reaction is "influenced by a number of variables." That statement is followed by a standard that asks students to "identify and test variables that affect reaction rates" and to "predict the effects of changes in variables (concentration, temperature, properties of reactants, surface area and catalysts)." Unfortunately, these three statements do not appear to be connected at all.

At the high school level, the lack of separate standards for physics and chemistry is particularly disappointing. Nothing in the entire document is relevant to a course in high school physics or chemistry.

Earth and Space Science

Like Kentucky's standards in other science disciplines, the standards for earth and space science are severely flawed. Important content is entirely missing, especially concerning rocks and minerals, the mechanics of earthquakes and volcanoes, and the details of plate tectonics.

There are but occasional glimmers of substantive content. For example, in eighth grade, we are told that students will understand the following:

> **The Earth is almost unimaginably old when viewed on a human time scale, and some processes that shape it are happening so slowly they cannot be easily detected in a lifetime. The accepted age of our Earth and solar system (4.6 billion years) is based on a wide variety of data collected by a number of different methods.**
>
> **Heat flow and movement of molten rock within the interior of the Earth results in crustal changes such as earthquakes, volcanoes, and continental drift.**
>
> **A model cannot represent a full-scale phenomenon with complete accuracy, even if it only addresses very few attributes of the original. (grade 8)**

Life Science

The earlier grades provide poor preparation for high school work, but there is some good material at the high school level, particularly with respect to heredity. However, there is *no* physiology; the eighth-grade material on the nervous system is the last thing students will learn about how their bodies work. Searches for "digestion" and "lung," for example, yield nothing.

In addition, some of the vagueness that permeates the lower grades does persist into high school. For example, one standard directs students to "describe and classify a variety of chemical reactions required for cell functions," and another to "explore the composition and function of the carbon compounds involved in metabolism." Neither of these includes any substantive content.

The standards also describe photosynthesis as a metabolic process, which it is not. And such key words as chloroplast and mitochondrion never appear.

The treatment of evolution deserves special mention. One of the "big ideas" is "biological change." Under this rubric, there is a good treatment of fossils in second grade, with a somewhat repetitious mention in fourth grade. Seventh grade offers this tantalizing "understandings" standard: "Fossils provide evidence of how biological change over time accounts for the diversity of species." This is followed in eighth grade by the equally promising "understanding" standard, "Observations of the fossil record provide evidence that helps to explain why externally diverse organisms are so similar at the molecular level," paired with the "concepts and skills" standard, "Research the most common fossils used to support theories of biological change."

But up to this point, the word *evolution* does not appear once. It finally appears, shyly, in the statement of the "big idea" of "biological change" at the high school level:

> **The only thing certain is that everything changes. At the high school level, students evaluate the role natural selection plays in the diversity of species. Modern ideas of evolution provide a scientific explanation for three main sets of observable facts about life on Earth: the enormous number of different life forms we see about us, the systematic similarities in anatomy and molecular chemistry we see within that diversity, and the sequence of changes in fossils found in successive layers of rock that have been formed over more than a billion years. (high school)**

This paragraph is followed by a clear statement of such important elements of evolutionary knowledge as natural selection, fossils, DNA sequences, anatomical similarities, and embryology. Yet the word "evolution" is never seen again.

These gaping content holes bring Kentucky's average score down to a two out of seven for content and rigor. (See Appendix A: Methods, Criteria, and Grading Metric.)

Clarity and Specificity

Lack of specificity and general ambiguity is a persistent problem for the Kentucky standards. And sometimes we find one without the other—an equally discomfiting situation. Long passages of vague statements are sometimes punctuated by excessively detailed bits that students cannot possibly address.

For example, in sixth grade, after general statements about responding to external environment, we suddenly face the following standard:

Explain how various organisms sense (e.g., hunger, fatigue, temperature awareness) and control their internal environments (e.g., fat metabolism, adrenaline release, perspiration) and how this contributes to their survival. (grade 6)

At this point students have seen nothing about fat or metabolism or hormones or neural function, so what they would do with it is a mystery. Too many ideas are alluded to, glanced at, approached obliquely, or mentioned vaguely in comma-delineated lists such as the above—or students are simply asked to look them up.

Much time and effort must have gone into the preparation of this 563-page document, but the approximately seventy-five pages devoted to science do not constitute a useful tool for guiding those whose task it is to realize a system of science education. Consequently, Kentucky earns an average score of one out of three for clarity and specificity. (See Appendix A: Methods, Criteria, and Grading Metric.)