SCIENCE

Nebraska

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

REPORT CARD

Content & Rigor	**1.3**
Scientific Inquiry & Methodology	0
Physical Science	4
Physics	0
Chemistry	0
Earth & Space Science	2
Life Science	2
Clarity & Specificity	**1.3**

Average numerical evaluations

Overview

The Nebraska science standards are inadequate in nearly every way. They lack sufficient depth and breadth at every grade span, and critically important areas receive woefully inadequate attention—or are completely absent.

Organization of the Standards

The Nebraska science standards are constructed in four strands: inquiry, physical science, life science, and earth/space science. Each strand is then divided into sub-strands and finally into standards. Nebraska does not provide grade-specific standards. Instead, standards are provided for four grade bands: K-2, 3-5, 6-8, and 9-12.

An additional document, the *Sample K-12 Science Curriculum*, assigns the standards found within the *Science Standards* grade bands to specific grades, though it states that districts have the option of changing the order of presentation. In addition, the document provides "content boundaries" for the standards, which include limits on "examples, types of measurement, clarifications, appropriate vocabulary, and exclusions for various science concepts and skills."

Content and Rigor

The K-8 physical science materials are the best that Nebraska's science standards have to offer. Unfortunately, they are barely passable, and everything else is worse. Great chunks of critical content are missing, while what's present is often pitched well below a reasonable grade level, weakly developed, or simply wrong.

Scientific Inquiry and Methodology

The scientific inquiry and methodology standards are essentially useless. Students in grades 3-5 are, for example, asked to "recognize many different people study science." Similarly, students in grades 6-8 are asked to "describe how scientific discoveries influence and change society." In neither case do the standards give any indication of what, specifically, students should know.

Students in grades 3-5 are also expected to "provide feedback on scientific investigations," but no guidance is provided as to what that may entail or what formal

Document(s) Reviewed

- *Nebraska Science Standards*. October 2010. Accessed from: http://www.education.ne.gov/science/
- *Sample K-12 Science Curriculum*. 2011. Accessed from: http://www.education.ne.gov/science/

concepts regarding science as a process are to be used. By grades 6-8, students move on to providing "appropriate critique of scientific investigations." And by high school, they are asked to "evaluate scientific investigations and offer revisions and new ideas as appropriate"—a tall order that is grounded in no real content.

Scanning the standards across grades, it is difficult to detect meaningful changes or a development of content. For example, in grades 3-5, students "ask testable scientific questions," yet not until grades 6-8 are students supposed to "formulate testable questions that lead to predictions and scientific investigations." One wonders whether the writers have a clear idea of what "testable" means.

Physical Science/High School Physics/High School Chemistry

The physical science material starts off well enough at the primary grades and progresses in depth through the grade spans covering Kindergarten through eighth grade. But at the high school level, the standards suffer a serious drop in quality—one might call it a collapse. The progression of the treatment of kinematics will serve as an example. Beginning in the grade band covering Kindergarten through second grade, students are asked to:

> **State location and/or motion relative to another object or its surroundings (in front of, behind, between, over, under, faster, slower, forward and backward, up and down)**
>
> **Describe how objects move in many different ways (straight, zigzag, round and round, back and forth, and fast and slow). (grades K-2)**

Then in successive grades, we find:

> **Describe motion by tracing and measuring an object's position over a period of time (speed). (grades 3-5)**
>
> **Describe motion of an object by its position and velocity. (grades 6-8)**
>
> **Describe motion with respect to displacement and acceleration. (grades 9-12)**

This sequence begins as a nice progression from simple qualitative observation of position and general types of motion, through more specific observation, to formal consideration of position and velocity. But then the high school standard is nothing more than an introduction of the term "displacement," with a substitution—rather than a supplementation—of acceleration for velocity. The standard gives no mention of anything quantitative—unacceptable for any high school course—let alone the kinematic equations essential to a physics course.

Throughout all grade spans, adequate space and attention are devoted to Newton's laws. Each receives a separate indicator in the appropriate grade spans, immediately followed by indicators addressing universal forces—magnetic, gravitational, and electrostatic.

Still there are some errors. Notably, Coulomb's law is stated incorrectly:

> **Recognize that an attractive or repulsive electric force exists between two charged particles and that this force is proportional to the magnitude of the charges and the distance between them. (grades 9-12)**

In fact, the force is *inversely* proportional to the *square* of the distance—a crucial difference. And, in a regrettable display of consistency, the same error is seen in the discussion of the universal law of gravitation. This sloppiness is attributable, at least in part, to the careful avoidance of any mathematical expressions and the substitution for verbal circumlocutions that are prone to error.

There are no separate standards for high school chemistry or physics. Some of the high school physical science entries might be construed as such, but the level of the material seems more appropriate for a physical science course in middle school or junior high. This is particularly true for the material on thermal physics introduced at the high school level.

The standards on energy are fairly clear, but the concepts of kinetic and potential energy are similarly deferred until high school. More problematic, the standards contain no single definition of energy; without a good understanding of what energy is, discussing energy conservation (which these standards stress) is a futile exercise.

Chemistry is given cursory—that is, grossly inadequate—treatment at the high school level. The periodic table gets but a single mention. And the important topic of chemical bonding is reduced to just one brief statement about ionic and covalent bonding: "Recognize bonding occurs when outer electrons are transferred (ionic) or shared (covalent)" (grades 9-12). Likewise, acids and bases (which we are told transfer hydrogen ions) and oxidation and reduction reactions (which transfer electrons) are also found together in just one standard: "Recognize a large number of chemical reactions involve the transfer of either electrons (oxidation/reduction) or hydrogen ions (acid/base) between reacting ions, molecules, or atoms" (grades 9-12). Many other necessary content topics are also either inadequately

addressed or missing completely. These topics include moles and stoichiometry, carbon chemistry, equilibrium, rates of reaction, solutions, gas laws, and molecular shape and polarity. With so much basic content missing, it would be a mistake to say that there is a course in chemistry outlined in the physical science standards.

Earth and Space Science

While some important earth and space science content is included from Kindergarten through eighth grade, serious gaps plague Nebraska's standards. For instance, while motion in the solar system is well covered, galaxies aren't mentioned anywhere. Nor are the effects of plate tectonics, other than in this amazingly broad standard:

> **Compare and contrast constructive and destructive forces (deposition, erosion, weathering, plate motion causing uplift, volcanoes, earthquakes) that impact Earth's surface. (grades 6-8)**

Similarly, a few grades earlier, students are asked to:

> **Recognize the difference between weather, climate, and seasons. (grades 3-5)**

There is nothing here about climate changes over time.

In the *Sample Curriculum* document, the earth and space science standards for high school are distributed between physical science and biology, the only two subjects that are listed outside of the standards for Kindergarten through eighth grade. Evaluating the dispersed earth and space science standards, we find that astronomy outside our own solar system is especially weak. The word "galaxy" does not appear. Further, there is little or no mention of plate-tectonic processes and effects, the workings of earthquakes and volcanoes, or the evidence for important theories such as the Big Bang.

Life Science

The life science standards are vapid and lifeless. There is only a moment of substance, which appears in the *Sample Curriculum* treatment of cellular composition of organisms, where seventh-grade students are directed to:

> **Identify the organs and functions of the major systems of the human body and describe ways that these systems interact with each other.**
>
> - **The major systems of the human body include: circulatory, digestive, endocrine, excretory, immune, integumentary, nervous, muscular, reproductive, respiratory, and skeletal. (grade 7)**

While the standard should more specifically explicate "the ways that these systems interact with each other," it is reasonably specific and includes much critical content. Unfortunately, such specificity is atypical. Other critical topics are so vague that one cannot assess their level of coverage. For instance, a high school standard asks students to "describe how an organism senses changes in its internal or external environment and responds to ensure survival" (grades 9-12).

Meiosis, mitosis, and Mendelian genetics appear nowhere from Kindergarten through eighth grade.

Even at the high school level, here is all we find regarding Mendelian genetics:

> **Describe that [*sic*] sexual reproduction results in a largely predictable, variety of possible gene combinations in the offspring of any two parents. (grades 9-12)**

The word "evolution" is missing entirely before high school, and its coverage in the high school standards is woefully inadequate, as shown below:

> **Identify different types of adaptations necessary for survival (morphological, physiological, behavioral).**
>
> **Recognize that the concept of biological evolution is a theory which explains the consequence of the interactions of: (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.**
>
> **Explain how natural selection provides a scientific explanation of the fossil record and the molecular similarities among the diverse species of living organisms.**
>
> **Apply the theory of biological evolution to explain diversity of life over time. (grades 9-12)**

This set of four standards provides a basis—albeit a minimal one—for the study of evolution. Unfortunately, it presents evolution as a topic separate from other biological matters rather than as the founding principle of the discipline. Note also the phrase "the theory of biological evolution." While technically accurate—there exist both the fact of evolution and the theory that explains the fact—this statement often reflects the creationist misuse of the everyday meaning of theory, as in "evolution is *only* a theory, and because it cannot be proven is therefore equivalent or inferior to other constructs." Note that the essential meaning of the second

standard would be fully conveyed by the succinct "Recognize that evolution explains..."

Taken as a whole, Nebraska's science standards do not articulate nearly enough of what students need to know and be able to do. They earn an average score of one out of seven for content and rigor. (See Appendix A: Methods, Criteria, and Grading Metric.)

Clarity and Specificity

The Nebraska standards usually avoid garbled language, but only because they say woefully little. The failure of the material to cover so many integral areas of science erodes its ability to be specific.

Take, for example, the following standard in earth and space science, in which the word "minerals" makes a mere cameo appearance:

> **Describe the characteristics of rocks, minerals, soil, water, and the atmosphere. (grades 3-5)**

Two things might be true here: Either the standards don't care much about these topics, or the authors were at a loss for ways to flesh out these concepts. Neither is reassuring, because both all but guarantee that Nebraska students will not receive adequate instruction in these topics.

As the life sciences section presented above demonstrates, the writers of the Nebraska standards do understand the importance of detail. Why, then would they settle for expectations like this one, in high school: "Describe how an organism senses changes in its internal or external environment and responds to ensure survival"? Such a passage, and the many others like it strewn throughout the rest of the document, begs for more information—and providing it would not have been a heavy lift.

This overall vagueness results in a score of one out of three for clarity and specificity. (See Appendix A: Methods, Criteria, and Grading Metric.)