SCIENCE

Delaware

GRADE	SCORES		TOTAL SCORE
C	Content and Rigor	3/7	5/10
	Clarity and Specificity	2/3	

REPORT CARD

Content & Rigor	**3.2**
Scientific Inquiry & Methodology	2
Physical Science	5
Physics	0
Chemistry	0
Earth & Space Science	5
Life Science	7
Clarity & Specificity	**2.4**

Average numerical evaluations

Overview

The Delaware science standards are generally robust, detailed, and thoughtful, and they present critical information clearly, with a minimum of jargon. Unfortunately, not all subjects are equally well covered; the document is uneven and its overall organization is somewhat cumbersome.

Organization of the Standards

The Delaware science standards are divided into eight "prioritized standards" (more commonly called strands): nature and application of science and technology, materials and their properties, energy and its effects, earth in space, earth's dynamic systems, life processes, diversity and continuity of living things, and ecology. For each strand, the state provides a series of "essential questions" and "enduring understandings," which are common across grade levels and which are meant to define the "big ideas" that students should learn. For example, in the strand covering nature and application of science and technology, three essential questions ask: "What makes a question scientific?" "What constitutes evidence?" and "When do you know when you have enough evidence?" A series of indicators is then provided for each group of essential questions at each of four grade bands: K-3, 4-5, 6-8, and 9-12. Finally, grade-specific standards are provided for all grades, K-12.

In addition, the state provides a second document that presents only essential questions, enduring understandings, and indicators by strand. While the grade-specific standards are not included in this document, its purpose is to prioritize the indicators as "essential," "important," or "compact." (Only the essential and important standards are assessed by the state.)

Content and Rigor

The Delaware standards have the potential for excellence, as shown in their virtually flawless handling of life sciences. Unfortunately, the confusing presentation—coupled with standards that are overly broad, omit essential content, or are impossible to achieve at the required grade level—detracts from their overall quality and rigor.

Document(s) Reviewed

- *Delaware Prioritized Science Standards*. 2005-06. Accessed from: http://www.doe.k12.de.us/infosuites/staff/ci/content_areas/science.shtml
- *Delaware Science Content Standards Clarification Document*. 2006. Accessed from: http://www.doe.k12.de.us/infosuites/staff/ci/content_areas/files/science/ClarifyingtheScienceContentStandards.pdf

Scientific Inquiry and Methodology

The scientific inquiry and methodology standards are generally well written and they increase in rigor and complexity from grade span to grade span. In addition, the standards deal admirably with the practicalities of the laboratory experience, demanding attention to precision and accuracy. Take, for example, the following high school indicator:

> **Be able to: Collect accurate and precise data through the selection and use of tools and technologies appropriate to the investigations. Display and organize data through the use of tables, diagrams, graphs, and other organizers that allow analysis and comparison with known information and allow for replication of results. (grades 9-12)**

Delaware also makes a clear distinction between what students are asked to "understand" and what they are asked to be able to do.

That said, there are two significant drawbacks. The first is that the standards claim, "as the body of scientific knowledge grows, the boundaries between individual disciplines diminish." While interdisciplinary study has become popular, it relies on deep comprehension and mastery of discipline-specific content.

Second, the Delaware inquiry standards are not well integrated with content. Take, for example, the following:

> **Understand that: In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical *body of scientific knowledge*. (emphasis added)**

> **Be able to: Communicate and defend the results of scientific investigations using logical arguments and connections with the known *body of scientific information*. (emphasis added) (grades 9-12)**

While the standards mention linking the process standards to the "body of scientific knowledge," there are content gaps (discussed in greater detail below) that would sometimes make it difficult for students to associate the results of their investigations with historical science knowledge as the standards demand.

Physical Science/High School Physics/High School Chemistry

Through ninth grade, the physical science standards are generally detailed, though the division of content among the standards is odd. Standard Two, titled "materials and their properties," is primarily devoted to presenting chemistry content. Standard Three, titled "energy and its effects," primarily presents physics content. While not incorrect, the terminology is peculiar.

The high school standards suffer from three serious problems:

First, physics and chemistry are not treated as independent courses. Rather, standards are presented together and scattered across two strands, making it difficult to piece together what, precisely, students should know and be able to do in which subject in which year.

The order of the high school physics standards is also confusing, as if the writers took paragraphs from a physics text, shuffled them at random, added a few paragraphs about chemistry, and re-stacked them. And while the grade-level expectations are somewhat less muddled, they still confuse more than they enlighten.

Second, too many standards are overly broad, asking either too much or too little of students. For instance, an eleventh-grade standard asks students to:

> **Construct models or diagrams (Lewis dot structures, ball and stick models, or other models) of common compounds and molecules (i.e., NaCl, SiO_2, O_2, H_2, CO_2) and distinguish between ionically and covalently bonded compounds. Based on the location of their component elements on the periodic table, explain the elements tendency [*sic*] to transfer or share electrons. (grade 11)**

That is a big order for a single expectation, and one that covers an unrealistically large chunk of a high school chemistry course.

Yet another standard asks students to:

> **Construct a solubility curve based on data collected. Describe solubility and saturation point using the particle model. (grade 7)**

But constructing a solubility curve involves time-consuming lab work and assumes the ability to control temperature fairly well. Is this doable? And what aspects of solubility and saturation is the student expected to "describe" here?

Third, while some standards ask the unattainable, others arbitrarily hold students back from learning grade-appropriate content. For instance, the standards sedulously avoid using the words atom and molecule until the ninth grade, which leads to the awkward use of such imprecise terms as "particle model."

And the Delaware standards repeat an unintentional scientific fraud that is far too common in science standards:

> **Conduct investigations to demonstrate the process of diffusion. Use the particle model to describe the movement of materials from an area of higher concentration to an area of lower concentration. (grade 7)**

What is intended and widely used as a demonstration of diffusion—in which a drop of colored water is placed in a tank of apparently still water—is misleading, because the observed effect is really due to residual currents and uncontrollable convection. Diffusion in solids, which is easier to control, is difficult or impossible to demonstrate at this level due to the equipment required.

Finally, some very important topics are missing from the chemistry material for grades nine through twelve. Among these are the mole concept, stoichiometry, chemical formulas, and carbon chemistry. The ideal gas law is not mentioned by name, although one standard weakly hints at its existence.

Earth and Space Science

The presentation of important earth and space science material is generally excellent. For instance, in grades six through eight, the standards explain that:

> **Constructive processes that build up the land and the destructive processes of weathering and erosion shape and reshape the land surface. The height of Earth landforms is a result of the difference between the rate of uplift and the rate of erosion at a particular location. (grades 6-8)**

That is perhaps the best interpretation and explanation of this idea in any state standard.

The properties of water are similarly well-expressed:

> **Use a model or a diagram to explain water's properties (e.g., density, polarity, hydrogen bonding, boiling point, cohesion, and adhesion) in the three states of matter. Cite specific examples of how water's properties are important (i.e., water as the "universal [solvent]"). (grade 9)**

And the discussion of polymer chemistry is unusual and highly desirable—perhaps owing to the looming presence of DuPont in the state.

Some important topics are, however, glossed over or omitted entirely. For instance, except for a brief mention in ninth grade, plate tectonics receives scant attention. And there is no mention of important concepts such as the greenhouse effect, the solar cycle, earthquakes and measuring, relative or absolute dating, or astronomical units.

Life Science

The life science material is concise and accurate, and contains all the important concepts and facts a high school graduate should learn. The content is divided among three strands—life processes, diversity and continuity of living things, and ecology—and while it would be preferable to organize the standards addressing this related content together, the development of the content doesn't suffer here the way it does in other areas of science.

Overall, the standards are clear and well-developed. For example, the reproduction, heredity, and development subtopic begins in Kindergarten and continues through third grade with observations of similarities and differences between parent and offspring. It moves to an in-depth analysis of these patterns for plants in fourth through sixth grades. It gives a good general overview of asexual versus sexual reproduction in sixth through eighth grades, with fertilization and egg development, chromosomes and DNA, and chromosome number. Then, in high school, there's a lucid series of specific units on DNA replication, mutation, meiosis, and the relationship of meiosis and heredity patterns.

Evolution is treated thoroughly and the standards make clear its role as the basic organizing principle of the life sciences. Beginning at the earliest grades, simple ideas are set forth and then systematically elaborated.

This combination of strengths and weaknesses earns Delaware an average score of three out of seven for content and rigor. (See Appendix A: Methods, Criteria, and Grading Metric.)

Clarity and Specificity

Most of the Delaware standards are clearly written and free from distracting jargon. In addition, the state sets clear and unambiguous priorities by clearly labeling the indicators that will be assessed by the state and by indicating which of those assessed standards is most important.

Unfortunately, the organization and presentation of the content is often confusing. Delaware has made the regrettable decision to eschew studying separate areas of science individually, preferring instead an "integrated approach" that scatters discipline-specific content across several strands. For instance, high school chemistry and physics content can be found in two strands—"materials and their properties" and "energy and its effects"—making it nearly impossible to piece together a comprehensive and rigorous high school chemistry or physics course. While organizing the standards in this way is never ideal, it has a particularly deleterious effect on the standards for high school physics and chemistry.

Taken together, these elements earn the First State a score of two out of three for clarity and specificity. (See Appendix A: Methods, Criteria, and Grading Metric.)