SCIENCE

Washington

GRADE	SCORES		TOTAL SCORE
C	Content and Rigor	3/7	6/10
	Clarity and Specificity	3/3	

REPORT CARD

Content & Rigor	**3.3**
Scientific Inquiry & Methodology	5
Physical Science	3
Physics	0
Chemistry	0
Earth & Space Science	5
Life Science	7
Clarity & Specificity	**2.9**

Average numerical evaluations

Overview

Washington's science standards are a study in extremes. In some areas—notably life science—the content is clearly presented, thorough, and free from errors. By contrast, other disciplines suffer from glaring omissions of important content. Taken together, Washington's standards earn an average grade, but this average masks wild variability in quality.

Organization of the Standards

The Washington science standards are divided first into four "Essential Academic Learning Responsibilities" (EALRs): systems, inquiry, application, and the domains of science. Only the last of these is devoted to science content, and it is divided into three domains: life science, physical science, and earth and space science.

Each EALR is then divided into a series of "big ideas." (There are nine big ideas in the domains of science EALR.) Then the state provides a core content summary that broadly describes what students should know and be able to do within each big idea.

Finally, the state provides content standards and performance expectations for each of five grade bands: K-1, 2-3, 4-5, 6-8, and 9-12. The content standards describe what students should know, and the performance expectation describes what they should be able to do. For instance, one content standard and related performance expectation for grades K-1 explains:

	Content Standard	**Performance Expectation**
	Students know that:	***Students are expected to:***
K-1 ES2A	**Some objects occur in nature; others have been designed and processed by people.**	**Sort objects into two groups: *natural* and *human-made*.**

Content and Rigor

The Washington standards hit glorious peaks—see life science in particular—and equally deep valleys.

Document(s) Reviewed

▶ *Washington State K-12 Science Learning Standards*. 2009. Accessed from: http://www.k12.wa.us/Science/Standards.aspx

High school physics and chemistry are essentially absent, but earth and space science offers some redemption.

Scientific Inquiry and Methodology

The Washington process standards cover most of the content that students need to learn, though they do so in a way that's neither particularly inspired nor particularly offensive. Fourth- and fifth-grade students, for example, are told that:

> **Scientists plan and conduct different kinds of *investigations*, depending on the *questions* they are trying to answer. Types of *investigations* include systematic *observations* and descriptions, *field studies*, *models*, and *open-ended explorations* as well as *controlled experiments*. (grades 4-5)**

Given a pre-selected research question, the related performance expectation asks students to:

> **…plan an appropriate *investigation*, which may include systematic *observations*, *field studies*, *models*, *open-ended explorations*, or *controlled experiments*.**

> **Work collaboratively with other students to carry out a *controlled experiment*, selecting appropriate *tools* and demonstrating safe and careful use of equipment. (grades 4-5)**

Like most of the inquiry standards, these are generally clear and grade-appropriate, and the content progresses well through the grades.

The standards do have a few flaws, however. As in many other states, some expectations descend into platitudes. For instance, the claim that people "in all cultures have made and continue to make contributions to society through science and technology" is overly broad—and is not entirely true. And the history of science receives no mention.

Physical Science/High School Physics/High School Chemistry

In general, the physical science standards are succinctly and correctly stated, in proper logical order. For instance, in the grade band covering second and third grades we find:

> ***Motion* can be *described* as a change in position over a period of time.**

> **There is always a *force* involved when something starts moving or changes its *speed* or direction of *motion*.**

> **A greater *force* can make an object move faster and farther.**

> **The relative strength of two *forces* can be *compared* by observing the difference in how they move a *common* object. (grades 2-3)**

Now that is good physics—and quite a lot of it—insightfully stated so that a second or third grader can understand it. Similarly challenging but reasonable expectations of students continue in higher grades.

Quantitative treatments of mechanics and other subfields of physics begin modestly in sixth through eighth grades, and in high school, mathematical statements are used wherever necessary.

The high school physical science material is excellent at a relatively low level, with first-rate information for planning a ninth-grade course. Unfortunately, there are no higher-level standards that could inform a rigorous high school physics course. And even for a physical science course, much essential material is missing. For instance, thermodynamics is slighted, as is optics.

Chemistry is covered only within the context of physical science, as there is no separate course devoted to high school chemistry. No doubt because it isn't treated separately, there are huge blind spots. For example, ionic and covalent bonds are mentioned—but no others. Nothing about molarity appears, nor any discussion of the prediction of chemical reactions between elements. The list of omissions goes on and on.

Earth and Space Science

Some subjects in this category are covered quite well, especially those related to space. For example, stars and galaxies, motion of planets, the Milky Way, and the solar system are all well covered. Standards addressing earth layers are equally strong, as demonstrated by the following standard:

> **The solid Earth is composed of a relatively thin crust, a dense metallic core, and a layer called the mantle between the crust and core that is very hot and partially melted. (grades 6-8)**

By contrast, other topics, many dealing with solid-earth processes, are incomplete or ignored. For example, there is scant mention of minerals (except when they are dissolved) and the mechanics of earthquakes and volcanoes. While plate tectonics gets some mention—especially in the elementary grades—the evidence supporting the theory is missing. There are also several gross errors or oversimplifications in the standards. Take, for example, the following performance expectation:

> ***Explain how*** **the age of landforms can be estimated by studying the number and thickness of rock layers, as well as *fossils* found within rock layers. (grades 6-8)**

For starters, the standard should ask students to explain the age of rocks, not of landforms. Furthermore, the phrase "the number and thickness of rock layers" is so oversimplified, it's simply wrong.

Similarly, the following standard oversimplifies the process of weathering:

> ***Weathering*** **is the breaking down of rock into pebbles and sand caused by physical processes such as heating, cooling, and pressure, and chemical processes such as acid rain. (grades 4-5)**

In fact, it's not the heating and cooling of rocks that is the major cause of physical weathering but rather the presence of *water* during such temperature shifts, an important distinction worth mentioning. And the products of weathering consist of more than just pebbles and sand; they also include clay and dissolved minerals.

There are some brighter spots. Fossils are thoroughly covered, and much time is spent explaining stars, galaxies, and planets and their motion. The notion of deep time is squarely addressed. Washington even produces some "wow" moments; its version of the ubiquitous "constructive and destructive forces" idea is more useful than most, as it specifically addresses uplift, weathering, and erosion without falling into the vague:

> ***Explain how*** **a given landform (e.g., mountain) has been shaped by processes that build up structures (e.g., uplift) and by processes that break down and carry away material (e.g., *weathering* and *erosion*). (grades 6-8)**

And the following general statement about plate tectonics is unique in mentioning the approximate rate of the motion:

> **The *crust* is composed of huge *crustal plates* on the scale of continents and oceans which move centimeters per year, pushed by *convection* in the upper *mantle*, causing earthquakes, volcanoes, and mountains. (grades 6-8)**

Representative of Washington's standards, this statement is rigorous but stumbles in that it opts for the general term "crust" instead of the correct "lithosphere."

Life Science

By far the strongest of the Washington standards are those for life science, which are thorough, well-explained, and grade-appropriate. For instance, Kindergartners and first-grade students are asked to:

> ***Compare*** **how different animals use the same body parts for different purposes (e.g., humans use their tongues to taste, while snakes use their tongues to smell). (grades K-1)**

And the physiology coverage through eighth grade is equally strong. (One important flaw is the complete lack of physiology coverage in high school.)

Evolution is covered well, too. The big idea devoted to biological evolution emerges in Kindergarten and first grade and continues from there, with a clear progression of content and rigor through the successive grades. In addition, there is significant coverage of fossils by fourth and fifth grades.

The standards also make the importance of evolution clear, specifically stating:

> **The scientific *theory* of *evolution* underlies the study of biology and explains both the *diversity* of life on Earth and similarities of all *organisms* at the chemical, cellular, and molecular level. *Evolution* is supported by multiple forms of scientific *evidence*. …*Evidence* for *evolution* includes similarities among anatomical and cell structures, and *patterns* of development make it possible to *infer* degree of relatedness among *organisms*. (grades 6-8)**

The strong coverage of evolution continues in high school, as evidenced by the following:

> **Both the fossil record and analyses of DNA have made it possible to better understand the causes of variability and to determine how the many species alive today are related. Evolution is the major framework that explains the amazing diversity of life on our planet and guides the work of the life sciences. (grades 9-12)**

In addition, common ancestry, deep time, and other essential concepts are addressed well.

Without the total failure of physics and the near-total failure of chemistry, the Washington standards would fare reasonably well in content and rigor. Unfortunately, these major stumbles overwhelm the standards' glimmers of excellence and drag the state's score down to a three out of seven for content and rigor. (See Appendix A: Methods, Criteria, and Grading Metric.)

Clarity and Specificity

At their best, the Washington standards contain statements that express critical content in crystal-clear prose. For instance, in the physical science material for grades six through eight we have:

> **Substances have *characteristic intrinsic properties* such as *density*, *solubility*, *boiling point*, and *melting point*, all of which are independent of the amount of the sample.**
>
> ***Students are expected to:***
>
> **Use *characteristic intrinsic properties* such as *density*, *boiling point*, and *melting point* to identify an unknown substance. (grades 6-8)**

Much of the rest of the document is similarly lucid and specific. But it is not perfect. As happens frequently in many states, an excellent set of standards is kneecapped by a truly dumb glossary. Consider some of the worst offenders in the Washington document:

> **Apply: The skill of selecting and using information in new situations or problems.**

As in "A good student acquires many applies"?

> **Chemical properties: Any of a material's properties, such as color, pH, or ability to react with other chemicals, that becomes evident during a chemical reaction.**

Of course, color is emphatically not a chemical property. And, as for pH, this implies that the chemical properties of HCl depend on its concentration, which is not true.

Sadly, these are the rule in the glossary, not the exception.

Omitting the silly glossary, however, the presentation and organization of the standards are generally top-notch. As such, they earn a solid three out of three for clarity and specificity. (See Appendix A: Methods, Criteria, and Grading Metric.)