SCIENCE

West Virginia

GRADE	SCORES		TOTAL SCORE
D	Content and Rigor	3/7	4/10
	Clarity and Specificity	1/3	

REPORT CARD

Content & Rigor	**3.2**
Scientific Inquiry & Methodology	5
Physical Science	4
Physics	2
Chemistry	4
Earth & Space Science	1
Life Science	3
Clarity & Specificity	**1.3**

Average numerical evaluations

Overview

The West Virginia science standards are a confusing and unsatisfactory hodgepodge. The mediocre treatment at the K-8 level descends into a bewilderment of ill-defined and overlapping courses at the high school level. Making matters worse, the rigor of the standards is wildly inconsistent, both within and across grades.

Organization of the Standards

West Virginia presents content standards for each grade, K-8, and for thirteen courses at the high school level, including: Physics I, Conceptual Physics, Chemistry I, Biology I, Earth Science, and two amorphous grade-specific courses (Ninth Grade Science and Tenth Grade Science). Process standards are presented by grade band, for grades K-4, 5-7, 8, and 9-12. The content is divided first into three "standards" (commonly thought of as "strands"): nature of science, content of science, and application of science. For each standard, the state provides several bullets that broadly describe what students should know and be able to do. For instance, under "content of science," the state indicates that, by the end of the year, fifth graders will:

> **Demonstrate knowledge, understanding, and applications of scientific facts, concepts, principles, theories, and models as delineated in the objectives.**
>
> **Demonstrate an understanding of the interrelationships among physics, chemistry, biology, and the earth and space sciences.**
>
> **Apply knowledge, understanding, and skills of science subject matter/concepts to daily life experiences. (grade 5)**

Finally, the state provides grade-specific learning objectives.

In addition, West Virginia offers a set of performance descriptors for each grade-specific learning objective that describe student mastery of the standard across five levels of achievement: novice, partial mastery, mastery, above mastery, and distinguished. These are presumably linked to state assessments.

Document(s) Reviewed

- *Twenty-First Century K-8 Science Content Standards and Objectives for West Virginia Schools*. 2009. Accessed from: http://wvde.state.wv.us/policies/p2520.3.pdf
- *Twenty-First Century 9-12 Science Content Standards and Objectives for West Virginia Schools*. 2010. Accessed from: http://wvde.state.wv.us/policies/p2520.35.pdf

Content and Rigor

Inconsistency and confusion dog the West Virginia standards. Content ranges from middling (physical science and chemistry) to poor (earth and space science). The sections that address "applications of science" harp endlessly on models and systems. Meanwhile, the presence of more than a few unrealistic goals for grade-level knowledge suggests that too little thought went into creating the standards.

Scientific Inquiry and Methodology

West Virginia's process standards are included within the "nature of science" standard which, according to the state, explores three topics: (1) science as a human endeavor, (2) historical and current discoveries, and (3) the history and nature of science. Oddly, the state suggests that 50 percent of instructional time be devoted to "active inquiry through investigations and hands-on activities," something that would be difficult to do for two thirds of the topics covered.

As is often the case with inquiry standards, the writers have tried to present process goals as measurable outcomes, leading to some poorly worded and bizarre standards. For instance, in Kindergarten, students will "demonstrate curiosity." What that means in practice is difficult to know.

In addition, process standards are presented by grade band, rather than by grade. Unfortunately, by grouping the standards this way, the rigor of the expectations is often inappropriate. For instance, it would be difficult for Kindergartners to "demonstrate an understanding of the history and nature of science." Moreover, the standards give no indication as to how these expectations are meant to increase in rigor from grade to grade.

Physical Science

West Virginia's physical science standards are rarely grade appropriate, oscillating between asking too much and too little of students. In first grade, for example, they are expected to "predict and investigate the buoyancy of objects in water," a tall order considering that this requires an understanding of ratios, which youngsters won't learn until much later. First graders also are asked to "create a plant or animal"—an impossibility at present, and likely to be too difficult for the foreseeable future.

In eighth grade, students are expected to know how to use the periodic table, the various models of the atom (Crookes, Thompson, Bohr, etc.), the factors that affect chemical reactions, and the Doppler Effect. Again, this is asking something that students at this level aren't likely to be able to achieve with any level of depth or rigor.

On the other hand, first graders are asked to "classify objects as living or non-living," when they could certainly do more rigorous work. And seventh graders are asked to "explain how changing latitude affects climate"—a task more suitable for younger students.

Many statements are carelessly written—or patently wrong. For example, third graders are asked to "relate changes in states of matter to changes in temperature." These are two unrelated concepts: During state changes, there are only changes in heat content, not in temperature.

Other statements reflect haphazard organization. In seventh grade, for example, students are asked to "perform experiments to identify substances and explain chemical reactions." Yet the discussion on atoms is not introduced until the following academic year.

Errors often creep in, too. In second grade, for instance, students are asked to identify which colors best conduct heat, when certainly the standards must intend to ask which colors best *absorb* heat.

High School Physics

The entire subject of physics is covered in eighteen one-sentence statements, making it impossible to cover all important topics. Worse, the statements are badly balanced, slighting or ignoring important issues (such as mechanics and thermodynamics) while overemphasizing others (particularly fluid mechanics). Paradoxically, Conceptual Physics—a remedial physics course outlined in the state standards—does a marginally better job of covering the most important material.

High School Chemistry

West Virginia high school students are offered the option of three different chemistry courses: Chemistry I, Chemistry II, and a lower-level Conceptual Chemistry course. Unfortunately, the chemistry content doesn't build coherently from grade to grade. Chemistry I is missing many important topics that are included in the lower-level Conceptual Chemistry course, including: enthalpy; kinetic theory; polar and nonpolar bonding; and proper definitions of pH, oxidation, and reduction. Also missing from Chemistry I are fundamental topics like VSEPR theory and Lewis dot techniques, and Hess's law. These topics are included in Chemistry II. Unfortunately, it's reasonable to assume that relatively few students will take advanced

chemistry and that far too many students will graduate from high school without being exposed to some critical content.

Earth and Space Science

The inconsistency of rigor that plagues the West Virginia standards is evident in the earth and space science standards as well. For example, sixth graders are asked to "compare and contrast continental drift hypothesis to the plate tectonic theory," a highly sophisticated and complex expectation for a twelve-year-old.

In addition, the performance indicators, which are meant to elucidate standards, are often just tangentially related to the standards they're meant to clarify. For example, a series of sixth-grade performance indicators asks students to do the following:

- **Distinguished: research current evidence in plate tectonics theory.**
- **Above Mastery: explain how geologic evidence is used to support the plate tectonics theory.**
- **Mastery: trace the history of the plate tectonics theory and associate life forms to geologic eras.**
- **Partial Mastery: describe plate tectonics theory and recognize that life forms change with geologic eras.**
- **Novice: label plates and recognize that life forms change over time. (grade 6)**

Unfortunately, the only grade-specific objectives to which these performance indicators are linked make no mention of plate tectonics. And although plate tectonics is mentioned in a different set of performance indicators, those don't clarify the prerequisite content students must master to prepare for these more advanced topics.

What's more, these indicators require an understanding of the relationship between life forms and plate tectonics to demonstrate "partial mastery"—yet the connections between plate tectonics and life forms is complicated. Recognizing how life forms change over time is a separate line of study and not a throw-away "partial mastery" concept. Further, it is puzzling that only "above mastery" students are expected to understand the basic geological evidence for plate tectonics, a fundamental concept that should be expected of all students, while the "mastery" level demands more knowledge and a higher level of analysis.

The ninth-grade Earth Science course contains a modest amount of astronomy and geology, which normally are contained within a separate earth and space science sequence. Both are handled with sweeping generalities, as in this standard:

> **Analyze several origin theories of the solar system and universe and use them to explain the celestial bodies and their movements. (high school earth science)**

Galaxies are not mentioned.

Life Science

Throughout the West Virginia standards, much text is devoted to useless descriptors of progress and inquiry, leaving the treatment of content marginal at best. Middle school in particular offers little sense as to what will be taught. Instead, vague dicta reign:

> **Identify the structures of living organisms and explain their functions. (grade 5)**
>
> **Classify living organisms according to their structures and functions. (grade 6)**
>
> **Discuss how living cells obtain the essentials of life through chemical reactions of fermentation, respiration and photosynthesis. (grade 8)**

For the content areas that are addressed, how teachers are to pursue them is largely left unstated. Students in fifth grade are asked to "compare and contrast how the different characteristics of plants and animals help them to survive in different niches and environments including adaptations, natural selection, and extinction," yet none of the key terms is explained. Again, in seventh grade, students are told to "explain how an organism's behavior response is a combination of heredity and the environment." But heredity has not been discussed, severely crippling the exercise.

Overall, evolutionary concepts prove hard to find. Indeed, neither the phrases nor the substance of evolution, variation, natural selection, or common ancestry appear anywhere in Kindergarten through eighth grade. Moreover, the performance descriptors in the standards fail to mention natural selection, implying that it will not be tested.

The course titled Tenth Grade Science offers a list of fifteen topics, in which students finally are introduced to DNA. But it's a strange meeting, because students are asked to "apply DNA analysis to current societal and technological issues (e.g., DNA's role in protein synthesis, heredity, cell division, or cellular functions)," rather than simply learning about these matters directly.

West Virginia also appears to flirt with creationism in the upper grades. Tenth-grade students must "construct

a scientific explanation for variation in the species and common ancestors using fossil records, homologous features and selective pressures" and are asked to "compare and contrast theories for the development, diversity and/or extinction of a species (e.g., natural selection, Lamarckism, or catastrophism)"—where catastrophism could include events such as Noah's Flood. So, although creationism is not explicitly mentioned, one infers an invitation to the lamentable "teach the controversy" creationist rhetoric regarding evolution.

The overall mark for content and rigor is a sub-par three out of seven (see Appendix A: Methods, Criteria, and Grading Metric), which would be lower save for slightly better handling of physical science and chemistry.

Clarity and Specificity

West Virginia's learning objectives are repetitive and disjointed. Far too much content is repeated nearly verbatim across grade levels, as in the following, which appears at every level from Kindergarten through fourth grade:

> **Demonstrate an understanding of the history and nature of science as a human endeavor encompassing the contributions of diverse cultures, scientists, and careers. (grades K-4)**

This standard is broad to the point of uselessness. Standards under the "application of science" banner are even more repetitious, harping about models and systems, grade after grade.

Worse, the standards themselves show a lack of flow and integration across grade levels. For example, mechanics objectives within the high school physics standards are scattered across the list of objectives, instead of being presented together in a coherent sequence.

Finally, the content itself is not organized by discipline, theme, or any other apparent structure. Instead, standards are all lumped together in a series of half-sentence arm-waves that rarely get specific.

The performance descriptors are complicated and breathless rubrics from which substantive details only rarely emerge. Often the middle tiers are the most sensible expectations, while the "distinguished" category describes levels of performance more properly expected of competent adult scientists. Some of the verbs employed describe lesson plans rather than measurable outcomes: observe, listen, study, explore, investigate.

Taken together, these drawbacks earn the science standards an average score of one out of three for clarity and specificity. (See Appendix A: Methods, Criteria, and Grading Metric.)