SCIENCE

# Alabama

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

**REPORT CARD**

| | |
|---|---|
| **Content & Rigor** | **2.7** |
| Scientific Inquiry & Methodology | 2 |
| Physical Science | 3 |
| Physics | 1 |
| Chemistry | 3 |
| Earth & Space Science | 4 |
| Life Science | 3 |
| **Clarity & Specificity** | **1.4** |

*Average numerical evaluations*

## Overview

Alabama's science standards generally fail to outline the essential science content teachers need to teach—and students need to learn. Although not every area is bereft of useful material, the treatment of concepts often is haphazard, incomplete, puzzling, and at times incorrect. The result is a hash from which frustrated educators will be hard-pressed to extract an effective curriculum.

## Organization of the Standards

The Alabama science standards are presented in four documents, one each for the grade bands covering K-2, 3-5, 6-8, and high school. For grades K-5, grade-specific standards are divided into three familiar strands: physical science, life science, and earth and space science. For grades 6-8, grade-specific standards are focused on a single content area each year: Sixth grade focuses on earth and space science, seventh grade on life science, and eighth grade on physical science (covering chemistry and physics). At the high school level, standards are presented for four core courses (physical science, biology, chemistry, and physics) as well as for ten discrete electives, including botany, forensic science, and zoology.

For each grade and course, individual standards include three component parts. First, the state presents content standards. Under the content standards is a series of bullets, which explain "content that is related to the standards and required for instruction." Examples are provided to clarify either content standards or bullets.

## Content and Rigor

Across the board, Alabama's standards are mediocre to poor. Large swaths of important information are missing, and what is present often receives cursory treatment. A penchant for bulleted lists does not serve the document well. Equally problematic, the material is occasionally far too challenging for the specified grade level—particularly considering the lack of adequate development that pervades the standards.

### Scientific Inquiry and Methodology

The standards explain that "process and application skills" should be "embedded throughout the content areas and applied through the use of inquiry." Unfortunately,

**Document(s) Reviewed[1]**

▶ *Alabama Course of Study: Science*. 2005. Accessed from: http://www.alsde.edu/html/sections/documents.asp?section=54&sort=4&footer=sections

[1] Fordham's 2005 evaluation also reviewed Alabama's 2005 content-standards document. Since 2005, we have updated and improved the evaluation criteria used to judge the standards. (See Appendix A for a complete explanation of the criteria used in this review.) Through this new lens, Alabama's science grade rose from an F to a D. The complete 2005 review can be found here: http://www.edexcellence.net/publicationsissues/publications/sosscience05.html.

due in large part to the standards' brevity and subsequent vagueness, there is little guidance about how, exactly, these skills should be embedded into the content. For instance, the standards explain that analyzing data involves "using collected data to accept or reject hypotheses," a woefully inadequate description of the importance of data to scientific inquiry. This lack of specificity permeates the Alabama inquiry standards. The state's guidelines on cultural diversity in science, for example, state that "integration of culturally relevant biographical sketches of male and female scientists from a variety of ethnic backgrounds...should be incorporated into scientific topics." Sure, but no guidance is given as to which scientists should be studied.

Worse, what little guidance does exist is often rife with errors. For instance, one standard claims that "formulating hypotheses" (an "advanced" skill) comes down to "making predictions of future events based on manipulation of variables." No, it does not.

## Physical Science

Physical science is covered in Kindergarten through fifth grade, as well as in eighth grade (which is solely devoted to the subject) and in a high school physical science course. In general, the eighth-grade coverage is spotty. Much content is present (at least in passing), including the atomic structure, chemical reactions, kinetic theory, mechanics, energy, hydrostatics, and waves. Yet many topics—such as gravitation, thermodynamics, optics, electromagnetism, and organic chemistry—are missing, and Alabama often fails to provide adequate detail for those topics that are covered. For instance, balancing chemical equations is introduced in eighth grade, as is chemical bonding. However, only ionic and covalent bonds are mentioned. As another example:

> **[Describe] acids and bases based on their hydrogen ion concentration. (grade 8)**

Much important content is missing here: What is meant by "concentration"? How is concentration measured? What are the properties, common names, and formulas of acids and bases? How does one use the pH scale, litmus, and other acid/base indicators? What is the mechanism of neutralization reactions?

This same situation holds true for high school physical science. Here, Alabama boasts some rigorous content (the implicit reference to Ampère's and Faraday's laws, for example), while simultaneously skipping numerous important topics. Optics, acoustics, hydrostatics and hydrodynamics, and alternating currents (except for a passing, cryptic mention of induction) are all absent.

And the last standard in the high school physical science section—"Identify metric units for mass, distance, time, temperature, velocity, acceleration, density, force, energy, and power"—reads like an odd afterthought, when it ought to be a central point.

## High School Physics

Admirably, the high school physics course specifies Algebra II with trigonometry as a prerequisite. But this hopeful sign only leads to disappointment. Kinematics is covered briefly and somewhat by implication, but all of dynamics is passed off and folded into other areas, as with the following:

> **Describe quantitative relationships for velocity, acceleration, force, work, power, potential energy, and kinetic energy. (high school physics)**

This does not bode well for real application of the laudable mathematical prerequisites.

What's more, the content that is present often lacks sufficient depth of focus, as is the case with thermodynamics, waves, optics, electromagnetism, and practical electricity.

The standards are further marred by inappropriate sequencing. For example, concepts of energy are presented before dynamics—though the former must be derived from the latter.

The wonderful, mysterious word "entropy" is introduced with no prior mention of any of the laws of thermodynamics on which the concept is based. Everything is condensed into the illogical statement, "Explain the concept of entropy as it relates to heating and cooling, using the laws of thermodynamics."

Likewise, the central quantum mechanical concept of wave-particle duality is inexplicably jammed into the sequence of statements concerning classical waves, and the student is somehow expected to "demonstrate" the phenomenon.

## High School Chemistry

As with the other disciplines, Alabama's chemistry standards suffer from vagueness and insufficient depth of coverage. For example, after appearing in the eighth-grade standards, chemical bonding is not mentioned again, except for this rather broad directive: "[Predict] ionic and covalent bond types and products given known reactants." And the entire topic of acid/base theory is summed up in only one bulleted item: "[Describe] acids and bases in terms of strength, concentration, pH, and neutralization reactions." The important concepts are there, but they need to be fleshed out.

Oddly, even as some basic concepts are omitted, advanced ones are included. In the nuclear chemistry standards, we see the following:

> **[Identify] atomic and subatomic particles, including mesons, quarks, tachyons, and baryons. (high school chemistry)**

The mention of tachyons (hypothetical particles whose *minimum* speed is the speed of light) is peculiar, since their existence is entirely speculative, while such significant particles as leptons (including electrons) and neutrinos are not mentioned at all. (What's more, the particles that *are* mentioned have more to do with modern physics than with chemistry.)

## Earth and Space Science

The authors of the Alabama standards have made an effort to provide reasonable earth science content. Unfortunately, given the terseness of the state's standards (all sixth-grade content is explained in one-and-a-half pages, for example), much critical context and necessary explanation is missing. Take this sixth-grade standard, in which students are asked to:

> **Explain the plate tectonic theory.**
>
> **Example: using terminology such as continental drift, seafloor spreading, lava, magma, eruption, epicenter, focus, seismic wave, and subduction zone**
>
> - **Describing types of volcanoes and faults**
> - **Determining energy release through seismographic data**
>
> **Example: using data from the Mercalli scale and the Richter scale. (grade 6)**

This short excerpt contains a laundry list of vocabulary. The terms covered could act as a skeleton of strong state standards, but their required depth of study is a mystery. As an example, consider seismic waves. Are students merely supposed to know that they cause ground shaking? Or are they to describe body waves—whether primary (P) or secondary (S)—and surface waves? Or, better still, are they to show how P and S waves may be used to locate an earthquake's focus and epicenter (two other terms on the list)? And so it goes: good ideas not developed quite enough. The peaks and valleys of this standard are representative of the standards as a whole.

Still, there are some brighter spots where the content is spelled out carefully, as in the third-grade material on minerals:

> **[Classify] rocks and minerals by characteristics, including streak, color, hardness, magnetism, luster, and texture. (grade 3)**

This misses the mark just a little—rock classification is done a bit differently than mineral classification. The Alabama high school geology elective covers rocks nicely as well, though the state's high school earth and space science standards (which appear only in elective courses) suffer from the same deficit as their elementary and middle school counterparts: large chunks of loosely related content, which *could* outline an excellent course, whiz by in single statements.

## Life Science

Alabama's life science standards start off on fairly firm footing—cells and tissues, photosynthesis, and plant and animal species are all well handled. In fourth grade, for example, students are to:

> **[Classify] common organisms into kingdoms, including Animalia, Plantae, Protista, Fungi, Archaebacteria, and Eubacteria. (grade 4)**

There are some *intimations* of evolution in the early grades, as in the following:

> **Identify characteristics of animals, including behavior, size, and body covering.**
>
> - **Comparing existing animals to extinct animals**
>
> **Examples: iguana to stegosaurus, elephant to wooly mammoth. (grade 2)**
>
> **Describe evidence of species variation due to climate, changing landforms, interspecies interaction, and genetic mutation.**
>
> **Examples: fossil records over geologic time, rapid bacterial mutations due to environmental pressures. (grade 7)**

At the high school level, biology is mostly good and includes some biochemistry and lots of genetics and environmental material. The high school course electives—genetics, botany, and human physiology—are also substantive. That said, there is one glaring deficit with the Alabama biology standards. Evolution, which should be a front-and-center feature of genetics, is all but absent.

Alabama is clearly frightened by the "E-word"—a phobia from which most other states have recovered. The term "evolution" occurs exactly once in the basic biology course, once more in the genetics elective course, not at all in any of the other seven life science electives, and (despite those

intimations) never prior to high school. Perhaps this is not surprising, given that the Alabama Department of Education officially considers creationism, an explicitly religious and non-scientific position, to be a form of evolution.[2]

The high school biology course has only this to say about evolution:

> **Describe protective adaptations of animals, including mimicry, camouflage, beak type, migration, and hibernation.**
>
> - **Identifying ways in which the theory of evolution explains the nature and diversity of organisms**
> - **Describing natural selection, survival of the fittest, geographic isolation, and fossil record. (high school biology)**

The odd implication here is that evolution and natural selection are sub-categories of the listed adaptations, rather than the center of the entire study. What are otherwise reasonable standards are marred by this flagrant omission of this central tenet of the life sciences.

With but a few bright spots in individual categories, Alabama's science standards earn a lamentable three out of seven for content and rigor. (See Appendix A: Methods, Criteria, and Grading Metric.)

## Clarity and Specificity

Some of Alabama's standards are presented clearly, particularly those for life science. Where the Yellowhammer State stumbles is in its specificity. The content, provided in list form, is often skimpy and lacks the detail needed to guide instruction. In high school physical science, for example, students are asked to "explain the relationship between electricity and magnetism." That is a too-quick once-over for a topic that, at a minimum, requires inquiry into Ampère's law and Faraday's law. Such nebulous standards are especially common with some of the more complex science topics—such as deep time—making it even less likely that students will learn the essential content they need.

Furthermore, careless writing abounds, resulting in some standards that are simply wrong:

> **[Determine] the resultant of collinear forces acting on a body**
>
> **Example: solving problems involving the effect of a tailwind or headwind on an airplane. (high school physical science)**

While the example does involve the addition of two collinear *vectors*, they are certainly not *forces*!

Taken together, these issues lower Alabama's clarity and specificity score to a one out of three. (See Appendix A: Methods, Criteria, and Grading Metric.)

[2] Michael Sibley, director of communications for the Alabama Department of Education, recently explained the state's position, saying: "The Alabama Course of Study deals with Theories of Evolution...Creationism is one of those theories." See Joshua Rhett Miller, "Claims that Bibles Were Distributed to Alabama Elementary Students Are Inaccurate, School Superintendent Says," *Foxnews.com*, March 24, 2011, http://www.foxnews.com/us/2011/03/24/alabama-superintendent-denies-claims-bibles-distributed-class/#ixzz1IVCPjXe0.