SCIENCE

New York

GRADE	SCORES		TOTAL SCORE
B+	Content and Rigor	6/7	8/10
	Clarity and Specificity	2/3	

REPORT CARD

Content & Rigor	**5.7**
Scientific Inquiry & Methodology	2
Physical Science	4
Physics	7
Chemistry	7
Earth & Space Science	7
Life Science	7
Clarity & Specificity	**2.0**

Average numerical evaluations

Overview

New York's standards remain rigorous and thoughtfully composed. There are but a few weaknesses, principally in the handling of scientific inquiry; the overall quality is laudable.

Organization of the Standards

New York's learning standards for math, science, and technology are divided into seven strands, called "standards." Specifically for science, Standard 1 speaks to scientific inquiry and Standard 4 deals with science content. (Standards 6 and 7 discuss science themes and process skills, especially in connection with math and technology.) This analysis concentrates on Standards 1 and 4.

The content standards for science are divided into two sub-strands: physical setting and living environment. A series of "key ideas" are provided for each sub-strand. Finally, grade-span expectations are provided for each key idea at three levels: elementary (grades K-4), intermediate (grades 5-8), and commencement.

In addition, New York provides a *Core Curriculum* (optional, though dealing specifically with state-tested content), which lists a series of "major understandings" for each of the grade-span expectations. For instance, an elementary expectation asks students to "describe the characteristics of and variations between living and nonliving things." The four major understandings spell out precisely what characteristics and variations are intended at this level:

- **1.1a Animals need air, water, and food in order to live and thrive.**
- **1.1b Plants require air, water, nutrients, and light in order to live and thrive.**
- **1.1c Nonliving things do not live and thrive.**
- **1.1d Nonliving things can be human-created or naturally occurring. (elementary grades)**

This is straightforward, clear, and grade-appropriate exposition.

Content and Rigor

New York's standards are generally outstanding, with excellent content in both the lower and upper levels in most disciplines.

Document(s) Reviewed

- *New York Learning Standards and Core Curriculum (Standards 1 and 4)*. 1996. Accessed from: http://www.p12.nysed.gov/ciai/mst/sci/sciencestand/scistand.html
- *Resource Guide with Core Curriculum.* May 2009. Accessed from: http://www.p12.nysed.gov/ciai/mst/sci/ls.html

Scientific Inquiry and Methodology

The scientific inquiry and methodology standards are perhaps the biggest blight on an otherwise strong set of student expectations. Not only are the inquiry standards awkwardly linked with "mathematical analysis" and "engineering design" standards, they are rife with platitudes, such as: "Students learn most effectively when they have a central role in the discovery process." New York's inquiry standards do not provide clear direction as to their application in the classroom. For example, elementary students are expected to "make informed decisions and solve problems" using interdisciplinary problem solving. Fair enough. But how? Further, there is no indication of how the various grades would achieve this goal in a progressive manner. The standards are further weakened by the overuse of jargon such as "cost/benefit trade-offs," "optimal choice," and "fair test." For instance, at the elementary level students are asked to:

> **Observe phenomena and evaluate them scientifically and mathematically by conducting a fair test of the effect of variables and using mathematical knowledge and technological tools to collect, analyze, and present data and conclusions. (elementary grades)**

There is virtually no content in this bloated and jargon-filled standard. Sadly, these are the norm, rather than the exception.

Physical Science

Relative to the strong coverage of other disciplines, elementary- and intermediate-level physical science is a weak spot for the New York standards. Too much critical content is omitted, particularly in elementary grades, when students should be learning critical prerequisite content that will lay the groundwork for later learning.

The standards do improve in depth and rigor as they progress through the grade levels—though weaknesses still occasionally emerge, even in the intermediate grades. The word "molecule" is frequently used, for example, but is never defined. And some standards misrepresent aspects of physical science altogether. The following is illustrative:

> **Energy can be transformed, one form to another. These transformations produce heat energy. Heat is a calculated value which includes the temperature of the material, the mass of the material, and the type of the material. (intermediate grades)**

Close, but no cigar. Heat energy is not necessarily involved in energy transformations. Heat is a mode of transfer of energy, not a fixed quantity of energy.

High School Physics

High school physics is covered in a complete and systematic way. The treatment begins with a step-by-step exposition of energy, beginning with:

> **All energy transfers are governed by the law of conservation of energy.***
>
> **Energy may be converted among mechanical, electromagnetic, nuclear, and thermal forms.**
>
> **Potential energy is the energy an object possesses by virtue of its position or condition. Types of potential energy include gravitational* and elastic*.**
>
> **Kinetic energy* is the energy an object possesses by virtue of its motion.**
>
> **In an ideal mechanical system, the sum of the macroscopic kinetic and potential energies (mechanical energy) is constant.* (high school physics)**

And generalizing to such matters as:

> **Energy may be stored in electric* or magnetic fields. This energy may be transferred through conductors or space and may be converted to other forms of energy.**
>
> **Moving electric charges produce magnetic fields. The relative motion between a conductor and a magnetic field may produce a potential difference in the conductor.**
>
> **Electrical power* and energy* can be determined for electric circuits. (high school physics)**

Here and elsewhere, the asterisks mark concepts and topics for which quantitative treatment is required—showing that the state requires a pretty thorough quantitative approach to the study of physics, something often lacking in states' standards.

Following the coverage of energy is, quite logically, the coverage of waves, kinematics and dynamics, and quantum physics. The treatment of this last broad topic is perhaps too brief, but this is largely compensated for by excellent coverage in high school chemistry both of thermodynamics and of atomic structure and interactions (more on this topic below). The relative brevity of treatment does not interfere with completeness, owing to the careful and knowledgeable organization of the subject matter.

High School Chemistry

The New York chemistry standards outline a solid, academic, college-prep high school chemistry course—the standards are truly a pleasure to read. Open the document to any page and you will find carefully crafted statements that are wonderfully specific, clearly telling the reader what students are expected to know and be able to do. Scientific terms are defined and the word "calculate" appears without shame when mathematical relationships are presented. To sample a flavor of the whole, consider these definitions of heat and temperature, so often slighted or muddled in state science standards:

> **Heat is a transfer of energy (usually thermal energy) from a body of higher temperature to a body of lower temperature. Thermal energy is the energy associated with the random motion of atoms and molecules.**
>
> **Temperature is a measurement of the average kinetic energy of the particles in a sample of material. Temperature is not a form of energy. (high school chemistry)**

This is correct, clear, and complete; not a word is wasted. From the outset, it is made clear that heat is not energy *per se* but a mode of energy transfer; the distinction is well made between heat and thermal energy.

Similarly, the dynamic nature of chemical equilibrium is set forth clearly in three standards:

> **Some chemical and physical changes can reach equilibrium.**
>
> **At equilibrium the rate of the forward reaction equals the rate of the reverse reaction. The measurable quantities of reactants and products remain constant at equilibrium.**
>
> **Le Châtelier's Principle can be used to predict the effect of stress (change in pressure, volume, concentration, and temperature) on a system at equilibrium. (high school chemistry)**

This is followed immediately by a straightforward presentation of Le Châtelier's principle.

Redox reactions and acid-base chemistry are also thoroughly covered, as are all the other key elements of a rigorous high school chemistry curriculum.

Earth and Space Science

Though there are a few black marks within New York's earth and space science standards (too much peripheral material sometimes detracts from the content, for example), the Empire State's standards in this discipline represent some of the best in the nation. The use of strong examples that clarify what, precisely, students should know or be able to do differentiate New York's standards from the rest. For example, the following three expectations appear in high school:

> **Minerals are formed inorganically by the process of crystallization as a result of specific environmental conditions. These include:**
>
> - **cooling and solidification of magma**
> - **precipitation from water caused by such processes as evaporation, chemical reactions, and temperature changes**
> - **rearrangement of atoms in existing minerals subjected to conditions of high temperature and pressure. (high school earth science)**
>
> **Age relationships among bodies of rocks can be determined using principles of original horizontality, superposition, inclusions, cross-cutting relationships, contact metamorphism, and unconformities. The presence of volcanic ash layers, index fossils, and meteoritic debris can provide additional information. (high school earth science)**
>
> **The regular rate of nuclear decay (half-life time period) of radioactive isotopes allows geologists to determine the absolute age of materials found in some rocks. (high school earth science)**

These examples, drawn from the *Core Curriculum*, leave little doubt as to what students should learn. But while the *Curriculum* clearly delineates what is expected of students, it suffers from one weakness: some important elementary content is delayed until high school.

Life Science

The elementary and intermediate life science standards are thorough and rigorous. Virtually all of the content is well presented and developed, and the section on human organ systems is particularly impressive.

The high school standards are also excellent throughout. In particular, the standards covering the integration of systems with disease and the way genetics is intertwined with embryological development and evolution are noteworthy.

Evolution is well covered. One quibble is that the high school document states: "According to many scientists, biological evolution occurs through natural selection." Because the document goes on to indicate that natural selection is key, and describes it well, we have reason to hope that the "according to many scientists" part—so dear to creationists—will vanish in the next rewrite.

With the exception of its treatment of inquiry and elementary-level physical science, the New York standards are clear, thorough, and rigorous. They earn an admirable average score of six out of seven for content and rigor. (See Appendix A: Methods, Criteria, and Grading Metric.)

Clarity and Specificity

New York's *Core Curriculum*, designed to build on the state's learning standards, contains some of the most elegant writing of any science standards document. Take, for example, the following two high school earth science standards:

> **The universe is vast and estimated to be over ten billion years old. The current theory is that the universe was created from an explosion called the Big Bang. Evidence for this theory includes:**
>
> - **cosmic background radiation**
> - **a red-shift (the Doppler effect) in the light from very distant galaxies. (high school earth science)**

> **Patterns of deposition result from a loss of energy within the transporting system and are influenced by the size, shape, and density of the transported particles. Sediment deposits may be sorted or unsorted. (high school earth science)**

Such clear exposition of accurate scientific material is typical of the *Core Curriculum*.

Unfortunately, the eloquence of that document is mitigated by the organization of the learning standards themselves, which are convoluted and confusing. Though not impossible, navigating these—the official standards—can be quite the headache. The poor organization of the learning standards lowers New York's clarity and specificity score to a two out of three. (See Appendix A: Methods, Criteria, and Grading Metric.)