VIRGINIA DEPARTMENT OF EDUCATION

BRIEFING

MIDDLE SCHOOL SCIENCE EDUCATION IN VIRGINIA

PRESENTED TO THE

JOINT SUBCOMMITTEE STUDYING SCIENCE, MATHEMATICS, AND TECHNOLOGY EDUCATION (HJ 90, 2008 GENERAL ASSEMBLY)

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BACKGROUND AND CONTEXT

- The Virginia Standards of Learning (SOL) define the content of the instructional program in each subject area. Each school division determines the methodology in which the content is taught and how the disciplines are integrated.

- The *Code of Virginia* requires the Board of Education to establish *Standards of Learning* for, at a minimum, English, mathematics, science, and history and social science.

  § 22.1-253.13:1. Standard 1. Instructional programs supporting the Standards of Learning and other educational objectives.

  B. The Board of Education shall establish educational objectives known as the Standards of Learning, which shall form the core of Virginia's educational program, and other educational objectives, which together are designed to ensure the development of the skills that are necessary for success in school and for preparation for life in the years beyond. At a minimum, the Board shall establish Standards of Learning for English, mathematics, science, and history and social science….

- The same section of the *Code of Virginia* also requires the local school boards to develop Kindergarten through grade 12 programs of instruction aligned with the *Standards of Learning.*

  C. Local school boards shall develop and implement a program of instruction for grades K through 12 that is aligned to the Standards of Learning and meets or exceeds the requirements of the Board of Education. The program of instruction shall emphasize reading, writing, speaking, mathematical concepts and computations, proficiency in the use of computers and related technology, and scientific concepts and processes;….

- The *Code of Virginia* requires that the standards be reviewed at least every seven years.

  § 22.1-253.13:1. Standard 1. Instructional programs supporting the Standards of Learning and other educational objectives.

  B….The Standards of Learning in all subject areas shall be subject to regular review and revision to maintain rigor and to reflect a balance between content

knowledge and the application of knowledge in preparation for eventual employment and lifelong learning. The Board of Education shall establish a regular schedule, in a manner it deems appropriate, for the review, and revision as may be necessary, of the Standards of Learning in all subject areas. Such review of each subject area shall occur at least once every seven years. Nothing in this section shall be construed to prohibit the Board from conducting such review and revision on a more frequent basis.

- The science standards were reviewed in 2002 and adopted by the Board of Education in 2003. The Curriculum Framework was adopted in May 2003. The next review of the Science Standards of Learning will begin in 2009. (An overview of the K-12 Science Standards of Learning is in Appendix A).

- The Science Standards of Learning for Virginia's Public Schools identify academic content for essential components of the science curriculum at different grade levels. Standards are identified for kindergarten through grade five, for middle school, and for a core set of high school courses — Earth Science, Biology, Chemistry, and Physics.

THE MIDDLE SCHOOL SCIENCE STANDARDS OF LEARNING

- **Grade 6 Science:** The concept of change is explored through the study of transformations of energy and matter. The standards present an integrated focus on the role of the sun's energy:
    - in the Earth's systems;
    - on water in the environment;
    - on air and atmosphere; and
    - on basic chemistry concepts.

  A more detailed understanding of the solar system and space exploration becomes a focus of instruction. Natural resource management, its relation to public policy, and cost/benefit tradeoffs in conservation policies are introduced.

- **Life Science** (generally taught in Grade 7): The Life Science standards emphasize a more complex understanding of change, cycles, patterns, and relationships in the living world. Students build on basic principles related to these concepts by exploring:
    - the cellular organization and the classification of organisms;

- the dynamic relationships among organisms, populations, communities, and ecosystems; and
- change as a result of the transmission of genetic information from generation to generation.

Inquiry skills at this level include organization and mathematical analysis of data, manipulation of variables in experiments, and identification of sources of experimental error.

- **Physical Science** (generally taught in Grade 8)**:** The Physical Science standards stress an in-depth understanding of the nature and structure of matter and the characteristics of energy. The standards place considerable emphasis on the technological application of physical science principles. Major areas covered by the standards include**:**
  - the organization and use of the periodic table;
  - physical and chemical changes;
  - nuclear reactions;
  - temperature and heat;
  - sound;
  - light;
  - electricity and magnetism; and
  - work, force, and motion.

- The existing structure for instructional delivery is such that school divisions have the flexibility to integrate the three years of science at the middle school level. Some school divisions accelerate students and they take Earth Science in the 8th grade.

EXTERNAL REVIEW OF STANDARDS

- The Thomas B. Fordham Institute published a state-by-state review of science standards in 2005. The Institute rated Virginia Science Standards of Learning with a grade of "A" and second in the nation (See Appendix B.).

- The American Federation of Teachers (AFT) evaluated Virginia's nationally recognized Standards of Learning against the academic standards of other states for clarity, specificity and content. The report by the nation's second-largest teachers union cited Virginia as the only state in the nation to meet the AFT's criteria for strong standards in English, mathematics, science, and history at all

grade levels and in all subject areas (See http://www.aft.org/news/2008/standards.htm.).

ASSESSMENT OF SCIENCE STANDARDS

- The Science Standards of Learning are assessed at grade levels 3, 5, 8 and end-of-course at high school. The federal *No Child Left Behind Act of 2001* (NCLB) now requires that science be tested at least once in elementary, middle, and high school and Virginia exceeds this requirement.

- All Standards of Learning tests have blueprints that serve as guides for teachers, parents, and students. The blueprints show how the Standards of Learning are covered by a test. The blueprints also show the reporting categories of test items, the number of test items, and general information about how the test questions are constructed. The grade 8 Science Standards of Learning test consists of content from grade 6, Life Science, and Physical Science (See Appendix C for testing blueprint.).

- The statewide pass rates for the last three years for the Science Standards of Learning tests for all grades is shown below:

Science Standards of Learning Pass Rates

Subject	2004-2005	2005-2006	2006-2007
Grade 3	89	90	88
Grade 5	81	85	88
Grade 8	87	87	89
Earth Science	80	82	84
Biology	83	83	87
Chemistry	88	87	91

Pass rates for tests administered in the 2007-2008 school year have not yet been released.

NATIONAL ASSESSMENT

- **National Assessment of Educational Progress (NAEP):** NAEP is a national representative and continuing assessment of what America's students know and can do in various subject areas. Assessments are conducted periodically in mathematics, reading, science, writing, the arts, civics, economics,

geography, and U.S. history. In 2005, this national test was administered to a representative sample of Virginia public school students in grades 4 and 8 in the area of science in order to compare Virginia's standards to those of other states.

- Virginia was one of only five states that saw significant increases in overall science achievement in both grades 4 and 8 on the 2005 NAEP. The Commonwealth was the only state in the nation in which students in both tested grades increased their level of achievement on all three subcomponents of the test (Earth Science, Physical Science, and Life Science).

NAEP Science Mean Scores, 1996 – 2005: All Students

	1996	2000	2005
Grade 4			
Virginia	No State Test	155	161
Nation	148	145	149
Grade 8			
Virginia	149	151	155
Nation	148	148	147

STATE SUPPORTED INITIATIVES FOR SCIENCE

- **Mathematics and Science Partnership (MSP) program:** Since 2003, the Virginia Department of Education (VDOE) has awarded approximately 9 million dollars in federal Title II, Part B, NCLB funds to Virginia institutions to support mathematics and science professional development programs for teachers. Partnerships must include an institution of higher education (IHE) and at least one school division. Priorities have included all grade levels of mathematics and science, as well as the integration of science, technology, engineering and mathematics.

- **Geospatial Instructional Applications Initiative (GIAI):** The VDOE has used federal funds for this middle and high school project. The primary goal is to develop and implement a statewide professional development program for using geospatial technologies as effective teaching and learning tools. This across-the-curriculum effort will engage students in an emerging technology and allow them to be more competitive in the work force.

- **Learn and Serve Virginia:** From 2006 to 2009, the primary goal of Learn and Serve Virginia will be to advance the concepts associated with environmental

service-learning by providing federal funds to local school divisions interested in establishing, expanding, implementing, or operating an environmental service-learning program at the middle or high school grade levels. Approximately $380,000 is available in National Corporation for Community Service funds (with 100 percent local match) to support this program in Virginia.

- **Governor's Career and Technical Academies:** The Governor's Career and Technical Academies are intended to expand options for the general population of students to acquire STEM literacy and other critical knowledge, skills, and credentials that will prepare them for high-demand, high-wage, and high-skill careers in Virginia. Please refer to the presentation by Dr. Lois Williams for further information.

HOW SCHOOL DIVISIONS INTEGRATE SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS TO SUPPORT THE STANDARDS OF LEARNING

- School divisions have many methods of integrating science, technology, engineering, and mathematics. Below are examples from three divisions.

    - **Albemarle County:** Middle school science teachers in Albemarle County teach portions of the science SOL by using an engineering design challenge created by University of Virginia engineering students. The University of Virginia School of Engineering and Applied Science makes the study of engineering fundamentals available to local students by providing engineering kits to local school divisions. An engineering student then goes into the classroom and collaborates with the classroom teacher to work with students.

    - **Stafford County:** The Virginia Demonstration Project (VDP) is a collaboration among the Dahlgren Navy Lab, The College of William and Mary, Stafford County Public Schools, King George County Public Schools, and Spotsylvania County Public Schools. It is a comprehensive, inclusive initiative to encourage middle school students to consider careers in science, technology, engineering and mathematics (STEM). VDP utilizes STEM-related, problem-based learning as a teaching methodology in life science and mathematics classes as a way to engage students in science and mathematics concepts. The scenarios focus on a science concept such as a coral reef oil spill or the impact of hurricanes, and

students use a robotic design challenge to solve the problem. The VDP involves middle school teachers and students as well as Dahlgren scientists and engineers as partners in this methodology.

- **Fairfax County:** Lessons meeting the middle school SOL that integrate nanotechnology are being introduced to middle schools in Fairfax County.

STUDENT PROGRAMS

- There are numerous student programs and competitions to support and supplement mathematics, science and technology education across the Commonwealth. Below are two examples.

  - **Virginia Junior Academy of Science (VJAS):** The VJAS, through its active statewide programs, serves as an effective stimulus for scientific research by sponsoring programs for the advancement of science in grades 7 through 12 and by encouraging students to enter scientific research investigations in competition for awards at the annual VJAS meeting. All members are eligible to participate in research competitions, attend and participate in the annual meeting, and compete for numerous honors and awards (See http://www.vacadsci.org/vjas-1.htm.).

  - **For Inspiration and Recognition of Science and Technology (FIRST) Robotics:** FIRST Robotics is a multinational, nonprofit organization, that aspires to transform culture, making science, mathematics, engineering, and technology as engaging for students as sports are today. Teams of high school students, sponsored and assisted by local companies and volunteers, design, assemble, and test a robot capable of performing a specified task in competition with other teams. *FIRST* also runs the FIRST LEGO League for children 9-14 years old (See http://www.usfirst.org.).

Appendix A

THE SCIENCE STANDARDS OF LEARNING

- Organization
  - ♦ Goals of the Science Standards of Learning
  - ♦ K-12 Safety
  - ♦ Instructional Technology
  - ♦ Investigate and Understand
  - ♦ Kindergarten through Physics Standards

- Standards
  - ♦ K - 6 Integrated Science - Life, Physical, Earth/Space
  - ♦ Life Science
  - ♦ Physical Science
  - ♦ Earth Science
  - ♦ Biology
  - ♦ Chemistry
  - ♦ Physics

- Strands: Kindergarten - 6th Grade
  - ♦ Scientific Investigation, Reasoning, and Logic
  - ♦ Force, Motion, and Energy
  - ♦ Matter
  - ♦ Life Processes
  - ♦ Living Systems
  - ♦ Interrelationships in Earth/Space Systems
  - ♦ Earth Patterns, Cycles, and Change
  - ♦ Resources

- Scientific Inquiry Skills - First Standard at Every Level (K.1, 1.1, 2.1, etc.)
  - ♦ Observing, Classifying, Measuring, Hypothesizing, Analyzing Data, etc., at each level

- Investigate and Understand
  "Investigate" refers to scientific methodology, and implies systematic use of the following inquiry skills:

- Observing
- Classifying and sequencing
- Communicating
- Measuring
- Predicting
- Hypothesizing
- Inferring
- Defining, controlling, and manipulating variables
- Designing, constructing, and interpreting models
- Interpreting, analyzing, and evaluating data.

"Understand" refers to various levels of knowledge application. In the Science Standards of Learning these knowledge levels include the ability to:

- Recall or recognize important information, key definitions, terminology, and facts
- Explain the information in one's own words, comprehend how the information is related to other key facts, and suggest additional interpretations of its meaning or importance
- Apply the facts and principles to new problems or situations, recognizing what information is required for a particular situation, explaining new phenomena with the information, determining when there are exceptions
- Analyze the underlying details of important facts and principles, recognizing the key relations and patterns that are not always readily visible
- Arrange and combine important facts and principles to produce a new idea, plan, procedure, or product
- Make judgments about information in terms of accuracy, precision, consistency, or effectiveness.

VIRGINIA

Points		Out of a Possible
A. Expectations, Purpose, Audience	11.5	12
B. Organization	9.0	9
C. Science Content and Approach	24.5	27
D. Quality	9.0	9
E. Seriousness	6.0	6
Inquiry	3	3
Evolution	3	3
Raw Score	66.0	69
Final Percentage Score	96	100
GRADE		**A**

Reviewed: Revised Science Standards of Learning Curriculum Framework and Science Standards for Learning (2003)

Virginia's is another enormous package. Unlike most, however, this one can be read with profit—even, in places, with pleasure—by a literate layperson. It was written to be read, and not just by state or school employees who *must* read it. There are two documents: "Science Standards of Learning," and a significant expansion, the "Standards of Learning Curriculum Framework." Standards are arranged in grade levels for K-6, then as life science and physical science for middle school (7-8), and finally by courses in high school.

A reviewer reported as follows: "Despite the great number of pages, I didn't see much verbiage and no silliness…. Elementary content grows through the strands Scientific Investigation, Reasoning and Logic; Force, Motion and Energy; Matter; Living Systems; Interrelationships in Earth/Space Systems; Earth Patterns, Cycles, and Change; and Resources. The introduction states that the standards are 'not intended to encompass the entire science curriculum' nor 'prescribe how the content should be taught.' I found this refreshing; and if the standards are the whole curriculum (at least in Earth/Space Science) it is enough. …"

The "Framework" repeats the Standards and amplifies them under three heads: Understanding the Standard; Overview; and Essential Knowledge, Skills, and Processes. These explain each standard and provide examples of what is to be learned and done. Such an organization, executed conscientiously, does demand a great deal of paper. In this case, then, the bulk may be justified. The combination of broad standards and detailed explication in the Framework reveals well sequenced curriculum, starting before grade 1 and culminating with a certain sophistication in high school— even in chemistry, where so many states fall down.

In physics, errors and misstatements do turn up, albeit fewer than in other state standards whose writers have tried to offer something comprehensive on the subject. The errors are mostly minor. Thus, "… refraction of light through water and prisms.…" Refraction does not occur "through" uniform transparent media but at their interfaces. This seems a common misconception in state standards. Or, "*Work* is the product of the force exerted on an object and the distance the object moves in the direction of the force." Wrong. Work is the product of the distance an object moves and *the component of the force along the direction of motion.* The object may not move at all in the "direction of the force." Curiously, several important quantitative relations are expressed algebraically in the physical science section but not in the physics section.

The life science treatment is sophisticated. It begins in kindergarten, but grade 1 already introduces material that is both serious and interesting to children: "Conduct simple experiments/investigations related to plant needs by changing one variable (food, air, water, light or place to grow) at a time. Students do not need to know the term variable." Interweaving of science content with science process continues through grade 6. In middle school, cell biology is balanced by ecology. Genetics begins, and so does the real study of evolution. The high school program opens with the history of discovery in biology! This, to keep things balanced, is matched in the program by biotechnology. Evolution has its appropriate place and is presented without the usual glosses and misunderstandings. The standards draw evidence from a variety of sources, including the fossil record, radiometric dating, genetics, biogeography, comparative morphology, and embryology.

Virginia, finally, manages to get matters of Inquiry and process right that most other states muddle. Virginia defines "theory" with the right words: "A theory is an explanation of a large body of information, experimental and inferential, and serves as an overarching framework … subject to change as new evidence becomes available." Grade: "A."

Source: The Thomas B. Fordham Institute, *The State of State Science Standards,* December 2005, http://www.edexcellence.net/doc/Science%20Standards.FinalFinal.pdf

Appendix C

SOL Testing Blueprint for Grade 8

Reporting Categories	Number of Items	Grade Six SOL	Life Science SOL	Physical Science SOL
Scientific Investigation	10	6.1a-k	LS.1a-j	PS.1a-n
Force, Motion, Energy, and Matter	15	6.2a, e 6.4a-g 6.5a, b 6.6a		PS.2a-f PS.3 a, b PS.4a-c PS.5a-c PS.6a-c PS.7a-d PS.8a-d PS.9a-c PS.10a-d PS.11a-c
Life Systems	7		LS.2a-d LS.3a, b LS.4a-c LS.5a-c LS.6a-c LS.13a-g LS.14a	
Ecosystems	7	6.7a-g	LS.7a-d LS.8a, b LS.9a-e LS.10a-c LS.11a-c LS.12a-e	
Earth and Space Systems	11	6.2b-d 6.3a-e 6.5c-g 6.6b-g 6.8a-i 6.9a-d	LS.14b, c	
SOL Excluded From This Test		None		
Total Number of Operational Items	50			
Field Test Items	10			
Total Number of Items	60			