These Questions and Answers should be considered a draft, and not a final document. They will be revised and made widely available, once the New York State Department of Education has issued final recommendations to the Board of Regents for new science standards and their implementation. Please do not cite this draft without permission of the Study Council at Syracuse University. Suggestions for additional questions and modifications or additions to the answers provided here would be gratefully accepted. Please contact Dr. Joseph Shedd, Associate Professor of Educational Leadership, Syracuse University School of Education, at jbshedd@syr.edu.

Questions and Answers (to the extent that they're available) about New York State's adoption of new P-12 Science Learning Standards

Prepared by The Study Council at Syracuse University

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1. Why do we need new science learning standards?

The development of new science learning standards for New York State was prompted by widespread concerns about the competitiveness of America's increasingly technology-dependent economy; concern that too few American students are choosing or are prepared to enter science, technology and engineering fields; evidence of lagging performance of all American students on international assessments of science achievement; evidence of a widening gap in science understanding between students from advantaged and disadvantaged backgrounds; and evidence that understanding science is becoming increasingly necessary in order for all members of our society to be informed citizens, knowledgeable consumers, and effective workers. All of us – not just those trained as scientists – need to have a basic understanding of science, and be able to talk knowledgeably about science with one another.

Our knowledge in different scientific disciplines, our understanding of science itself as a set of concepts and processes, and our understanding of how students develop knowledge of these ideas, concepts and processes have grown dramatically in the fifteen years since science learning standards were last published for America's schools. Not only does the content and pedagogy of science education need to be updated, but students need to learn how to *continue* to learn about science throughout their lives, as the knowledge they will need in the future changes constantly. The new science learning standards now being considered by the New York State Education Department, for adoption later this year by New York's Board of Regents, draw heavily on the Next Generation Science Standards (NGSS). The NGSS are the product of a lengthy development process sponsored by the nation's leading scientific organizations, including the National Research Council, the American Association for the Advancement of Science, and the National Science Teachers Association. They were then reviewed several times by various groups of science educators, administrators, higher education faculty members, scientists and engineers, and representatives of business and industry across New York State. While there were (and in

some cases, still are) lively disagreements among these various stakeholders about particular standards (discussed beloe), virtually all of them endorse the need for new standards and the proposition that the Next Generation Science Standards should be used as the basis for New York's own science standards.

2. What are the main features of the new science standards?

The new standards are structured around three major dimensions: scientific and engineering practices, crosscutting concepts, and key ideas in four disciplinary areas: physical sciences; life sciences; earth and space sciences; and engineering and technology. The science and engineering practices encompass the critical thinking, communication and other skills and habits that scientists and engineers use to develop new knowledge, solve problems, and apply existing knowledge to questions and problems in the real world. The crosscutting concepts encompass basic principles, like cause and effect, systems, patterns, energy, stability and change, that are fundamental to all sciences and engineering and that students (learning to think like scientists and engineers) can use to draw connections among them. The key disciplinary ideas, identified by experts in each field, are those that represent key organizing principles in particular disciplines, provide tools for investigating more complex ideas, and often provide the foundation for knowledge in the other sciences (ideas like matter, force and motion in the physical sciences, ecosystems and evolution in the life sciences, geospheric, hydrospheric, and atmospheric systems in the earth and space sciences, and design principles in engineering).

The basic idea that runs throughout the standards is that none of these dimensions functions independently of the others, and that curriculum, instruction, and assessment should all be organized to help students understand and appreciate their connections. To emphasize these connections, the standards themselves are framed as "performance expectations" that integrate all three dimensions. One fourth-grade performance expectation, for example, specifies that students should be able to "ask questions and predict outcomes about the changes in energy that occur when objects collide." Including the scientific practices (ask questions and predict outcomes) in the standard is meant to guarantee that cross-cutting concepts (energy) and discipline-specific ideas (in this case, physical science ideas about the interaction of matter) will not be reduced to dry facts or definitions that students will memorize without understanding or being able to use them in real-life situations.

Three other prominent features of the new science standards are (1) their inclusion of engineering as an explicit focus of learning, to emphasize the application of scientific knowledge to real-world problems; (2) the organization of standards in sequences that are meant to develop students' knowledge in each discipline (and across disciplines) from one grade level to the next in elementary schools and in grade bands in middle schools and high schools; and (3) the insistence that all students should be expected and enabled to meet all the standards, rather than treating some sciences (typically, chemistry and physics) as specialized electives that are reserved for limited numbers of students. School districts would be free to develop advanced courses in any science subject, so long as they guarantee that all students take courses to meet all the standards.

3. In what ways are the proposed New York State science learning standards likely to be similar to or different from the Next Generation Science Standards being considered by other states?

We do not have a final answer to this question, because the New York State Education Department is currently drafting a third set of proposed standards, based on feedback from statewide stakeholders to a second draft released in December 2015. This second draft retained most of the NGSS's structure and content, but added a set of standards for Pre-Kindergarten classrooms, added, dropped or paired down a few middle school standards, and added several new standards to the high school sequences in each science, six of them in physics and chemistry. The Department did not explain its rationale for these changes, but those who proposed them appear to believe that the NGSS's authors neglected content important for those wanting to pursue careers in science and engineering, while those who object to the proposed additions believe that they upset the NGSS's carefully-designed sequences and that adding significantly more content will force teachers to give more superficial attention to all content, rather than exploring the most important concepts more actively and in greater depth. It is possible that some of these issues will be sorted out when the Department develops guidelines for advanced courses that offer students opportunities to go beyond the courses needed to meet the basic standards.

4. How would the new standards change science education in New York State?

The most prominent change, for many teachers and students, would be a shift from presenting science as a body of information to be memorized, to engaging in science as a process of using existing knowledge and discovering new knowledge to answer questions and solve problems about the natural world. Some observers have said the new standards will represent a shift from "direct instruction" to learning based on "inquiry," but this distinction is misleading, since promoting "inquiry" has been an announced purpose of national and New York science learning standards for over twenty years. It is more accurate to say that the new standards will have students *learn science by doing science*, by developing knowledge of key ideas and crosscutting concepts through the processes of planning and conducting investigations, analyzing data, and making sense of what the data reveal. This will almost certainly require teachers to engage students in a variety of kinds of learning, all of which will require students' *active engagement*. The active engagement required of students is indicated by the gerunds and verbs that are built into the performance expectations: using, interpreting, generating, evaluating, participating, questioning, arguing, defending, explaining, designing, selecting, choosing, predicting, testing, constructing, critiquing. Active engagement is also necessary to develop *dispositions* that are critical to the processes of science and engineering: logical thinking, precision, open-mindedness, questioning one's own reasoning and conclusions, collaborating with others, objectivity, skepticism, and integrity (as in, honest reporting of findings and giving credit to others' work).

The State Education Department and local districts will probably have to reconsider the organization and sequence by which different sciences are addressed in high school, not only to ensure that all students have coursework in chemistry and physics, which have typically been taught as electives, but also because the standards indicate that physics provides many of the foundational ideas on which biology, chemistry, earth science, and engineering depend. Some observers argue that this means that physics should be the first discipline-specific science course required of all students. (Teaching physics first would allow it to be taught when most students are learning algebra, which is employed heavily in physics.) The authors of the NGSS do not take a definitive position on this argument, but rather, offer examples of three alternative ways high school science might be organized. One option would be to combine basic physics and chemistry into a single "physical sciences" course, with life sciences and earth sciences as separate courses; another option would be to offer physics, chemistry, and biology courses, with earth sciences integrated in all three; and a third would drop the idea of separating courses by disciplines and integrate them all in three "thematic" courses sequenced by which key ideas build on others and most closely connect with one another. Engineering principles would be integrated in all courses under any of these options. Again, none of these suggestions would prevent districts from offering advanced high school electives in any of the sciences, so long as the basic science courses that all students take meet all the New York State standards.

Finally, the new science learning standards would require a significant increase in attention to science in elementary schools. The standards assume that students will begin middle school with a much stronger grounding in science than most elementary students currently receive. Most elementary schools provide little time for science instruction, and provide their teachers with minimal professional development or materials with which to teach it. (Most university teacher preparation programs don't provide much attention to teaching science either. Even Syracuse University's elementary preparation program, which has students take two substantive science courses and one science teaching methods course, has difficulty ensuring that its candidates have much opportunity to teach science lessons in their student teaching field placements.)

Besides addressing all of these concerns, schools will confront a more basic dilemma implementing the new science standards. Calls to increase the attention paid to science in elementary schools are likely to be interpreted as calls to *reduce* the attention to language arts, mathematics, social studies, the arts, and other subjects. One way of circumventing this "zero-sum" dilemma might be to develop more ways of *integrating* science and other subjects in common lessons, for example, using mathematics to analyze scientific data, social studies to explore the social consequences of scientific developments, and language arts to formulate and share scientific arguments. But efforts to integrate science instruction with other subjects would require school systems to rethink how all subjects are taught, not simply "tack" science content onto one or another subject. For example, although *reading* informational text and data are important to learning in both science and language arts, as they are in all subjects, they are not appropriate substitutes for actually *doing science*: that is why many observers believe that writing, speaking and listening to others' explanations are generally more important literacy skills in science.

5. What will the curriculum materials and lesson plans that implement the new standards look like, and who will develop them?

These are big (still open) questions. The proposed New York State Science Learning Standards are not, themselves, a curriculum or a set of instructions on how to teach science, but several of their features will affect how curriculum materials and lessons are designed. Their emphasis on performance expectations and developing understanding and mastery of science and engineering practices will require learning to be more "hands on" than it has been in many science classrooms. Their sequence of standards from grade-to-grade will provide a structure for what the curriculum at each grade and school level will need to address. Because teachers at each grade or band level will be expected to address the same standards, there will be more opportunities and incentives for them to work within and across districts to develop common curriculum materials and lesson plans. (The current lack of prescribed sequences allows schools and even individual teachers to pick and choose which subjects they will address and in which order, and makes collaboration less feasible and necessary.) Elementary and secondary teachers, school administrators, university pre-service teacher preparation programs, university faculties of arts and sciences and engineering, as well as professional associations, science- and technology-intensive businesses, research organizations, and nonprofit organizations like hospitals, museums and zoos could play important roles in these development efforts. The key will be to ensure that curriculum development is a collaborative effort of all or many of these groups and not one assigned to one of them. In New York, Boards of Cooperative Education Services will almost certainly play key roles in organizing these collaborative efforts and providing teachers with professional development to implement the new materials and lessons.

6. What assessments will be used to assess students' learning under the new standards? How do we know that these assessments won't divert more time from learning than standardized tests already do?

Again, these are open questions. There are no plans for developing a uniform nationwide set of science tests aligned to the new standards, as there were for the Common Core State Standards in language arts and mathematics. New York's current standardized science tests in the fourth and eighth grades and its Regents examinations in the four basic sciences actually test students' understanding (and to some extent, their ability to apply) scientific knowledge more effectively than the general public realizes, but new tests will have to be developed to reflect the new standards. These tests will almost certainly have to put more emphasis on students demonstrating their ability to *use* what they have learned in extended performance exercises that integrate science and engineering practices, cross-cutting concepts, and discipline-specific key ideas. But integrating the science and engineering practices, in particular, into tests that are administered to all New York's students at a given grade level or subject at a given time will be challenging.

New York already has some experience meeting these kinds of challenges. A recent federally-sponsored study of strategies for assessing science learning under the new standards cites New York's Regents examination in life sciences as a possible model for other states to follow: students, in groups, currently engage in four extended scientific investigations in biology classes over the course of a year, and then answer a series of questions about these investigations on their final Regents examination. The model isn't perfect – it would have to be adjusted if it were to be used in other grades and other Regents subjects, and some have questioned the quality of the exercises presently used -- but the idea of developing performance exercises that would serve simultaneously as teaching modules and assessments could be the key to integrating science and engineering practices into standardized assessments. It could also provide a way of addressing the concerns that many parents and others have raised about "diverting" time from teaching and learning to taking tests. Devoting more time to more extensive assessments does not *have* to mean devoting less time to learning, if the exercises are designed to serve both purposes.

7. How much confidence can we place in the new standards? How much research is there to back them up?

A lot of expertise and research went into formulating the science standards presently being considered by New York State. The Next Generation Science Standards, which serve as the foundation for New York's efforts, were developed by the National Research Council (the research dissemination arm of the National Academies of Sciences) as well as the American Association for the Advancement of Science and the National Science Teachers Association, which together engaged a panel of experts in science, engineering, cognitive science, teaching and learning, curriculum, assessment and education policy to draft a "Framework for K-12 Science Education." Published in 2012, the Framework provided the blueprint for the development of the actual standards. Writing and review teams from twenty-six states, including New York, drafted the standards, involving K-12 teachers, state science and policy staff members, higher education faculty, scientists, engineers, cognitive scientists, and business leaders. Their efforts were coordinated by Achieve, a nonprofit research organization first organized by a bipartisan group of governors and business leaders in the mid-1990's, which also coordinated development of the Common Core State Standards in language arts and mathematics.

The developers of the Framework and the standards themselves drew on extensive bodies of research on various issues, including key developments in each of the sciences, the sequencing of science concepts and ideas, cognitive development of science understanding and critical thinking in science learning, and how countries whose students perform well on international tests of science learning organize their systems of science education. (Those studied: Ontario Canada, Chinese Taipei, England, Finland, Hong Kong, Hungary, Ireland, Japan, Singapore and South Korea.) These studies served as the basis for many of the NGSS's most prominent features, including the integration of practices, cross-cutting concepts, and discipline-specific key ideas in performance expectations; the principle of developing a solid foundation of general science knowledge in elementary and middle

schools before offering discipline-specific courses in high school; the sequencing of topics from grade-to-grade; and the inclusion of engineering within the framework of science education.

8. How much will it cost to implement the new standards? Where will the money and other resources to develop and implement them come from?

This, too, is an open set of questions. New York is beginning to develop plans for implementing new science standards just as it is having to adjust to the loss of federal monies (under the Race-to-the-Top program) that helped fund the initial implementation of Common Core State Standards in language arts and mathematics. State leaders have yet to indicate how (or how heavily) they plan to underwrite the costs of developing curriculum materials, assessments, and professional development for all the teachers and instructional specialists who will be responsible for implementing the new standards. With school districts constrained by restrictions on raising local taxes without support from super-majorities of voters, it is doubtful that individual districts will be able to absorb the substantial costs of implementation by themselves, even with BOCES assistance. In addition, New York and other states will have to review and possibly revise their requirements for teacher certification, and work with colleges and universities to revise their pre-service teacher preparation programs, to ensure that new elementary teachers are well-prepared to teach science and all teachers are prepared to integrate different sciences with each other and (perhaps) with other subjects as well. Implementation will almost certainly require financial support from many sources, and collaboration among federal, state, BOCES, local districts, colleges, and community partners.