

The Brain in Science Education: What Should Everyone Learn?

By Jo Ellen Roseman, Ph.D., and Mary Koppal



Courtesy of the University of California, Davis, Center for Neuroscience

Editor's note: Dr. Jo Ellen Roseman and Mary Koppal, from the American Academy for the Advancement of Science (AAAS), discuss how brain science fits into national classroom curricula. While recommendations published by AAAS, the National Research Council, the Society for Neuroscience, and the College Board all include standards relating to the brain, what students actually learn in the classroom varies greatly from state to state.

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A complementary article, "Promoting Brain Science Literacy in the K-12 Classroom," is available online at <http://dana.org/news/cerebrum/detail.aspx?id=28896>

What should everyone learn about the brain?

At the national level, the American Association for the Advancement of Science (AAAS) describes what adults should know in its seminal work *Science for All Americans*.¹ AAAS also recommends learning goals for K-12 students in its *Benchmarks for Science Literacy*^{2,3} and *Atlas of Science Literacy*^{4,5} and the National Research Council (NRC) offers a similar set of goals in its *National Science Education Standards*.⁶ States and school districts use the AAAS and NRC recommendations as a basis for the design of their own standards, which then inform the development of curriculum and assessment materials (those commercially developed as well as those developed with grant funds). In addition, the neuroscience community has developed its own set of core concepts that K-12 students and the general public should know about the brain and nervous system and has correlated those concepts to the national standards.⁷

Between the AAAS and NRC recommendations, there are some areas of broad consensus on what students should know. According to AAAS's *Benchmarks* and *Atlas*, for example, students in the elementary to middle school grades should understand the following ideas:

- The brain enables human beings to think and sends messages to other body parts to help them work properly.
- The brain gets signals from all parts of the body telling it what is happening in each part. The brain also sends signals to parts of the body to influence what they do.
- Interactions among the senses, nerves, and brain make possible the learning that enables human beings to predict, analyze, and respond to changes in their environments.⁸

The National Research Council's *Standards* offers very similar concepts in the following knowledge statements:

- Internal cues (such as hunger) and external cues (such as changes in the environment) influence the behavior of individual organisms. Humans and other organisms have senses that help them detect internal and external cues.

- All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions when living in a constantly changing external environment.
- Regulation of an organism's internal environment involves sensing that environment and changing physiological activities to keep conditions within the range required to survive.⁹

For high school students, both the AAAS and the NRC learning goals include the role of the nervous system in the rapid transmission of information throughout the body through electrochemical signals. Some but not all of these ideas are also present in the most recent college- and career-readiness standards for science developed by the College Board.¹⁰

Beyond the basic but important concepts about the structure and function of the brain and the nervous system, only AAAS has specified any further knowledge in this area as essential to science literacy. For example, AAAS recommends that an understanding of mental health—including ideas about the mind/body relationship, factors that shape behavior, ways of coping with mental distress, and the diagnosis and treatment of mental disorders—be considered foundational knowledge for all students. AAAS also includes learning as a topic that should be part of a common core of knowledge. Neither the NRC *Standards* nor the College Board *Standards* includes any of these additional brain-related concepts in its recommendations. None of the national standards documents specifies an understanding of the brain that is as detailed and extensive as the core concepts recommended by the Society for Neuroscience.

Although most states claim to have based their science standards on the AAAS *Benchmarks* and the NRC *Standards*, they are not bound by these national recommendations and often interpret them in very different ways so that there is little consistency in standards across the states. As a result, many states list the structure and function of human body systems as a broad topic in their standards, but only some—including Minnesota and North Carolina, for example—specify ideas about the nervous system; others, such as California and Texas, do not. Because of their strong influence on the content included in and excluded from science textbooks, which have been shown to play a central role in determining what is taught in the classroom, the state science

standards are an extremely powerful leverage point for anyone seeking to change the content of the science curriculum.¹¹

Brain scientists, like all members of the scientific community, have a key role to play in promoting a wider understanding of the concepts and skills that are important to their field and to science more generally. To help shape their state and local science standards, researchers and clinicians can volunteer to work with state boards of education to review new and revised science standards documents; they can also work with textbook selection committees to ensure that instructional materials are scientifically accurate and include the science content intended by their state standards. In addition, brain scientists can become effective advocates for high-quality science education for all students in their local communities.

Other models of engagement might also be useful. For example, as the issue of global climate change has become more urgent, earth and atmospheric scientists in federal agencies, universities, and non-governmental organizations have worked together to identify important information for students and adults to understand about climate and the impacts of and responses to climate change. Now that they have developed a framework that lays out the essential principles that all citizens should know about climate science,¹² federal agencies such as NOAA and NASA are funding efforts to develop effective ways to help a wide range of public audiences understand the science and engage in the relevant issues. Project 2061, AAAS's science literacy initiative is leading one such effort. The project is identifying data collected by the National Oceanic and Atmospheric Administration (NOAA) and NASA that can be translated into classroom activities designed to help students understand a variety of weather and climate phenomena and the scientific principles that explain them. Similar efforts to identify phenomena-based learning experiences in the brain sciences—aligned to national and state standards and to the Neuroscience Core Concepts—could be the focus of productive collaborations between brain scientists and K-12 science educators and researchers.

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