

## Teacher Content Knowledge

Accomplished science teachers possess a strong understanding of the concepts, themes, principles, laws, theories, terminology, and factual information that demarcate the specific bodies of scientific knowledge that they are responsible for teaching. They also understand how those bodies of knowledge connect with other scientific disciplines. Accomplished science teachers recognize the importance of mathematics in science and are able to make its application visible to their students. For example, an accomplished teacher would be able to apply algebra to stoichiometry or calculating the speed of an object, geometry to vector analysis or the refraction of light, statistics to determining averages, and probability to Punnett squares. Accomplished teachers stay well informed about current research and developments in science. Teachers understand the role that technology and engineering play in shaping the constructed environment, human interactions, and daily life.

Not only do accomplished teachers have a deep understanding of the specific content knowledge they teach, but they also comprehend the unifying concepts and processes that cut across all areas of science, including cause and effect, systems, patterns, quantity, energy and matter, stability versus change, and structure and function. While instructing their students in the specific subject matter of science, accomplished teachers continually refer to these big, crosscutting concepts, emphasizing their ultimate importance.

All accomplished science teachers possess an understanding of core ideas in the following aspects of science.

### Earth and Space Sciences

Accomplished science teachers understand the current theories about the origin, composition, and structure of the universe and the motion of the objects within it. They also understand that many of the phenomena observed on Earth involve interactions among components of air, water, and land that are driven by the transfer of energy. Accomplished teachers realize that various cycling processes shape the Earth's surface, and they understand the relationship of these processes to environmental conditions in the Earth's atmosphere, oceans, and land masses. Accomplished teachers understand earth and space science through an interacting systems approach.

### Life Sciences

Accomplished science teachers understand the diversity and unity that characterize organisms; the genetic basis for the transfer of biological characteristics from one generation to the next; the structure and function of cells; the organization and physiology of living organisms; the dependence of all organisms on one another and on their environment; the flow of energy and matter in the living environment; the behavior of organisms; the basic concepts of the evolution of species; and the consequences of species loss.

## Physical Sciences

Accomplished science teachers understand the basic properties of matter and the principles governing the interactions between matter and energy and between matter and other matter; the conservation of energy and energy transfer; motion and the principles that explain it; the nature of atoms and molecules and the behavior and interactions between them; the forces that exist between and within objects and atoms; and waves and their applications.

## Depth of Knowledge

Accomplished science teachers have in-depth knowledge of those disciplines they teach in addition to a foundation of scientific knowledge in all of the disciplines. Consider the example of clouds and precipitation. Accomplished science teachers know how the water cycle affects the origins of water vapor in the atmosphere; the principles of evaporation, condensation, and convection; the fact that different cloud types are related to various weather patterns; and the phenomenon and causes of acid rain. However, teachers specializing in earth, environmental, and space sciences have a greater depth of understanding of how natural phenomena such as volcanoes produce emissions of nitrogen and sulfur oxides and how these atmospheric pollutants can impact air and water quality. Teachers specializing in the life sciences have a deeper knowledge of the effects of acid rain on the ecosystem and on the structures and functions of various organisms. Teachers specializing in the physical sciences know more specific information about how acid anhydrides dissolve in water and react with carbonates and metals or how rain falls at a constant velocity when the forces on it are balanced. Regardless of their particular specializations, accomplished teachers understand the relationship of the topic of clouds and precipitation to the crosscutting concepts of energy and matter, flows, cycles, and conservation.

Accomplished science teachers at both the early adolescent and the adolescent-young adult levels ensure that they have the necessary knowledge and skills to teach the curriculum and meet the cognitive needs of students. If a gap in their own scientific understanding is identified, teachers seek out formal or informal science learning opportunities (such as college classes, workshops, conferences, research experiences, and opportunities that combine pedagogy and science) to deepen those understandings. As naturally curious lifelong learners, accomplished science teachers continually expand their content knowledge to remain current and enhance their students' science learning. (See [Standard VII—Advancing Professionalism](#).)

Accomplished science teachers recognize that the overall coherence of their understanding is more valuable than mere recall of fact. The knowledge base of accomplished science teachers is highly integrated.

## Reflective Practices

Accomplished teachers reflect on the nature of science. These teachers reflect on their understanding of science as a human endeavor to understand natural

phenomena. They try to determine how well they incorporate the tenets of science in their instruction. Accomplished teachers reflect on how the nature of science is represented in the curricular choices they make, and the degree to which students demonstrate an understanding of the nature of science. Accomplished teachers monitor how often they use explicit instruction to make connections for students between classroom investigations and the nature of science. Teachers analyze the opportunities they give students to experience the nature of science in their science activities, and teachers evaluate the ways in which they attempt to make those experiences more transparent to their students.

Accomplished science teachers reflect on their understanding of inquiry. They think about the degree to which they guide students in making connections between classroom investigations and understandings about scientific inquiry. Teachers monitor not only students' understanding of content but their understanding of the practice of science, which includes scientific inquiry. Accomplished teachers also reflect on the frequency and extent of opportunities for students to engage in scientific inquiry. Accomplished teachers reflect on how often their learners engage in making observations; posing questions; referencing other data; planning investigations; using tools to gather, analyze, and interpret data; developing hypotheses and justifying claims; and communicating results.

Accomplished teachers reflect on how their own content knowledge and pedagogical knowledge support the practice of teaching science. These teachers reflect on their depth of comprehension and monitor their developing scientific understandings. In specific areas where they perceive gaps in their content knowledge, accomplished teachers participate in professional learning opportunities. Accomplished teachers reflect in order to identify authentic applications of content understandings to real-world situations. Finally, accomplished teachers reflect on their role as lifelong learners and the ways in which they model a commitment to learning science.