Atoms: The Building Blocks of Matter

Student Objectives

- Examine how significant scientific theories are developed.
- Explore the work of scientists who contributed ideas to the field of quantum mechanics.
- Develop a timeline of key scientists to show how the work of each one built on the efforts of those who came before them.

Materials

- *Elements of Chemistry: Atoms: The Building Blocks of Matter* video
- Computer with Internet access
- Print resources about the history of the our understanding of the structure of the atom
- Large sheet of butcher block paper
- Colored pencils and markers

Procedures

1. Begin the lesson by asking students to consider the following questions: How are scientific ideas developed? Do you think one scientist comes up with the idea, or do scientists collaborate? Ask students to write their responses on a sheet of paper and put away their papers until the end of the lesson.
2. Tell students that the focus of today's lesson is how scientists learned about the structure of the atom. Their ideas culminated in what is called quantum mechanics, a set of discoveries that may be considered one of the biggest scientific accomplishments of the 20th century. To provide students with background information, have them watch the segment "Electron Behavior," in the program *Elements of Chemistry: Atoms: The Building Blocks of Matter*.
3. Explain that the class will develop a timeline illustrating what and when scientists contributed to the understanding of the atom's structure. Ask one or two volunteers to draw a timeline from 1900 to 1930 on butcher block paper. Then divide students into groups of three or four; each one to focus on one scientist and his contribution to the understanding of quantum mechanics.
4. Assign each group to one of the following scientists listed below; a brief explanation of each contribution is included.
    - *Max Planck:* In 1900 he put forth the idea that radiation is emitted in discrete quantities that he called quanta.
    - *Albert Einstein:* Building on Planck's ideas, in 1905 Einstein published the idea that the "quanta" was a bundle of light that behaved like a particle.
    - *Ernest Rutherford:* Working with colleagues Hans Geiger and Ernest Marsden in 1911, Rutherford was the first to hypothesize that the center of the atom, which he called the nucleus, is small, dense, and positively charged.
    - *Niels Bohr:* In 1913, he proposed a model of the atom with electrons orbiting the nucleus similar to the planets revolving around the sun. The orbits of electrons depend on their energy, and electrons can jump from one energy level to another; and energy travels in discrete quantities.
    - *James Chadwick and E.S. Bieler*: They proposed in 1921 that a strong force held the nucleus together.
    - *Louis de Broglie:* He proposed in 1924 that electrons could behave as waves under some conditions, a finding that helped scientists understand that the atom didn't behave like the solar system because electrons do not move in regular orbits.

- *Erwin Schrodinger:* Building on de Broglie's idea that electrons act like waves in some situations, he developed the basic equation of quantum mechanics in 1926.
- *Werner Heisenberg:* In 1927 he proposed that it is impossible to know the position and velocity of an electron at the same time; this concept is called the uncertainty principle.
- *Max Born:* Working with Heisenberg in 1927, Born modified Schrodinger's equation of quantum mechanics. His idea helped scientists develop the model of an atom with a nucleus surrounded by electrons at different locations when they are in different energy states.

5. Give students time in class to research their scientists. The following Web sites have useful information.
   - http://www.epa.gov/radiation/understand/rutherford.htm
   - http://www.chemistry.mcmaster.ca/esam/Chapter_1/intro.html
   - http://www.chemistry.mcmaster.ca/esam/Chapter_1/section_1.html
   - http://particleadventure.org/particleadventure/other/history/quantumt.html
   - http://www.cartage.org.lb/en/themes/Sciences/Physics/Atomicphysics/Atomicstruc ture/AtomicTimeline/AtomicTimeline.htm
   - http://www-history.mcs.stand. ac.uk/~history/HistTopics/The_Quantum_age_begins.html
   - http://mooni.fccj.org/~ethall/quantum/quant.htm
   - http://www.oberlin.edu/physics/dstyer/StrangeQM/history.html
6. After students have conducted their research, have them fill in information on the timeline. Once the timeline is complete, ask each group to present a report about the scientist, identifying his contribution and how his work borrowed from that of other scientists.
7. Conclude the lesson by asking students to look at the papers they completed at the beginning of the lesson. Ask what they have learned about this process. How would they modify their original ideas?

Assessment

Use the following three-point rubric to evaluate students' work during this lesson.

- **3 points:** Students demonstrated a deep understanding of how important scientific theories are developed; worked well with their group to conduct in-depth research; and were highly involved in the development of the class timeline.
- **2 points:** Students demonstrated a satisfactory understanding of how important scientific theories are developed; worked satisfactorily with their group to conduct research; and were involved in the development of the class timeline.
- **1 point:** Students demonstrated little or a poor understanding of how important scientific theories are developed; did not work well with their group to conduct research; and were barely or not involved in the development of the class timeline.

Vocabulary

atom
Definition: The fundamental unit of matter made up of protons, neutrons, and electrons
Context: Democritus, a scientist who lived in ancient Greece, was the first person to suggest that everything was made of tiny particles called atoms.

electron
Definition: A negatively charged part of an atom that moves in the space around the nucleus
Context: Werner Heisenberg developed the uncertainty principle, which states that it is impossible to know the position and velocity of an electron at the same time.

nucleus
Definition: The center of an atom that includes positively charged protons and neutral neutrons
Context: Based on a series of experiments conducted by his colleagues Hans Geiger and Ernest Marsden, Ernest Rutherford concluded that the center of an atom is a small, dense area referred to as the nucleus.

quanta
Definition: The name given to the discrete quantities of energy emitted by radiant heat energy, or

radiation
Context: In 1900 German physicist Max Planck proposed that heat energy is emitted or absorbed in discrete units he called quanta.

waves
Definition: The way that electrons behave under certain circumstances
Context: Louis de Broglie discovered that at times electrons behave like particles, but at other times hey behave like waves.

Academic Standards

National Academy of Sciences

The National Science Education Standards provide guidelines for teaching science as well as a coherent vision of what it means to be scientifically literate for students in grades K–12. To view the standards, visit this Web site: http://books.nap.edu/html/nses/html/overview.html#content.
This lesson plan addresses the following national standards:

- Physical Science: Structure of atoms
- History and Nature of Science: Nature of scientific knowledge; Historical perspectives

Mid-continent Research for Education and Learning (McREL)

McREL's Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education addresses 14 content areas. To view the standards and benchmarks, visit http://www.mcrel.org/compendium/browse.asp.
This lesson plan addresses the following national standards:

- Science: Physical Sciences – Understands the structure and properties of matter
- Nature of Science – Understands the nature of scientific knowledge
- Language Arts: Viewing – Uses viewing skills and strategies to understand and interpret visual media; Writing: Uses the general skills and strategies of the writing process, Gathers and uses information for research purposes; Reading: Uses reading skills and strategies to understand and interpret a variety of informational texts