Matter

Student Objectives

- Explain scientists' ideas about the structure of the atom over the last century.
- Describe the scientific underpinnings of the different models that have been proposed.
- Communicate the progression of ideas about the structure of the atom through words and pictures.

Materials

- *Elements of Physics: Matter: Atoms and Molecules* video
- Computer with Internet access
- Print resources about the structure of the atom
- Sheets of poster board
- Markers and colored pencils

Procedures

1. Begin the lesson by asking students to draw a picture of what they think an atom looks like. Ask them to put their images away until the end of the lesson.
2. Tell students that the present-day model of the atom has evolved over many years. To give students some background into contemporary thinking, have them watch the segment "The Ties that Bind," part of the program *Elements of Physics: Matter: Atoms and Molecules*.
3. Explain to students that the history behind our current thinking about the atom is an interesting example of how scientific ideas change as a result of experimentation. Tell students that they will work in small groups to develop a pictorial history of our changing ideas about the atom. They will draw each model proposed and write a caption describing what it shows and the scientific thinking behind the model. Tell students to make sure to show the relationship between the nucleus and the electrons in the drawings of each model.
4. Divide students into small groups of three or four. Give each group one or two sheets of poster board, and put out colored pencils and markers so that students have access to them. Give students time in class to research the topic. Suggest that they use any print resources available, or the Web sites below:
    - http://molaire1.club.fr/e_histoire.html
    - http://everything2.com/index.pl?node=atom
    - http://www.lbl.gov/abc/wallchart/chapters/02/1.html
    - http://www.eurekalert.org/features/doe/2004-12/djna-emo122204.php
    - http://www.broadeducation.com/htmlDemos/AbsorbChem/HistoryAtom/page.htm
    - http://www.lbl.gov/abc/wallchart/chapters/02/4.html
5. Here is a brief chronology summarizing the history of the atom.
    - **"Plum-Pudding" Model**
      Based on the work of J.J. Thomson, who discovered that electrons have a negative charge (about 1897), this model presents the atom as a collection of negatively charged electrons mixed with positively charged particles.
    - **Rutherford Atom**
      Based on the work of Ernest Rutherford in 1911, this model is the first to establish the nucleus in the center of the atom, with negatively charged electrons orbiting it, as planets orbit the sun.

- **Rutherford-Bohr Atom**
  In 1913, Niels Bohr improved upon the Rutherford model by stating that electrons travel the nucleus in a fixed orbit. At times, electrons can move from one energy level to another.
- **Charge-Cloud Model**
  With the emergence of Werner Heisenberg's Uncertainty Principle, which states that it is impossible to know both the location and speed of an electron at the same time, scientists developed what is known as the charge-cloud model. According to this model, electrons move around the nucleus, but no attempt is made to show the orbital paths of the electrons. The electrons are depicted within a cloud to indicate that they are traveling at high speeds.
- **Quantum Model of the Nucleus**
  In 1930, James Chadwick discovered the neutron, which was found to have the same mass as the proton. With this discovery, it became clear that the mass of an atom came from the nucleus.
- **Nuclear Shell Model**
  This model is used to describe the behavior of electrons orbiting the nucleus of an atom. Electrons arrange themselves in shells around the atom, with the outermost shell called the valence shell. If this shell has eight electrons, it is considered stable. During chemical reactions, the valence shell will gain or lose electrons to increase its stability.

6. At the beginning of the next class, give students time to meet in groups and finish their drawings and captions. Then bring the class together for a discussion. Ask volunteers to share their ideas about the atom. Make sure that students understand the differences between each phase in the development of ideas about the structure of the atom.
7. Conclude the lesson by asking students to revisit the drawings they made before completing this activity. How have their ideas changed as a result of researching the atom? Do students think that ideas about the atom will continue to evolve? If so, what new ideas could emerge that might change thinking about the atom?

Assessment

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

- **3 points:** Students showed a deep understanding of scientists' ideas about the atom; could describe in great detail the scientific underpinnings of each model of the atom; and were able to communicate their findings in words and pictures clearly and accurately.
- **2 points:** Students showed some understanding of scientists' ideas about the atom; could describe in some detail the scientific underpinnings of each model of the atom; and were able to communicate their findings in words and pictures satisfactorily.
- **1 point:** Students showed a weak understanding of scientists' ideas about the atom; had difficulty describing the scientific underpinnings of each model of the atom; and had difficulty communicating their findings in words and pictures.

Vocabulary

atom
Definition: The fundamental unit of matter made up of protons, neutrons, and electrons
Context: As scientists learn more about the relationship between electrons and the nucleus of an atom, their ideas about the atom and what it looks like change.

electron
Definition: A negatively charged part of an atom that moves in the space around the nucleus
Context: Electrons configure themselves around an atom in the most stable possible arrangement.

neutron
Definition: A particle found in the nucleus of an atom that does not have an electrical charge
Context: James Chadwick won the Nobel Prize in Physics for discovering the neutron.

proton
Definition: A particle found in the nucleus of an atom that has a positive electrical charge
Context: The protons of an atom stay bundled together in the nucleus because of the strong nuclear force found there.

quark
Definition: Tiny particles that are components of protons and neutrons
Context: The current thinking about protons and neutrons is that protons are made of three quarks that result in a positive charge, while neutrons are made of three quarks that result in no charge.

valence shell
Definition: The outermost shell of an atom that can gain or lose electrons during chemical reactions
Context: If there are eight electrons in the valence shell, then the atom is stable.

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 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: 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