# *Elements of Chemistry*
# *Atoms: The Building Blocks of Matter*
# Teacher's Guide

| **Grade Level:** 9–12 | **Curriculum Focus:** Physical Science | **Lesson Duration:** Three class periods |
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## Program Description

Examine the fundamental building blocks of all matter and how knowledge of the atom has changed our view of the universe. Students will take a look at the structure of atoms and at the composition of different elements, isotopes, and ions. They'll also be introduced to the basic ideas of quantum theory.

## Lesson Plan Summary

Students examine how scientific theories are developed; then they work in small groups to learn about scientists who developed ideas concerning quantum mechanics. The class creates a timeline highlighting key scientists, their contributions, and discoveries.

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## Onscreen Questions

- How does chemistry affect your life?
- Where can nuclear reactions occur?
- Why was Russia able to take advantage of Niels Bohr?
- How does espionage help and hurt international relations?

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## Lesson Plan

### *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 particle5.
   - *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/Atomicstructure/AtomicTimeline/AtomicTimeline.htm
    - http://www-history.mcs.st-and.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

## DVD Content

This program is available in an interactive DVD format. The following information and activities are specific to the DVD version.

### *How To Use the DVD*

The DVD starting screen has the following options:

***Play Video***—This plays the video from start to finish. There are no programmed stops, except by using a remote control. With a computer, depending on the particular software player, a pause button is included with the other video controls.

***Video Index***—Here the video is divided into sections indicated by video thumbnail icons; brief descriptions are noted for each one. Watching all parts in sequence is similar to watching the video from start to finish. To play a particular segment, press Enter on the remote for TV playback; on a computer, click once to highlight a thumbnail and read the accompanying text description and click again to start the video.

***Curriculum Units***—These are specially edited video segments pulled from different sections of the video (see below). These nonlinear segments align with key ideas in the unit of instruction. They include onscreen pre- and post-viewing questions, reproduced below in this Teacher's Guide. Total running times for these segments are noted. To play a particular segment, press Enter on the TV remote or click once on the Curriculum Unit title on a computer.

***Standards Link***—Selecting this option displays a single screen that lists the national academic standards the video addresses.

***Teacher Resources***—This screen gives the technical support number and Web site address.

## *Video Index*

**I. Atoms and Isotopes** (5 min.)
Discover the properties and composition of atoms and isotopes and learn how to determine the atomic mass of an element.

**II. Stable Ion** (4 min.)
Ions are created when atoms gain or lose at least one electron. Examine positive and negative ions in the context of nuclear radiation and fission and fusion reactions.

**III. Electron Behavior** (6 min.)
Gain an understanding of the structures of atoms and the behavior of electrons to see how it's possible to predict how elements combine.

**IV. The Red Bomb: Stolen Secrets** (33 min.)
Trace the history of the first Soviet bomb, which was built in part, thanks to secrets stolen from the United States.

## *Curriculum Units*

1. Atoms and Elements
Pre-viewing question
Q: What do you know about atoms?
A: Answers will vary.

Post-viewing question
Q: What is an isotope and how is the number of an isotope determined?
A: An isotope is an element's atom that has a different number of neutrons, or a copy of an element with a different atomic mass. Isotopes have the same chemical properties as other atoms of an element, but they may have a different mass. The number of the isotope is determined by adding the protons and neutrons.

2. Ions and Nuclear Reactions
Pre-viewing question

Q: What do you know about nuclear energy?
A: Answers will vary.

Post-viewing question
Q: How is an ion positive or negative?
A: An ion with more electrons than protons is negative because the atom takes on a negative charge. An ion with fewer electrons than protons is positive because it has a positive electrical charge.

3. A Top-Secret Team
Pre-viewing question
Q: What makes a country a superpower?
A: Answers will vary.

Post-viewing question
Q: Why did Stalin issue an ultimatum about developing a nuclear bomb?
A: When the U.S. dropped the atomic bomb on Japan, Russia realized its world position was weak without such technology, and this infuriated Stalin. He issued the ultimatum that a Soviet bomb must be ready in five years.

4. Spies Help the Soviets
Pre-viewing question
Q: How difficult is it for countries to maintain secrets?
A: Answers will vary.

Post-viewing question
Q: How did the Soviets obtain details of the U.S. bomb?
A: The Allies agreed to pool their talents for the Manhattan Project in 1943, and German physicist Klaus Fuchs was included. He was given clearance to work on the U.S. atomic bomb program although he had been a communist. He began passing sensitive documents and vital nuclear information to the Soviets, including a blueprint of the first U.S. bomb in 1945.

5. Niels Bohr and the Soviets
Pre-viewing question
Q: Do you think countries should share scientific and military knowledge?
A: Answers will vary.

Post-viewing question
Q: Why did the Soviets turn to Niels Bohr for help building a bomb?
A: Niels Bohr was one of the leading atomic physicists. During World War II, he advised that nations share atomic knowledge, which Allied leaders ignored. The Soviets thought he might be persuaded to put his ideals into action and reveal U.S. atomic secrets.

6. Russia's First Nuclear Reactor
Pre-viewing question
Q: Why is collaboration necessary for work on a major project?
A: Answers will vary.

Post-viewing question
Q: What did the Soviet scientists face if the experimental nuclear reactor had not worked?
A: The Soviet scientists would have lost their jobs and possibly their lives.

7. The First Red Bomb"
Pre-viewing question
Q: What do you know about the Cold War?
A: Answers will vary.

Post-viewing question
Q: How might history have been different if the Soviets had failed to build an atomic bomb?
A: Answers will vary.