



Topic: How Atoms Work

<http://www.howstuffworks.com/atom>



Grade 9-Adult

An integrated lesson plan covering one session of approximately 1.5 - 2 hours.

Lesson-Planning Approach

Some learners perceive their “world” as a whole, where all things are interconnected and dependent upon each other. These “integrated” students face major challenges in coping with our dominant educational, social, and economic systems, which tend to present information in a linear fashion without the necessity of integration into meaningful context. Integrated students are at-risk of failing as they attempt to grasp information in ways that do not match their experience. Among large populations of at-risk students are many from Native American and similar cultures who do not regard their world as a sum of parts but as a blend of all that they experience.

This lesson plan does include some traditional, linear approaches to delivering information (checklists, rules, analysis, problem solving and organization). In addition to the traditional, linear delivery of information, this lesson plan also includes some of the following strategies, designed to appeal to at-risk students as they learn academic/life skills:

- ❖ Integration of technology
- ❖ Story telling/anecdotal information
- ❖ Non-competitive group and team work
- ❖ Performance-based assessment and rubrics
- ❖ Visual presentations and practice through technology and other means
- ❖ Project-based assignments that integrate family and community
- ❖ Activities appealing to multiple intelligences (Gardner)
- ❖ Application of Scientific Method to formulate and solve a problem.

Lesson Overview

This lesson is designed to familiarize students with the concept of atoms and how they combine to form molecules and compounds. Animations and resources are available on the internet. Students will create a model of an atom using an old CD. From their results, they will write a summary, apply relevant vocabulary, and answer questions about the project using correct punctuation, sentence structure, and experimental method.

Lesson Objectives

Project Objectives: When students complete this session, they will be able to...

- ❖ design and create a CD model of an atom.
- ❖ label common parts of an atom.
- ❖ explain how each major part of an atom operates.
- ❖ combine atoms and predict how they will react with other atoms.
- ❖

Integration of Other Functional/Academic Skills: (Critical thinking is required throughout the lesson.) Students will be able to...

Math: locate a specific element on the periodic table and calculate the net charge of the atom

Reading: apply technical vocabulary; find main points and meaning in written passages.

Writing: summarize; define; explain

Listening: Create CD from oral instruction

Science apply scientific method and correctly format an experiment

Technology: apply basic features of Microsoft Word and search a site on the Internet

Anne McGinley (2001)

Atoms

State/National Standards (Complete as Appropriate)

<http://www.cde.state.co.us/cdeassess/sci.htm#standards> 1,2,5,6

Websites

Required:

<http://www.howstuffworks.com/atom>

Support:

<http://antoine.frostburg.edu/chem/senese/101/index.shtml>: General Chemistry Online

<http://library.thinkquest.org/10380/introduction.shtml> Journey into the atom

<http://www.miamisci.org/af/sln/phantom/> The Atoms Family

Pre-requisites: Read at sixth grade level or above.

Required Materials

- ❖ 1 molecular model to share with 2-3 students.
- ❖ Periodic Table
- ❖ Old CD, and beads, sequence, etc. to use for protons and electrons
- ❖ 1 Box of Paper Clips

Handouts (Included at the end of this document)

- ❖ Copy of the Periodic Table ([Handout 1](#)) <http://www.cs.ubc.ca/cgi-bin/nph-pertab/tab/periodic-table>

Anne McGinley (2001)

Atoms

- ❖ Lesson Checklist ([Handout 2](#))
- ❖ Experimental Design ([Handout 3](#))
- ❖ History of the Atom ([Handout 4](#)) <http://www.howstuffworks.com/atom>
- ❖ Lesson Rubric ([Handout 5](#)) [rubric generator](#)

Required Equipment/Technology

- ❖ 1 computer, with Internet connection and a MS Word for every group of 2-3 students
- ❖ Projector
- ❖ Atomic models of basic atoms and DNA double helix

THE LESSON

Note: Students do not learn from what you do but from what you have them do.

PART I

Preparation

Activity	Instructor Notes
Research the topic. Practice the paperclip activity.	Read the link http://www.howstuffworks.com/atom about early scientists trying to figure out what makes up the world around us.
Gather old CD's and objects to use as protons and electrons.	It works best to mention neutrons as something that adds weight in the nucleus but has not charge. Do not attempt to include them in the models at this point
Examine handouts.	Be sure you understand the periodic table.

Presentation

<p>Observe how to find URL's and navigate relevant sites. Have students watch the atom animation on the how atoms work http://www.howstuffworks.com/atom Do the paper clip activity.</p>	<p>Show students how to use URL addresses. Show students how to look up words and information in http://encarta.msn.com/ , http://dictionary.msn.com/ , Have students practice accessing several different URL's with your help.</p>
--	--

Performance and Practice (See Power Point Presentation)

Instructions for students	Teacher notes
<p>Assemble the models to create 4 different elements on the periodic table</p>	<p>Give students the models and explain how to determine the number of protons and electrons from the periodic table.</p>
<p>Go to the Internet and visit http://www.howstuffworks.com/atom Read and print article explaining how an atom works. In a group or in pairs, look up words at http://dictionary.msn.com/ and write definitions.</p>	<p>Help pairs or groups refine and make sense of the information.</p>
<p>Reread the article for meaning, discussing main points. Demonstrate familiarity with terms (list of terms) Paste in your notebook</p>	<p>Have students underline or note important points from the article</p>
<p>Explain how the periodic table is arranged. Create atom models with</p>	<p>Complete the exercise WITH students. Help them arrive at answers. Use the atom sites suggested</p>

Old CD's	and help arrive at solutions together.
Demonstrate understanding by creating a model of 4 different atoms and writing a paragraph about your element (from CD)	Have students draw 4 more atoms and turn them in with a written explanation of how the periodic table is arranged.

Lesson Assessment Strategy (Formative – As the lesson progresses)

Preparation, Presentation and Overall Implementation (Instructor)

1. Are the instructions and expectations for the class clear from the beginning?
2. Am I spending sufficient time on modeling the skills I want students to acquire?
3. Is there enough variety in the lesson to appeal to most learning preferences?
4. How many learning intelligences am I addressing?
5. Are students “connecting” to lesson objectives? How?
6. How is this lesson “integrated?”

Performance and Practice (Student)

1. Do all students have the skills to follow instructions? If not, what measures am I taking to address the challenge?
2. Are all students participating in the activities either by active observation or by voicing their thoughts?
3. Am I identifying the strengths of each student and pairing/grouping people accordingly? What results am I getting?
4. How are students performing? Are all of them able meeting 80% of the lesson objectives? If not, what am I doing to help them achieve more?

Technology

1. Is the technology working?
2. How are students reacting to the technology, and what do I need to remember when I teach this lesson again?
3. How are students applying or wanting to apply their technical skills in other areas?

Anne McGinley (2001)

Atoms

Activity Checklist (Handout 2)

Discuss the topic.	
Handle and examine the atom models.	
Examine and discuss handouts.	
Observe how to find URL's and navigate relevant sites.	
Assemble the models	
Go to the Internet and visit http://www.howstuffworks.com/atom Read the article explaining how atoms work. In a group or in pairs, look up words at http://dictionary.msn.com/ and write definitions.	
Reread the article for meaning, discussing main points.	
Respond in writing to the model building	
Discuss what a summary is.	
In a group, summarize how an atom works. Have someone in the group report the summary and have other students comment on whether anything important was left out.	
Compose a summary paragraph about your element, including all major points and illustrations. Complete the rubric	

Important Terms

- **atom** - smallest piece of an element that keeps its chemical properties
- **compound** - substance that can be broken into elements by chemical reactions
- **electron** - particle orbiting the nucleus of an atom with a negative charge (mass = 9.10×10^{-28} grams)
- **element** - substance that cannot be broken down by chemical reactions
- **ion** - electrically charged atom (i.e., excess positive or negative charge)
- **molecule** - smallest piece of a compound that keeps its chemical properties (made of two or more atoms)
- **neutron** - particle in the nucleus of an atom with no charge (mass = 1.675×10^{-24} grams)
- **nucleus** - dense, central core of an atom (made of protons and neutrons)
- **proton** - particle in the nucleus of an atom with a positive charge (mass = 1.673×10^{-24} grams)

How Atoms Work, by Craig Freudenrich, PhD.

© 2000 How Stuff works

What is an Atom? The Legacy of Ancient Times Through the 19th Century

The modern view of an atom has come from many fields of chemistry and physics. The idea of an atom came from ancient Greek science/philosophy and from the results of 18th and 19th century chemistry:

- concept of the atom
- measurements of atomic mass
- repeating or periodic relationship between the elements

Concept of the Atom

From the ancient Greeks through today, we have pondered what ordinary matter is made of. To understand the problem, here is a simple demonstration from a book entitled "[The Extraordinary Chemistry of Ordinary Things, 3rd Edition](#)" by Carl H. Snyder:

1. Take a pile of paper clips (all of the same size and color).
2. Divide the pile into two equal piles.
3. Divide each of the smaller piles into two equal piles.
4. Repeat step 3 until you are down to a pile containing only one paper clip. That one paper clip still does the job of a paper clip (i.e., hold loose papers together).
5. Now, take a pair of scissors and cut that one paper clip in half. Can half of the paper clip do the same job as the single paper clip?

If you do the same thing with any element, you will reach an indivisible part that has the same properties of the element, like the single paper clip. This indivisible part is called an **atom**.

The idea of the atom was first devised by **Democritus** in 530 B.C. In 1808, an English school teacher and scientist named **John Dalton** proposed the modern atomic theory. Modern **atomic theory** simply states the following:

- **Every element is made of atoms** - piles of paper clips.
- **All atoms of any element are the same** - all the paper clips in the pile are the same size and color.
- **Atoms of different elements are different (size, properties)** - like different sizes and colors of paper clips.

- **Atoms of different elements can combine to form compounds** - you can link different sizes and colors of paper clips together to make new structures.
- In chemical reactions, **atoms are not made, destroyed, or changed** - no new paper clips appear, no paper clips get lost and no paper clips change from one size/color to another.
- In any compound, **the numbers and kinds of atoms remain the same** - the total number and types of paper clips that you start with are the same as when you finish.

Dalton's atomic theory formed the groundwork of chemistry at that time. Dalton envisioned atoms as tiny spheres with hooks on them. With these hooks, one atom could combine with another in definite proportions. But some elements could combine to make different compounds (e.g., hydrogen + oxygen could make water or hydrogen peroxide). So, he could not say anything about the numbers of each atom in the molecules of specific substances. Did water have one oxygen with one hydrogen or one oxygen with two hydrogens? This point was resolved when chemists figured out how to weigh atoms.

How Much Do Atoms Weigh?

The ability to weigh atoms came about by an observation from an Italian chemist named **Amadeo Avagadro**. Avagadro was working with gases (nitrogen, hydrogen, oxygen, chlorine) and noticed that when temperature and pressure was the same, these gases combined in definite volume ratios. For example:

- One liter of nitrogen combined with three liters of hydrogen to form ammonia (NH_3)
- One liter of hydrogen combined with one liter of chlorine to make hydrogen chloride (HCl)

Avagadro said that at the same temperature and pressure, equal volumes of the gases had the same number of molecules. So, by weighing the volumes of gases, he could determine the ratios of atomic masses. For example, a liter of oxygen weighed 16 times more than a liter of hydrogen, so an atom of oxygen must be 16 times the mass of an atom of hydrogen. Work of this type resulted in a relative mass scale for elements in which all of the elements related to carbon (chosen as the standard -12). Once the relative mass scale was made, later experiments were able to relate the mass in grams of a substance to the number of atoms and an atomic mass unit (amu) was found; **1 amu** or **Dalton** is equal to 1.66×10^{-24} grams.

At this time, chemists knew the atomic masses of elements and their chemical properties, and an astonishing phenomenon jumped out at them!

The Properties of Elements Showed a Repeating Pattern

At the time that atomic masses had been discovered, a Russian chemist named **Dimitri Mendeleev** was writing a textbook. For his book, he began to organize

elements in terms of their properties by placing the elements and their newly discovered atomic masses in cards. He arranged the elements by increasing atomic mass and noticed that elements with similar properties appeared at regular intervals or **periods**. Mendeleev's table had two problems:

- There were some gaps in his "periodic table."
- When grouped by properties, most elements had increasing atomic masses, but some were out of order.

To explain the gaps, Mendeleev said that the gaps were due to undiscovered elements. In fact, his table successfully predicted the existence of gallium and germanium, which were discovered later. However, Mendeleev was never able to explain why some of the elements were out of order or why the elements should show this periodic behavior. This would have to wait until we knew about the structure of the atom.

In the next section, we will look at how we discovered the inside of the atom!

The Structure of the Atom: Early 20th Century Science

To know the structure of the atom, we must know the following:

- What are the parts of the atom?
- How are these parts arranged?

Near the end of the 19th century, the atom was thought to be nothing more than a tiny indivisible sphere (Dalton's view). However, a series of discoveries in the fields of chemistry, electricity and magnetism, radioactivity, and quantum mechanics in the late 19th and early 20th centuries changed all of that. Here is what these fields contributed:

- The parts of the atom:
 - **chemistry** and **electromagnetism** ---> **electron** (first subatomic particle)
 - **radioactivity** ---> **nucleus**
 - **proton**
 - **neutron**
- How the atom is arranged - **quantum mechanics puts it all together**:
 - **atomic spectra** ---> **Bohr model** of the atom
 - **wave-particle duality** ---> **Quantum model** of the atom

Chemistry and Electromagnetism: Discovering the Electron

In the late 19th century, chemists and physicists were studying the relationship between electricity and matter. They were placing high voltage electric currents through glass tubes filled with low-pressure gas (mercury, neon, xenon) much

like [neon lights](#). Electric current was carried from one electrode (**cathode**) through the gas to the other electrode (**anode**) by a beam called **cathode rays**. In 1897, a British physicist, **J. J. Thomson** did a series of experiments with the following results:

- He found that if the tube was placed within an electric or magnetic field, then the **cathode rays could be deflected or moved** (this is how the [the cathode ray tube \(CRT\) on your television](#) works).
- By applying an electric field alone, a magnetic field alone, or both in combination, **Thomson could measure the ratio of the electric charge to the mass of the cathode rays**.
- He found the **same charge to mass ratio of cathode rays was seen regardless of what material was inside the tube** or what the cathode was made of.

Thomson concluded the following:

- **Cathode rays were made of tiny, negatively charged particles**, which he called **electrons**.
- The **electrons had to come from inside the atoms** of the gas or metal electrode.
- Because the charge to mass ratio was the same for any substance, the **electrons were a basic part of all atoms**.
- Because the charge to mass ratio of the electron was very high, the **electron must be very small**.

Later, an American Physicist named [Robert Milikan](#) measured the electrical charge of an electron. With these two numbers (charge, charge to mass ratio), physicists calculated the mass of the electron as 9.10×10^{-28} grams. For comparison, a U.S. penny has a mass of 2.5 grams; so, 2.7×10^{27} or 2.7 billion billion electrons would weigh as much as a penny!

Two other conclusions came from the discovery of the electron:

- Because the electron was negatively charged and atoms are electrically neutral, **there must be a positive charge somewhere in the atom**.
- Because electrons are so much smaller than atoms, **there must be other, more massive particles in the atom**.

From these results, Thomson proposed a model of the atom that was like a watermelon. The red part was the positive charge and the seeds were the electrons.

Radioactivity: Discovering the Nucleus, the Proton and the Neutron

About the same time as Thomson's experiments with cathode rays, physicists such as by Henri Becquerel, Marie Curie, Pierre Curie, and Ernest Rutherford

were studying [radioactivity](#). Radioactivity was characterized by three types of emitted rays (see [How Radioactivity Works](#) for details):

- **Alpha particles** - positively charged and massive. Ernest Rutherford showed that these particles were the nucleus of a helium atom.
- **Beta particles** - negatively charged and light (later shown to be electrons).
- **Gamma rays** - neutrally charged and no mass (i.e., energy).

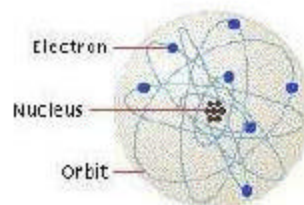
The experiment from radioactivity that contributed most to our knowledge of the structure of the atom was done by Rutherford and his colleagues. Rutherford bombarded a thin foil of gold with a beam of alpha particles and looked at the beams on a fluorescent screen, he noticed the following:

- Most of the particles went straight through the foil and struck the screen.
- Some (0.1 percent) were deflected or scattered in front (at various angles) of the foil, while others were scattered behind the foil.

Rutherford concluded that the **gold atoms were mostly empty space**, which allowed most of the alpha particles through. However, some **small region of the atom must have been dense** enough to deflect or scatter the alpha particle. He called this dense region **the nucleus** (see [The Rutherford Experiment](#) for an excellent Java simulation of this important experiment!); the nucleus comprised most of the mass of the atom. Later, when Rutherford bombarded nitrogen with alpha particles, a positively charged particle that was lighter than the alpha particle was emitted. He called these particles **protons** and realized that they were a fundamental particle in the nucleus. Protons have a mass of 1.673×10^{-24} grams, about 1,835 times larger than an electron!

However, protons could not be the only particle in the nucleus because the number of protons in any given element (determined by the electrical charge) was less than the weight of the nucleus. Therefore, a third, neutrally charged particle must exist! It was **James Chadwick**, a British physicist and co-worker of Rutherford, who discovered the third subatomic particle, the **neutron**. Chadwick bombarded beryllium foil with alpha particles and noticed a neutral radiation coming out. This neutral radiation could in turn knock protons out of the nuclei of other substances. Chadwick concluded that this radiation was a stream of neutrally charged particles with about the same mass as a proton; the neutron has a mass of 1.675×10^{-24} grams.

Now that the parts of the atom were known, how were they arranged to make an atom? Rutherford's gold foil experiment indicated that the nucleus was in the center of the atom and that the atom was mostly empty space. So, he envisioned the atom as the positively charged nucleus in the center with the negatively charged electrons circling around it much like a planet with moons. Although he had no



Rutherford's view of the atom

evidence that the electrons circled the nucleus, his model seemed reasonable; however, it presented a problem. As the electrons moved in a circle, they would lose energy and give off light. The loss of energy would slow the electrons down. Like any [satellite](#), the slowing electrons would fall into the nucleus. In fact, it was calculated that a Rutherford atom would last only billionths of a second before collapsing! Something was missing!

Pueblo Community College
Cortez, CO

Name:
Teacher: Anne McGinley
Date: Wed. Oct 10, 2001
Course: Biology

How Atoms Work

Students will explore and describe how atoms work using manipulatives and internet

Expectations:

Criteria:	Level 4 (80% - 100%)	Level 3 (70% - 79%)	Level 2 (60% - 69%)	Level 1 (50% - 59%)
Knowledge				
identify chemical substances and reactions in everyday life	always or almost always identifies chemical substances and reactions in everyday life	often identifies chemical substances and reactions in everyday life	sometimes identifies chemical substances and reactions in everyday life	rarely identifies chemical substances and reactions in everyday life
explain the periodic law	explains the periodic law with thorough understanding	explains the periodic law with considerable understanding	explains the periodic law with some understanding	explains the periodic law with limited understanding
Thinking				
use the octet rule to explain how different elements combine	uses the octet rule to explain how different elements combine with thorough comprehension	uses the octet rule to explain how different elements combine with considerable comprehension	uses the octet rule to explain how different elements combine with some comprehension	uses the octet rule to explain how different elements combine with limited comprehension
Communication				
use appropriate scientific vocabulary	always or almost always uses appropriate scientific vocabulary	often uses appropriate scientific vocabulary	sometimes uses appropriate scientific vocabulary	rarely uses appropriate scientific vocabulary
select and use proper modes of representation to communicate ideas, plans, and results	always or almost always selects and uses proper modes of representation when communicating	often selects and uses proper modes of representation when communicating	sometimes selects and uses proper modes of representation when communicating	rarely selects and uses proper modes of representation when communicating
construct molecular models	constructs molecular models with excellent accuracy	constructs molecular models with considerable accuracy	constructs molecular models with some accuracy	constructs molecular models with limited accuracy