Scrutinizing the Atomic Theory

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INTRODUCTION

It is very discouraging to ask students questions about the atom, only to find out that they have not bought into the idea that atoms even exist. It is understandable, however, if we consider that the human race itself did not believe in the existence of atoms until fairly recently (within the last several hundreds of years). We need to develop patience with learners who do not immediately swallow all the things we tell them in science. In this unit I am working to provide a developmental approach to the modern theory of the atom, so that students can see where we have been and how we got to this point in our understanding of the world of the small.

After all, very few students have beheld with their eyes, the atom. The evidence is not overwhelming. With the atomic force microscope (one of the few techniques capable of generating pictures of individual atoms) still sporting a very high price tag, it is unlikely that students as a group will be doing much viewing of the atom first hand any time soon. However, over the years people have come up with the theories about the atom; those theories, although they ultimately proved to be incorrect, were useful for their time in that they provided a way of organizing the data that was available. Additionally they allowed for the making of predictions that would either validate the theories or push them aside in favor of more accurate ones.

Current pedagogical thinking would dictate that students do not readily learn what we tell them is true. Of course in science, truth is constantly changing as we investigate in more detail the physical realm, and truth in science is understandably continually in flux. Nevertheless, particularly in science, there are some things it is important for us to hardwire into their mental framework so that students can organize and categorize all the volumes of information flowing into their portals from all directions. It is important that students get a chance to trace the historical development of our notions about the basic particles so that they are not being asked to accept things that just spring from nowhere. We wonder why students seem to go blank when they are confronted with heavy-duty standardized testing and yet part of the problem is found in the way we present things to them as being absolute truth dropped out of heaven instead of ideas that organically develop through time fueled by more and more convincing evidence, changing and morphing through a process of keeping what works and constructing what is required.

In this unit students will be asked to work in groups to develop a poster that has a scientist to represent the different period of the development of the atomic theory. First it should have a picture of the model's author (Democritus, Dalton, Thomson, Rutherford, Bohr, Schrodinger). Beside the picture, there will be a diagrammatic representation of the model itself, including labels and explanations that would render the model comprehensible. There would be a discussion and drawings of the ideas that the model replaced or expanded upon.

The primary intention for creating this unit is to provide a creative way to introduce students to the history of the atom and challenge them to use their imagination to explore its former knowledge. This unit will allow the students the opportunity to creatively research, scan the Internet, make historical observations, and utilize cooperative group work. The curriculum unit will provide a framework in the science class to integrate with other curricula. The students will learn to prioritize (rank in order of importance), infer (read between the lines), draw conclusions, and summarize information.

A great way to incorporate unique ideas, exceptional teaching skills, intrinsic motivation, and enthusiasm for the classroom is through using activities in the curriculum that will increase student interest. The opportunity to develop and disseminate materials that would assist others will have significant impact on the overall classroom by incorporating the teacher's skills into the educational environment. The curriculum unit could be customized to focus on the particular needs and interests of the student and the teacher. Materials will be incorporated to keep the skills current and give students practice with questions similar to those they will encounter on semester examinations and standardized tests. Student activities with Internet-based science labs will be identified and used in the classroom activities.

This curriculum unit will be taught to a mixed-ability class of students. This will make teaching more challenging. The ninth grade students that I teach have the lowest mathematic skills. Many of my students possess Attention Deficit Hyperactivity Disorder (ADHD). Some have been diagnosed and others have not yet received the necessary medical attention. Many years ago, if a student had too much energy, he was told to run around on the playground for a while. Now doctors give him drugs. Some authorities seem to think that we have more students with attention problems because this generation is easily bored due to excessive television viewing and permissive parents who buy them too many toys. As educators, we are left with the decisions of how to deal with these students. So our decisions are based on a mix of theories learned in teacher education, trial and error, craft knowledge, and gut instinct. Such gut knowledge often serves us well, but is there anything sturdier to rely on? These students really present a different challenge. This lesson may be used with the middle school physical science class as well.

It is desired that the varied activities of this lesson will help to combat or relieve some of the problems of the ADHD. The breaking of the tasks into smaller chunks helps, that is makes tasks shorter and more manageable. Prompts should be used, especially for rules and time intervals. Prompts on time are also important to these students. Some have trouble focusing attention and remaining organized. Upon completing cooperative work, keep reminding them of the rules. Immediate and frequent consequences are necessary. Making the consequences immediate may help them to make that connection. For example, a child may be told to work alone for a few minutes if he is disturbing others. Positive consequences should follow positive behaviors, as well. The child should be rewarded or praised when he politely works cooperatively with the group in which he was originally placed.

The specific questions guiding the unit are:

1. Who discovered the atomic theory?
2. Was the discoverer a philosopher or scientist?
3. Were there inadequacies about the atomic theory?

BACKGROUND

Knowledge of the atom is something that belongs to our own time. But actually the idea of the atom goes back more than 2,300 years ago. The earliest atomists belong to a group of philosophers who, centuries before the birth of Christ, began to reason about the world around them. They were the famous philosopher-naturalists of ancient Greece.

Before these men were born, it was thought that everything in the world was the work of gods, genies, and demons of all kinds. The Greek thinkers began to reason systematically. They used logic and tried to understand and explain nature and her laws. These philosophers were the very first (recorded) who reasoned that there is such a thing as a law of nature that a reasoning mind can detect and understand.

The enlightened period in the history of mankind began with the great Thales of Miletus, a city in Asia Minor. Thales was the first of the Greek philosopher-naturalists. He traveled a great deal and at one time he must have conferred with Babylonian astronomers who were diligent observers of the sky. Thales inspected their tables which had faithfully recorded all eclipses of the sun and the moon that had been observed since thousands of years before their time. The Babylonians and people in this age thought that a huge dragon resided in the sky, and every once in a while the dragon would swallow the sun or the moon and obscure these heavenly lights in the awful coils of its tail. Thales knew that these eclipses returned at certain regular intervals. He began to draw conclusions and make predictions that came true. Exact data go back to the ancient Greeks. Thus we can say that the light of reason began to shine for the first time when the light of the sun was blotted out temporarily by the moon. The ideas of the Greek philosophers were possibly not much more than lucky guesses. They did nothing to test their "hunches" by making experiments. Little did they imagine that the future scientists would be able to prove that atoms exist and even weigh and measure them.

OVERVIEW OF THE ATOM

About 80 years after the death of Thales, the philosopher Democritus was born in Abdera, a little town in Thrace, a providence of ancient Greece. The Greeks have a long tradition of having a word for everything and this case was no different. The word they had for atom was *atomos*. Ancient Greek philosophers were exceedingly curious about matter, the stuff of which all substances are made – the air we breathe and the water we drink, our clothes, and tools, the earth under our feet, the roof over our heads, smoke rising from a fire, or even the amazing things that go on in our own bodies. Everything consisted of matter, but the Greeks wondered what is matter? How small can it be and still exist? Democritus was intrigued by these questions and he applied himself to reasoning out logical answers. His solution, arrived at some 2,500 years ago, maintained that the basic building block of all matter is the *atomos* (*uncuttable*), or the atom. According to William Anderson, Democritus visualized the atom as smaller than anything man had previously conceived, so small as to be invisible. The atom he presented was the final unit of all matter; it was indestructible and indivisible. He theorized that identical matter consists of identical atoms, but the differences between one type of matter and another are reflections of the differences in size, shape and weight of their respective atoms. However, they did not suspect one thing that turned out to be correct centuries later: *The atoms are in constant motion*.

Around 1800 there were many chemists conducting countless chemical experiments in their laboratories. They weighed and measured. These scientists found that some elements did not mix in any desired amounts. Some combined in a chemical reaction. These scientists' work was very important, but somehow they did not realize the way in which nature combines her elements to form many different compounds that were already known in this time. A remarkable law states that elements combine only in certain proportions. John Dalton was the first who recognized this law in all its striking clarity and he lifted it out of the tables that chemists had written. Then he recognized that this wonderful law could be explained by the atom. So Dalton began to design his famous atomic theory of matter. He claimed that there exists an unknown force that acts between atoms to hold them together. He even drew pictures of his atom – little dots and circles with rays indicating the force that acts between them. He also drew pictures of how atoms group together to form larger pieces of matter. The students will portray him as they create the live time-line of the atom.

In 1897, J. J. Thomson provided the first hint that the atom is made up of even smaller particles. Thomson was studying the passage of an electric current through a gas. The gas gave off rays that Thomson showed were made of negatively charged events. Thomson called the negatively charged particles "corpuscles." Today they are known as electrons. Thomson was never able to find the positively charged particles to make the atom neutral.

In 1903 the famous English scientist Ernest Rutherford and his chemical co-worker, Frederick Soddy, did most of this fascinating detective work. They came forth with their explanation of radioactivity. It destroyed the atom of Dalton, and the element of Boyle. According to Haber, it proved that the atom had been misnamed since Democritus first named it. No longer could it be considered "uncuttable." Rutherford and Soddy showed that some atoms, at least, cut themselves to pieces by their own actions. In 1908, Rutherford devised an experiment to test Thomson's model. He fired a stream of positively charged particles at a very thin sheet of gold foil. Surrounding the foil was a screen coated with a material that glowed whenever a positively charged particle hit the screen. Rutherford knew that positive charges repel other positive charges. Because of the way his positively charged particles acted, he proposed that an atom had a small *nucleus*. The nucleus is tiny compared to the atom as a whole. To get an idea of the size of the nucleus in an atom, think of a marble in a baseball stadium. The baseball stadium represents the size of the atom while the marble represents the nucleus.

Rutherford's model proposed that negatively charged electrons were held in an atom by the attraction between them and the positively charged nucleus. But he did not state where the electrons are in the atom. In 1913, the Danish scientist Neils Bohr proposed an improvement to the Rutherford model that placed each electron on a specific energy level. According to Bohr's model, electrons move in definite orbits around the nucleus, much like planets circle the sun.

By 1926, scientists had developed the **electron cloud model** of the atom that is used today. An electron cloud is the area around the nucleus of an atom where its electrons are most likely to be found. The electrons are located in an electron cloud surrounding the nucleus of the atom. Because an electron's mass is small and the electron is moving so quickly about the nucleus, it is impossible to describe its exact location in an atom. An electron cloud is a region of space in which the electrons of the atom are found.

It is important that students get a chance to trace the development of our notion of the basic particles so that they are not being asked to just accept things that spring from nowhere. In this unit, students will work in groups to develop posters that have six things. First it should have a picture of the model's author (Democritus, Dalton, Thomson, Rutherford, Bohr, and DeBroglie). Beside the picture, there will be a diagrammatic representation of the model itself including labels, and explanations that would render the model comprehensible. There would be a discussion and drawings of the ideas that the model replaced or expanded upon. There would be a section where concurrent related world events are listed. One person from each group would volunteer to present the poster to the class in sequence starting with the Greek *atomos*. Each scientist would be given a chance to introduce himself, talk about the ideas that were vague at the time, discuss how the ideas and theories are an improvement over the current thinking, and, of course, the model in detail.

Our school just set up a computer lab for the science department. A casual search of the Internet yields a phenomenal amount of material for each scientist named above. Students will not have a problem locating pictures, biographical information, and materials outlining the intellectual achievements of the theorists who have helped shape our current understanding of the atom. Allowing students time to look at atomic theory as a living, developing model may seem like a non-essential expenditure of precious class time, but the alternative, leaving students with no mental picture of what scientists mean when they say the word "atom," is going to cost time and effort in every other aspect of the curriculum. It is going to condemn students to a life of memorizing instead of understanding.

UNIT OBJECTIVES

This unit is designed to aid students to predict, trace and analyze the historical development of the atom over the last 1500 years.

1. The students will describe the development of the atomic theory and the changes that have taken place in it.
2. The students will describe the contributions of key scientist including Dalton, Thomson, Rutherford, and Bohr to the modern atomic theory and draw a model of each of these scientists' atoms.
3. The students will analyze the experiments by the above-mentioned scientist and list what they learned from the experiment.

This unit is designed for one to two weeks with assessments. Additional details will be obtained as the students observe and experience the carefully planned and implemented demonstrations of the atomic models of Democritus, Dalton, Thomson, Rutherford, and Bohr.

Day 1 & 2 - Students will design and present the atomic model posters.
Day 3 & 4 - Teacher demonstrates the lab activities for each scientist of the history of the atom.
Day 5 - Students demonstrate drawings as they relate to the above scientist.
Day 6 - Students demonstrate drawings of Bohr's model of the atom (Hands–on activity).
Day 7- Lab and assessment

CONTENT

Democritus proposed the idea that atoms make up all substances, and that the atom was *uncuttable* (solid particles that could not be subdivided). This concept of the atom's structure remained unchallenged until the 1900s. Then researchers began to discover through experiments that atoms were composed of still smaller particles. He believed movement of atoms caused the changes in matter that he observed.

Although Democritus's theory of the atom explained some observations, Democritus was unable to provide the evidence needed to convince people that atoms really existed. Throughout centuries that followed, some people supported Democritus's theory while other theories were proposed.

John Dalton, in the 1800s, was able to offer proof that atoms exist. His model of the atom was a simple solid sphere. Experimental data indicated that whenever a given compound was formed, the element combined in the same percentage by mass. In Dalton's model, an atom is an indivisible sphere with a uniform density throughout. All atoms of the same element have the same mass and chemical behavior, while atoms of different elements have different masses and different chemical behavior. He is considered to be the Father of the Atomic Theory.

J. J. Thomson in 1897 set out to explore the passing of current through gases at low pressure. He discovered the electron from this experiment. When Thompson tested the experiment, he found the ratio of the charge of an electron to its mass to be constant.

He did another experiment in which he attracted a beam of electrons to a positively charged metal plate, concluding that the beam must be negative since opposites attract. Based on Thompson's observation from the experiment, he concluded that these atoms of gas did release negatively charged particles. These particles from the gas had to be negative because of the principle of charges that opposites attract and they were always attracted to the positive plate or positive anode. Thompson named these particles electrons. Unlike the deflection of electrons, which was the same for all gases, Thompson found that the deflection of positive ions varied with different gases in the tube.

As a result of Thompson's further studies, another piece of the atomic puzzle had been revealed. Revising Dalton's atomic model, Thompson imagined an atom to be like plum pudding – a common desert of that era. The pudding representing the positive charge and most of the mass of the atom was uniformly distributed throughout a sphere. The plums were the electrons scattered throughout the pudding in order to make the atom electrically neutral. This was the first major modification of the atomic theory since Dalton's theory.

Earnest Rutherford's gold-foil experiment yielded evidence of the atomic nucleus. Rutherford and his coworker aimed a beam of alpha particles at a sheet of gold foil surrounded by a fluorescent screen. Most of the particles passed through the foil with no deflection at all. A few particles were greatly deflected. Rutherford concluded that most of the alpha particles pass through the gold foil because the atom is mostly empty spaces. The mass and positive charges are concentrated in a small region of the atom. Rutherford called this region the nucleus. Particles that approach the nucleus closely are greatly deflected. He proposed that satellites called electrons travel in orbits around the nucleus. The nucleus has a positive charge of electricity while the electrons each have a negative charge. The charges carried by the electron add up to the same amount of electricity as resides in the nucleus, and thus the normal state of the atom is neutral.

Neils Bohr, a student of Rutherford, believed Rutherford's model needed improvement. He changed Rutherford's model to include newer discoveries about how the energy of an atom changes when it absorbs or emits light. He considered the simplest atom, hydrogen, which has one electron. Bohr proposed that an electron is found only in specific circular paths, or orbits, around the nucleus. This accounts for the development of the Energy Level model of the atom. His theory that the atom contained energy levels within it on which the electron could travel is based upon the line spectra that he observed from hydrogen and other element when the atoms were excited with high voltage or heat energy like a flame test. Bohr suggested that electrons in an atom move in set paths around the nucleus much like the planets orbit the sun in our solar system. In Bohr's model, each electron has a certain energy level that is determined by its path around the nucleus. The path defines the electron's *energy level*. Electrons can only be in certain energy levels. They must gain energy to move to a higher energy level or lose energy to move to a lower level.

Neils Bohr developed a theory to account for the location of electrons around the nucleus of an atom. He believed that his theory would explain the light emitted by burning different elements. He proposed that electrons follow specific paths, or orbits**,** around the nucleus. These paths, or energy levels, are numbered starting with the lowest as 1, the next 2, the next highest as 3, and so forth. The number of the energy letter is denoted by *n*. The higher the energy levels of an atom, the farther its electrons are located from the nucleus. Bohr's model resembled a planetary system where the electrons revolved around the nucleus. The first energy level, nearest the nucleus, was called n = 1. Each level thereafter increased by one number to n =7. The orbits about the nucleus are called energy levels because they are different and very specific energies associated with each level. Bohr knew energy was being added to an element when it was heated or when an electrical current was passed through the element. This extra energy has to go somewhere. The added energy is absorbed by the electrons in the outermost orbit (farthest from the nucleus). Because there are specific amounts of energy associated with each energy level, the electron absorbing all of this extra energy can no longer stay in the orbit (energy level) in which it belongs. Instead, it will jump to another energy level located farther away from the nucleus. This is called an *excited electron***.**

This electron will not spend the rest of its time in this far away energy level. The excited electron is now very unstable. Because this is an unstable state, the electron will soon fall back to its normal state. To do this, it has to emit exactly the same amount of energy it had absorbed in the first place. This is where the atomic spectra enter the picture. Bohr's theory of the atom gave birth to the **quantum theory,** a name that reflects the notion that atoms absorb and emit energy in a quantized manner.

At first Bohr's model appeared to be very promising. The energy levels calculated by Bohr closely agreed with the values obtained from the hydrogen emission spectrum. However, when Bohr's model was applied to the atoms other than hydrogen, it did not work at all. Although some attempts were made to adapt the model using elliptical orbits, it was concluded that Bohr's model was fundamentally incorrect, according to Stephen Zumdahl. The model is however, very important historically, because it showed that the observed quantization of energy in atoms could be explained by making simple assumptions. Bohr's model paved the way for later theories. It is important to realize, that the current theory of atomic structure is in no way derived from the Bohr model. Electrons do not move around the nucleus in circular orbits (249).

By the mid – 1920s it had become apparent that the Bohr model could not be made to work. A totally new approach was needed. This is when the next two physicists were at the forefront of this effort and pursued this line of reasoning.

Erwin Schrodinger is given credit for the most current electron cloud model of the atom. He developed mathematical equations to describe the motion of electrons in atoms. His work led to the electron cloud model. Each energy sublevel corresponds to an orbital of a different shape, which describes where the electron is likely to be found. There is a regularity of the plots in that all *s* orbital have the same shape. All *s* orbitals have the shape of a sphere. The three orbitals in the *p* sublevel for atoms all have the same shape. All *p* orbitals are shaped like a long balloon squeezed together in the middle. Because there are three of these in every major sublevel, they are found to point along the direction of a set of *x, y, z* coordinate axis intersecting at the nucleus.

Pursuing the line of reasoning that de Broglie introduced, Schrodinger decided to attack the problem of atomic structure by giving emphasis to the wave properties of the electron. To both physicists, the electron bound to the nucleus seemed similar to a **standing wave,** and they began research on a **wave mechanical model** of the atom**.**

The most familiar example of a standing wave occurs in association with musical instruments such as guitars or violins, where a string attached at both ends vibrates to produce the musical tone. The waves are described as standing, since they are stationary. The waves do not travel the length of the string.

Louis Victor de Broglie recognized the possibility that atomic-sized particles can have wave-like properties. He used the photoelectric effect to demonstrate that light, usually thought of as having wave properties, can also have the properties of particles. According to Kotz and Treichel, de Broglie proposed in 1925 that a free electron of mass *m* moving with a velocity *v* should have an associated wavelength. This idea was revolutionary because it linked the particle properties of the electron (*m* and *v*) with a wave property (?) (269).

SAFETY

In designing the laboratory experiments, there is a major emphasis placed on safety. As the laboratory demonstrations are developed, you will notice laboratory demonstrations without the use of strong chemicals that are considered dangerous. However, regardless of the strength of the chemicals, it is always important that you take safety precautions by being cognizant of space, being careful while handling equipment, and always wearing protection. If you spill something, clean it up properly. If you dispose of materials, do so in an appropriate manner. When you are finished with a laboratory, clean the workspace, and then wash your hands. If you instruct students properly, they will feel comfortable while working in a chemistry laboratory setting.

LESSON 1: INTERNET SEARCH OF THE HISTORY OF THE ATOM

Purpose

To acquire skill using the Internet and obtain information on the pioneers that developed the atomic theory.

Background

Students will go to Yahoo and do a search for the history of the atom. The materials have to be read by the students and when the correct information is found, they should print it out. The information will be obtained for the following scientists: Democritus, John Dalton, J. J. Thomson, Earnest Rutherford, Neils Bohr, Erwin Schrodinger, and Louis Victor de Broglie.

Procedures

After collecting information, the students will assemble the historical development of the atom with their group. Upon completion of this activity, an oral presentation will be presented to the class with another group video taping the presentation that will be judged later.

LESSON 2: ATOMIC STRUCTURE OF THE ATOM

Purpose

Research and describe the historical development of the atomic theory.

Background

Students will work in groups of four to develop the posters. First it should have a picture of the model's author (Democritus, Dalton, Thomson, Rutherford, Bohr, and Schrodinger). After designing the poster, there will be a diagrammatic representation of the model itself including labels and explanations that would render the model comprehensible. There will be a discussion and drawing of the idea that the model replaced or expanded upon.

Materials

Computer paper
color pencils/map colors or markers
IPC Glencoe Text (pages 547 to 549)
Ruler
creative imagination
Cellophane tape

Procedures

1. Each group will receive 6 sections of computer paper or 6 sheets of white paper taped together.
2. The text – pages 547 to 549 – provides the information for each scientist.
   a. The scientist's name
   b. The drawing of the atom associated with the scientist discovery
   c. Information regarding the scientist
   d. The date of scientific discovery
3. On the last sheet, draw and label the atom that best represents the modern atom.

This activity is designed for one day. Additional details may be obtained as the student progresses on the carefully detailed work. The answers are provided for you but the keys to any good lesson are student engagement and teacher enthusiasm.

LESSON 3: ATOMIC MODEL DEMONSTRATIONS AND EXPERIMENTS FOR DEMOCRITUS, DALTON, THOMPSON, RUTHERFORD, AND MODERN ATOMIC THEORY.

Purpose

Demonstrate various activities depicting the various stages of the development of the Atomic Theory.

Materials

Cheese squares for each group, plastic knife, 2 collecting bottles, 6 Volt battery, 2 pieces of insulated wire, shallow tray with water, faucet with tap water, sink, charged comb or balloon, chicken wire, M & M's, chocolate chip cookies, balloons with sesame seeds

Safety

Safety goggles, gloves and apron

Democritus

Background Information: (Bold faced info is worth discussing)

Democritus proposed that elements consist of tiny, solid particles that could not be subdivided. He called these particles – *atomos*. The actual meaning of the word is uncuttable.

Who was Democritus? He was a Greek Philosopher who lived in about 400 BC.

What is a philosopher? Someone who loves coming up with ideas about things such as life, nature, morals, etc.

Was he a scientist? No, he did no experiments as far as we know. He may have done simple smashing demonstrations described below but no data was collected or recorded.

Demonstration or Experiment: The teacher will provide each table with real cheese squares and a plastic knife. Ask the students to cut the cheese in half and keep cutting in half – eating the other piece until the cheese can not be divided into halves anymore by ordinary means. Advise the students that this, what is left, is what uncuttable (indivisible) means according to Democritus.

Was Democritus right? No, but we did not witness the breaking down of atoms until the time of J.J. Thomson around 1900, some 2500 years later.

Why was the atomic theory not believable? No experiments.

John Dalton

He is sometimes called the Father of the Atomic Theory. He was the first scientist to experiment to try to prove the existence of the atom. His theory is listed below and only one of the points is true.

Dalton's Atomic Theory:

1. All elements are composed of tiny indivisible particles called atoms.
2. Atoms of the same element are identical.
3. Atoms of different elements can physically mix together to form compounds.
4. Chemical reactions occur when atoms are separated, joined or rearranged.

Ask the students to see which of these statements are true today and which of these are false?

Actually, only # 4 is true.

Laws of Electromagnetism

This can be demonstrated with bar magnets. Take two bar magnets from the materials shelf. You will note that the ends of each bar magnet are labeled N (north – seeking) and S (south – seeking). Because the poles of the magnet exhibit behavior similar to electrical charges, we will label the ends as positive (+) and negative (-). In this way the ends of the magnet can represent positive and negative electrical charges. An interesting exercise is to take two bar magnets and observe what occurs when the positive pole of one magnet is placed next to the negative pole of the other magnet. Try this. Next, place the two positive poles of the magnet together. Record you observation in the space below.

(+) next to (-) ____________________________
(attraction or repulsion)

(+) next to (+) ____________________________
(attraction or repulsion)

The ends of the bar magnets do not carry any electrical charges, but the behavior of the magnetic pole is similar to that of charged particles. Charged particles are particles with either a positive charge (+) or a negative charge (-). We call two negative charges or two positive charges **like charges.** The laws of electromagnetism state two like charges repel one another while unlike charges attract one another. Knowledge about the interactions of charged particles was extremely important or valuable in the discovery of the particles making up atoms because these particles were found to carry electrical charges.

J. J. Thomson

Demonstration

Use a small stream of water from the sink. Tell the children the story of Thomson's Gas tube experiment as described above. Advise the students that the stream of water represents the flow of electrons from the anode to the cathode in this gas tube. Finally, charge a balloon positive by rubbing it vigorously against your hair or a cloth. (Wool or fur is best but a good sweater fabric will work.). Next bring the charged side of the balloon next to the stream of water and watch it bend.

***What happens to the water stream*?** (It should be attracted up to three or four inches depending on the charge.)

What point of Dalton's theory did Thomson prove wrong? (That atoms are indivisible, cannot be broken down into smaller particles).

***Why did Thomson have to have the positive mass in his model of the atom*?** (He needed a positive mass to hold onto the electrons that were negative. Remind them that opposites attract.)

Ernest Rutherford

Demonstration

Get a piece of chicken wire and hold it up while throwing M & M's toward it. As the M & M's hit the wire, they are deflected while the others go through. Place a chocolate chip cookie near by and students can compare Rutherford's model with Thompson's, model.

***What happens to the alpha particles when they hit the wire*? (**They are deflected).

***Rutherford did not know what to do with the electron discovered earlier. Why did the atom have to have electrons also*? (**It had to be electrically neutral; atoms in their neutral state are not charged).

Neils Bohr

Demonstration

1. The first part of the demonstration is to add a few sesame seeds to a large balloon and inflate it.
2. Shake the seeds around the balloon to stimulate the electron moving around outside the nucleus. This is actually what Rutherford thought, but Neils Bohr thought there was much more to it than that. (Point out to the students how scientists feed off each other's ideas and challenge each other's theories to get a better idea of what is going on). If sesame seeds are not available, grains of wheat kernels will serve the same results.
3. Draw the analogy for the students that the atom is like a bookcase with different levels, and each level can hold so many electrons and each level represents a specific energy level within the atom where the electrons are moving.

Modern Atomic Model

To understand this idea, think of a cow in a pasture where some areas have green grass and others none. Where would you most likely find this cow? Yes in the areas where there is grass. An electron orbital describes a region in space where an electron is most likely to be found. There is an "s" orbital (with a circular shape) at every energy level. It is the lowest energy level and it will be the first orbital to fill with electrons.

The students will complete a probability lab to demonstrate this concept.

ASSESSMENT QUESTIONS

1. Explain what the Greek word *atomos* means.
2. How can the color of flames be used to classify chemicals?
3. Whose theory of the atom gave birth to the quantum theory?
4. What is a line spectrum?
5. How is an electron excited?
6. Write the electron configuration of atoms.
7. Draw orbital diagrams of the first ten elements.
8. From your time line, which of the authors was not a scientist?
9. Describe the Bohr Model of the atom.
10. Explain the relationship between atomic spectra and the development of the quantum mechanical theory
11. How would you describe an alchemist?
12. How would you describe an atom?
13. What are atoms made off?
14. List the charges of particles of atoms?
15. How would you describe the orbital of an electron?
16. What are energy levels?
17. Summarize the main ideas of Dalton' atomic theory.
18. Explain why Dalton was more successful than Democritus.
19. Compare an atoms structure to a ladder.
20. Explain how the path of an electron differs in Bohr's model and in the Modern Model of the atom.

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Zumdahl, Stephen. Chemistry. Lexington, MA: D. C. Heath and Company, 2002.

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He gives the story of nuclear energy, including its history. He also gives meaning to the *atom.*

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This book was written in memory of Ernest Rutherford and Peter Kapitza.

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Asimov, Isaac. *Inside the Atom.* New York: Abelard – Schuman Inc., 1966.
The latest atomic discoveries have been incorporated in this book. He explains that every thing is made up of atoms and then discusses the atomic arrangement.

Fermi, Laura. *Atoms in the Family.* Chicago: University of Chicago Press, 1954.
It gives the birth certificate of the atomic era, and gives encounters of her life and the work made possible through the squash-court experiment.