# Atoms

## Teacher's Guide
## Middle School

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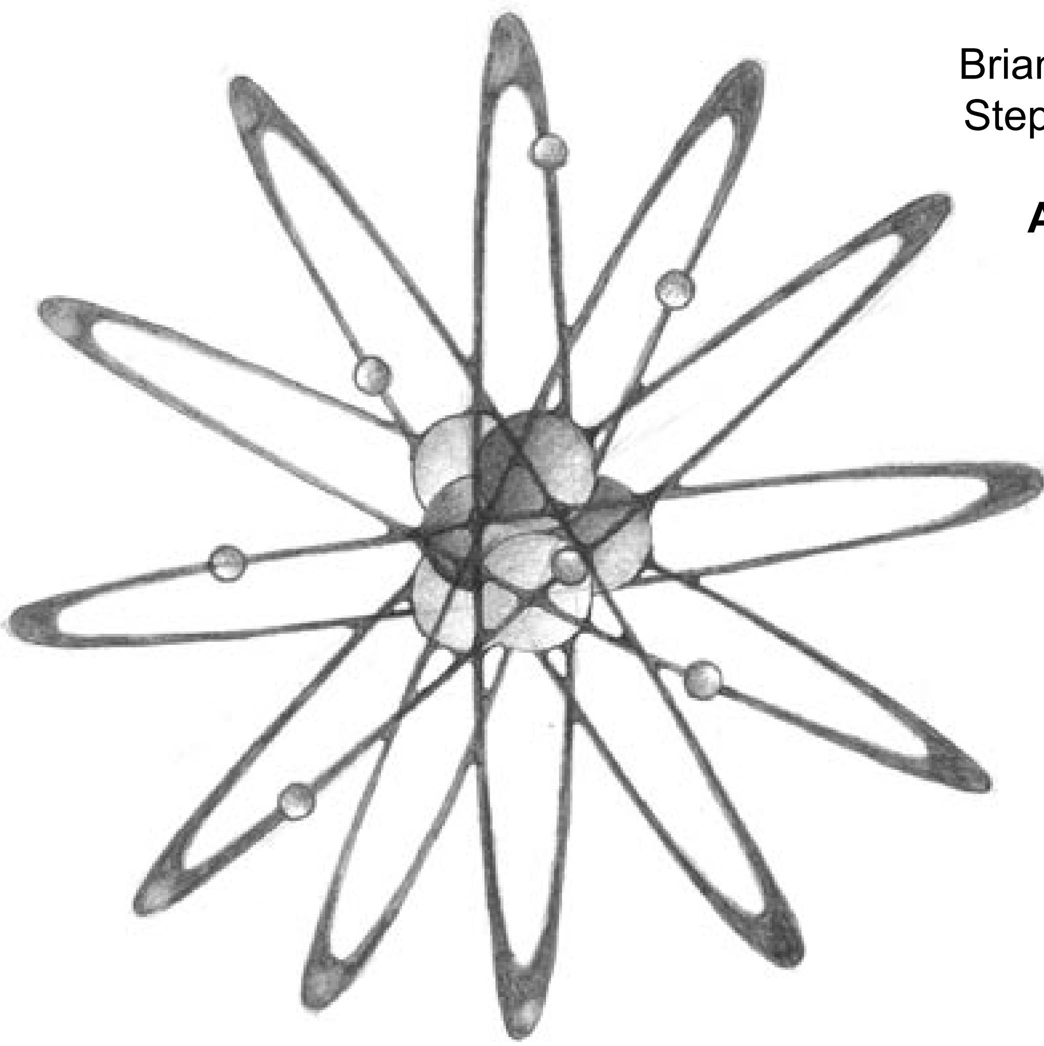

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# A Message from our Company. . .

Dear Educator:

Thank you for your interest in the educational videos produced by the Visual Learning Company. We are a Vermont-based, family owned and operated business specializing in the production of quality educational science videos and materials.

We have a long family tradition of education. Our grandmothers graduated from normal school in the 1920's to become teachers. Brian's mother was an elementary teacher and guidance counselor, and his father was a high school teacher and superintendent. This family tradition inspired Brian to become a science teacher, and to earn a Ph.D. in education, and led Stephanie to work on science educational programs at NASA.

In developing this video, accompanying teacher's guide, and student activities, our goal is to provide educators with the highest quality materials, thus enabling students to be successful. In this era of more demanding standards and assessment requirements, supplementary materials need to be curricular and standards based - this is what we do!

Our videos and accompanying materials focus on the key concepts and vocabulary required by national and state standards and goals. It is our mission to help students meet these goals and standards, while experiencing the joy and thrill of science.

Sincerely,

Brian and Stephanie Jerome

# National Standards Correlations

## National Science Education Standards
**(Content standards: 5-8, National Academy of Sciences, c. 1996)**

As a result of their activities in grades 5-8, all students should develop an understanding that:

History and Nature of Science - Content Standard G:

- Many individuals have contributed to the traditions of science. Studying some of these individuals provides further understanding of scientific inquiry, science as a human endeavor, the nature of science, and the relationships between science and society.
- Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently take for granted.

Physical Science - Content Standard B:

- Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. In chemical reactions, the total mass is conserved. Substances often are placed in categories or groups if they react in similar ways; metals are an example of such a group.

Physical Science - Content Standard E:

- Students should organize materials and other resources, plan their work, make good use of group collaboration where appropriate, choose suitable tools and techniques, and work with appropriate measurement methods to ensure adequate accuracy.

## Benchmarks for Science Literacy
**(Project 2061 – AAAS, c. 1993)**

The Physical Setting - The Structure of Matter - (4D)

By the end of 8th grade, students should know that:

- All matter is made up of atoms, which are far too small to be seen directly through a microscope. The atoms of any element are alike but are different from atoms of other elements. Atoms may stick together in well-defined molecules or may be packed together in large arrays. Different arrangements of atoms into groups compose all substances.
- Scientific ideas about elements were borrowed from some Greek philosophers of 2,000 years earlier, who believed that everything was made from four basic substances: air, earth, fire, and water. It was the combinations of these "elements" in different proportions that gave other substances their observable properties. The Greeks were wrong about those four, but now over 100 different elements have been identified, some rare and some plentiful, out of which everything is made. Because most elements tend to combine with others, few elements are found in their pure form.

# Student Learning Objectives

Upon viewing the video and completing the enclosed student activities, students will be able to do the following:

- Explain that matter is made up of tiny particles we cannot see.
- Describe the fact that atoms are the building blocks of matter. Atoms of the same element are alike.
- Discuss some of the important contributions of John Dalton including the concepts that pure substance called elements are made up of the same type of atom, atoms of different elements are different from each other, and that compounds are formed by joining the atoms of two or more elements.
- Recognize the important discoveries made by sicentists such as J.J. Thomson, Henri Becqerel, Pierre Curie, Marie Curie, Ernest Rutherford, and Niels Bohr.
- List the three types of subatomic particles found in the atom: neutrons, protons, and electrons.
- Create a simple diagram of an atom labelling the protons, neutrons, and electrons.
- Describe the role and position of protons and neutrons in the nucleus. Also state that most of the mass of an atom is found in the nucleus.
- Describe the fact that electrons have a negative charge and orbit around the nucleus.
- State that the atomic number is equivalent to the number of protons in an atom.
- Understand that an isotope is an atom that has the same number of protons as another atom of the same element, but a different number of neutrons.
- Explain the meaning of atomic mass unit (AMU) and describe how AMUs are used to compute the mass of an atom.
- Describe that the sum of the protons and neutrons of an atom is called the mass number.
- Define the atomic mass as the average of all the isotopes of an atom.

# Assessment

## Preliminary Assessment:

The Preliminary Assessment, provided in the Student Masters section, is an assessment tool designed to gain an understanding of students' pre-existing knowledge. It can also be used as a benchmark upon which to assess student progress based on the objectives stated on the previous pages.

## Video Review:

The Video Review, provided in the Student Masters section, can be used as an assessment tool or as a student activity. There are two main parts. The first part contains questions that can be answered during the video. The second series of ten questions consists of a video quiz to be answered at the conclusion of the video.

## Post Assessment:

The Post Assessment, provided in the Student Masters section, can be utilized as an assessment tool following completion of the video and student activities. The results of the Post Assessment can be compared against the results of the Preliminary Assessment to evaluate student progress.

# Introducing the Video

Before showing the program, ask students to take out a piece of scrap paper and a pencil. Hold up a piece of copper wire or an aluminum can. Tell them that the substance is made up of copper or aluminum, depending on what you choose. Next, ask students to create an enlarged drawing of what the smallest particle of one of these substances might look like. Allow them several minutes to complete their drawings.

After they have completed their drawings ask for volunteers to share their drawings with the class, explaining some of the features they included. As a class discuss how they felt making their drawings. Were they frustrated, puzzled, or confused? Tell them that over the past several centuries scientists faced the same challenge: to develop an understanding of what the smallest particles of matter looked like and how they behaved.

Tells students to pay close attention to the program to see how some the the greatest minds in history struggled to understand the nature of atoms. You may also want to write some important terminology on the board such as atom, subatomic particle, proton, neutron, electron, isotope, and atomic mass. Tell students that the meaning of these terms will be discussed in the program.

# Video Viewing Suggestions

The student Master “Video Review” is provided for distribution to students. You may choose to have your students complete this Master while viewing the program or to do so upon its conclusion.

The program is approximately 20-minutes in length and includes a ten-question video quiz. Answers are not provided to the Video Quiz on the video, but are included in this teacher’s guide. You may choose to grade student quizzes as an assessment tool or to review the answers in class.

The video is content-rich with numerous vocabulary words. For this reason you may want to periodically stop the video to review and discuss new terminology and concepts.

# Video Script: Atoms

1. Have you ever wondered what a flower is made of?…
2. …or the feathers on a bird?
3. …or what makes up the clothes you are wearing?
4. Have you ever thought about what water is made of?…
5. …or air?…
6. …or snow? All these things are made of matter.
7. Matter has mass and takes up space, or in other words, it has volume.
8. But, what is matter made up of? Matter is made up of tiny particles called atoms.
9. What do these particles look like?
10. What is inside them? And what makes them different from each other?
11. During the next few minutes we are going to explore these questions and others as we explore the fascinating features of atoms.
12. **Graphic Transition – Small Particles**
13. This is a piece of copper flashing.
14. Let's cut it in half, then cut it in half again, and then cut it in half again. If it were possible to continue to cut the copper in half, what is the smallest possible piece that we could make?
15. The smallest possible piece is an atom.
16. But exactly what are atoms? Let us take a closer look at this question.
17. **Graphic Transition – Early Ideas About Atoms**
18. More than 2,000 years ago the Greek philosopher, Democritus, stated that matter could not be divided into smaller and smaller pieces forever. Eventually, the smallest piece of matter could be obtained.
19. This idea was largely forgotten until the early 1800's. That is when English chemist John Dalton…
20. …began observing the activities of weather by studying gases. Through his experiments and observations Dalton developed the basic ideas of the atomic theory.
21. Dalton concluded that pure substances called elements are made of extremely small particles called atoms.
22. He stated that atoms of the same element are exactly alike.
23. And the atoms of different elements are different from one another.
24. Dalton also stated that atoms could not be changed into different types of atoms by chemical reactions.
25. He also theorized that compounds are formed by joining the atoms of two or more elements.
26. These ideas served as the basis for what is known as the atomic theory.

# Script (cont.)

**27. Graphic Transition – Thomson's Model of Atoms**
28. Late in the 19th century, in 1897, another scientist by the name of J.J. Thomson hypothesized that atoms are made up of even smaller particles.
29. Thomson conducted experiments in which an electric current was passed through tubes pumped almost empty of air.
**30. You Observe!** What do you see when the electric current passes through the tube?
31. You can see that light is given off. This light is created by rays traveling through the tube.
32. Thomson observed that when a magnetic charge is introduced, the rays are deflected.
33. Thomson reasoned that the rays were made up of negatively charged particles.
34. Today, we know these negatively charged particles found in atoms are electrons.
35. Thomson also hypothesized that positively charged material existed in the atom.
36. In his model of the atom, he proposed that an atom was made of a positively charged material in which negatively charged electrons were scattered.
37. His model of the atom became known as the "plum pudding" model. He envisioned small electrons embedded in the atom, much like raisins embedded in pudding.
38. At about the same time, Henri Becquerel, Pierre Curie, and Marie Curie were learning fascinating things about the way certain elements emit energy in a process called radiation.
**39. Graphic Transition – Rutherford's Model of the Atom**
40. In 1911, building upon the previous work of other scientists, Ernest Rutherford, a British scientist, developed a revised theory of the atom.
41. In one famous experiment he fired a stream of positively charged particles at a thin sheet of gold foil.
42. He observed that most of the positively charged particles passed right through the gold foil.
43. He concluded that the particles in the gold foil contained a great deal of empty space,…
44. …contradicting Thomson's ideas of a solid atom.
45. Also, while most of the positively charged particles passed through the foil, some bounced directly backward.
46. Knowing that positive charges repel each other, Rutherford concluded that atoms were made up of a small, dense, positively charged center which repelled positively charged particles fired at it.
47. He named the center of the atom the nucleus.
48. Rutherford hypothesized that the positively charged particles were concentrated in the nucleus of the atom…

# Script (cont.)

49. …and negatively charged electrons were scattered around the space outside the nucleus.
50. **Graphic Transition – Bohr Model of the Atom**
51. In 1913, a Danish scientist by the name of Niels Bohr improved upon Rutherford's model of the atom.
52. While Rutherford proposed that negatively charged electrons were held in orbit by the positively charged nucleus, he did not describe the location of the electrons.
53. Niels Bohr proposed that electrons move in orbits around the nucleus.
54. And he proposed that these orbital paths, or energy levels are located at various distances from the nucleus.
55. Today, we refer to Bohr's theory as the Bohr Model of the Atom.
56. **Graphic Transition – Subatomic Particles**
57. Today, we know that all matter is made up of tiny particles called atoms.
58. In fact, atoms are the building blocks of matter.
59. As we discussed, many scientists over the centuries have contributed to our present day understanding of the atom.
60. We now know that atoms are made up of smaller particles called subatomic particles.
61. The three main subatomic particles include protons, neutrons, and electrons.
62. Protons are positively charged subatomic particles located in the nucleus of an atom.
63. Neutrons are subatomic particles that have a neutral charge. They are also located in the nucleus.
64. Electrons are tiny subatomic particles that whirl around the outside of the nucleus. Electrons carry a negative charge.
65. **Graphic Transition – The Nucleus**
66. As we already stated, the nucleus is the dense core of an atom.
67. The nucleus contains over 99 percent of the mass of an atom.
68. However, it occupies only about 1/100,000 of the space.
69. If we let this marble represent the nucleus of an atom, it would occupy this much space in this football stadium…
70. …with the electrons orbiting at the far ends of the stadium.
71. Within the nucleus are located protons and neutrons.
72. Protons have a positive charge and also have mass.
73. Scientists use a special unit of mass called an atomic mass unit or AMU for short to measure the mass of protons.
74. One proton has a mass of one AMU.

# Script (cont.)

75. Neutrons have a neutral charge and a mass that is just slightly greater than that of a proton.
76. However, the mass of a neutron is generally considered to be one atomic mass unit.
**77. You Compare!** What makes atoms different from each other?
78. The answer lies in the number of protons. Different atoms have different number of protons.
79. For example, a helium atom has two protons…
80. …and aluminum atoms have 13 protons.
81. The number of protons in the nucleus is called the atomic number.
82. Hydrogen, for example, has one proton, and has an atomic number of one.
83. Whereas, oxygen has eight protons, and has an atomic number of eight.
**84. Graphic Transition – Isotopes**
85. The atomic number of an element does not change; meaning the number of protons is constant.
86. But, the number of neutrons of an element can change.
87. Believe it or not, atoms of the same element can have different numbers of neutrons. These are called isotopes.
88. An isotope is an atom that has the same number of protons as another atom of the same element, but a different number of neutrons.
89. The element carbon found in this pencil tip can be an isotope.
90. For example, carbon may have six neutrons or eight neutrons.
**91. Graphic Transition – Atomic Mass**
92. The sum of the protons and neutrons of an atom is called the mass number.
93. The element sulfur found in this yellow stone has 16 protons and 16 neutrons.
**94. You Compute!** What is the mass number of sulfur?
95. The mass number of sulfur is achieved by adding 16 protons and 16 neutrons to get a mass number of 32.
96. In nature, a sample of a given element contains a mixture of the isotopes of that element. For example, carbon can exist as carbon 12 and carbon 14.
97. These isotopes are averaged together to get the atomic mass. Atomic mass is the average of the isotopes of an element.
98. Carbon has an atomic mass of 12.011 which represents the average mass of its existing isotopes.
**99. Graphic Transition - Electrons**
100. While neutrons and protons are small, electrons found swirling around the nucleus are even smaller.
101. In fact, electrons are approximately 1/2,000 the mass of a proton or neutron.

# Script (cont.)

102. While electrons are extremely small, they do have a charge – a negative charge.
103. In atoms with an overall neutral charge, the number of electrons equals the number of protons.
104. Electrons orbit the nucleus at extremely fast speeds. In fact, electrons may speed around the nucleus a billion times in one second!
105. Scientists refer to the general space that electrons occupy as the electron cloud.
106. The electron cloud can be thought of as similar to the space where bees are found swarming around a hive.
107. Electrons are locked into certain areas within the electron cloud.
108. These areas are called energy levels.
109. Electrons with a relatively low amount of energy have their electrons located in energy levels close to the nucleus.
110. Whereas, high-energy atoms possess electrons located farther from the nucleus.
111. The arrangement of electrons in energy levels is very important in determining how an atom will interact with other atoms.
112. **Graphic Transition – Summing Up**
113. During the past few minutes we have explored some of the fascinating characteristics of atoms.
114. We saw how our understanding of atoms has increased through the work of different scientists such as John Dalton who stated that an element is made up of the same kind of atoms.
115. And that compounds are made up of two or more different kinds of atoms joined together.
116. We saw how J.J. Thomson's experiments led him to believe that atoms are made up of smaller particles.
117. Ernest Rutherford built on Thomson's ideas and stated that atoms possess a positively charged dense nucleus surrounded by negatively charged electrons.
118. In 1913, Niels Bohr proposed that electrons move in definite orbits around the nucleus, which we now refer to as Bohr's Model of the Atom.
119. Today, we know that both protons and neutrons make up the nucleus of an atom.
120. While the nucleus occupies a small amount of an atom's space it represents 99% of its mass.
121. Finally, we discussed how swirling negatively charged electrons form an electron cloud around the nucleus.
122. So, the next time you look across a room…
123. …or take a walk. Think about the atoms found in matter.
124. You just might think about your world a little differently.

# Script (cont.)

**125. Graphic Transition – Video Assessment**

Fill in the correct word to complete the sentence. Good luck and let us get started.

1. _________ has mass and volume.
2. An ________ is the smallest complete particle of matter.
3. The three main subatomic particles include protons, _________, and electrons.
4. ________ possess a positive charge.
5. Protons and neutrons make up the________.
6. A neutron has an atomic mass of about _________.
7. An atom with six protons and six neutrons has a mass number of ________.
8. The atomic number of an atom is equal to the number of _______.
9. _____________ have a negative charge.
10. Electrons orbit in paths called _________ levels.

# Student Assessments and Activities

## Assessment Masters:

- Preliminary Assessment
- Video Review
- Post Assessment

## Student Activity Masters:

- Modelling Atoms
- History of the Atom
- Vocabulary of *Atoms*

# Answers to Student Assessments

**Preliminary Assessment (pgs. 20-21)**

1. particles
2. atoms
3. element
4. compounds
5. subatomic
6. nucleus
7. neutral
8. protons
9. electrons
10. negative
11. true
12. true
13. false
14. false
15. false
16. true
17. true
18. false
19. true
20. false

**Video Review (pg. 22)**

1. Light is given off when the electric current passes through the tube.
2. Different atoms have different atomic numbers, or numbers of protons.
3. The mass number of sulfur is 32. This answer is achieved by adding sulfur's 16 protons and 16 neutrons together.

**Video Quiz (p. 22)**

1. matter
2. atom
3. neutrons
4. protons
5. nucleus
6. one AMU (atomic mass unit)
7. twelve
8. protons
9. electrons
10. energy

**Post Assessment (pgs. 23-24)**

1. atoms
2. neutral
3. negative
4. particles
5. element
6. subatomic
7. protons
8. nucleus
9. electrons
10. compounds
11. true
12. true
13. false
14. true
15. false
16. false
17. false
18. true
19. true
20. false

# Answers to Student Activities

**<u>Modeling Atoms</u> (pg. 25-26)**

1. Answers will vary.
2. Answers will vary. The atomic number is the number of protons in the atom.
3. Answers will vary. The mass number is the sum of the protons and neutrons in an atom.
4. Protons, neutrons, and electrons are subatomic particles.
5. Protons have a positive charge. Neutrons have a neutral charge. Electrons have a negative charge.

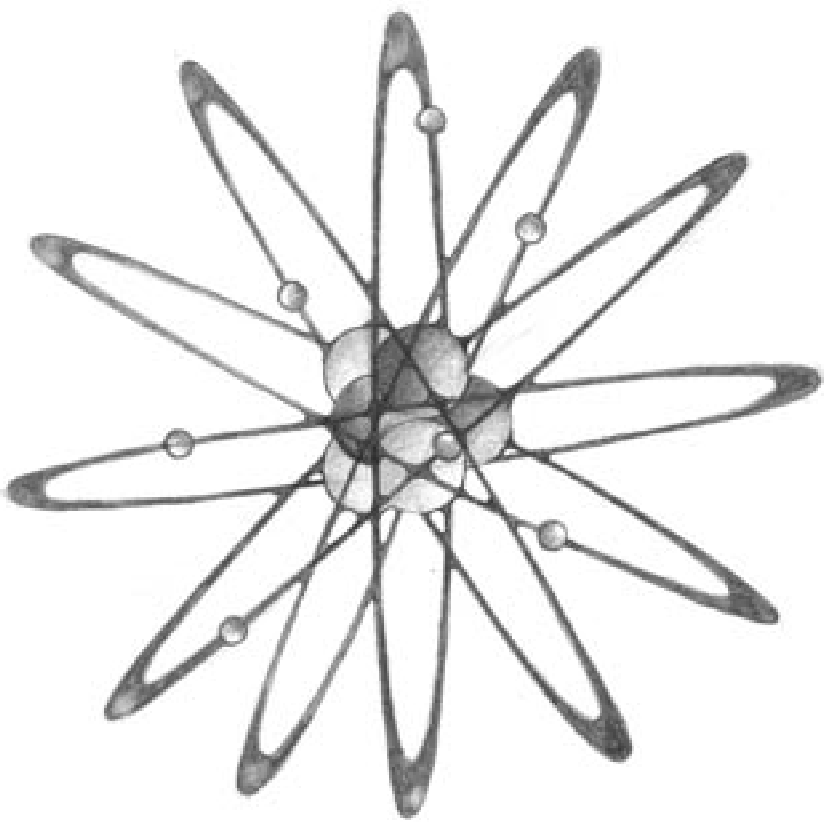
**<u>History of the Atom</u> (pgs. 27-29)**

1. Advances in technology have helped atomic research advance.
2. Democritus' idea was ignored for a long time because it couldn't be proven. After technology advanced the idea could be proven true.
3. J.J. Thomson developed the plum pudding model.
4. Marie Curie researched ways to use radioactivity in medicine.
5. Nuclear fission can be used a source of energy to be converted to electricity, which people use every day.

**<u>Vocabulary of *Atoms*</u> (pg. 30)**

1. c - nucleus
2. a - atoms
3. e - element
4. g - compound
5. b - proton
6. i - neutron
7. d - electron
8. f - atomic number
9. j - mass number
10. h - isotope

# Assessment and Student Activity Masters



**Name** ______________________________

# Preliminary Assessment

**Directions:** Fill in the blank with the correct word. A list of possible answers is provided at the bottom of the page.

1. Matter is made up of tiny _______________ we cannot see.

2. _______________ are often referred to as the building blocks of matter.

3. Atoms of the same _______________ are alike.

4. _______________ are found by joining the atoms of two or more elements.

5. An atom is made of smaller particles called _______________ particles.

6. Protons and neutrons are located in the _______________.

7. Neutrons have a _______________ charge.

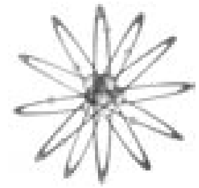
8. The number of _______________ in an atom is called the atomic number.

9. ______________ are found swirling around the nucleus of an atom.

10. Electrons have a _______________ charge

| | |
|---|---|
| atoms | neutral |
| compounds | nucleus |
| electrons | particles |
| element | protons |
| negative | subatomic |

**Name** ____________________



# Preliminary Assessment

**Directions:** Decide whether the statement is true (T) or false (F).

11. Matter is made up of small particles called atoms. T F

12. Atoms cannot be changed into different atoms by chemical reactions. T F

13. Most of an atom's mass is in the electron cloud. T F

14. There are only two different types of subatomic particles. T F

15. Neutrons have a negative charge. T F

16. Orbitting electrons occupy most of the volume of an atom. T F

17. All protons are similar to one another and all neutrons are similar to one another. T F

18. The sum of the protons and neutrons of an atoms is called the atomic number. T F

19. Carbon isotopes can have an atomic mass of 12 or 14. T F

20. Electrons are very slow moving atomic particles. T F

**Name** ____________________

# Video Review

**Directions:** During the course of the program, answer the questions as they are presented in the video. At the end of the video, answer the Video Quiz questions.

**You Observe!**

1. What do you see when the electric current passes through the tube?

**You Compare!**

2. What makes atoms different from each other?

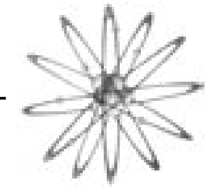
**You Compute!**

3. What is the mass number of sulfur?

**Video Quiz**

1. _______________ has mass and volume
2. An _______________ is the smallest complete particle of matter.
3. The three main subatomic particles include protons, _______________, and electrons.
4. _______________ possess a positive charge.
5. Protons and neutrons make up the _______________.
6. A neutron has an atomic mass of about _______________.
7. An atom with six protons and six neutrons has a mass number _______________.
8. The atomic number of an atom is equal to the number of ______________.
9. _______________ have a negative charge.
10. Electrons orbit in paths called _______________ levels.

 **Name** ______________________________



# Post Assessment

**Directions:** Fill in the blank with the correct word. A list of possible answers is provided at the bottom of the page.

1. _______________ are often referred to as the building blocks of matter.

2. Neutrons have a _______________ charge.

3. Electrons have a _______________ charge.

4. Matter is made up of tiny _______________ we cannot see.

5. Atoms of the same _______________ are alike.

6. An atom is made up of smaller particles called _______________ particles.

7. The number of _______________ in an atom is called the atomic number.

8. Protons and neutrons are located in the _______________.

9. _______________ are found swirling around the nucleus of an atom.

10. _______________ are formed by joining the atoms of two or more elements.

| | |
|---|---|
| atoms | neutral |
| compounds | nucleus |
| electrons | particles |
| element | protons |
| negative | subatomic |

**Name** ____________________

# Post Assessment

**Directions:** Decide whether the statement is true (T) or false (F).

11. Atoms cannot be changed into different atoms by chemical reactions. T F

12. All protons are similar to one another and all neutrons are similar to one another. T F

13. Electrons are very slow moving subatomic particles. T F

14. Matter is made up of small particles called atoms. T F

15. Most of an atom's mass is in the electron cloud. T F

16. Neutrons have a negative charge. T F

17. The sum of the protons and neutrons of an atom is called the atomic number. T F

18. Orbitting electrons occupy most of the volume of an atom. T F

19. Carbon isotopes can have an atomic mass of 12 or 14. T F

20. There are only two different types of subatomic particles. T F

**Name** ______________________________

# Modelling Atoms

**Background:** If you were able to continually cut a piece of copper wire in half, eventually you would end up with the smallest piece of copper possible. This piece of matter is called an atom. Copper, and other substances such as aluminum, oxygen, gold, and carbon are all examples of elements. An element is a pure substance made up of just one kind of atom. There are over 100 known elements on Earth.

An atom is the smallest possible part of an element that still has the properties of that element. The atoms of one element are different than the atoms of another kind of element. The way an atom is arranged gives it unique properties that make it different from other atoms.

While atoms are extremely small, they are made up of yet smaller particles called subatomic particles. There are three types of subatomic particles: protons, neutrons, and electrons. The nucleus is the center of the atom and it contains protons and neutrons. These two types of subatomic particles in the nucleus account for over 99% of an atom's mass. Protons have a positive charge, and neutrons have a neutral charge. Electrons are negatively charged subatomic particles that are only about 1/2000 the size of protons and neutrons. Electrons move at very high speeds orbiting around the nucleus.

Each element has a different number of protons, neutrons, and electrons. In this activity you will create a model of an atom.

**Materials:** red and green modeling clay or play dough, circular paper cut-outs from a hole punch, an assigned atom

**Directions:**

1. Your teacher will write the names of atoms on pieces of paper along with the numbers of protons, neutrons and electrons that atom has. Obtain one of these pieces of paper from your teacher.
2. Obtain some red and some green modelling clay (or play dough). The red will symbolize the protons and the green will symbolize the neutrons.
3. Make the protons by forming small bulbs of modeling clay (or play dough) about the size of a pea. Create the number of protons as stated for your atom.
4. Next, make your neutrons with green modeling clay (or play dough). Create the number of neutrons as stated for your atom.

Name ______________________________

# Modeling Atoms (cont.)

5. After making both your protons and neutrons you are ready to assemble the nucleus of your atom. Carefully create a sphere of neutrons and protons. Try to keep protons from sitting next to other protons.
6. Now you are ready to insert the electrons. In reality, an electron is 1/2000 the size of a proton or neutron and the orbitting electrons would be tens of meters away from the nucleus with the scale of this model. But for the sake of this excercise, use the paper cut-outs provided by your teacher.
7. Count out the number of electrons as stated for your atom. Space the electrons out evenly in a circular pattern around the nucleus.
8. Compare the structure of your atom to other atoms in the classroom. Then answer the following questions.

**Questions:**

1. What is the element of your atom?

2. What is its atomic number?

3. What is the mass number?

4. What kind of particles are protons, neutrons, and electrons?

5. What kinds of charges do protons, neutrons, and electrons have?

**Name** ______________________________

# Early History of the Atom

**Background:** For thousands of years scientists have attempted to better understand matter and the tiny particles that make up matter. Over 2,000 years ago, the Greek philosopher Democritus pondered whether matter could be divided into smaller and smaller pieces forever. He theorized that eventually the smallest piece of matter could be obtained. He called these particles atomos, which means “not to be cut” or “indivisible”. Today we call such particles atoms.

Since the time of Democritus our understanding of atoms has greatly increased. Dozens of women and men have devoted their lives to atomic research. Through their creative energies, hard work, and advances in technology, we now know a tremendous amount about atoms.

In this activity you will read about some of the significant advances in understanding the atom and about the people behind those advances. You will then record these events on a timeline.

**Materials:** ruler, long piece of paper (at least 1 meter in length), colored pens and pencils

**Directions:**

1. Read the information on the following page about significant advances in understanding the atom. Notice that each event has a date associated with it.
2. Obtain a long piece of paper, pens, pencils, and a ruler from your teacher.
3. In this activity, you will use these materials to create a timeline which illustrates some of the major scientific breakthroughs which have improved our understanding of the atom.
4. Use a ruler to measure the length of the piece of paper. Make a timeline which starts at 100 B.C. and continues through present day. This spans over 2,100 years. Develop a scale which permits you to include this amount of time on your piece of paper.
5. Once you have figured out your scale, write 100 A.D. in the bottom left hand part of the piece of paper, and then put this year’s date in the bottom right. Draw a straight line between these two dates along the bottom of the page. Label dates along the line using the scale that you figured out.
6. Summarize the key discoveries and place them at the appropriate points on the timeline. You may want to use different colored pens and pencils to make your timeline more colorful.
7. When you have finished creating your timelines share them with the class. Look up additional discoveries relating to the atom and add these to your timeline.

**Name** ______________________________

# Early History of the Atom (cont.)

**Examples of Major Disoveries:**

- 100 B.C. - Democritus suggested that matter was made up of small particles. He believed there were an infinite number of small, hard, atoms. He thought that atoms were all different sizes and shapes, always moving, and able to join together. There were some other Greek philosophists, called atomists, who supported his idea. Not many people believed in Democritus' idea, and since atoms couldn't be seen, there wasn't any way to prove it was true. Therefore, his idea was largely ignored for about 2,000 years.

- 1803-1807 - John Dalton proposed his atomic theory of matter. In his theory, he stated that:
  - All matter is made up of atoms, which are indivisible and indestructible particles.
  - All atoms of an element are exactly alike.
  - Different elements have different kinds of atoms.
  - By joining two or more atoms, compounds can be formed.

- 1897 - J.J. Thomson performed experiments which led him to believe that atoms are made up of smaller particles. In his experiments, he passed an electric current through a tube pumped almost completely empty of air to create a ray of light. He then applied a magnetic force to the current. When the rays were deflected from the magnetic force, he thought that the rays must be made of some negatively charged material. He hypothesized that some positively charged material also existed in the atom. He developed a model of the atom called the plum pudding model in which atoms are made up of positively charged material with negatively charged electrons scattered throughout.

- 1896 - Henri Becquerel discovered radioactivity accidentally when he left some uranium salt on a photographic plate and returned to find that the film had been exposed in places where it was in contact with the uranium salt. He thought that the uranium had given off invisible energy, which he called radiation.

- 1898 - Marie and Pierre Curie discovered radioactive elements polonium and radium, the elements that make up uranium salt. Henri Becquerel had suggested that they research the uranium salt that had exposed his film two years earlier.

- 1911 - Marie Curie won the Nobel Prize for chemistry for her work with radium and polonium. She went on to research ways in which radioactivity could be used in medicine.

- 1911 - Ernest Rutherford developed the idea that atoms were made up mostly of empty space in which electrons orbitted, and he hypothesized that atoms had a small, central,

# Early History of the Atom (cont.)

positively charged nucleus. In his well-known experiment, he shot a stream of positively charged particles at a sheet of gold foil and found out that many of the particles went through the foil rather than reflecting off it. Because the particles could pass through the sheet of gold foil, he could tell that the atoms in the sheet of gold foil had empty space to allow that to happen. And because some particles reflected off the foil, Rutherford thought that there must be some part of the atom that was dense and positively charged. The positively charged nuclei in the gold foil atoms repelled some of the positively charged particles that were being shot at it.

- 1913 - A Danish scientist named Niels Bohr improved upon Rutherford's idea of atomic structure by developing a new atomic model. His model of the atom had a central nucleus with electrons orbitting in specific energy levels. In this model, there is one orbit per electron.

- 1939 - Lise Meitner published a paper that she had written with her cousin Otto Frisch describing nuclear fission, which she had just discovered. Nuclear fission is the splitting of atoms which creates large amounts of energy.

- 1942-1946 - The Manhattan Project focused on developing the atomic bomb. The Manhattan Project was led by a team of some of the world's top scientists. It was an industrial and scientific effort which researched, tested and eventually produced the first atomic bomb. It was a top secret project in which even the workers weren't allowed to know what they were working on. The atomic bomb that was developed used nuclear fission to create an enormous amount of energy and radiation. Fortunately many non-military uses for nuclear energy were indirectly developed as a result of the knowledge gained in the project.

**Questions:**

1. What factors helped atomic research advance?

2. Why was Democritus' idea ignored for so long?

3. Who developed the plum pudding model?

4. Which scientist researched ways to use radioactivity in medicine?

5. How is nuclear fission used today?

Name ______________________________

# Vocabulary of Atoms

**Directions:** Unscramble the vocabulary words in the first column. Match the words to the definitions in the second column.

____ 1. uunslec ________________

____ 2. sotma ________________

____ 3. leentme ________________

____ 4. opudonmc ________________

____ 5. rtonpo ________________

____ 6. eunntro ________________

____ 7. lertceno ________________

____ 8. tmcoia umbnre ________________
________________

____ 9. sasm umbnre ________________
________________

____ 10. osieopt ________________

a. often called the building blocks of matter

b. a positively charged subatomic particle

c. the part of the atom where protons and neutrons are located

d. a negatively charged subatomic particle

e. a “pure” substance, made up of only one kind of atom

f. the number of protons in an atom of an element

g. a chemical combination of two or more atoms

h. an atom that has the same number of protons as another atom of the same element, but a different number of neutrons

i. a neutrally charged subatomic particle

j. the number of protons and neutrons in an atom