

Lesson 2: Atomic Structure (2 Days)

☐ Getting Started

In the first lesson, you were briefly introduced to the concept of structure and function. In this lesson you will take a closer look at atomic structure by developing an atomic model. The **atomic model** is a representation of the structure of an atom. By building a basic model, you will learn more specific details about the particles that make up the atom: the electron, the proton, and the neutron. The **electron** is a negatively charged particle with a small mass — it is found in all matter. It orbits the center, or nucleus, of the atom. The **neutron** is a particle that has zero electrical charge (also called a **neutral** charge) and a mass approximately equal to that of a proton. A **proton** is a particle that is a component of all atoms and carries a positive charge equal to that of the electron's negative charge. The **nucleus** (plural = nuclei) is the positively charged central region of an atom that consists of protons and neutrons. The nucleus contains most of the mass of the atom.

This lesson has three parts. The first two introduce you to the basics of atomic structure. The third part is a quick historical investigation that will give you insight into how scientists discovered that the atom was indivisible. During this lesson, keep in mind that all matter is made up of atoms or combinations of different atoms.

Stuff You Need

- blank paper
- compass (kit)
- construction paper (kit)
- glue stick
- hole punch
- ruler
- scissors

Ideas to Think About

- How do we know that atoms are made up of different parts?
- What is the importance of each part of the atom?
- How do these "same parts" make so many different elements?

Things to Know

- **atomic model**: a representation of the structure of an atom
- **nucleus**: the positively charged central region of an atom, consisting of protons and neutrons and containing most of the mass of the atom
- **electron**: a negatively charged particle with a small mass that is found in all matter; orbits the nucleus of an atom
- **neutron**: a neutral particle with a mass approximately equal to that of a proton
- **neutral**: having no charge

- **proton:** a particle that is a component of all atomic nuclei and carries a positive charge equal to that of the electron's negative charge

**Atoms: Protons, Neutrons, Electrons**

www.beyondthepage.com/link/2873/

Click the Play Video button to view a short animation about the structure of an atom. Then answer the questions in the "Reading and Questions" section.

☐ **Reading and Questions**

Watch the video found at the provided web link and then answer these questions.

1. What is located at the center of every atom? What two particles are found there?

2. What determines an element's atomic number (its number on the periodic table)?

3. Where are electrons located in an atom?

4. What are the electrical charges of protons, neutrons, and electrons?

Activities

☐ Activity 1: Making a Basic Atomic Model

In this activity, you will create a model of a fluorine atom and a sodium atom.

Note: For this activity, one important thing to recognize is that atoms that make up elements are not different for different states of matter. An atom for a solid is the same as an atom for a liquid or a gas of the same element. You will learn more about different states of matter in Lesson 4.

As you create your models, keep in mind that the atom has three parts — the neutron, the proton, and the electron — and that each part has a specific location:

- The protons and the neutrons are bundled together in the nucleus
- The electrons are in "orbit" around the nucleus

Each atom has layers around the nucleus called shells or orbitals. Each orbital can hold a certain number of electrons. For example, the shell closest to the nucleus is the 1st orbital ($n = 1$), and the maximum number of electrons it can contain is 2.

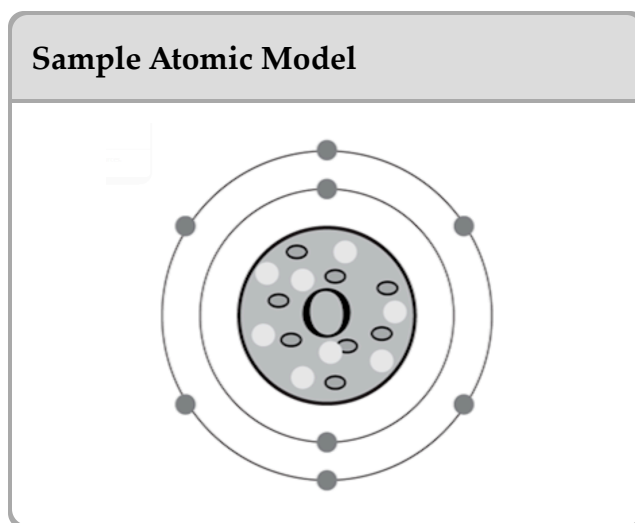
In the 2nd orbital ($n=2$), the maximum number of electrons is 8, and in the 3rd orbital ($n=3$), the maximum number of electrons is 18.

For example, the element oxygen (atomic symbol = O) has the following numbers:

- Electrons: 8
- Neutrons: 8
- Protons: 8

The nucleus of an oxygen atom contains 8 protons and 8 neutrons. Around the nucleus are 8 electrons — the first orbital contains two electrons, and the second orbital contains six. The total number of electrons = Two (2) + Six (6).

The "Sample Atomic Model" diagram for oxygen shows the nucleus with 8 protons and 8 neutrons, a shell around the nucleus with 2 electrons, and another shell with 6 electrons.



As you create your own models, refer to the "Making a Basic Atomic Model" sheet for details.

Note: The sample atomic models you will create are not to scale. The goal of this activity is for you to develop the basic concept of the structure of an atom.

Creating a Fluorine Model

Now you will create a model of a fluorine (atomic symbol = F) atom. Fluorine is a gas that has the following numbers of each particle (use the colors in parentheses for your model):

- Electrons: 9 (black)
- Neutrons: 10 (gray)
- Protons: 9 (another color)

Follow these directions to make your own model of a fluorine atom:

1. Use a hole punch and the specified colors of construction paper to punch out the correct number of electrons, neutrons, and protons for fluorine.
2. On a sheet of blank paper, use a compass to draw a circle with a 4 inch diameter (2 inch radius). This circle represents the nucleus of the atom. (Be sure that the protons and neutrons all fit within the nucleus. Although protons and neutrons can touch, you may need to make your circle bigger if they are too crowded.)
3. Use a glue stick to attach the protons and neutrons within the nucleus.
4. Using the compass, draw a second circle larger than the first. (You should have about one-half inch between the two lines.)
5. Use the glue stick to affix the proper number of electrons on this circle; this is the 1st orbital ($n=1$).
6. Using the compass, draw a third circle larger than the second, leaving about one-half inch between this line and the 1st orbital.
7. Put the proper number of electrons on this circle; this is the 2nd orbital ($n=2$).

Creating a Sodium Model

Next, create a model of an atom of sodium (chemical symbol = Na). Sodium is a solid. It has the following number of each particle:

- Electrons: 11
- Neutrons: 12
- Protons: 11

Follow these directions to make your model of a sodium atom:

1. Repeat the procedure used for fluorine (including colors used) with the correct number of particles for sodium.
2. Use the compass to draw a fourth circle larger than the third (about one-half inch from the second shell). This is the 3rd orbital.
3. Paste the correct number of electrons on each orbital.

Activity 2: Comparing a Solid and a Gas

In this brief activity, you will look carefully at the atomic models you just created. Use the "Comparing a Solid and a Gas" activity page to list two similarities and two differences between the two atomic models. Do not worry about possible differences in scale size. **HINT:** Look at the particles carefully.

Day 2

☐ Activity 3: A Timeline of Discoveries

For this activity you will learn about several important scientists and their discoveries. You will create a timeline representing the chronology of their discoveries and what each discovery was. Ask your parent which option to complete.

You may find the following links useful:



J.J. Thomson — 3 Experiments, 1 Big Idea

www.beyondthepage.com/link/6168/

Also click the "Corpuscles to Electrons" link at the bottom of the page to learn more about J.J. Thomson.



J.J. Thomson — The Discovery of the Electron

www.beyondthepage.com/link/2822/



Discovery of the Electron and Nucleus

www.beyondthepage.com/link/6231/

**Rutherford model**

www.beyondthepage.com/link/8765/

**Ernest Rutherford**

www.beyondthepage.com/link/2820/

**Frederick Soddy/Margaret Todd**

www.beyondthepage.com/link/2819/

**Niels Bohr**

www.beyondthepage.com/link/2818/

**Erwin Schrodinger**

www.beyondthepage.com/link/2824/

**Erwin Schrodinger**

www.beyondthepage.com/link/2825/

Option 1: Learning about Discoveries

For this option, read the information on the "Scientists" (Option 1) page. Next, cut out each rectangle and paste it on the sheet, "A Timeline to Figuring Out the Pieces" (Options 1 and 2). Use the links for this activity to learn more about any scientists or discoveries that interest you.

Option 2: Researching Discoveries

For this option, read the information provided in the links for this activity and take notes about each scientist's discoveries related to atoms. Use the "Scientists" (Option 2) page to write one or two of the scientists' major discoveries. Next, cut out each rectangle and paste it on the sheet, "A Timeline to Figuring Out the Pieces" (Options 1 and 2).

☐ **Activity 4: Vocabulary Review**

To close out the lesson, review vocabulary terms using the "Vocabulary Review" pages provided. Cut out the boxes on each page and then mix the cards up. Match each term with the appropriate illustration. You may also want to use the cards to play a game of Memory. Also refer to the "Things to Know" section at the beginning of the lesson and make sure you are familiar with the words' definitions.

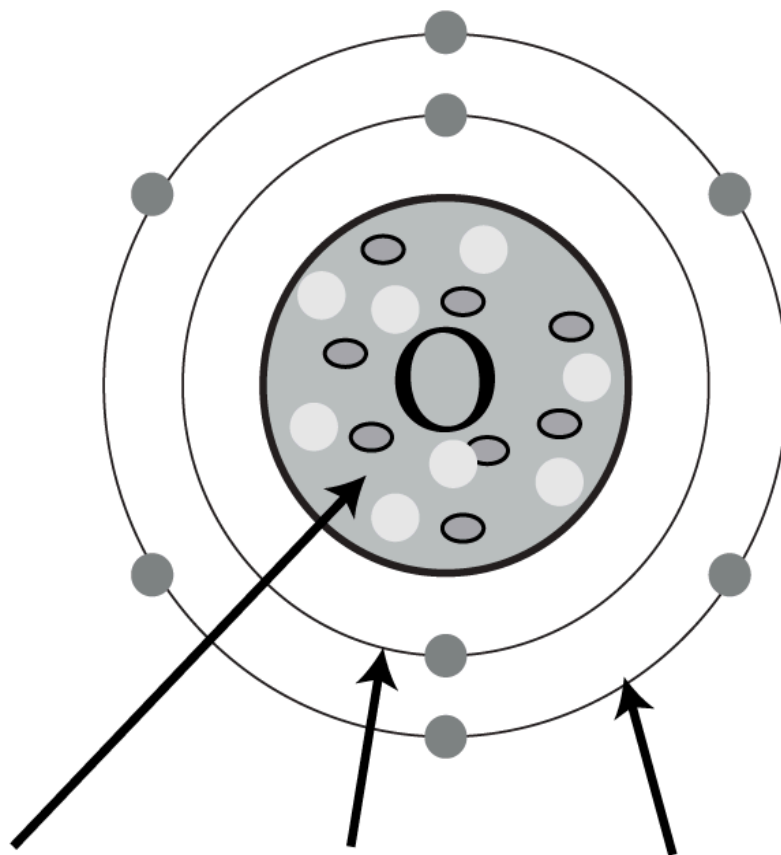
Activity Extension

For additional review of the vocabulary, write the definitions of the words on the back of each vocabulary card you used in Activity 4. Hold onto these so that you can review the words over the course of the unit.

Wrapping Up

In this lesson, you have learned a little about atomic structure. Keep in mind that as science has progressed, more and more detail has been collected about the structure of matter. As you review this lesson, keep in mind that atomic structure is highly complicated and that you will continue to learn more about it and how it influences matter as the lessons in this unit progress. Be sure to review the parts of the atom, how atomic structure can be drawn in two dimensions, and how electron shells are set up.

Making a Basic Atomic Model



Nucleus: 8 protons; 8 neutrons; 1st Orbital (two electrons); 2nd Orbital (six electrons)

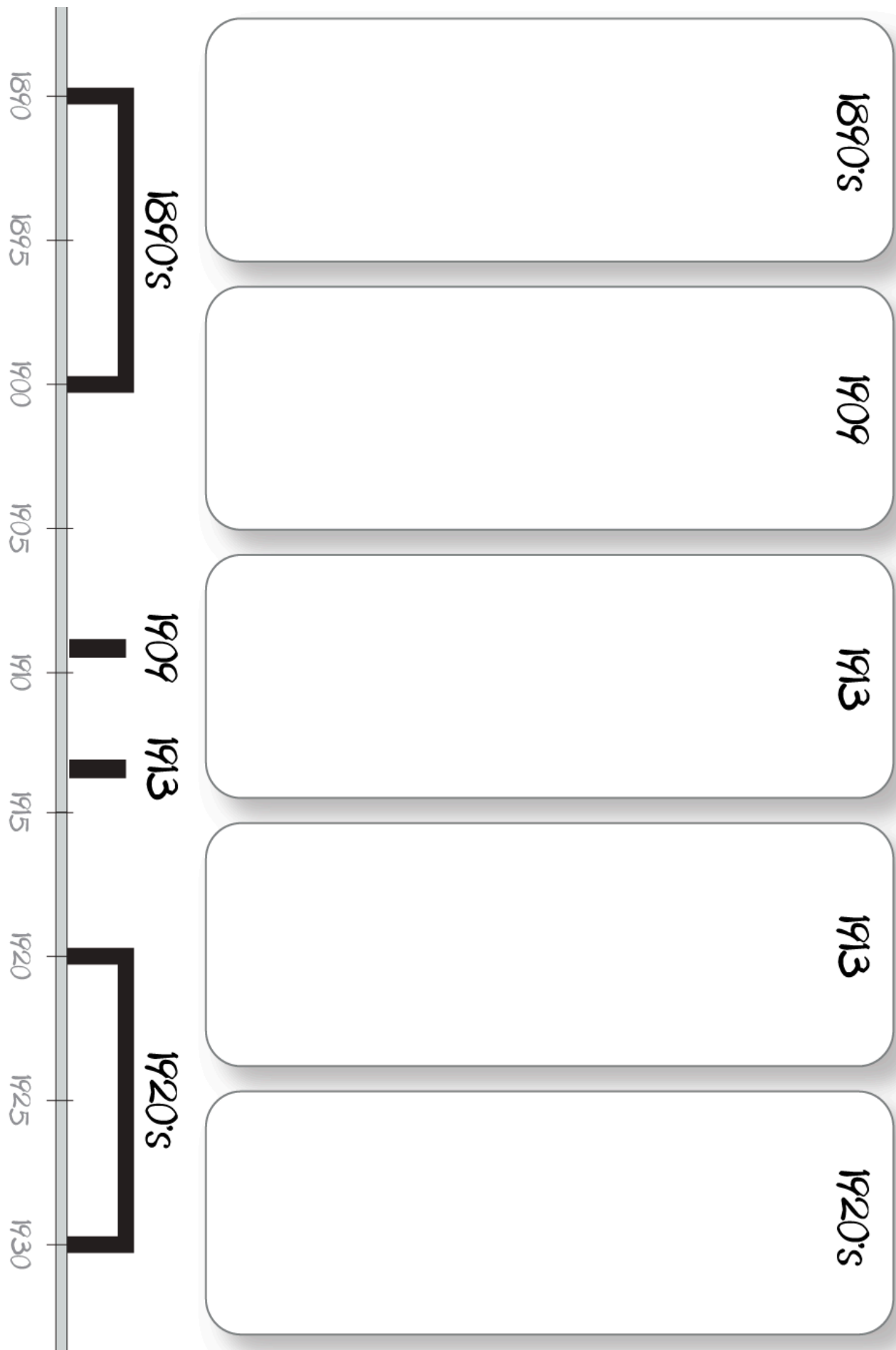
- The atom has three parts: the neutron, the proton, and the electron.
- Each part has a specific location
 - The protons and the neutrons are bundled together in the nucleus
 - The electrons are in “orbit” around the nucleus
- Each atom has orbitals. Each orbital can hold a maximum number of electrons (see below)
 - 1st Orbital ($n=1$): Maximum number of electrons is two (2)
 - 2nd Orbital ($n=2$): Maximum number of electrons is eight (8)
 - 3rd Orbital ($n=3$): Maximum number of electrons is eighteen (18)
- Once an orbital is filled, go to the next orbital.
 - For example: The element oxygen has the following numbers.
 - Electrons: 8
 - Neutrons: 8
 - Protons: 8
 - The total number of electrons equals eight.
 - The first orbital has two electrons.
 - The second orbital has six electrons.
 - Total number of electrons = Two (2) + Six (6)
- Your model will have the following look:
 - Nucleus: 8 protons; 8 neutrons
 - Two orbitals: 2 electrons; 6 electrons

COMPARING A SOLID AND A GAS

SIMILARITIES

DIFFERENCES

A Timeline to Figuring Out the Pieces



Directions: Place the name of the scientist and the discovery at the appropriate date on the timeline.

J. J. Thomson

Through his work on cathode rays in 1897, he discovered the electron and concluded that they were a component of every atom. He overturned the original belief that atoms are indivisible. Thomson assumed that negatively charged electrons were distributed throughout the atom. He developed what was known as the plum pudding model.

Ernest Rutherford & Ernest Marsden
(Hans Geiger)

Blasted a sheet of gold foil with alpha rays (positively charged helium atoms) and discovered that the particles were deflected. Rutherford understood the gold foil experiment to suggest that the positive charge of a heavy gold atom and most of its mass was concentrated in a nucleus at the center of the atom.

Frederick Soddy/ Margaret Todd

Discovered that there appeared to be more than one type of atom at each position on the periodic table. The term isotope was coined by Margaret Todd as a suitable name for different atoms that belong to the same element.

Niels Bohr

Suggested that electrons were confined to orbits and could jump between different orbits. This did not occur freely but required the addition or subtraction of energy to the atom.

Erwin Schrödinger

Developed a mathematical model of the atom that described the electrons as three-dimensional; ideas included considering the electron as a wave rather than as a small piece (or point) of matter.

Directions: Using the links provided, research each scientist and his or her major discoveries. Write a brief summary of the discoveries and then attach the card to the appropriate place on the timeline.

J. J. Thomson

Ernest
Rutherford
(Hans Geiger &
Ernest Marsden)

Frederick
Soddy/
Margaret Todd

Niels Bohr

Erwin
Schrödinger

VOCABULARY REVIEW

**atomic
model**

indivisible

nucleus

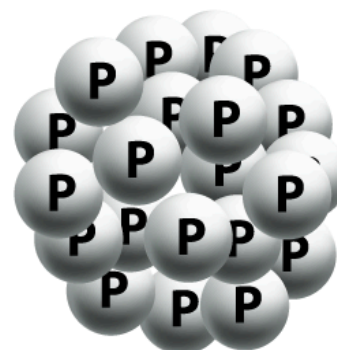
electron

neutron

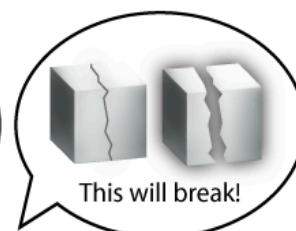
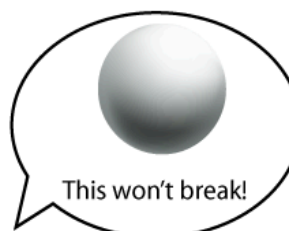
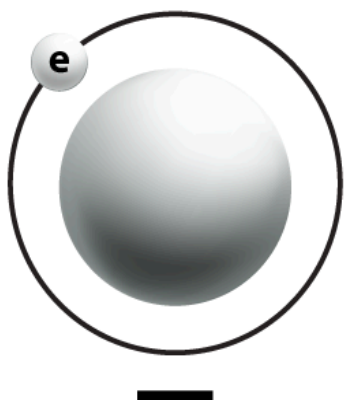
neutral

proton

VOCABULARY REVIEW

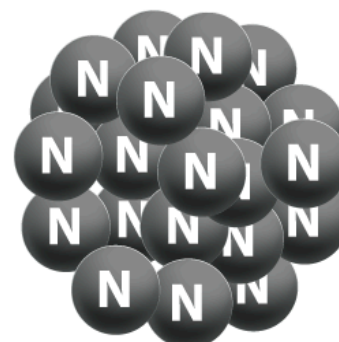
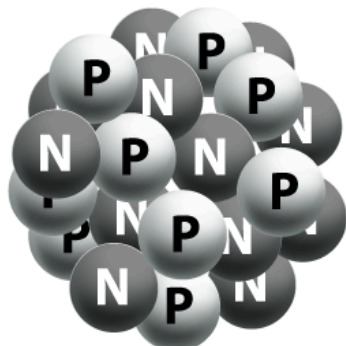
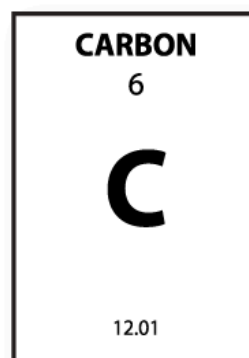


+



$$3 - 3 = 0$$

1P + 1e = neutral



zero (0)

Lesson 2: Atomic Structure (2 Days)

Getting Started

? Ideas to Think About

- How do we know that atoms are made up of different parts?
- What is the importance of each part of the atom?
- How do these "same parts" make so many different elements?



Things to Know

- **atomic model:** a representation of the structure of an atom
- **nucleus:** the positively charged central region of an atom, consisting of protons and neutrons and containing most of the mass of the atom
- **electron:** a negatively charged particle with a small mass that is found in all matter; orbits the nucleus of an atom
- **neutron:** a neutral particle with a mass approximately equal to that of a proton
- **neutral:** having no charge
- **proton:** a particle that is a component of all atomic nuclei and carries a positive charge equal to that of the electron's negative charge

⦿ Skills

- Understand the structure, classifications, and physical properties of matter. (S)
- Recognize that all matter is made up of atoms. (S)
- Know that atoms of the same element are all alike but are different from the atoms of other elements. (S)
- Be able to describe the structure and parts of an atom and identify the properties of an atom including mass and electrical charge. (S)

Introducing the Lesson

This lesson will take two days because it covers the history of atomic models and also asks your child to produce a basic atomic model. The order of the lesson works to give your child a frame of reference to consider. The lesson is self-inclusive and doesn't rely on information from Lesson 1, although it is possible that your child may make some connections between the lessons.

On Day 1 your child will create models of fluorine and sodium atoms and compare the two. On Day 2 he will create a timeline about important scientific discoveries related to the atom.

Reading and Questions

1. What is located at the center of every atom? What two particles are found there?

The nucleus. Protons and neutrons.

2. What determines an element's atomic number (its number on the periodic table)?

The number of protons found in the atom. (Since the number of protons equals the number of electrons, it's fine if your child included electrons in her answer.)

3. Where are electrons located in an atom?

They orbit the nucleus.

4. What are the electrical charges of protons, neutrons, and electrons?

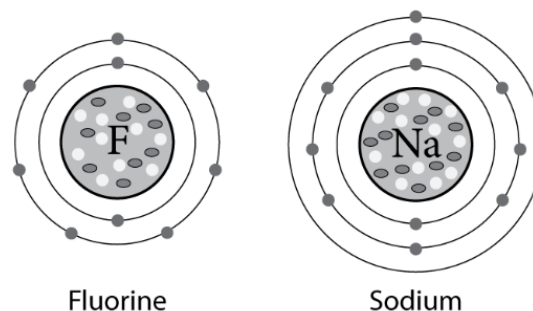
Protons - positive charge; neutrons - no charge or a neutral charge; electrons - negative charge.

Activities

Activity 1: Making a Basic Atomic Model

Your child will make atomic models that should look something like this.

At this stage, your child may offer several responses based on prior conceptions. You will want to look for the following answers. If any of these answers are missing, encourage your child to think through them as you review the lesson.



Answer Key:

Similarities	Differences
Same atomic particles (protons, neutrons, electrons)	One is a solid; one is a gas
Number of protons = number of electrons	Number of orbitals (fluorine has 2 and sodium has 3)
	Number of electrons on last orbital (fluorine = 7; sodium = 1)

Day 2

Activity 3: A Timeline of Discoveries

Help decide which option your child should complete for this activity. The first option is easier and better if you have less time. The second option encourages your child to do her own research and will be a good option for students particularly interested in science and its development over time.

Option 1: Learning about Discoveries

For this option, your child will paste information in the appropriate place on a timeline. Encourage her to use the links to learn more about scientists or discoveries that interest her. Refer to the answer key for Option 2 for the correct dates.

Option 2: Researching Discoveries

You can review your child's answers for either option using the following key:

J. J. Thomson (1890s): through his work on cathode rays in 1897, he discovered electrons and concluded that they were a component of every atom. Thomson assumed that negatively charged electrons were distributed throughout the atom. He developed what was known as the plum pudding model.

Ernest Rutherford (Hans Geiger and Ernest Marsden) (1909): blasted a sheet of gold foil with alpha rays (positively charged helium atoms) and discovered that the particles were deflected. Rutherford understood the gold foil experiment to suggest the positive charge of a heavy gold atom and that most of its mass was concentrated in a nucleus at the center of the atom.

Frederick Soddy/Margaret Todd (1913): discovered that there appeared to be more than one type of atom at each position on the periodic table. The term isotope was coined by Margaret Todd as a suitable name for different atoms that belong to the same element.

Niels Bohr (1913): suggested that electrons were confined to orbits and could jump between different orbits. This did not occur freely but required the addition or subtraction of energy to the atom.

Erwin Schrödinger (1920's): developed a mathematical model of the atom that described the electrons as three-dimensional; ideas included considering the electron as a wave rather than as a small piece (or point) of matter.

Activity 4: Vocabulary Review

This activity will help your child review the terms introduced in this lesson.

If your child has extra time or you think she could use additional reinforcement of the lesson's vocabulary, ask her to also complete the "Activity Extension" section.

Wrapping Up

Questions to Discuss

- Do all elements have the same number of electrons? (No, atoms of two different elements may have different numbers of electrons.)
- What major discoveries about the atom have occurred in the last two centuries? (The idea that matter is made up of divisible particles called atoms; the divisible atom is made up of protons, electrons and neutrons. Refer to Activity 3 for additional discoveries.)

Things to Review

- There are differences among different types of matter.
- Each part of the atom has a specific location.
- The protons and the neutrons are bundled together in the nucleus.
- The electrons are in orbit around the nucleus.
- Each atom has orbitals (also called shells) that have a limited number of electrons.
- Once an orbital is filled, it will hold no more electrons and thus a new orbital is necessary.
- Changes in the atomic model have occurred because of scientists' discoveries.