# Modeling the Atom

| | | |
|---|---|---|
| **Strand** | Matter | |
| **Topic** | Investigating atoms, elements, molecules, and compounds | |
| **Primary SOL** | 6.4 | The student will investigate and understand that all matter is made up of atoms. Key concepts include<br>a) atoms consist of particles, including electrons, protons, and neutrons;<br>b) atoms of a particular element are alike but are different from atoms of other elements;<br>c) elements may be represented by chemical symbols. |
| **Related SOL** | 6.1 | The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which<br>c) scale models are used to estimate distance, volume, and quantity;<br>i) models and simulations are designed and used to illustrate and explain phenomena and systems. |

## Background Information

An *element* is made of identical or nearly identical atoms. An *atom* is the smallest unit of matter and consists of a dense, central, positively charged *nucleus* surrounded by a complex system of *electron* orbitals. Atoms are not divisible by ordinary chemical or physical means.

There are three basic subatomic particles that make up an atom: the *proton*, the *neutron*, and the *electron*. (There are smaller parts, called *quarks,* that make up these subatomic particles, but that is not a focus at this level.) An atom can be distinguished from other atoms by how many protons it has in its nucleus. For example, an atom of hydrogen has one proton in its nucleus, whereas helium has two protons in its nucleus. The number of protons in a particular atom determines the atom's identity and, therefore, is always the same. Protons have a positive charge, and electrons have a negative charge. In a neutral atom, the number of electrons is the same as the number of protons. Protons and neutrons are found only in the nucleus of the atom. Electrons are found in complex orbitals around the nucleus and are constantly in motion. Sometimes atoms of the same element may have varying numbers of neutrons.

As students use the materials provided in this activity to construct simple models of several different atoms, stress that the area in which the electrons move is very complex and cannot be adequately depicted with a model. They will learn how to represent the various electron orbitals when they study chemistry in high school. For the purpose of this activity, they need only to have their model represent the relative positions of each of the subatomic particles that make up the atom.

**Materials**

- Modeling clay in three different colors
- Plastic knives
- Copies of the attached handout
- Large bag of candy, such as M&M's or jelly beans, in two colors

- Large bag of smaller-size candy in one color
- Metric rulers
- Large, round paper plates
- Atomic structure display chart or projection
- Periodic table of the elements (in textbook or display chart)

## Vocabulary

*atom, electron, element, neutron, nucleus, proton, subatomic particle*

## Student/Teacher Actions (what students and teachers should be doing to facilitate learning)

*Introduction*

1. Group students into pairs, and have each pair brainstorm objects that have certain matter on the outside and different matter at the center, and that are made of different materials. Start them off by mentioning how an egg has a hard shell, a white, and a yolk at its center.
2. Have groups share their answers, writing them on the board to create a master list.
3. Show the class a diagram of an atom, and explain that atoms could also be added to the list because they have a nucleus in the center and electrons in an area surrounding the nucleus.
4. Have each group revisit its list and identify which part of each object would be similar to the nucleus. Once groups have completed their lists, work as a class to identify the "nucleus" of each object on the master list.
5. Explain that the nucleus is made up of two kinds of particles, and write the following definitions on the board:
   - **proton.** A stable particle with a *positive* charge.
   - **neutron.** A particle with *no* charge; a particle that is *neutral*.

   Help the class decide a way to remember that a proton is positively charged: for example, *pro* means supporting something and feeling *positive* toward it. Work with the class to come up with a motion that indicates "positive" for proton, such as thumbs up. Next, decide a way to remember that a neutron is neutral and has no charge. Explain that if something is neutral, it takes no sides: in this case, it means that the particle has no charge. Come up with a motion that indicates "no" for neutron, such as shaking head or an umpire's safe motion to show there is no out.
6. Have the students fill in the blanks and use the motions they have come up with as you read the following sentences: "The center of an atom is called the _____. The nucleus is made up of two kinds of particles, the _____ and the _____. Protons have a _____ charge, and neutrons have _____ charge."
7. Show the diagram of the atom once more, and ask the class what surrounds the nucleus. Add the following definition on the board:
   - **electron.** A particle with a *negative* charge.

   Work with the class to come up with a motion that indicates "negative" for electron, such as thumbs down.
8. Review the parts of the atom again, incorporating the motions.

*Procedure*

1. To help students grasp the concept of an atom being three dimensional, have them make clay models, using at least three different colors of clay to represent the three different kinds of particles. Have them make several small balls of one color to represent the protons and of another color to represent the neutrons in the nucleus. Have them gently push the protons and neutrons together to form a sphere to represent the nucleus. The students should be given the size of subtime particles and asked to create a scale model of the atom.
2. Explain to students that electrons move very, very fast and that we cannot pinpoint exactly where a given electron is at any point in time, but only the area in which it is likely to be found (uncertainty principle). The area where we expect to find the electrons is called the *electron cloud.* Point out to students that they may see illustrations in textbooks that depict the electrons in circular orbits around the nucleus, and explain that this is an outdated and incorrect model of the atom that was proposed by Niels Bohr in the early 1900s. This model was soon disproved and is not considered to be an accurate representation of the atom. The electron cloud model is the model of the atom accepted by the scientific community today.
3. Instruct students to gently cover their clay "nucleus" with a layer of the third color of clay to represent the electron cloud region in which the electrons are found. Then, have students use plastic knives to cut their "atom" in half in order to observe its cross section.
4. Hand out copies of the attached Atomic Structure worksheet, and allow time for students to draw their atom's "cross section." Ask them to label the parts of their drawing to show where we might expect to find the nucleus, a proton, a neutron, and an electron.
5. Have students separate the large candies into two color groups—one color to represent protons and another color to represent neutrons. Each student will need at least eight pieces of each color.
6. Have the students arrange the large candies in the center of their paper plate to represent the nucleus of a carbon atom. The nucleus should contain six of each of two different colors—a total of 12—to represent the nucleus of the carbon atom. Discuss with the class where the six electrons should be placed. Should they all go in a clump in the center? All around the rim? Evenly spaced out in an area outside the nucleus? Spaced along concentric rings outside the nucleus? Help students understand that due to the electrons' complex motion in the electron cloud region, none of these arrangements will accurately depict the electrons' positions within the region. Have students come to consensus on how they want to show the electrons in the cloud region.
7. Have students make a simple drawing of their model of the carbon atom.
8. Have students refer to the periodic table of elements to find the chemical symbol for carbon, noting that it is element six and that it has six protons. Have students use the periodic table and the same candy pieces to draw and label simple models of the hydrogen, nitrogen, and oxygen atoms.

*Observations and Conclusions*

1. Discuss the different elements that were modeled in the lessons. Include in the discussion the charge and location of each type of subatomic particle.

2. Explain that carbon is a solid at room temperature, while hydrogen, nitrogen, and oxygen are gases. Discuss how the atomic composition of each element defines the characteristics of that element.

## Assessment

- **Questions**
  - Where are the subatomic particles of an atom located, and what is the charge that each has?
  - How does an atom of one element differ from that of another element?
- **Journal/Writing Prompts**
  - Write a metaphor for each subatomic particle found in an atom.
  - Describe the subatomic parts of an atom.
- **Other**
  - Assess the drawings of the atom models, checking that the protons and neutrons are found in the central nucleus and the electrons are shown in the "electron cloud" outside the nucleus.
  - Have students use other materials to create three-dimensional models of an atom. Specific elements might be assigned for this task.

## Extensions and Connections (for all students)

- Have students create a periodic table, using the plate and candy method. This will require a lot of candy, so you may want to limit it to the first 30 elements.
- Have students create models of additional atoms, using the plate and candy method. Extend this activity into a mathematics lesson.

## Strategies for Differentiation

- Create the nametags "Electron," "Proton," and "Neutron," and have students become designated elements from the periodic table. Have selected students gather as a nucleus as other selected students "Swirl" in the electron cloud for one of the designated elements. Have remaining students identify the element by the number of each type of sub-atomic particle.
- Have student pairs use flashcards to identify elements by their chemical symbols.
- Provide access to the Internet or texts for students to gather information on elements and atoms. Check Internet site to see whether it has a browse aloud feature.
- Have students use the media center to research scientists who were involved in understanding the structure of atoms and the discovery of new elements. Have students record how the scientists' findings affect people today.
- Conduct a Think-Pair-Share of the clay activity.

# Atomic Structure

**Name:** _____ **Date:** _____ **Class:** _____

## Materials

Modeling clay in three different colors; large, round paper plate; pencil, centimeter ruler (optional); large candies in two different colors, smaller candies in one color

## Procedure

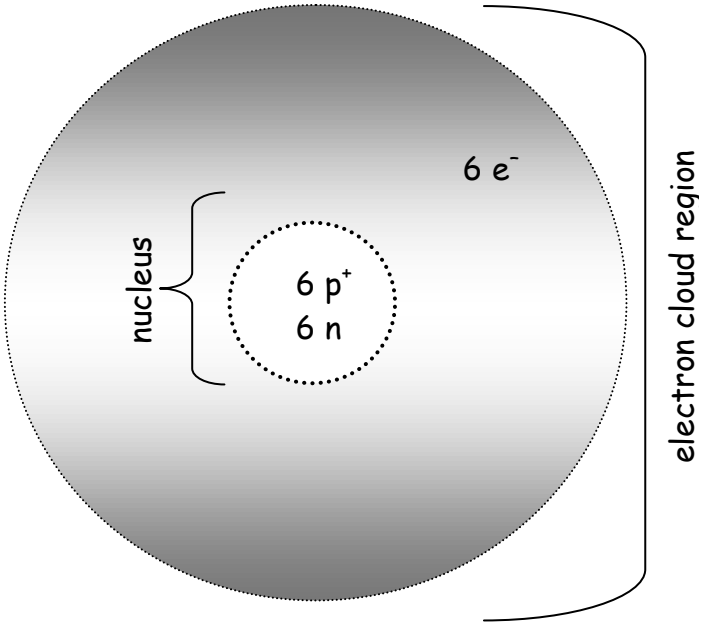
1. In the space below, draw a diagram to illustrate the clay model of a typical atom you created. Label the following parts: nucleus, proton, neutron, electron cloud region.

2. Draw a circle with a diameter of roughly 5–6 cm in the center of the paper plate. Then, use the large candy pieces (representing protons and neutrons) and the small candies (representing electrons) to model a carbon, hydrogen, oxygen, and nitrogen atom.

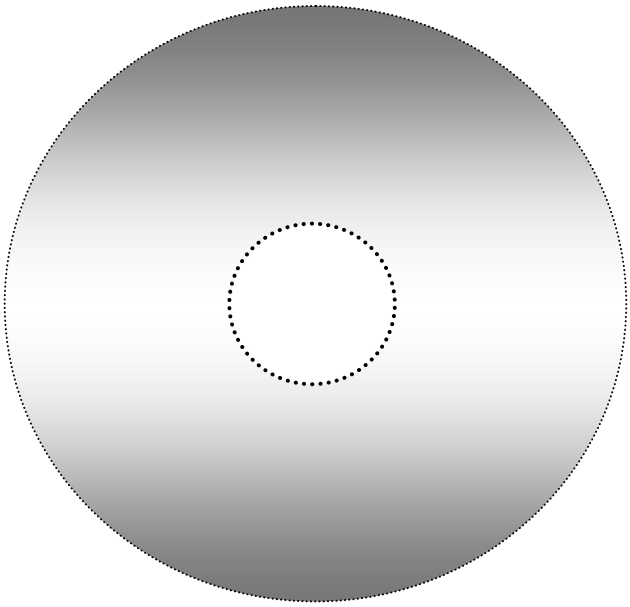
| Element | Symbol | Protons (+) | Neutrons | Electrons (–) |
|---|---|---|---|---|
| Carbon | C | 6 | 6 | 6 |
| Hydrogen | H | 1 | 1 | 1 |
| Oxygen | O | 8 | 8 | 8 |
| Nitrogen | N | 7 | 7 | 7 |

3. Fill in and label each diagram on the following page to illustrate the relative position of each atom's parts. Make sure to label the following parts: nucleus, proton, neutron, electron cloud region, as shown in the first diagram.

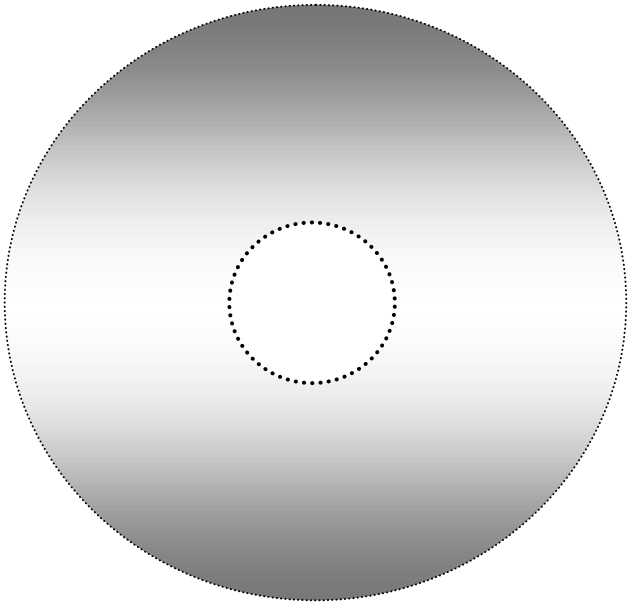
## Carbon




## Hydrogen



## Oxygen



## Nitrogen