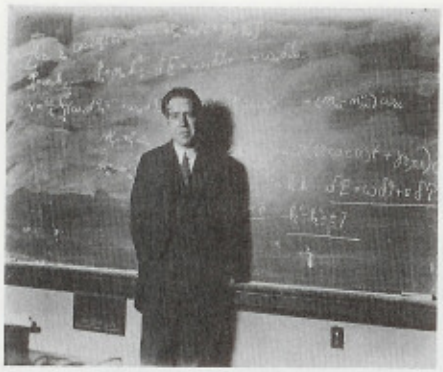


9-9. *Niels Bohr (1885–1962) was a young scientist who constructed a model of the atom in 1913.*

electrons around its nucleus. All atoms of gold are alike. All gold atoms would not be alike if the 79 electrons in each atom were arranged in a different way from other gold atoms.

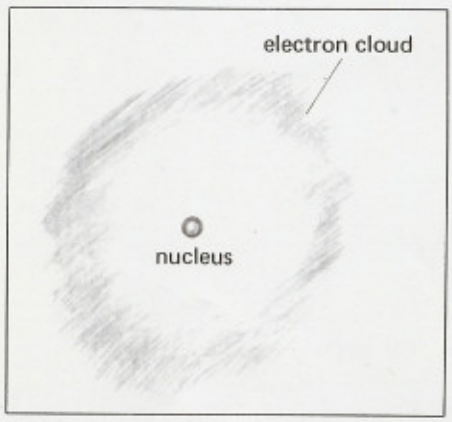
In 1913, Niels Bohr, a Danish scientist who worked in Rutherford's laboratory, provided a theory to explain how electrons move around atomic nuclei. See Fig. 9-9. According to Bohr's theory, electrons moving around a particular kind of atomic nucleus are able to follow only certain orbits. For example, the electrons in two different gold atoms are found to follow orbits that are identical in both atoms. Each electron moves in an orbit that is a definite distance from the nucleus.

This model is a common one used to indicate the number of electrons, protons, and neutrons found in the atoms. Niels Bohr first used this model with circles to represent the paths of the electrons. It is usually called the Bohr model of the atom. Scientists have replaced this model with a modern version based on the mathematics of probability and wave motion. The modern version explains much of the information that exists today concerning the chemical behavior of atoms.

If you could see an atom, it might look like a fuzzy sphere. See Fig. 9-10. The fuzziness represents a cloud of electrons whirling around the nucleus at high speed. Each electron makes billions of trips around the nucleus in 1 sec. But these electrons do not buzz around the nucleus like a swarm of bees. Each electron must follow an orbit within an **electron shell.** An *electron shell* is a definite orbit that electrons follow as they move around a nucleus. Within a shell, electrons may move in all directions. See Fig. 9-11.

Electron shell
A region around an atomic nucleus in which electrons move.

9-10. *Electrons move so fast that they can be thought of as forming a cloud around an atomic nucleus.*



Each electron shell can only hold a certain number of electrons. The one electron in a hydrogen atom moves around the nucleus in the first shell. The two electrons in helium also move in the first shell. Two electrons are the limit for this shell. The next electron shell can only hold 8 electrons. Figure 9-12 shows the electron arrangement of the first 10 elements. This figure shows the electrons in circles where each circle represents an electron shell. Keep in mind that the shells are not flat as shown in the drawings. Table 9-3 shows all the electron shells of the first 20 elements.

9-3. ELECTRON SHELLS

Suppose that the earth could be squeezed together until the nucleus of every atom was jammed against its neighbor. The entire planet would then be reduced to a globe only about one km in diameter. The earth, like all other forms of matter, is made up of atoms that are filled with empty space. This is the modern scientific model of the atom: atoms consist of electrons whirling around a tiny central nucleus. This lesson deals with the way in which electrons orbit the nuclei of atoms.

When you finish lesson 3, you will be able to:

- Describe the way in which electrons move around an atomic nucleus.
- List the arrangement of the electrons in different kinds of atoms.
- Identify chemical symbols for some common elements.

In some ways, the modern atomic model is like the solar system. The solar system has the sun at its center. An atom has a nucleus at its center. The force of gravity acting between the sun and the planets causes each planet to follow a particular orbit around the sun. Electrical force acting between the negatively charged electrons and the positively charged nucleus causes the electrons to move around the nucleus. But an atom is different from a solar system in one important way. In a solar system, planets can follow many different orbits around the central body. In a million solar systems, there could be a million different arrangements of the planets. This is not true for electrons moving around an atomic nucleus. For example, each atom of gold (atomic number = 79) has 79

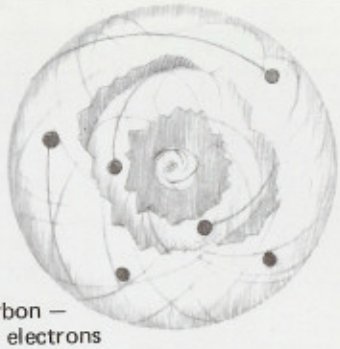
There are a total of 7 electron shells. The smallest number of electrons a shell can hold is 2 in the first shell. Eighteen to 32 electrons are found in some of the higher shells.

TABLE 9-3
Electron Shells for the First 20 Elements

Atomic Number	*Element*	*Shells* 1	2	3	4
1	Hydrogen	1			
2	Helium	2			
3	Lithium	2	1		
4	Beryllium	2	2		
5	Boron	2	3		
6	Carbon	2	4		
7	Nitrogen	2	5		
8	Oxygen	2	6		
9	Fluorine	2	7		
10	Neon	2	8		
11	Sodium	2	8	1	
12	Magnesium	2	8	2	
13	Aluminum	2	8	3	
14	Silicon	2	8	4	
15	Phosphorus	2	8	5	
16	Sulfur	2	8	6	
17	Chlorine	2	8	7	
18	Argon	2	8	8	
19	Potassium	2	8	8	1
20	Calcium	2	8	8	2

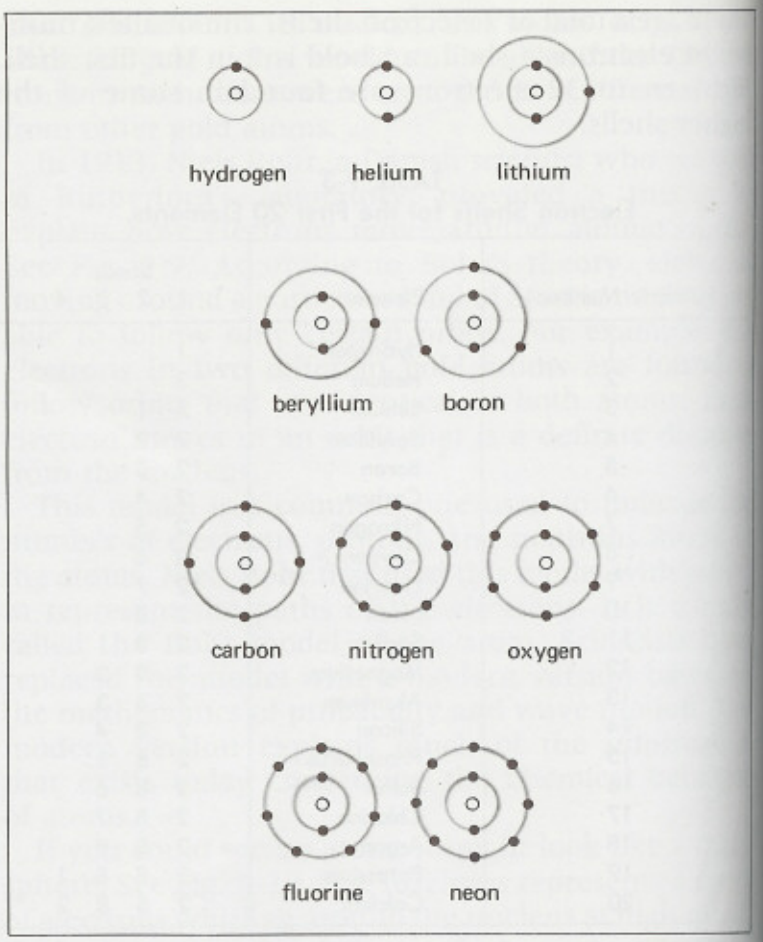
The number of electrons in the electron cloud around the nucleus differs in each element. To describe a particular atom you must know its atomic number. The atomic number tells how many protons are in the nucleus and also how many electrons are moving around the nucleus. The electrons fill the shells in which they are able to move. The first shell closest to the nucleus is filled first, then the second shell is filled, and so on until the total number of electrons is used up. For example, a sodium atom with atomic number 11 has 11 electrons. Two of these electrons are found in the first shell, 8 more are in the second shell, and the remaining one is found in the third shell.

Up until now, the name of each chemical element has been written out (hydrogen, helium, and so forth). For many years, chemists had to do the same thing. The chemist Berzelius knew that **symbols** were used


carbon —
six electrons
in two shells

9-11. *Electron shells are made up of electrons moving at a certain average distance from the nucleus.*

Symbol
One or two letters used to represent an atom of a particular element.



9-12. *The electron arrangements of the first ten elements.*

in algebra and physics. A *symbol* is a form of shorthand. Berzelius suggested that scientists also use symbols for the chemical elements. These symbols consist of one or two letters of the element's name. The symbol for hydrogen is H. The symbol for helium is He. When there are two letters in a symbol, the first letter is capitalized, the second letter is not.

The symbol for mercury is Hg. Does this surprise you? H and g are not part of the word "mercury." The answer is simple. Different languages have different words for mercury. The scientists decided to use the Latin name of the element. "Mercury" in Latin is *hydrargyrum*. Table 9-4 is a list of the 105 known elements and their symbols.

Try to remember the symbols for these elements. Being able to use the symbols of the elements will make your work in science easier.