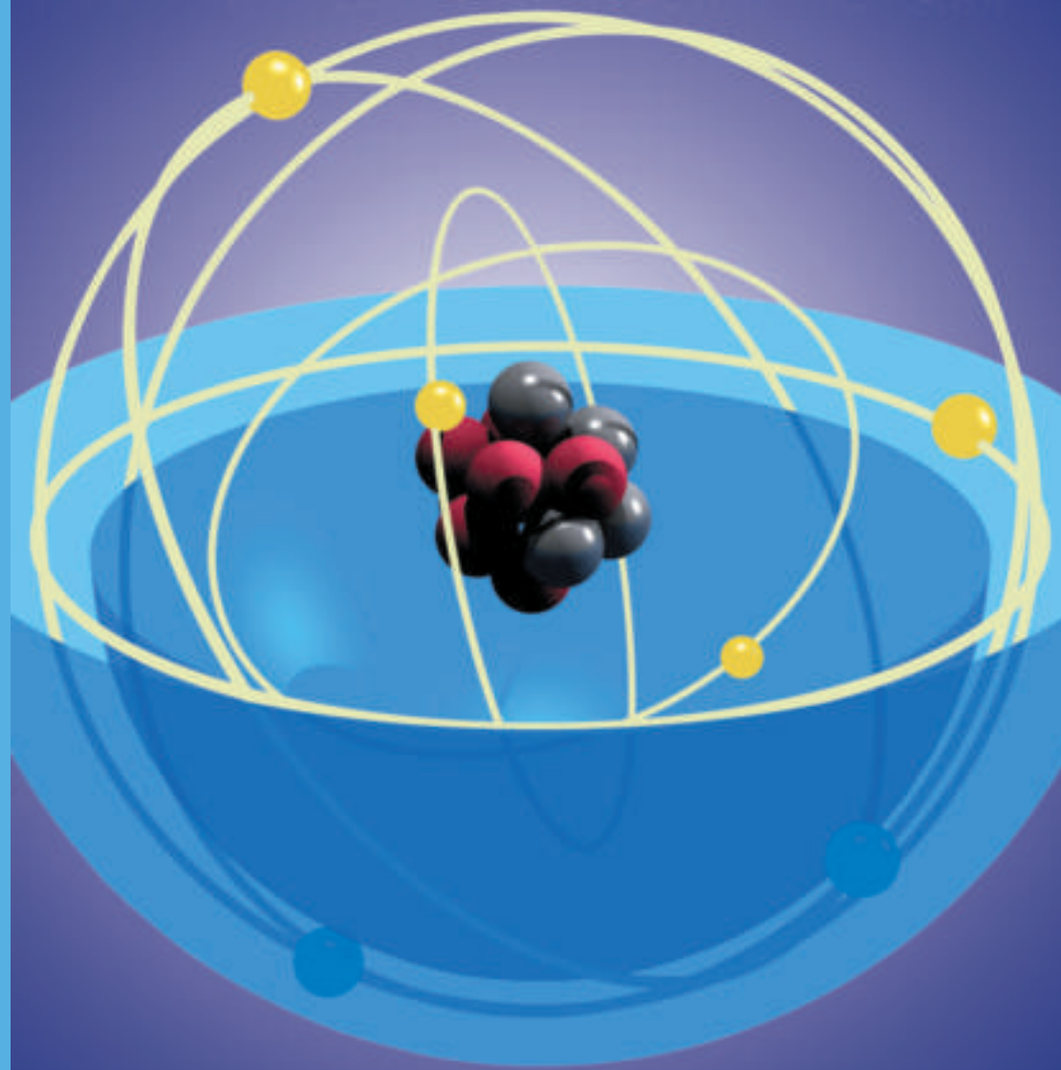
Science

Science

Physical Science

Atoms



by Sam Brelsfoard

Genre	Comprehension Skill	Text Features	Science Content
Nonfiction	Sequence	• Captions • Diagram • Glossary	Matter

Scott Foresman Science 6.13

PEARSON Scott Foresman

DK

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Vocabulary

chemical change
chemical property
condensation
density
mass
physical change
physical property
volume
weight

Extended Vocabulary

anion
cation
covalent bond
ionic bond
nuclear fission
nucleus
quark
valence shell

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Atoms

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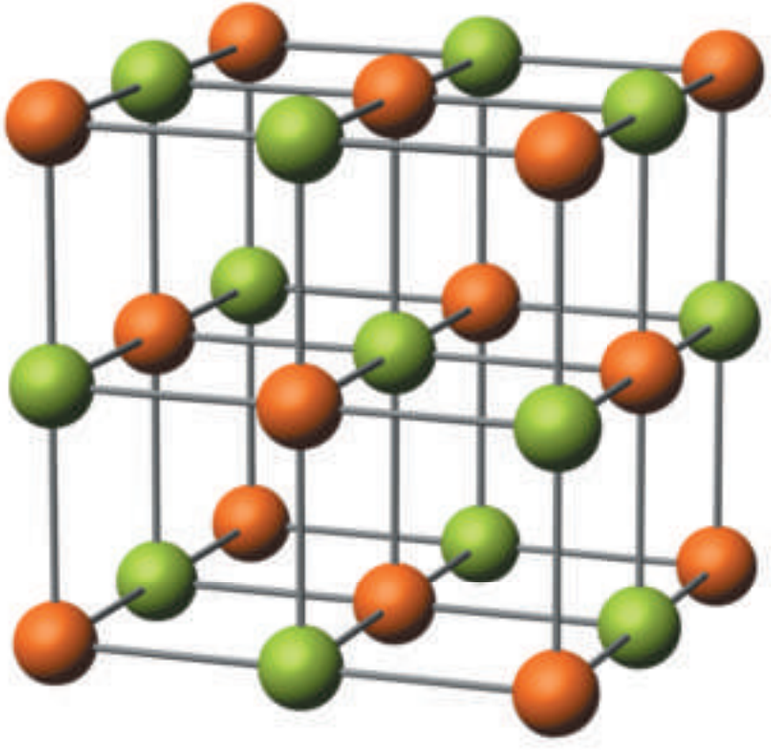

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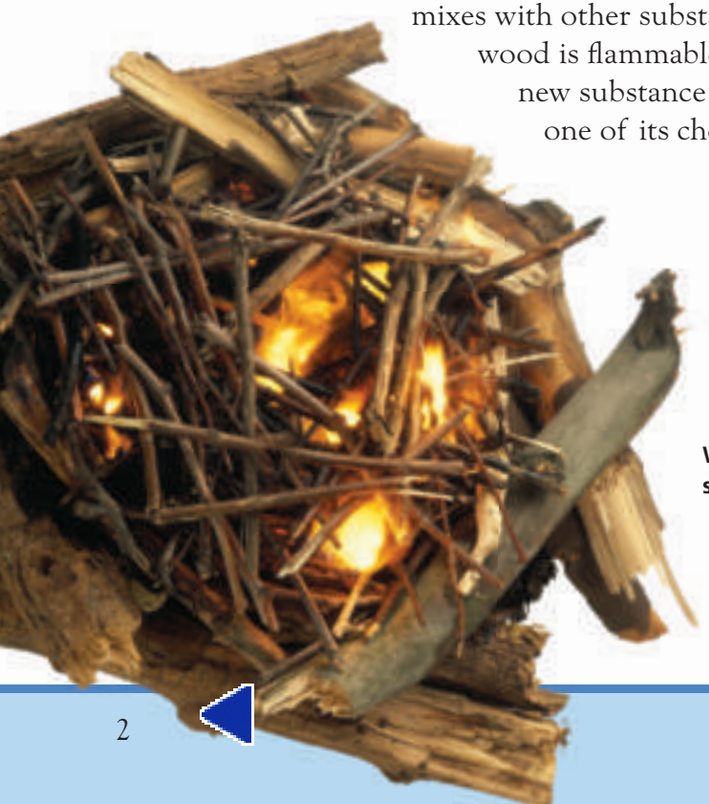
What You Already Know

Mass, weight, and volume are properties of matter, which can be measured. Using these measurements, you can figure out other properties of matter. In order to determine something's density, divide its mass by its volume. Every element and compound has a unique density, so density can be used to identify materials. For example, if you determine that the density of a cube of metal is 8.96, and you learn that the density of copper is 8.96, you can be certain that you have a cube of copper.

The physical properties of copper help to identify it. You can see that copper has a reddish color, a shiny luster, and a smooth texture. It is also malleable, which means that it can be easily shaped by being pounded or hammered. It is ductile, which means it can also be turned into a wire. Its ability to conduct electricity is also a physical property.

Chemical properties are the ways a substance mixes with other substances. The fact that wood is flammable and changes into a new substance when it burns is one of its chemical properties.



Wood changes into a new substance when it burns.

Matter can be in any of four states—solid, liquid, gas, or plasma. Matter is made out of tiny particles that move and bump into each other. The energy of the particles and how strongly they are attracted to each other determine the state of matter. Matter can change from one state to another. Temperature can affect the force of attraction between particles. When you heat a substance, its particles will gain energy and move faster. If there is enough heat, the particles can break some of the force of attraction between them.

When water boils, the particles in the water speed up, and the water changes into water vapor, a gas. When the particles cool and slow down again, they start to attract each other and turn back into liquid, or condense. When the particles are cooled further, they attact each other even more and change to a solid.

You know that matter is made up of tiny particles called atoms. In this book, you will learn about even tinier particles that atoms are made of.

Boiling water changes into water vapor.

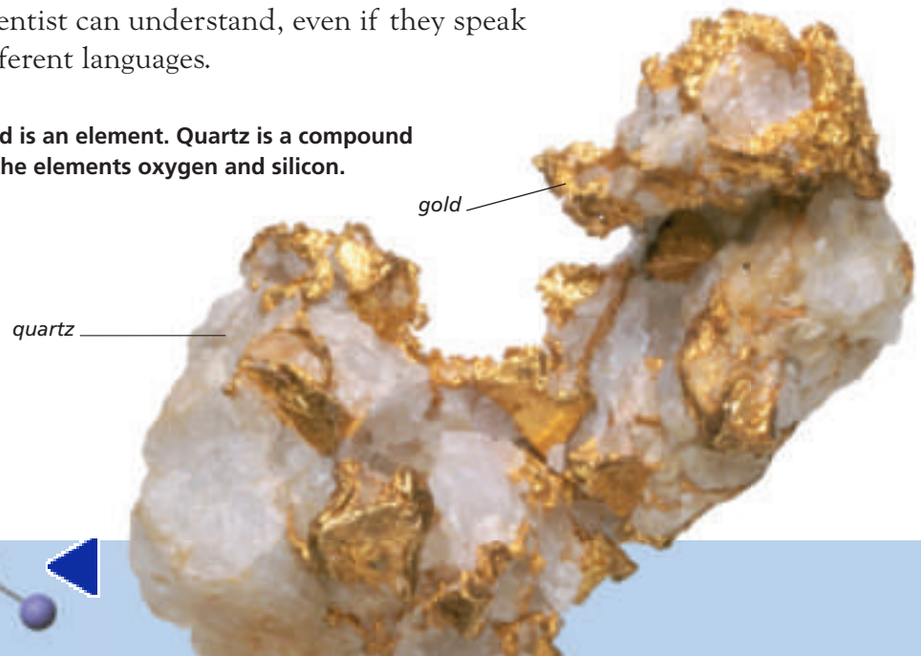
Atoms and Elements

An element is a substance that is pure and cannot be broken down into different substances. There are about ninety-four known naturally occurring elements in the universe. There are an additional twenty elements that have been created by humans. Some elements that you may be familiar with are oxygen, carbon, and chlorine.

The smallest particle of an element that still has all the properties of the element is called an atom. A compound is formed when one element is chemically joined to one or more other elements. Table salt, or sodium chloride, is a compound that you are probably familiar with. It is made up of the elements sodium and chlorine.

Quartz is also a compound. It is made up of the elements oxygen and silicon. Gold, on the other hand, is an element. Gold cannot be broken down into a more simple substance.

In order for people around the world to talk and write about elements and compounds in a way that everyone can understand, a code was developed. Using this code, one scientist can write out formulas that another scientist can understand, even if they speak different languages.

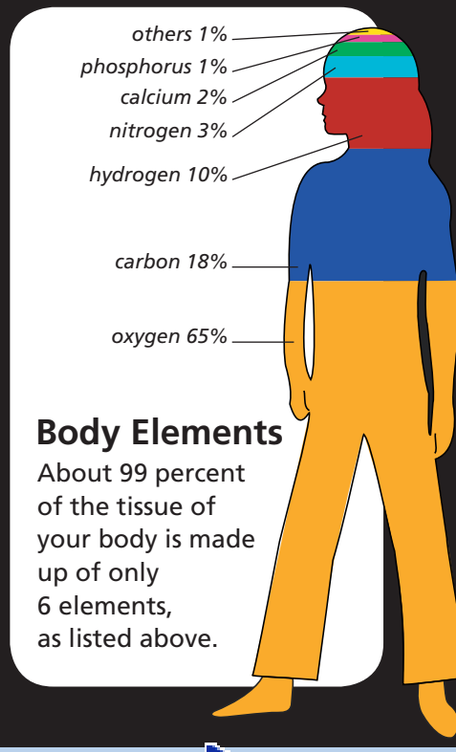


Gold is an element. Quartz is a compound of the elements oxygen and silicon.

Hydrogen and helium are two of the most basic elements that can be found in space.

In this code each element has a symbol. The symbol for many elements is simply the first one, two, or three letters of their English name. Hydrogen's symbol is H, and helium's symbol is He. Sometimes the symbols come from the Latin name for the element. The symbol for sodium is Na, which stands for "natrium." To write the name of a compound using these symbols, you simply place one symbol next to the other. The symbol for table salt, or sodium chloride, is NaCl.

Everything in the universe is made up of elements. About 65 percent of your body is composed of the element oxygen. The human body contains about fifty different elements. The top six elements that are found in your body make up 99 percent of you. They are oxygen, carbon, hydrogen, nitrogen, calcium, and phosphorus.



Body Elements

About 99 percent of the tissue of your body is made up of only 6 elements, as listed above.

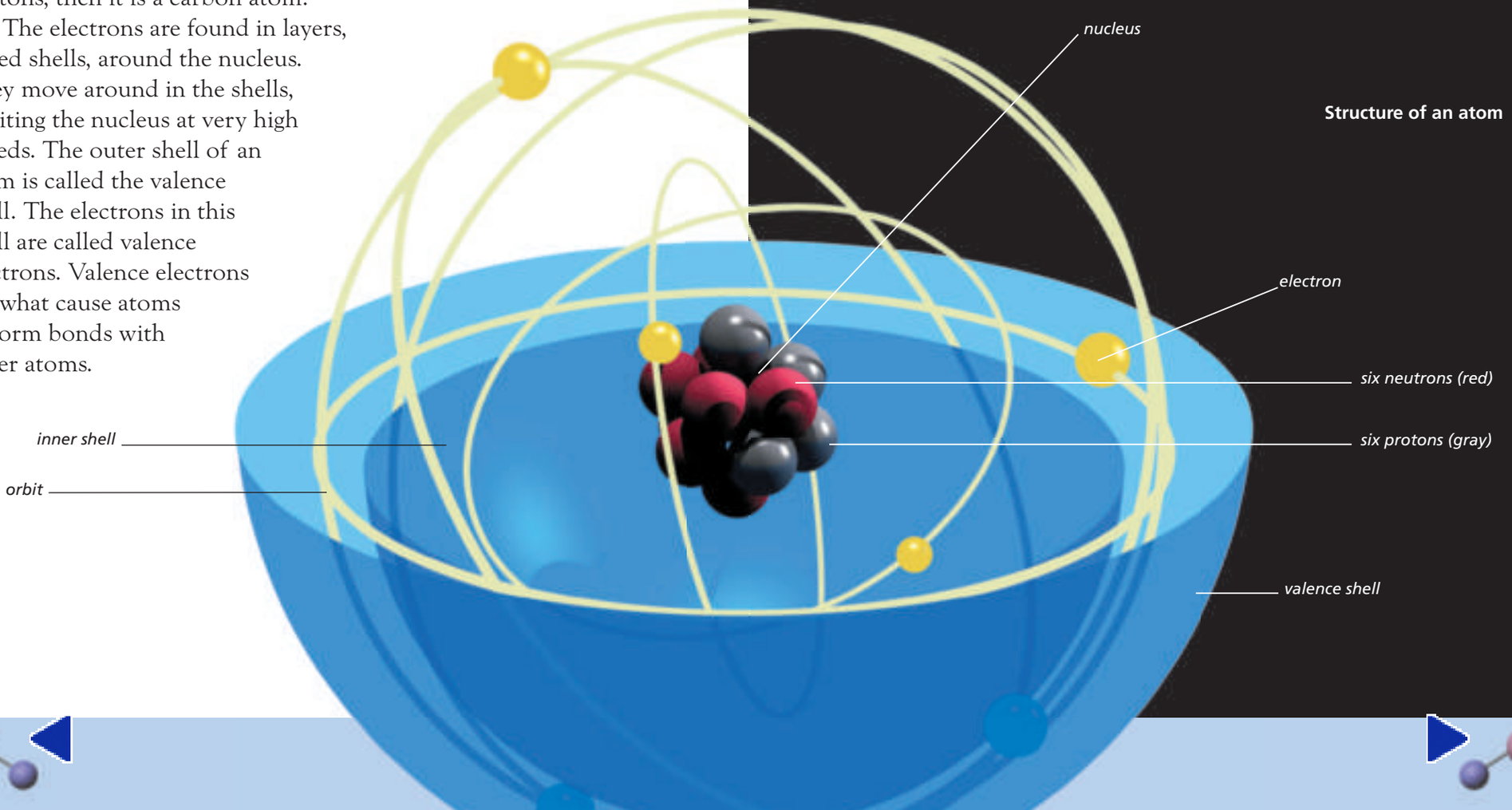
Inside the Atom

Atoms are extremely small. But they are made up of even smaller parts, called subatomic particles. The three main types of subatomic particles are electrons, protons, and neutrons. Protons have a positive charge. Neutrons are neutral because they have no charge. Electrons have a negative charge. Protons and neutrons are at the center, or nucleus, of the atom. The number of protons in the nucleus of an atom determines what element that atom is. If an atom has only one proton, then we can be sure that it is a hydrogen atom. If an atom has six protons, then it is a carbon atom.

The electrons are found in layers, called shells, around the nucleus. They move around in the shells, orbiting the nucleus at very high speeds. The outer shell of an atom is called the valence shell. The electrons in this shell are called valence electrons. Valence electrons are what cause atoms to form bonds with other atoms.

Ions

An ion is an atom with an electrical charge. A neutral atom has an equal number of protons and electrons. The negative charges of the electrons are cancelled out by the positive charges of the protons. This gives the atom no charge. If it loses an electron, it becomes a positive ion, or a cation. The positive protons outnumber the negative electrons. When a neutral atom gains an electron, it becomes a negative ion, also known as an anion. In an anion, there are more negative electrons than positive protons.



Structure of an atom

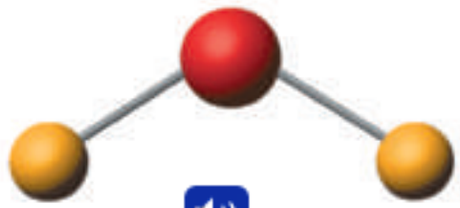
Joining Together

If the valence shell of an atom is not full of electrons, the atom is unstable. To become stable, an atom can either gain electrons in the valence shell until the shell is completely full or lose them until the shell is completely empty. Atoms do this by joining with other atoms in a process called bonding. Two main types of bonds that atoms can have are covalent bonds and ionic bonds.

Covalent Bonds

A covalent bond can occur between atoms that need electrons to fill their valence shells. To do this, the atoms share electrons. Oxygen needs eight electrons to fill its outer shell, but it only has six. Hydrogen needs two electrons, but it only has one.

To fill the two empty spaces in its valence shell, oxygen shares the electrons of two hydrogen atoms. The molecule that results is one you are probably familiar with: water.



Water, or H_2O, is a molecule made from two hydrogen atoms and one oxygen atom.

Covalent bonds can take the form of single, double, or triple bonds, depending on the number of electrons shared. Single bonds share one electron, double bonds share two, and triple bonds share three.

Covalent bonds are stronger than most other types of bonds. Covalent bonds are more common between nonmetal atoms.

Water is a simple covalent compound. Two atoms of hydrogen and one of oxygen make a water molecule.

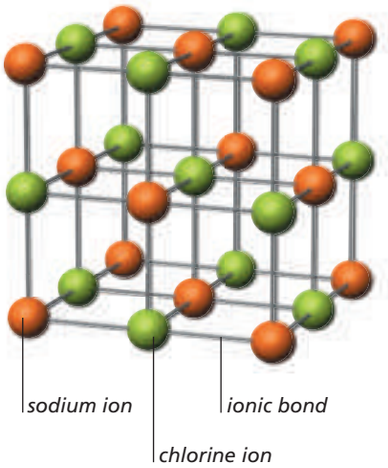
Ionic Bonds

An ionic bond forms when electrons are actually transferred from one atom to another. Sodium and chlorine join with an ionic bond to form table salt. A sodium atom has only one electron in its valence shell. It would need seven additional electrons to fill its shell. It is much easier for sodium to give up one electron than to gain seven. Chlorine has one open space in its valence shell. When sodium and chlorine mix together, the sodium atom gives its extra electron to the chlorine atom.

When the sodium atom gives up an electron, its charge changes. It now has more protons than electrons, giving it a positive charge. The chlorine atom now has more electrons than protons, giving it a negative charge. The different charges of the atoms cause them to stick together, similar to two magnets. This attraction is what causes an ionic bond.

Salt is a compound that contains ionic bonds between sodium and chlorine atoms.

If one were to drop sodium into a bucket of chlorine, a violent reaction would occur. This happens because the chlorine and sodium are strongly attracted to each other. The chlorine atoms quickly pick up the electrons that the sodium atoms are releasing. When everything settles, sodium chloride is all that is left. The sodium and the chlorine are chemically tied together through ionic bonds.

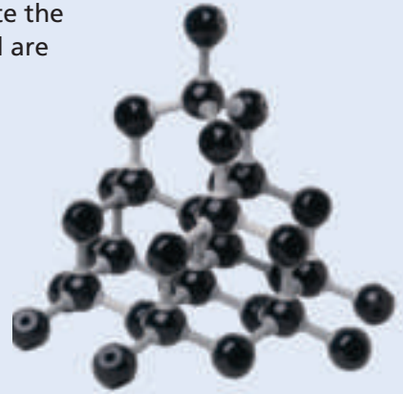


Sodium chloride is made up of positively charged sodium atoms and negatively charged chlorine atoms. They are held together by ionic bonds.

Carbon

Carbon is found in nature in many different forms, including graphite and diamond. Graphite is soft and diamond is hard. They are different because they have different molecular structures. In graphite the carbon atoms are arranged in sheets and are able to slide over each other. Diamond carbon atoms are arranged in a stiff geometric structure.

graphite carbon atoms



diamond carbon atoms

Splitting Apart

The atoms of some elements are very unstable and break down naturally. Such an atom might have too many protons, neutrons, or both in its nucleus. These protons and neutrons leave the nucleus, producing a type of energy called radiation. Elements that give off radiation are radioactive. Atoms of several elements, such as radium and uranium, are radioactive.

Radiation can be used positively to help combat cancer.

Radiation can destroy cells in the body. But scientists have found many positive uses for radiation. In radiation therapy, tumors are treated with blasts of gamma rays to kill cancer cells.

We must be very careful with radiation because exposure to large doses or even repeated exposure to small doses can be very dangerous. Scientists use instruments called Geiger counters to test whether radiation is at safe levels.

Geiger counters can detect many different types of radiation.

In 1939, scientists discovered that it is sometimes possible to split an atom with an unstable nucleus. The best-known radioactive material is uranium. It is one of the easiest elements to split. When uranium atoms are split, they release huge amounts of energy. This process is called nuclear fission.

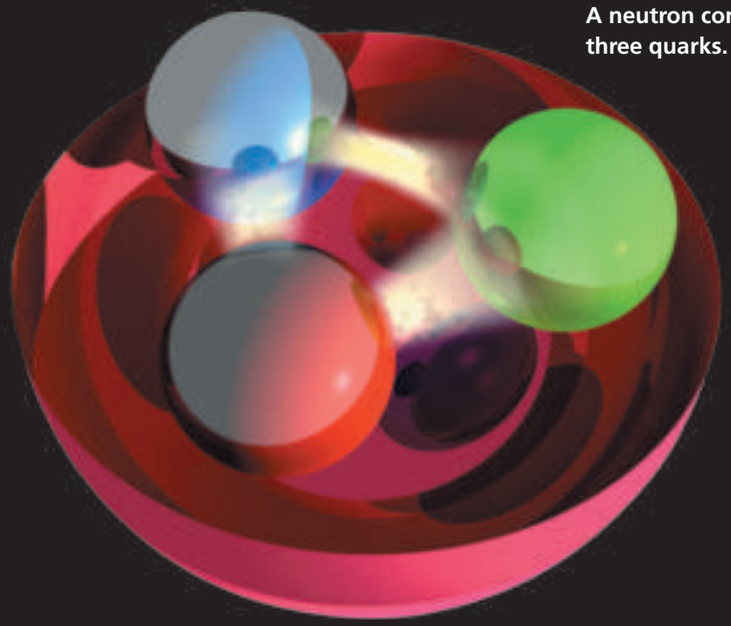
In order to split an atom, scientists force a neutron through its nucleus. When this happens, the atom splits into two new atoms. In addition to energy, this reaction releases particles that fly off in all directions. Some of these particles are released as radiation. Others strike the nuclei of other uranium atoms, causing them to split. When they split, they also release particles, which split still more nuclei. This is called a chain reaction. The energy that is produced by the chain reaction is in the form of heat. This heat can be used to make steam, which can spin generators to produce electricity.

Nuclear fission is used to generate electricity in power plants such as this one.

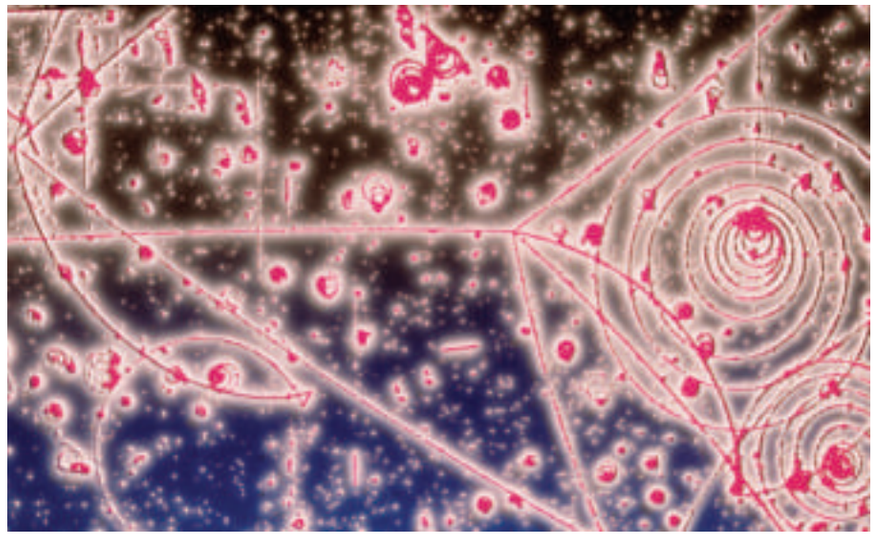
Smaller and Smaller

In the 1800s, it was believed that the atom was the smallest particle. It would take millions of atoms lined up to stretch across the head of a pin. Eventually, protons, neutrons, and electrons were discovered. These particles are about one million times smaller than the smallest atom! It's hard to believe that there could be anything smaller than that, but there is. In the 1960s, scientists discovered an even smaller particle, the quark. Quarks make up neutrons and protons.

Very little is known about quarks. They are always found in groups, and there are six different types, or "flavors." These are called up, down, top, bottom, strange, and charmed. Different combinations of flavors make up different particles. Protons are made of two up quarks and a down quark. Neutrons are made of two down quarks and an up quark.



A neutron consists of three quarks.



This computer image shows collisions between particles in a particle accelerator.

No one has ever seen a quark. How do we know they exist? In the 1960s, scientists were discovering many particles that were similar to protons and neutrons. They began to wonder if there was a more basic particle that had not been discovered yet. They called this undiscovered particle the quark, after a nonsense word in a book by Irish author James Joyce.

The existence of the quark was proven in 1968 by using a particle accelerator. A particle accelerator is a huge ring-shaped machine that measures several kilometers across. Particles travel around the ring at very high speeds and then crash into each other. Scientists used an accelerator to crash a tiny particle into a proton. By observing how the particle behaved as it passed through the proton, they concluded that the proton was not solid. It was made up of several extremely tiny particles. These particles were quarks.

Quarks are the smallest, most basic particles known. But quarks may be made up of even smaller particles. The more we learn about these tiny bits of matter, the more we learn about how all matter behaves.

Glossary

anion	a negatively charged ion
cation	a positively charged ion
covalent bond	a bond in which atoms share electrons
ionic bond	a bond in which one atom gives an electron to another atom, giving the atoms different charges and causing them to become attracted to each other
nuclear fission	the process of splitting an atom in two
nucleus	the center of an atom, which holds the protons and neutrons
quark	tiny particles that make up neutrons and protons
valence shell	the outer shell of an atom, around which the valence electrons orbit

What did you learn?

1. What is the difference between an element and a compound?

2. What three subatomic particles make an atom?

3. Why do hydrogen and oxygen bond together to make water?

4. Writing in Science Write a description of the structure of an atom. Use details from this book to support your answer.

5. **Sequence** Describe how an ionic bond might be formed. Use the sequence words *first, then,* and *finally* in your description.