Atoms

KIDS DISCOVER

SETTING THE PERIODIC TABLE

FOSSIL DATING

PLEASE PASS THE NaCl

THE PLUSES & MINUSES OF PROTONS & ELECTRONS

How Small Is Small?

"Atom." The word comes from the Greek *a-tomos,* meaning "indivisible." At the time these particles were named, scientists thought that atoms were the smallest bits of stuff existing in nature. We now know differently, but the name stuck.

About one hundred different kinds of atoms exist. Most are found in nature. Scientists make others in a laboratory.

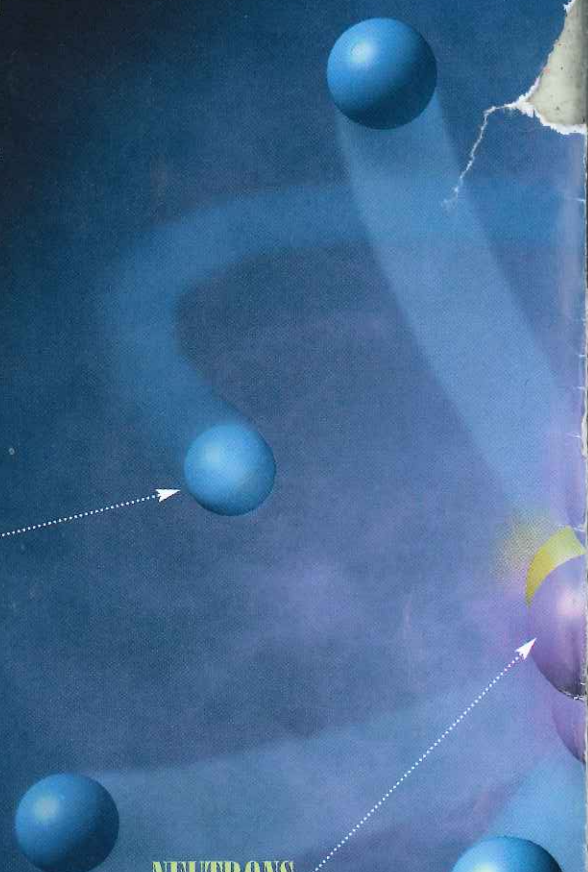
Some things, such as gold, lead, and iron, are "pure": that is, they are made up of only one kind of atom. Other things, such as plants, wood, and plastic, are made up of a combination of atoms. How atoms are organized and held together determines whether they form an apple, a glass of water, or air in a balloon.

Atoms are always moving, even the atoms that make up solid things like a block of wood. Of course, you can't see or feel the movement because the atoms are so small and densely packed together.

When you think of atoms, think very small. Many millions of atoms would fit on the head of a pin.

ATOMS

Atoms are mostly empty space, with a nucleus (center) of protons and possibly neutrons, surrounded by electrons. If the nucleus were the size of a golf ball, the closest electron would be more than half a mile away. If the nucleus were the size of the period at the end of this sentence, the closest electron would be about 55 yards away.



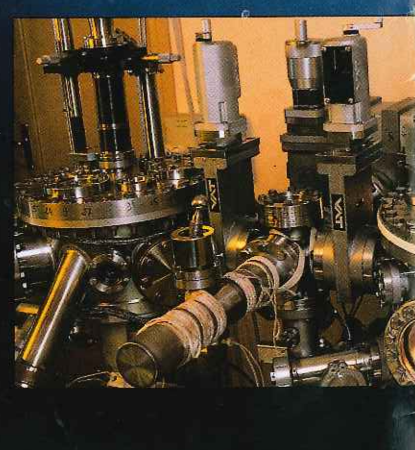
ELECTRONS

Electrons are negatively charged particles that move around the nucleus. An atom may have one or many electrons, but all atoms of the same type—for example, all copper atoms—have the same number of electrons.

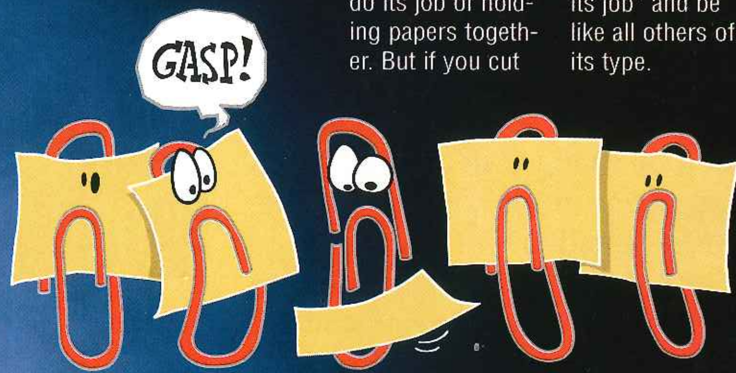
NEUTRONS

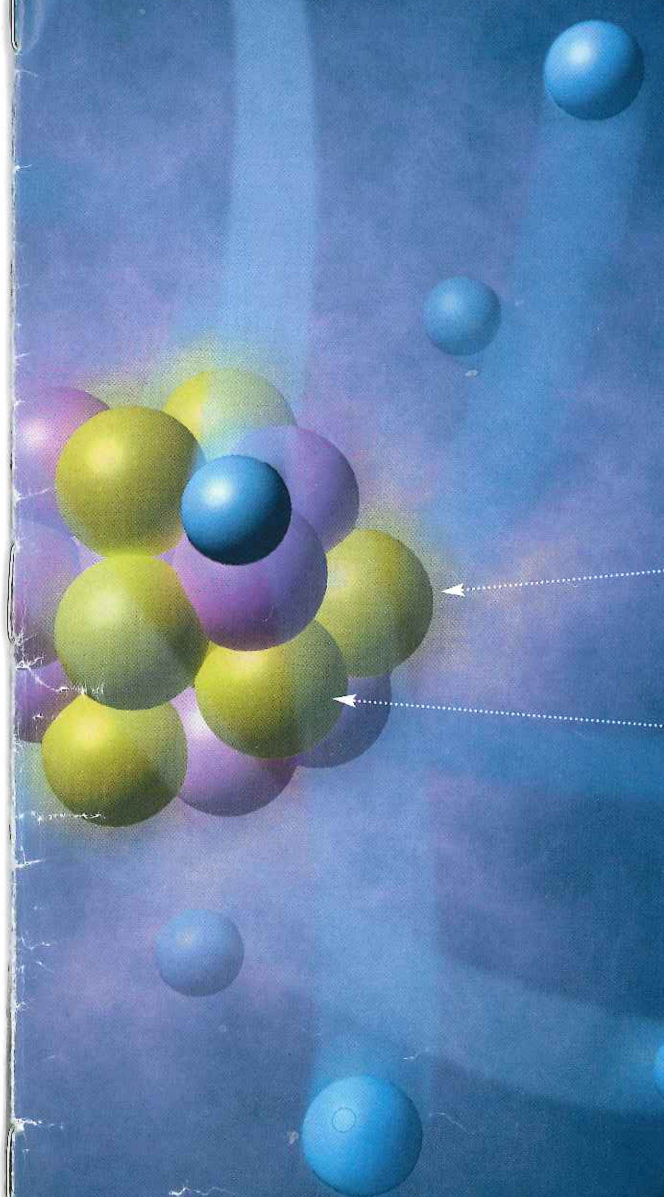
Neutrons are neither positively nor negatively charged. They have no charge at all. They are neutral. An atom may have none, one, or many neutrons.

➤ **The Scanning** Tunneling Microscope, or STM, makes it possible to see atoms. It operates like an old-fashioned phonograph needle that skims the surface of a vinyl record and picks up information in the form of grooves. The "needle" of an STM picks up the presence of atoms on the surface of a material, such as iron or copper.



To understand what an atom is takes some imagination. Carl H. Snyder, a chemist at the University of Miami, explains it this way. Imagine a pile of paper clips, all the same size and color. Divide the pile in half again and again until you have one paper clip left. The one paper clip can still do its job of holding papers together. But if you cut it in half, it cannot do its job. In fact, it is no longer a paper clip. An atom is like the one uncut paper clip. It is the smallest it can be and still "do its job" and be like all others of its type.



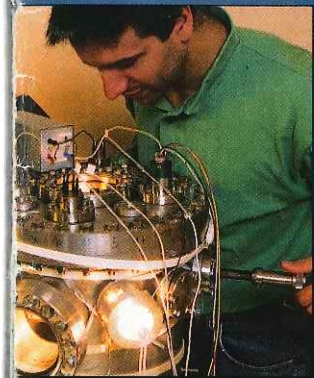


NUCLEUS

The nucleus is the dense, central core of an atom. It is made up of protons and neutrons. Every atom has an equal number of electrons and protons. Most of the "stuff" that makes up an atom—in other words, most of its mass—is in the nucleus. Protons repel each other, like the matching poles of a magnet. However, a nuclear force, called a strong force, holds the nucleus together.

PROTONS

Protons are positively charged. The nucleus of an atom may have one or many protons, depending on the kind of atom it is.



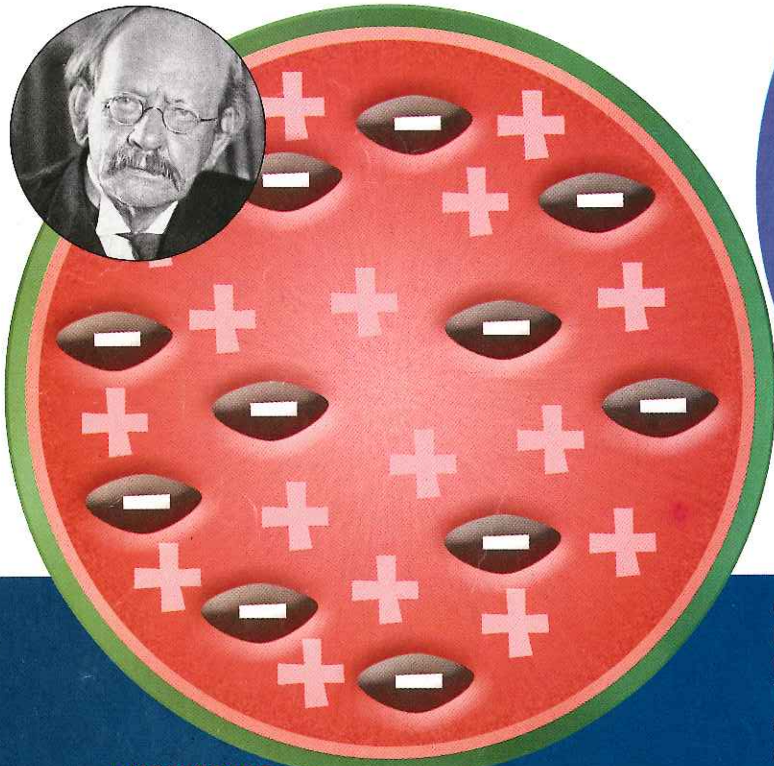
In this artist's computer rendering of an STM image, the ring is made up of 48 iron atoms on a copper surface.

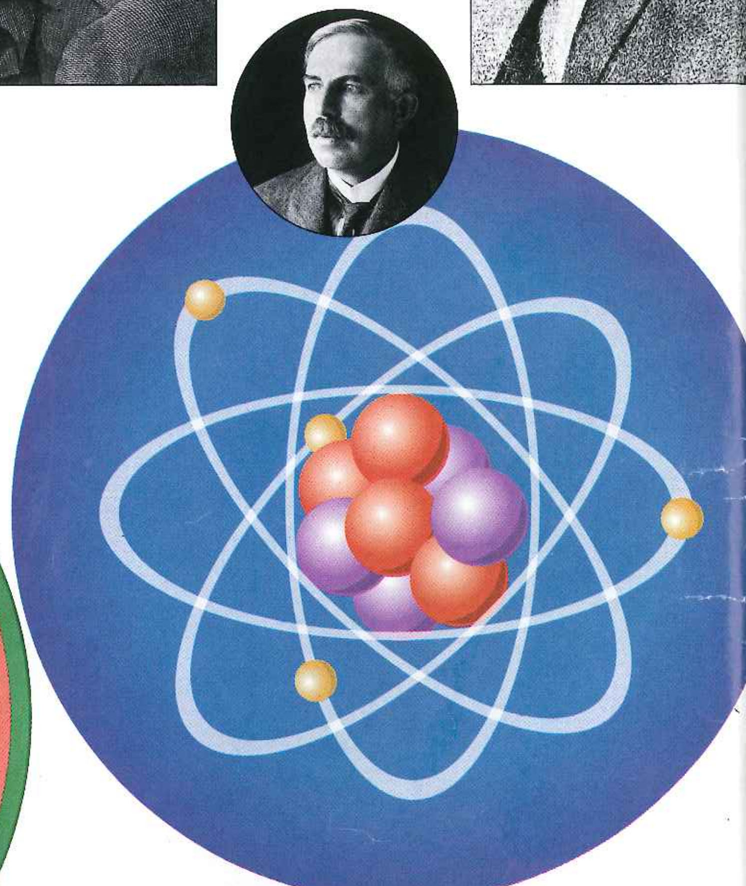
Atomic Benchmarks

Our understanding of atoms dates back to the Greek philosopher Democritus. Around 530 B.C., Democritus wrote that atoms moved about in a void, bouncing off one another or interlocking to form clusters. He believed that all changes in the world were the result of changes in the movement of atoms or in the way atoms were packed together.

Democritus's ideas remained pretty much unchallenged until the 19th century, a time that marked the beginning of startling discoveries about the atom—discoveries that continue today.

◀ **IN 1808, JOHN** Dalton, British teacher and scientist, proposed the modern atomic theory, suggesting that atoms are tiny spheres with hooks that allow them to connect.





THOMSON'S MODEL

In 1897, British physicist J. J. Thomson experimented with passing electric current through a glass tube filled with gas. This work led him to conclude that atoms contained negatively charged particles. Thomson called these particles electrons. He knew, however, that atoms were neutral—not negative or positive. So he figured they must also contain positively charged material in order to offset the negative charge of the electrons. To illustrate his understanding, Thomson created a model of an atom that looked very much like a watermelon. The seeds stood for electrons, and the red part stood for the positively charged area that surrounded them.

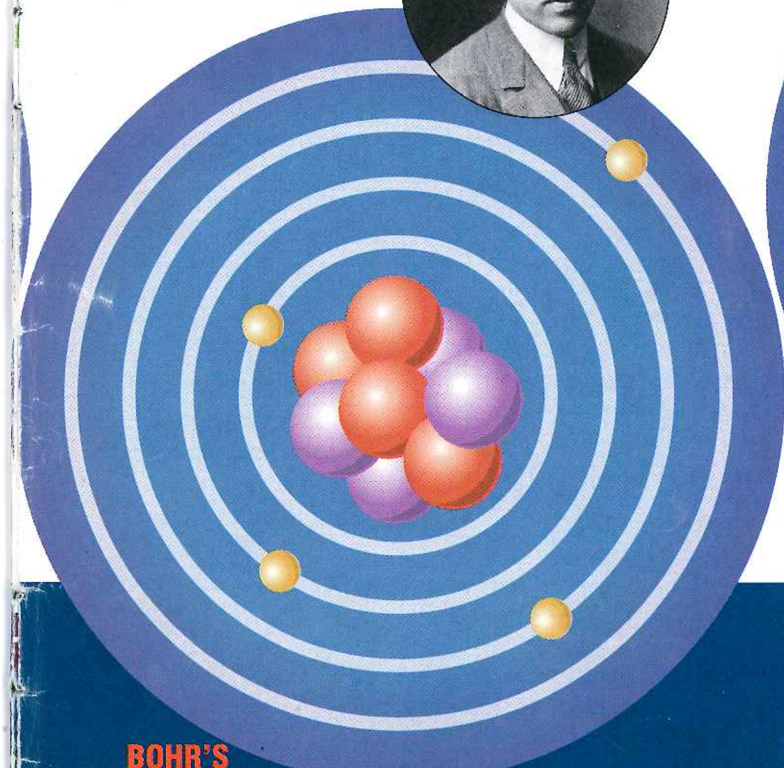
RUTHERFORD'S MODEL

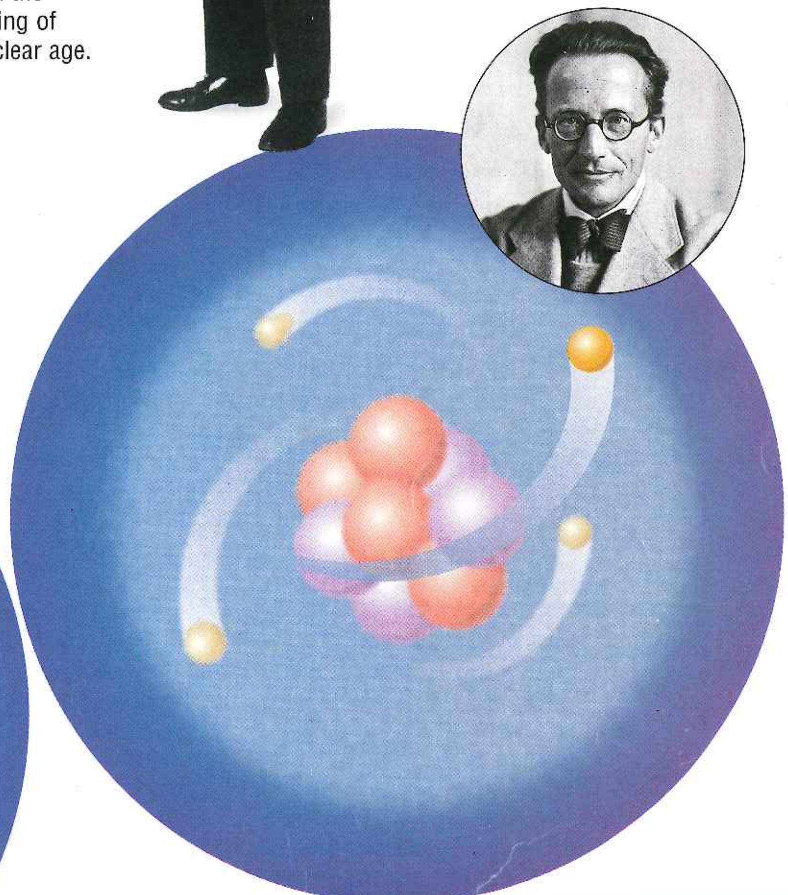
In the early 1900s, Ernest Rutherford, a British physicist, discovered that gold atoms were mostly empty space, but dense in the center. This central area he called the nucleus. Additional work led him to discover that the nucleus contained positively charged particles, which he called protons. To show his concept, Rutherford created a model that showed a nucleus in the center with electrons orbiting around it, much like moons orbiting a planet.

◄ In 1811, Amedeo Avogadro, Italian lawyer and physicist, recognized the difference between atoms and molecules, which are two or more atoms bound together. He also figured out a way to measure the mass of atoms, which led to the atomic mass unit, or amu, the unit of measure we use today.

◄ In 1932, British physicist James Chadwick proved that neutrons exist. He established that when atoms are bombarded with energy, neutrons come streaming out of the nucleus with enough force to split apart another atom. This discovery marked the beginning of the nuclear age.

◄ In 1963, American physicist Murray Gell-Mann proposed the quark theory, which stated that protons and neutrons are made up of even smaller particles called quarks.





BOHR'S MODEL

Danish physicist Niehls Bohr, working at about the same time as Rutherford, experimented with light and determined that electrons existed only at certain distances from the nucleus. Unlike Rutherford's model, in which electrons circle ever closer to the nucleus until they collapse into it, the electrons in Bohr's model are stable unless they absorb additional energy. Then they jump to a greater distance from the nucleus but return to their original distance.

SCHRÖDINGER'S QUANTUM MODEL

Austrian physicist Erwin Schrödinger wondered why electrons should be limited to specific orbits at specific distances from the nucleus. In 1924, he proposed a new model of the atom, one in which electrons moved in cloud-like orbitals rather than in precise paths. According to Schrödinger and others at the time, it was impossible to know the exact position of an electron. The best we could do was know where it probably was. Most physicists today are working with Schrödinger's model of the atom. But stay tuned. There are sure to be more developments in the story.

It's Elemental

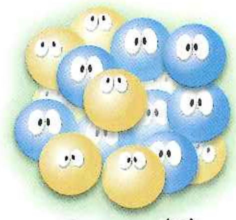
Imagine burnt toast. The black particles you can scrape off the bread are actually clumps of carbon atoms. All carbon atoms are alike; they have the same number of protons. In the same way, all oxygen atoms are alike, all iron atoms are alike, and so on. Each kind of atom is an element. Carbon, oxygen, and iron are three of over one hundred elements.

The atoms of different elements differ in the number of protons and electrons they have. Atoms with more electrons, such as uranium, which has 92 electrons, tend to be larger than atoms with fewer electrons, such as hydrogen, which has one electron.

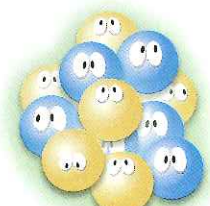
Atoms also differ in mass—the amount of stuff or matter in something. For example, a ping-pong ball and a golf ball are about the same size, but a golf ball has greater mass. The mass of an atom is related mostly to its number of protons and neutrons. Mass is measured in atomic mass units. Each proton and each neutron has a mass of one atomic unit, or one amu.

FOUR ELEMENTS MAKE UP MOST LIVING THINGS—INCLUDING YOU! THE ELEMENTS ARE OXYGEN, CARBON, HYDROGEN, AND NITROGEN.

Oxygen is an element that occurs naturally. About 20 percent of the air you breathe is made up of oxygen. About 60 percent of your body mass is oxygen. An oxygen atom has 8 protons and 8 neutrons and an atomic mass of 16. Oxygen combines with hydrogen to form water, H_2O. When oxygen atoms are grouped in threes, they form a molecule known as ozone (O_3). Ozone is a gas in the upper atmosphere which shields us from the sun's dangerous ultraviolet rays.



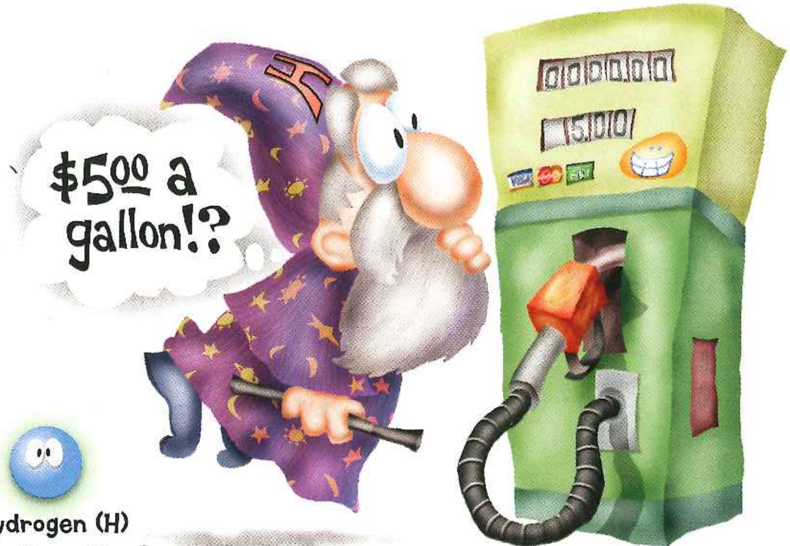
Oxygen (O)
Atomic mass = 16



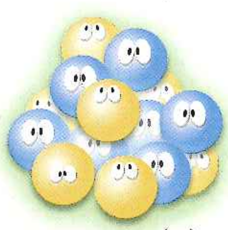
Carbon (C)
Atomic mass = 12

A carbon atom has 6 protons and 6 neutrons and an atomic mass of 12. Just like all other kinds of atoms, how carbon atoms are organized, held together, and combined with other atoms determines what they form. Carbon atoms that are bound to each other in the shape of flat sheets form graphite. Graphite is often used in lubricants for machinery. Carbon is mixed with atoms of other elements to form the lead in your pencil. Carbon combines with oxygen to form carbon dioxide (CO_2). Carbon dioxide is what you exhale when you breathe. It is also the fizz in the sodas you drink.

Hydrogen is the most common element in the universe. It is also the lightest, with an atomic mass of 1. In its most common form, hydrogen has 1 proton and no neutrons. Hydrogen combines with carbon atoms to form gasoline, candle wax, kerosene, and petroleum. Hydrocarbons, as these compounds of hydrogen and carbon are called, are very common.

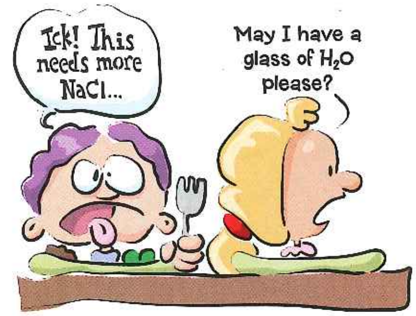


Hydrogen (H)
Atomic mass = 1



Nitrogen (N)
Atomic mass = 14

Nitrogen has 7 protons, 7 neutrons, and an atomic mass of 14. It makes up almost 80 percent of our atmosphere. Nitrogen is an important part of protein, the major ingredient of cell tissue. Plants use nitrogen and other elements to manufacture amino acids, the building blocks of protein.



▲ **When two or** more atoms come together, they form a molecule. Molecules may be made up of the same atoms or different atoms. When two atoms of hydrogen (H) and one atom of oxygen (O) come together, they form a molecule of water, H_2O. When one atom of sodium (Na) combines with one atom of chlorine (Cl), the result is sodium chloride, or NaCl, known as salt.

URANIUM MINE

YELLOW CAKE

URANIUM PELLETS

▲ **Uranium has 92** protons and 146 neutrons and an atomic weight of 238. It is the heaviest of all naturally occurring elements. Uranium is radioactive, which means it gives off high-energy rays that can be dangerous if people are exposed to large quantities of them. Uranium is the element used to make nuclear bombs and nuclear energy. In nature, uranium is a silvery-white metal. Deposits are found on most of the continents, especially North America. After uranium is mined, it is processed into a concentrate called yellow cake, which is then compressed into pellets. The pellets may be used to produce nuclear energy.

Atoms Tell All

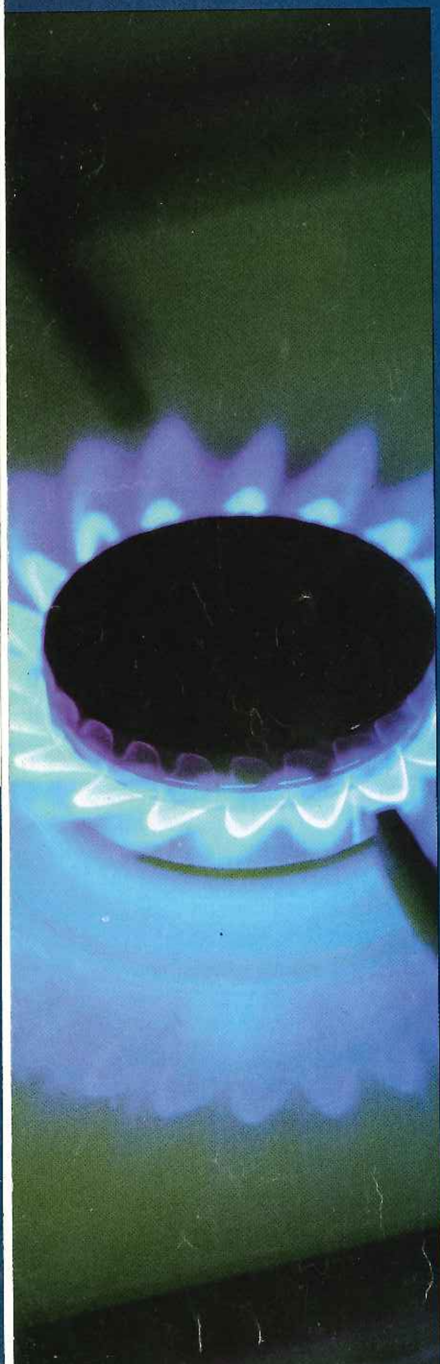
Why do lightbulbs glow? Why are the flames of fires different colors? How can scientists figure out the age of a fossil? How is it possible to see inside your body? Atoms and their behavior

LIGHTS UP!

When energy, such as light or heat, is applied to atoms, their electrons move away from the nucleus. However, they quickly return to where they came from. As they return, they give off the energy they absorbed. The energy they give off is light.

THE GLOW OF A LIGHTBULB

In a lightbulb, free electrons—those not bound to an atom—move along a wire, or filament. The free electrons in the wire bump into the atoms in the filament. Then the electrons of the atoms in the filament move further away from the nucleus. When returning to their original position, they give off energy as light. This is the light we see.



THE COLOR OF FIRE

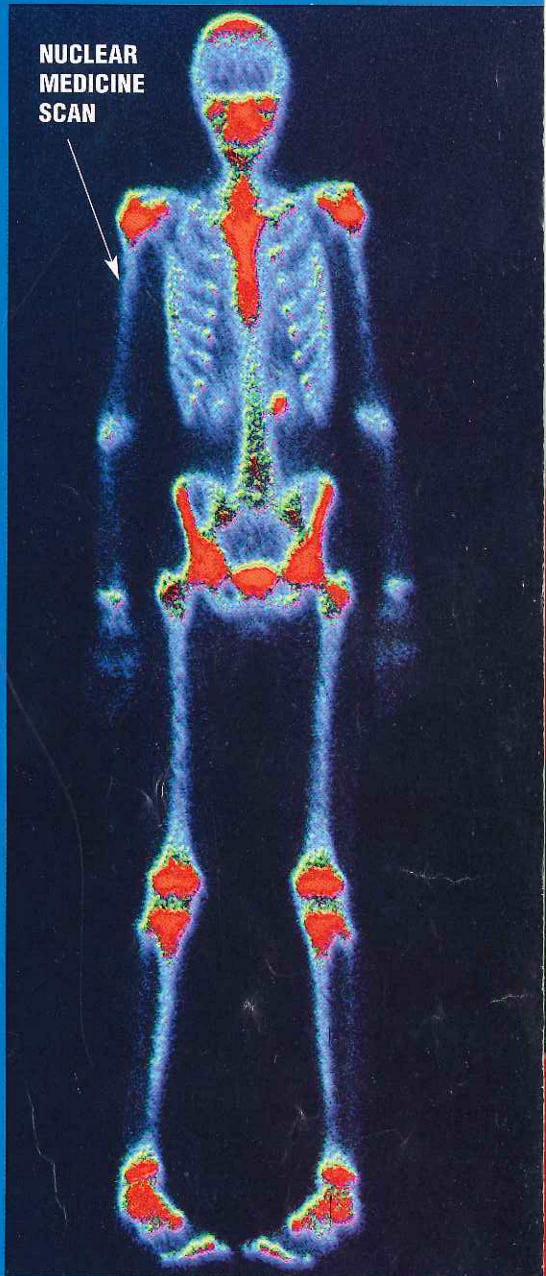
Fuel is necessary for fire. However, some fuels, such as natural gas, transfer more heat to atoms than other fuels, such as wood. When it comes to fire, the amount of energy electrons absorb and give off affects the flame's color. Less energy creates an orange flame. More energy creates a blue flame. That's why the flames of a wood fire are orange, and the flames on a gas stove are blue.

can help explain these phenomena, as well as almost every other phenomenon in the universe, including what heat is, how sound is made, and even what makes the sun shine. Here are two ideas about atoms that help answer these questions.

NEUTRONS AWAY!

The properties of an atom are based on the number of protons it has. For example, all hydrogen atoms have one proton. But some hydrogen atoms have no neutrons, some have one neutron, and some have two. These different forms of hydrogen are called isotopes. Most isotopes are stable, which means they don't change over time. But the isotopes with extra neutrons are not stable, which means they give off their extra energy in a process of radioactive decay. The energy is in the form of rays that can penetrate paper, wood, and in some cases even concrete.

SCIENTISTS CAN USE CARBON DATING TO FIGURE OUT HOW LONG AGO THIS ANIMAL DIED.



NUCLEAR MEDICINE SCAN

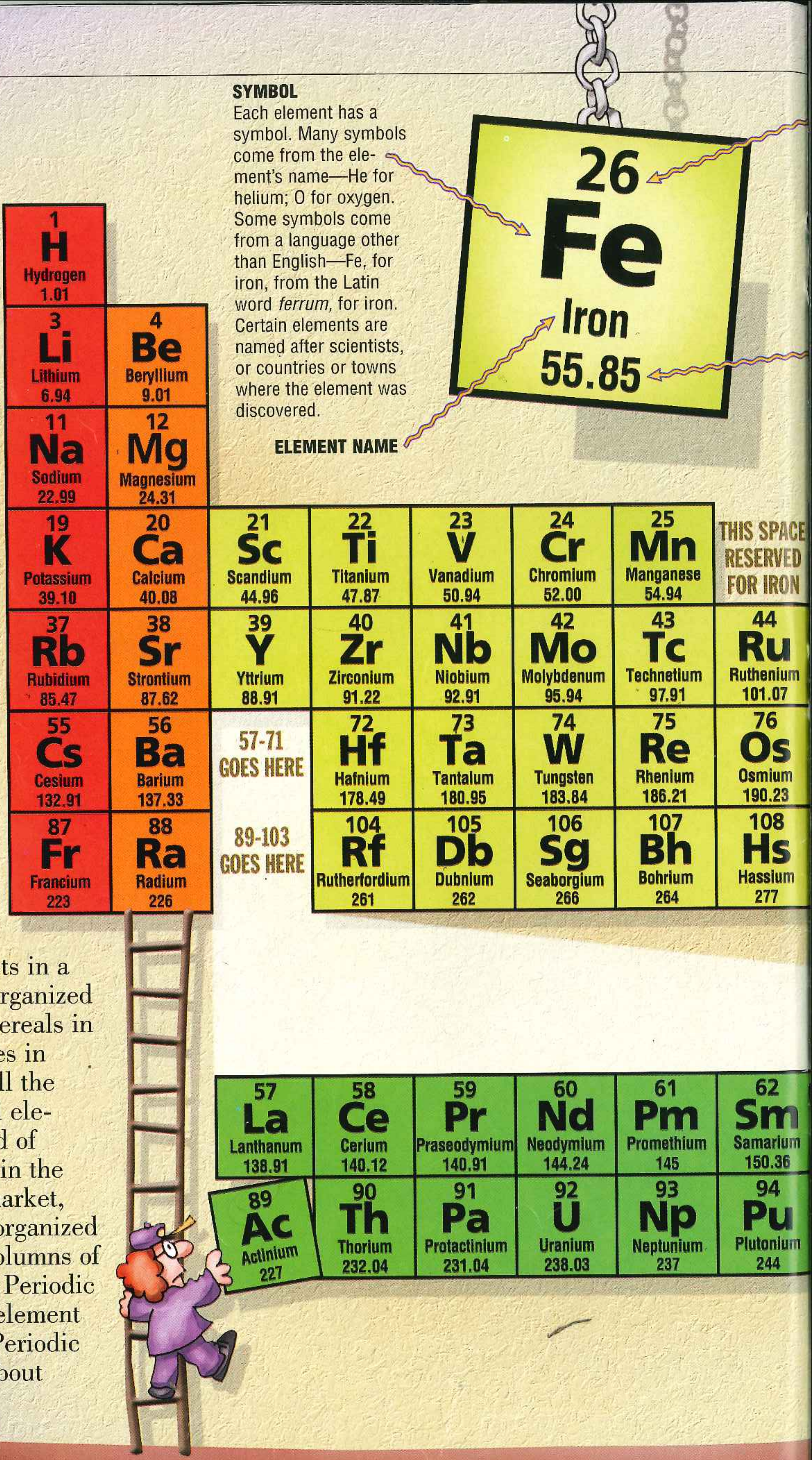
CARBON-14: TELLING THE AGE OF A FOSSIL

Most carbon atoms have 6 protons and 6 neutrons, but some have 8 neutrons. The extra neutrons give these carbon atoms an atomic mass of 14, which is where the name carbon-14 comes from. All living things have regular carbon atoms and a small percent of carbon-14 atoms. The carbon-14 atoms decay and are replaced continually. When a plant or animal dies, the carbon-14 atoms continue to decay, but they are not replaced. As a result, the ratio of regular carbon atoms to carbon-14 atoms increases. By examining a fossil and calculating the ratio of regular carbon atoms to carbon-14 atoms and comparing it to the ratio in living things, scientists can figure out how long ago the animal or plant died and, therefore, how old the fossil is.

IMAGING THROUGH RADIOACTIVITY

Radioactive isotopes, which are also called radioisotopes, can penetrate a person's skin, but not the bones. As a result, we can see inside a person's body. Radioisotopes are used in making PET scans and MRIs, images that give information about the form and function of the body.

THE PERIODIC TABLE



Just as the products in a supermarket are organized by similarities—cereals in one spot, beverages in another—so are all the different chemical elements. But instead of "sitting" together in the aisles of a supermarket, the elements are organized in the rows and columns of a chart called the Periodic Table. Where an element is located in the Periodic Table tells a lot about the element.

ATOMIC NUMBER
The atomic number is the number of protons in the atom's nucleus. Atomic numbers begin at the top left of the table (H is number 1) and continue from left to right, row by row.

ATOMIC MASS UNIT
The atomic mass (amu) tells how heavy the element is. The atomic mass is the number of protons and neutrons in the element. He, helium, has 2 protons and 2 neutrons.

									2 He Helium 4.00
				5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
				13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.07	17 Cl Chlorine 35.45	18 Ar Argon 39.95
27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.41	31 Ga Gallium 69.72	32 Ge Germanium 72.64	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80
45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29
77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.20	83 Bi Bismuth 208.98	84 Po Polonium 208.98	85 At Astatine 209.99	86 Rn Radon 222.02
109 Mt Meitnerium 268	110 Ds Darmstadtium 271	111 Rg Roentgenium 272							

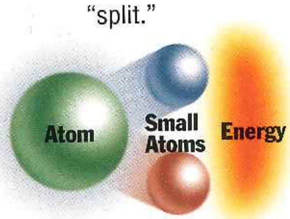
Source: IUPAC and Los Alamos National Laboratory

FAMILY OF ELEMENTS
Elements that behave in the same way are grouped by color. Some are metals, such as iron. Some are gases, such as helium.

63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.97
95 Am Americium 243	96 Cm Curium 247	97 Bk Berkelium 247	98 Cf Californium 251	99 Es Einsteinium 252	100 Fm Fermium 257	101 Md Mendelevium 258	102 No Nobelium 259	103 Lr Lawrencium 262

Fission Fusion No Con-fusion

The word "fission" comes from the Latin word **fissus,** which means "split."



Consider the paper on which these words are printed. The ink used in the printing. The chair you are probably sitting on. The food you eat. Each of these things, and everything else for that matter, is alike in some important ways. Each is made of matter, which has mass. Mass is a form of energy. However, the energy of mass is not usable until a chemical reaction takes place. For example, energy is stored in a piece of wood, but this energy is not usable until a chemical reaction, such as burning, takes place. When wood is burned, energy is released in the form of heat. The heat can be used for

FISSION

In 1932, British scientist John Cockcroft and Irish scientist Ernest Walton bombarded atoms of lithium (a very lightweight silvery metal) with a stream of protons moving at high speeds. Each atom split into two. But the two new atoms had less mass than one lithium atom. Where did the extra mass go? As Einstein predicted, it transformed to energy, so much energy that it caused the new atoms to move about violently, bombarding other atoms they came in contact with. This same process is the basis for all nuclear power in use today.

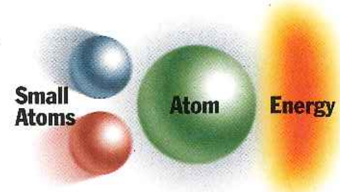
▼ **Most nuclear** reactors use uranium-235 instead of lithium and bombard it with neutrons instead of protons. As a uranium atom splits in two, it gives off two or three neutrons plus huge amounts of energy. The extra neutrons, moving at great speeds, bombard other uranium-235 atoms and cause them to split, giving off still more neutrons. The process repeats in a chain reaction in a nuclear reactor core. The amount of energy released in the chain reaction is controlled by a cooling pool, (below), and control rods, under construction at a nuclear power plant (bottom).

▲ **A nuclear bomb** is an uncontrolled chain reaction. Energy and heat build until the uranium blows itself apart. The U.S. is the only country to have dropped a nuclear bomb during wartime—on Hiroshima, Japan, on August 6, 1945, and a few days later on Nagasaki. The devastation was enormous. Soon after, Japan surrendered and World War II ended. At the time, most people in the U.S. were in favor of dropping the bomb. Looking back, the decision has become controversial.

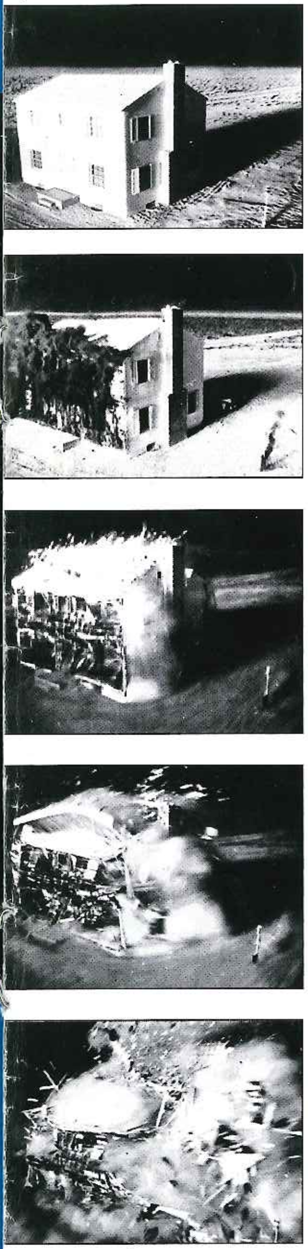
many things, such as heating a room or toasting a marshmallow.

This is the great understanding that Albert Einstein summarized in 1905 in his now famous equation: $E=mc^2$. Put simply, mass and energy are variations of each other. Mass is a visible form of energy and becomes pure energy when moving fast enough. The c^2 in the equation stands for the particular speed at which matter is transformed to energy. That speed is 34,596,000,000 (miles per second) squared, the speed of light times itself.

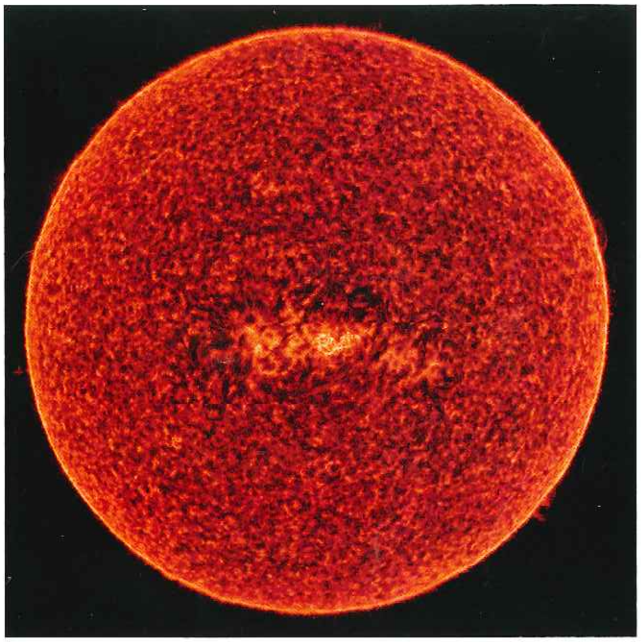
The idea in Einstein's equation is key to understanding fission, nuclear power, and almost everything else in, under, and around our world.



FUSION

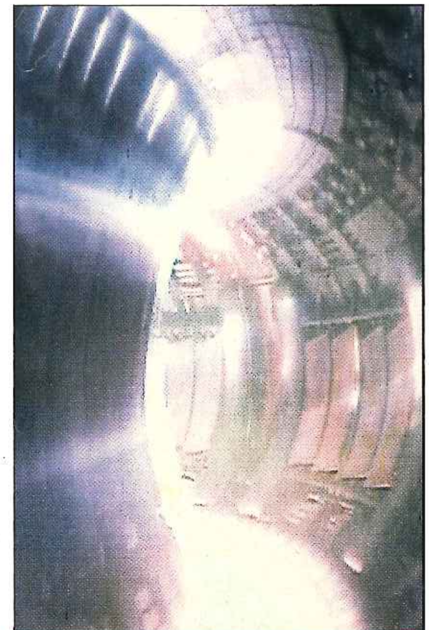


EFFECT OF NUCLEAR BLAST ON WOOD-FRAME HOUSE LOCATED THREE-FIFTHS OF A MILE FROM GROUND ZERO AT A NEVADA TEST SITE, 1953



▲ **FUSION IS THE** opposite of fission. It takes place when the nuclei (plural of "nucleus") of two atoms collide and combine to make a new atom. During fusion, some amount of mass becomes energy—just as Einstein predicted.

Fusion takes place on stars like the sun all the time. In fact, it is solar fusion that provides heat and light for Earth. Creating fusion on Earth, however, isn't so easy. The protons in a nucleus repel, or push against, each other. If they are to fuse, they must collide with a force stronger than the force that pushes them apart. The way to do that is to heat atoms until they are moving so fast that when they collide, they fuse instead of bouncing off each other. The problem is the amount of energy needed to heat atoms to such a high temperature. When we find cheaper and more efficient ways of heating atoms, fusion energy may be a practical answer to our energy needs. Until then, it is the stuff of research scientists.



AN INFRARED IMAGE TAKEN INSIDE JET (JOINT EUROPEAN TORUS), THE FIRST FUSION FACILITY TO ACHIEVE SIGNIFICANT PRODUCTION OF CONTROLLED FUSION, IN 1991.

THE (NOT YET) FEASIBLE: It is still too expensive to use fusion energy. However, many feel there is good reason to solve the problems that are now in the way.

+ PLENTIFUL FUEL: It can be taken from water and from lithium, a metal available in many parts of the world.

+ NO RISK OF A NUCLEAR ACCIDENT: The amount of fuel needed is so small that an uncontrolled chain reaction would be impossible.

+ NO AIR POLLUTION: Oil and other polluting fuels are not needed for fusion energy.

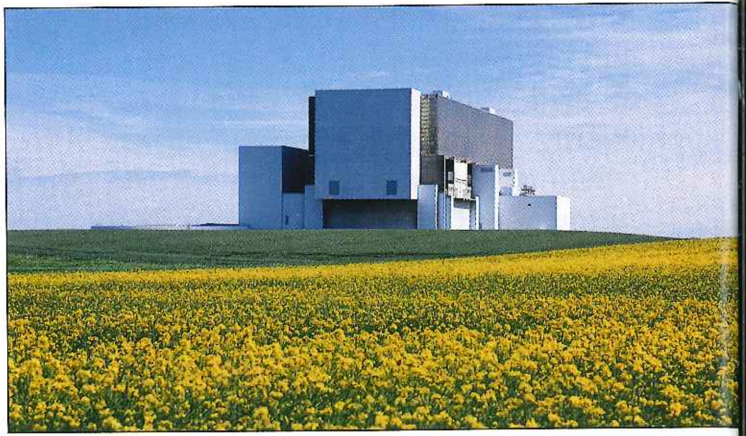
+ RADIOACTIVITY ASSOCIATED WITH FUSION DECAYS QUICKLY: There wouldn't be a need to bury nuclear waste, which stays radioactive for thousands of years.

Going Nuclear

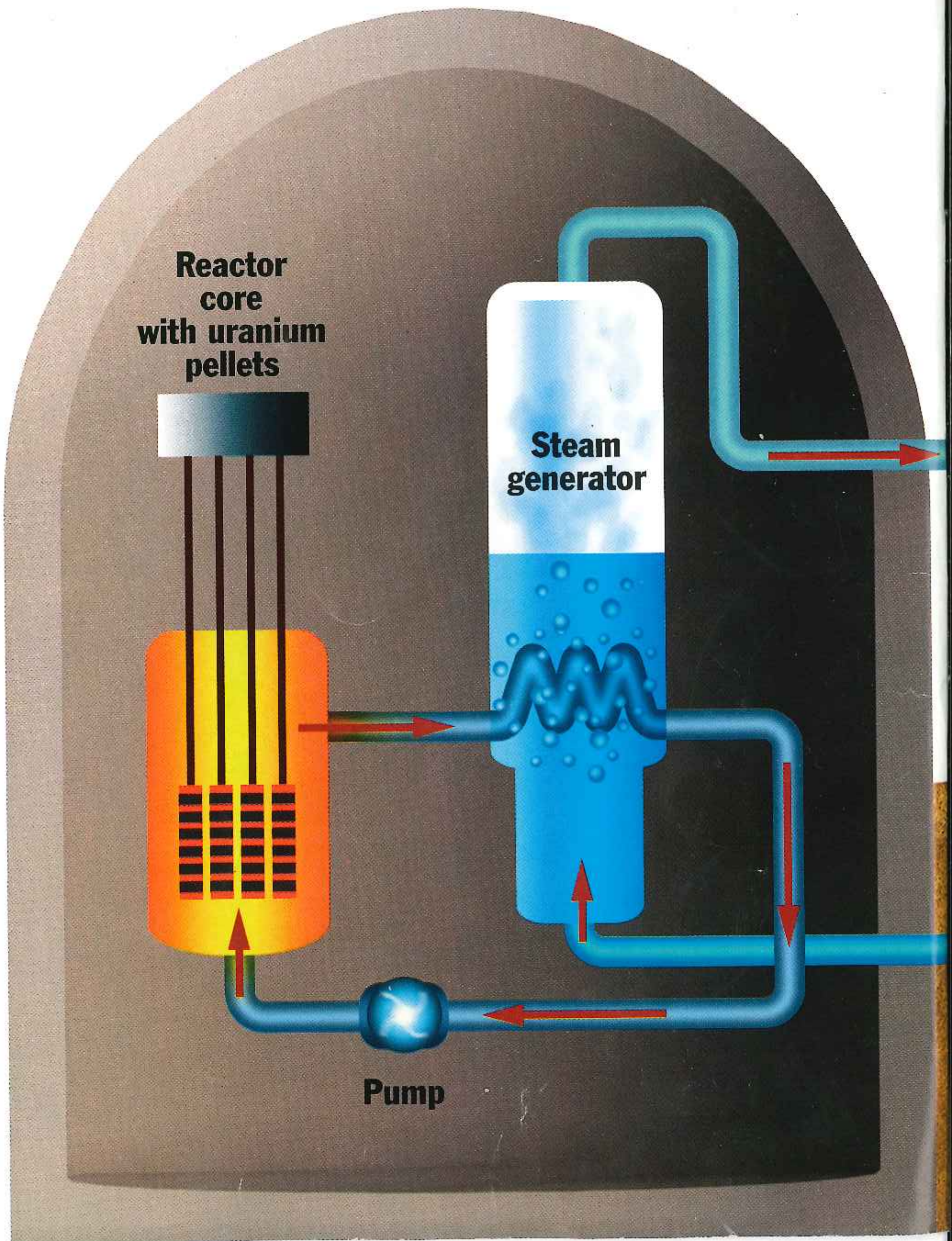
Why are oil prices so high? How can we reduce our dependence on foreign oil? Why aren't we building more nuclear power plants? More nuclear energy may

Nuclear power plants use fission to release enormous quantities of heat from small amounts of fuel. The heat boils water to create steam, which turns the turbines that make electricity. This is the electricity sent to homes and businesses that use nuclear power.

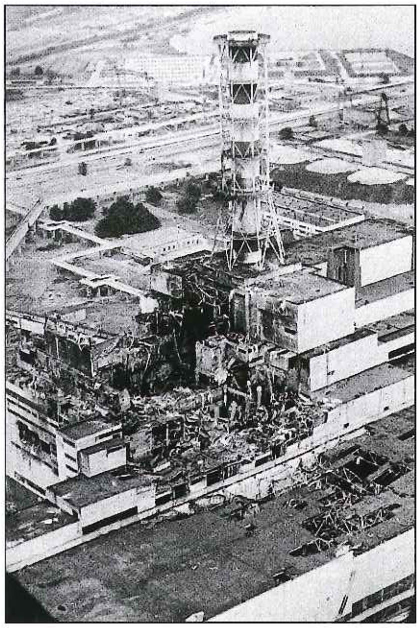
➤ **The cost of** building a nuclear power plant is high. But once the plant is operating, the cost of producing energy is low.



▲ **In 1979, one of** the reactors at the Three Mile Island nuclear power plant in Pennsylvania had a partial meltdown (uranium pellets overheated). People living nearby were evacuated. The radiation, however, was contained, and officials concluded that the accident had no significant effect on people's health. Above, a worker wears a protective suit during the cleanup operation.



reduce our dependence on other fuels. But the solution is not so simple. There is much that is good about nuclear energy but much cause for concern.



➤ **A CHAIN REACTION** went out of control in 1986 at a nuclear power plant in Chernobyl, Ukraine. Explosions took place, and a huge fireball broke open the protective casing. Radioactive atoms were released into the environment, with effects felt all over the northern hemisphere. Ten thousand people died, and 135,000 people were evacuated. Access within 18 miles of the plant was forbidden. Chernobyl is one of the most radioactive spots on Earth, and 20 years later, the land is still too dangerous to farm.

GOOD

CHEAP Most nuclear reactors use uranium as fuel. About one ton of uranium supplies the same amount of energy as 16,000 tons of coal or 80,000 barrels of oil. There's enough uranium on Earth for 500 to 1,000 years of energy.

CLEAN Supporters say nuclear energy is "green." In contrast, burning coal and oil adds carbon dioxide to the atmosphere, which increases the greenhouse effect and global warming. According to many scientists, nuclear energy does not contribute significantly to the greenhouse effect.

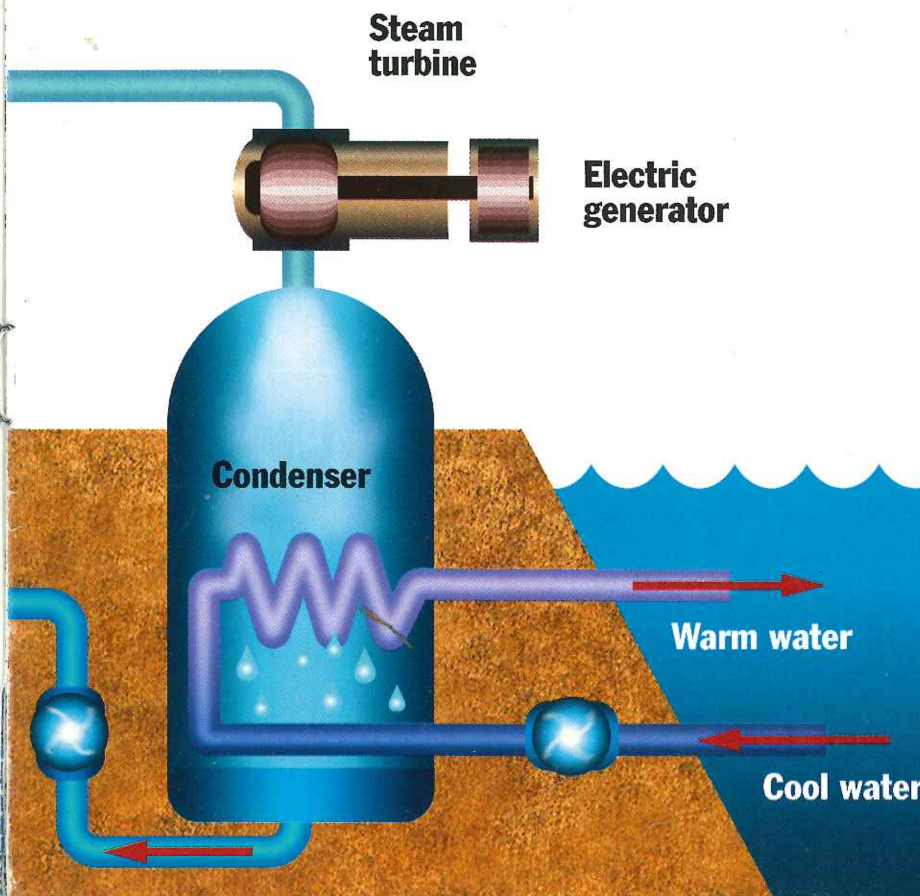
SAFE People who support nuclear energy emphasize the safety mechanisms in a nuclear power plant. Supporters also point out that in comparison to the tens of thousands of Americans who die each year from respiratory diseases caused by the burning of coal and oil, nuclear power is safe.

BAD

DANGEROUS When the uranium pellets in the rods at the core of a reactor are overheated, they may melt. Tremendous quantities of radiation can be released into the environment, causing widespread death, illness, destruction, and environmental damage for decades to come.

DIRTY The waste products of a nuclear energy plant are highly radioactive and dangerous...and remain so for thousands of years. To keep people and the environment safe from contamination, the waste must be buried almost half a mile below ground.

RISKY Nuclear power plants are run by people. Even the best-trained people can make mistakes. When it comes to nuclear power, even a small mistake can have catastrophic results.



A LASER WORLD

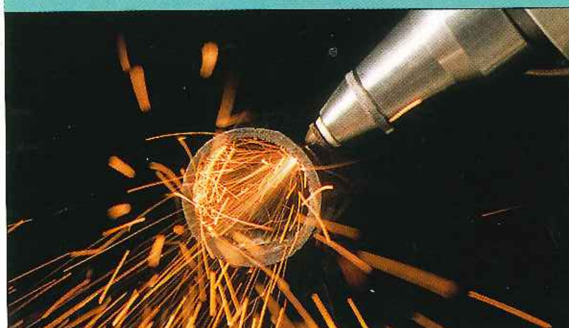
In some ways laser light is like every other kind of light. It is the result of atoms' electrons giving off light energy as they jump back toward the nucleus. In other ways, however, laser light is quite different. Laser light is one specific color of light. The color is determined by the energy of the light. Lower-energy lasers are red; higher-energy lasers may be blue or violet. Some laser light is not visible to the human eye at all. In addition, laser light has a tight beam that is strong and concentrated. Ordinary light, like the light from a flashlight, is spread out and weak by comparison.

One rule, however, holds true for all lasers: Do not look a laser in the eye. Some give off a light brighter than the sun's. Others give off heat that can burn the skin and set clothes on fire. Most lasers are not playthings. Lasers are used in a variety of ways, from supermarket scanners to eye surgery. Some say lasers will change our lives as much as computers have.

TAG BUT DON'T TOUCH

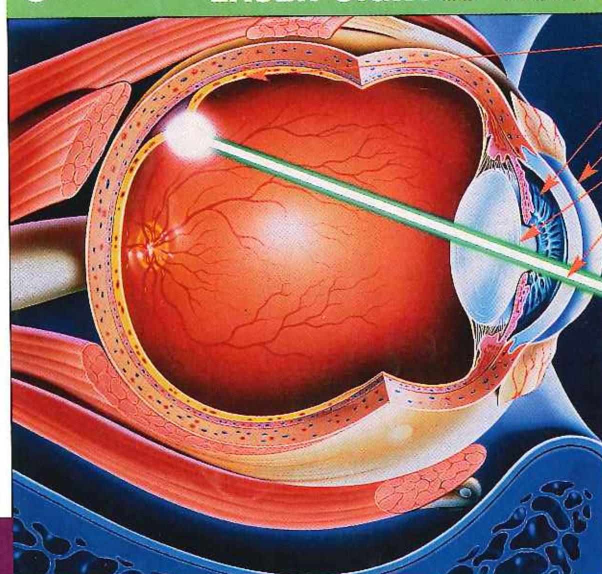
Laser tag equipment uses a low-level infrared, or heat, laser that is harmless and not visible to the human eye. Each player wears a sensor that reacts when hit by a laser.

HEAT CUTTER



Lasers are used in many types of machinery. This CO_2 laser gives off an infrared beam so strong it actually cuts through steel by melting it.

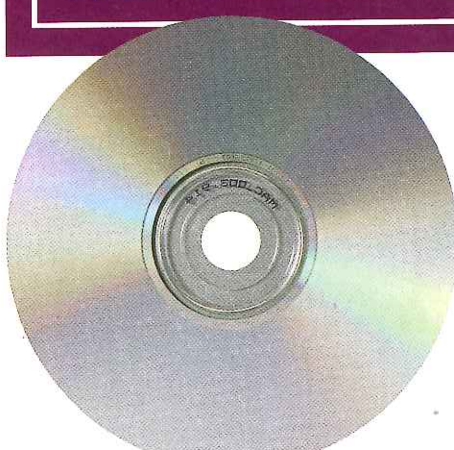
LASER-SIGHTED VISION



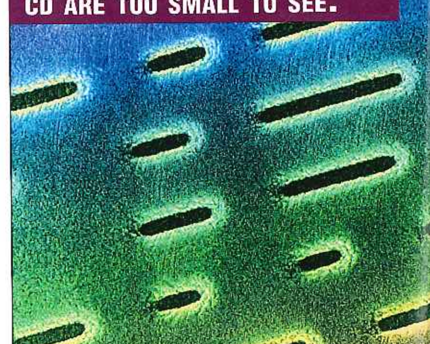
The cornea of your eye is like its front window. Light passes through the cornea and into the rest of your eye. Together, the cornea and lens focus the light on

CDs AND CD PLAYERS

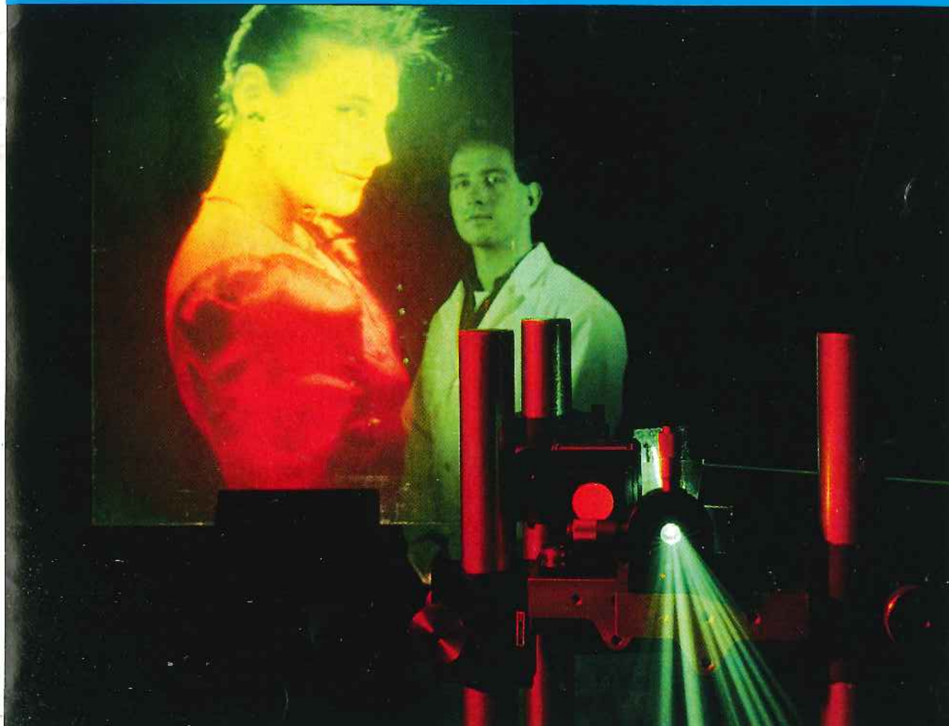
A CD is made of plastic, molded with a long, continuous track of very tiny bumps. The bumps contain digital information, or data, which can be "read" by a laser beam. A CD player contains a laser beam and a lens that focuses the beam on the track. Bumps on the track reflect light differently from the rest of the track. A sensor picks up these differences, which are then translated into digital audio or visual signals.



THE MICROSCOPIC BUMPS ON A CD ARE TOO SMALL TO SEE.



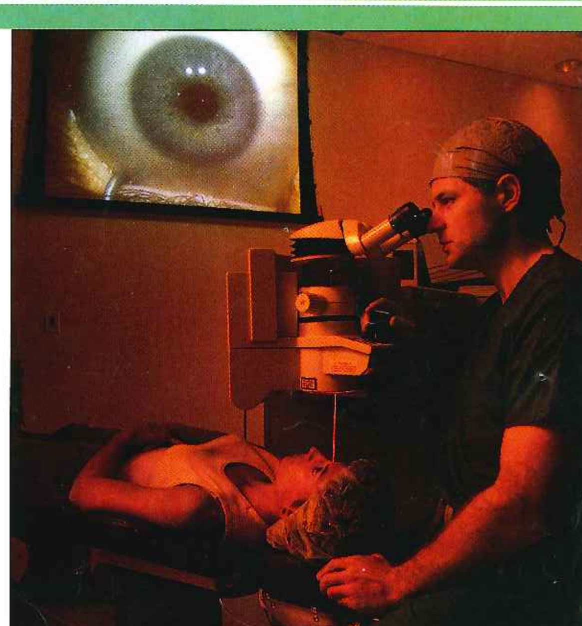
HOLOGRAMS



You may have seen stickers that seem to shine, photos that seem to change as the light changes, and pictures of people whose eyes seem to follow you. These images are probably holograms, photos taken with laser light. To achieve the effect, a laser beam is split in two. One beam lights up the object. The other beam, the reference beam, goes to a photographic plate near the object. Once developed, the light from the two sources creates the 3-D look of a hologram.

the retina. If the retina becomes detached (left), a condition that can occur spontaneously or as a result of injury or disease, a laser can be used to reattach it. The laser scorches small parts of the retina, sealing it back in place.

A laser can also be used to correct blurry vision that results when light focuses in front of or behind the retina instead of exactly on it. By changing the shape of the cornea, the laser changes where light focuses. A surgeon touches the surface of the eye with tiny pulses of laser light. The light actually vaporizes the part of the cornea it touches. By working slowly, the doctor controls how much and which parts of the cornea are removed. In most cases, a patient's vision is greatly improved. Often, glasses are no longer needed. Laser surgery has become so popular that it is sometimes performed in shopping malls!



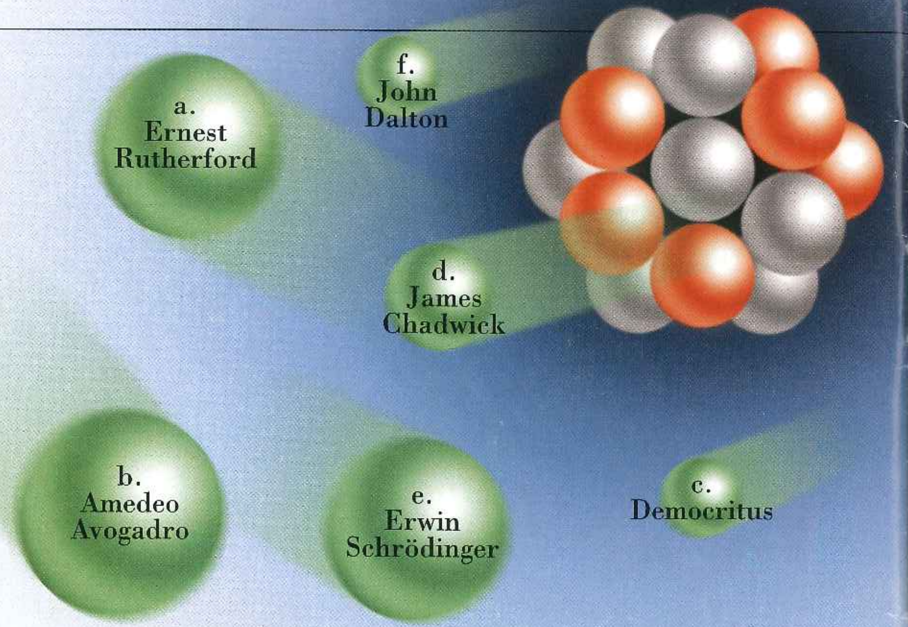
GETTING THE PRICE

Bar codes are everywhere, and so are laser scanners that can read them. The scanner shines a laser beam back and forth over the stripes of the bar code. A sensor picks up the pattern of light and dark bands. The information is then read and interpreted digitally and recorded in the computer/cash register.

Atom Guys

Match each accomplishment with the person's name.

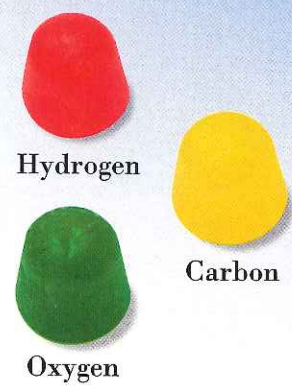
_____ 1. Discovered neutrons in 1932, marking the beginning of the nuclear age
_____ 2. Named the nucleus and protons
_____ 3. In 1808, proposed the modern atomic theory
_____ 4. Figured out how to measure the mass of an atom
_____ 5. First wrote about atoms
_____ 6. In 1924, proposed currently accepted model of atom

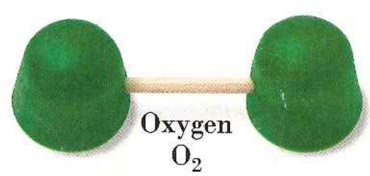


Building Molecules

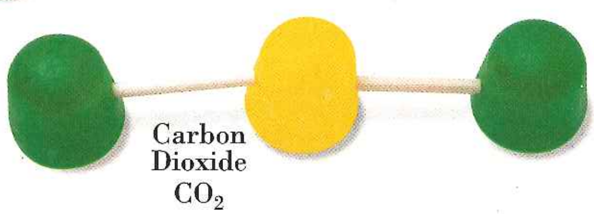
A molecule is two or more atoms bound together. Of course, atoms and molecules are much too small to see with the naked eye. But here is a way to get a rough idea of how atoms of different kinds form molecules. You will need gumdrops of different colors and toothpicks.

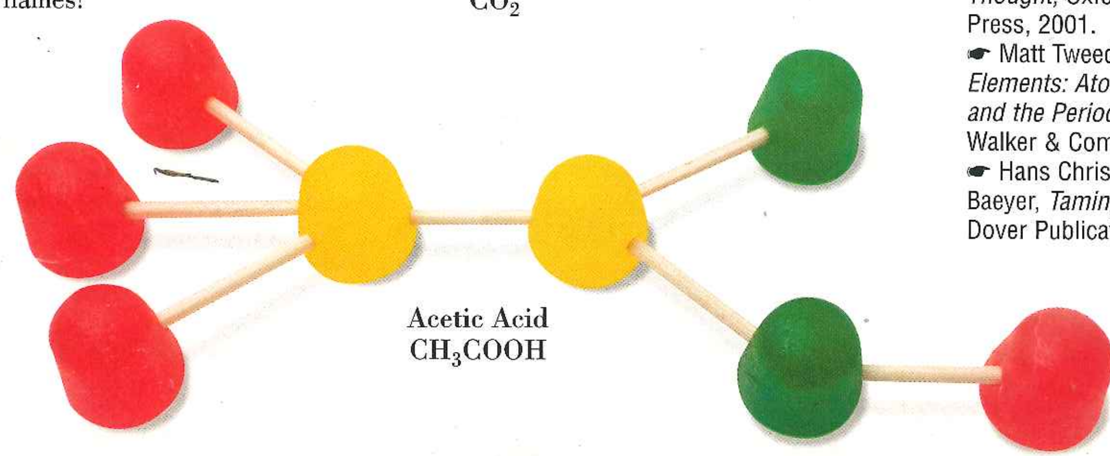
Make a color code. Each color gumdrop represents a different kind of atom. For example, red might be hydrogen, green might be oxygen, yellow might be carbon. Use the toothpicks to bind together different atoms. Here are some common molecules you might start with.





Find out what other kinds of molecules are made and show them in gumdrops. Or invent your own molecules and give them names!





More Reading on Atoms

Children's Books

- Christopher Cooper, *Eyewitness: Matter,* DK Children, 1999.
- Hazel Richardson, *How To Split the Atom,* Franklin Watts, 2001.
- Victoria Sherrow, *The Making of the Atomic Bomb,* Lucent Books, 2000.
- Melissa Stewart, *Atoms,* Compass Point Books, 2003.

Adult Books

- Isaac Asimov, *Atom: Journey Across the Subatomic Cosmos,* Plume, 1992.
- Jeff Hughes, *The Manhattan Project: Big Science and the Atom Bomb,* Columbia University Press, 2003.
- Bernard Pullman and Axel R. Reisinger, *The Atom in the History of Human Thought,* Oxford University Press, 2001.
- Matt Tweed, *Essential Elements: Atoms, Quarks, and the Periodic Table,* Walker & Company, 2003.
- Hans Christian von Baeyer, *Taming the Atom,* Dover Publications, 2000.