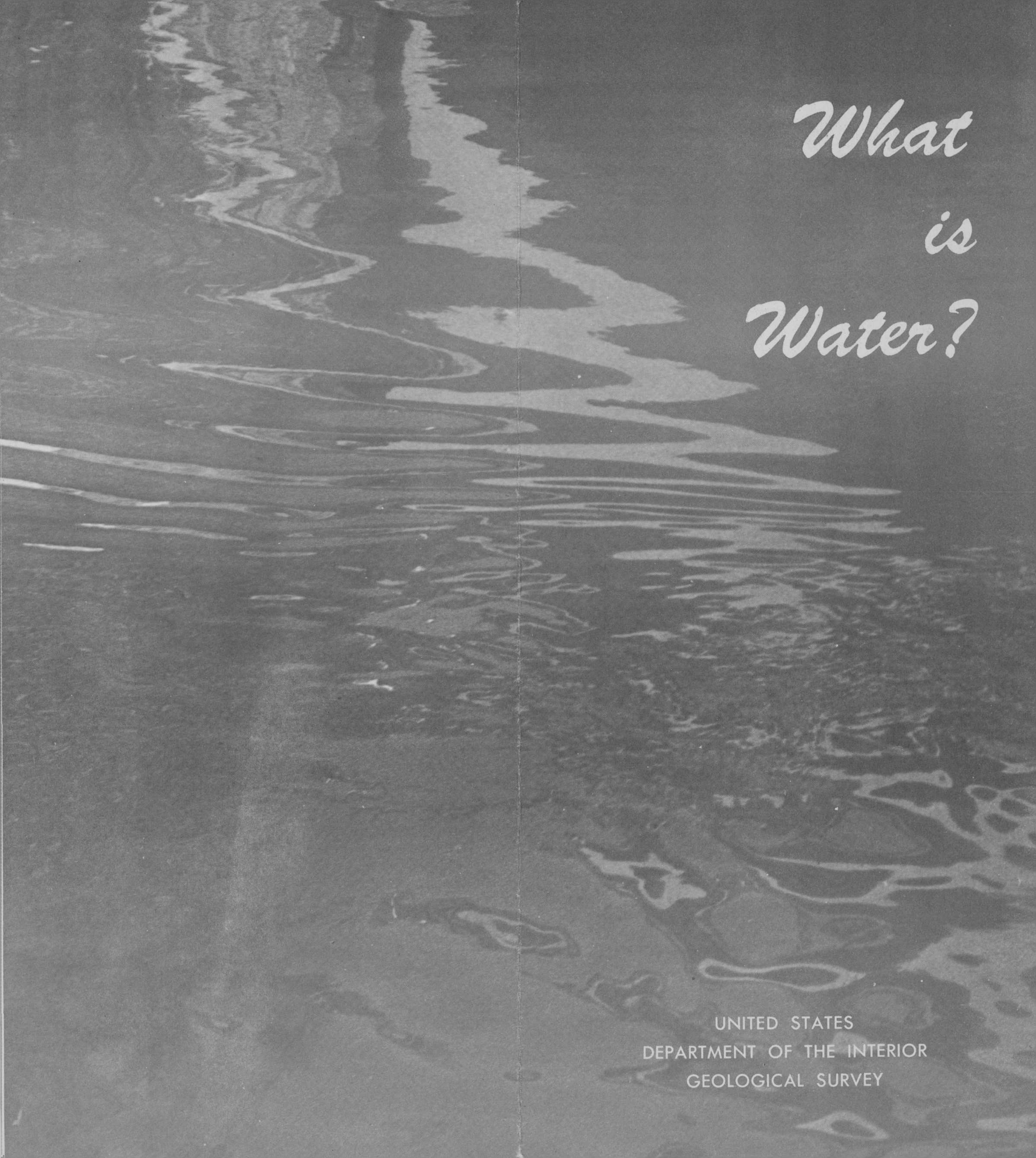
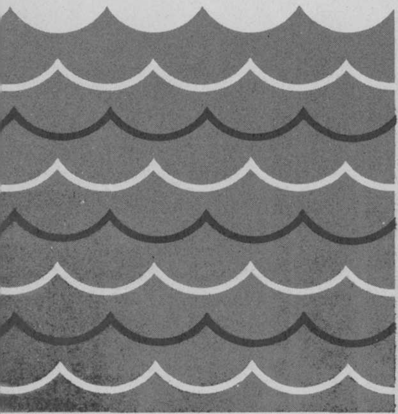


What is Water?

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY



What is Water?

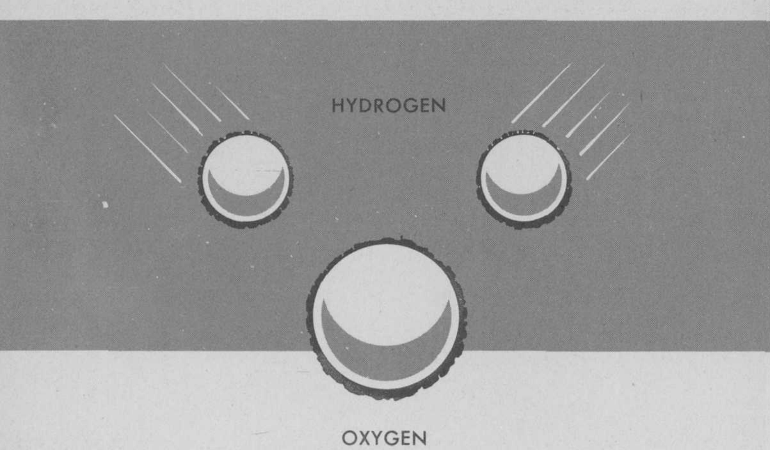
If a schoolboy asked this question, you would answer it easily enough. "Why, water is a liquid found in and around the earth. Water is the sea, lakes, streams, springs—and what comes gushing out of the tap when we turn it on."

If he still looks a little unsatisfied, you would explain that our bodies are three-fourths water, and that water covers three-fourths of the earth's surface.

But you would have to admit to yourself that these facts, interesting as they are, do not quite answer the boy's question: "What *is* water?"

If you have a basic knowledge of chemistry, you could say something like this:

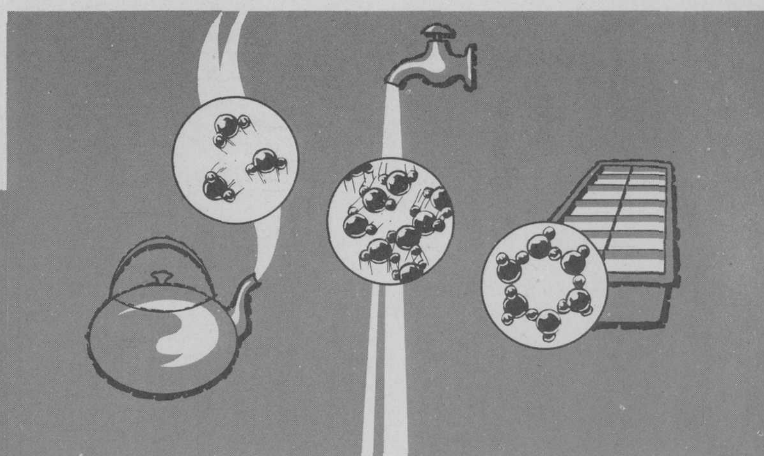
Each ounce of water is made up of numberless tiny particles called *molecules*, invisible to the naked eye. Each molecule is composed of even smaller particles called *atoms*. In each molecule of water there are two atoms of hydrogen for one of oxygen. That is why chemists call water "H_2O." Hydrogen and oxygen under proper conditions are gases, but when combined in these proportions they form a liquid—water.



Sounds simple, doesn't it?—and yet it isn't quite as simple as it sounds. You might not want to go into so much detail with your young friend, but water is not composed only of common hydrogen and oxygen. In 1934, Dr. Harold Urey discovered minute portions of a third component in water. He called the material *deuterium*. Later a fourth substance known as *tritium* was found to be part of water.

Actually, deuterium and tritium are not completely new elements, but so-called *isotopes* of the element hydrogen; that is, they are special hydrogen atoms that weigh more because they contain extra neutrons. The formula H_20 still stands, but we should remember that chemically, water is much more complex than this simple formula suggests.

Your explanation of water is still not complete, however. What about snow and ice? Or fog and vapor? They are water, too. Water can appear as solid, gas, or liquid. In fact, water is the only substance on earth that appears in three distinct forms of matter within the normal range of climatic conditions. The form it takes depends on the vigor of motion of its molecules. At low temperature, the molecules are relatively quiet, literally because they have less energy. This is the condition that produces ice, the solid form of water. When frozen, the water molecules form in hollow circles, as shown. At moderate temperatures, when the molecules are activated by the extra heat energy, water is liquid. The molecules are close together; yet they slip around freely. This is what gives liquid its flowing motion. At high temperatures, the molecules move about violently, colliding with one another and forming vapor, an invisible gas.

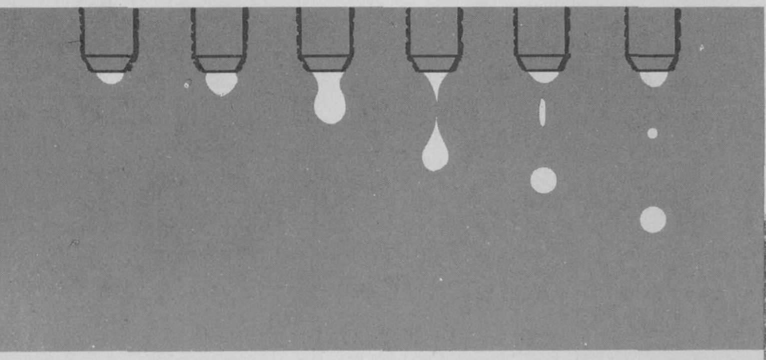


By this time the young student has realized that water, far from being simple, is actually quite complicated. For instance, most substances shrink as they get colder until they finally freeze, but water expands slightly just before it freezes and during the freezing process. If frozen water bursts the radiators in the garage, the family of your inquiring young friend may not be very happy about this peculiar property of water!

Because of this expansion, ice is lighter than water, whereas almost all other compounds are heavier when frozen. This is fortunate, because if ice were heavier than liquid water, lakes and streams would freeze from the bottom up instead of from the top down. They would become solid ice and in cold climates the deepest layers might not melt even in the summer. Solid freezing would have a disastrous effect on fish and water plants, which could not live through the winter at all.

Another remarkable fact about water is its heat capacity. Heat capacity means the ability of a substance to absorb a great deal of heat without itself becoming extremely hot. Water's heat capacity is the highest of all substances in nature except ammonia. For instance, an empty pan on a gas flame will very quickly become red-hot and then burn black. But if some water is placed in the pan over the same flame, the water will absorb heat from the pan. The pan will become hot, but not red-hot, and the temperature of the water will rise only a few degrees, comparatively speaking.

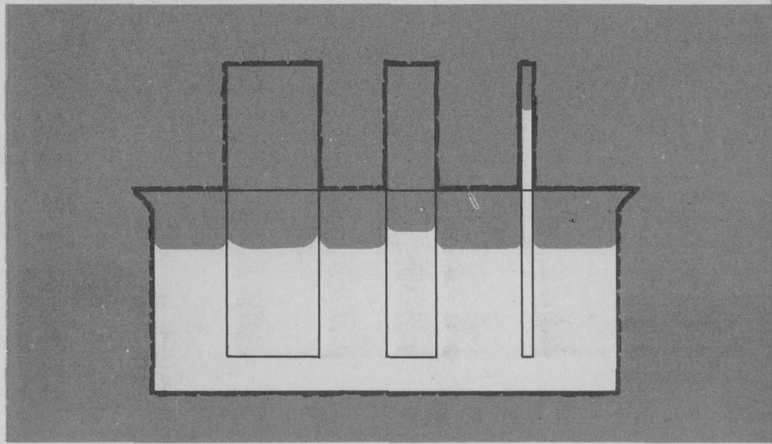
The heat capacity of water enables the oceans to be huge reservoirs of solar warmth and to keep our weather from going to great extremes of either hot or cold. The moderating effect of water is noticeably lacking in the desert. Lakes and streams are absent and the blanket of water vapor is very thin, so that the burning rays of the sun pour through in the daytime and warmth escapes rapidly at night.



Another unusual property of water is its extremely high *surface tension.* Surface tension is the ability of a substance to stick to itself. If you watch a drop of water fall from a spout, you will see it cling to the tap, stretch very thinly, then finally let go. Immediately it forms a sphere and this sphere resists deformation. To split water apart and make it form two new surfaces, tremendous force is necessary. Scientists estimate that 210,000 pounds of force would be needed to pull apart a column of pure water having a diameter of 1 inch, provided the water is absolutely pure. (It is difficult to make water pure enough to prove this.) In contrast, only about 100,000 pounds of force is required to pull apart a 1-inch steel cable.

Because of its high surface tension, a water surface can support objects heavier than itself—a needle, for instance, or insects that "skate" around on the water.

Water not only sticks to itself, but also sticks to other surfaces. In a very narrow column like a plant root or stem, the combination of surface tension with adhesion gradually pulls water upward. This upward movement is known as *capillarity,* and is partly responsible for the circulation of water in the soil and of blood in the body.



But perhaps water's most remarkable property is its action as a solvent. Given enough time, water can and does dissolve everything exposed to it. Each drop of rain is an independent sphere, like a tiny bullet, which can break away minute fragments of even the hardest rock. As they strike the earth and become a flowing liquid, the raindrops surround and move fine particles of soil. Water carries the soil particles into streams and finally down to the flood plains, deltas, and the sea.

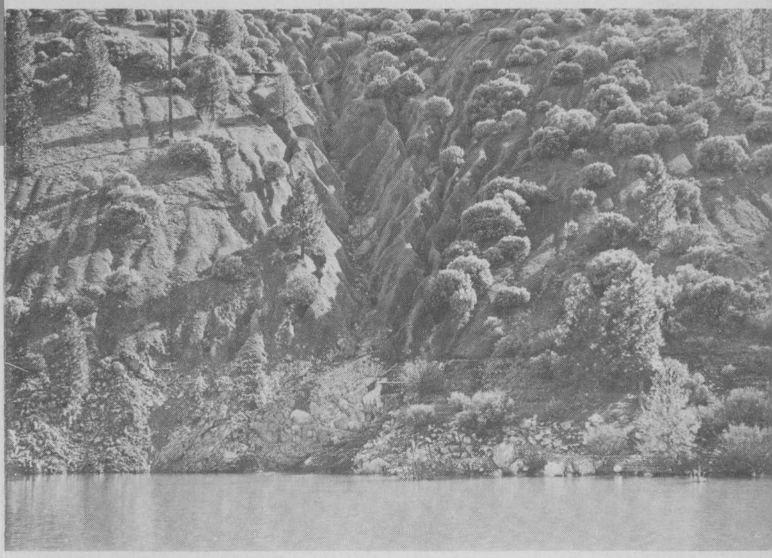
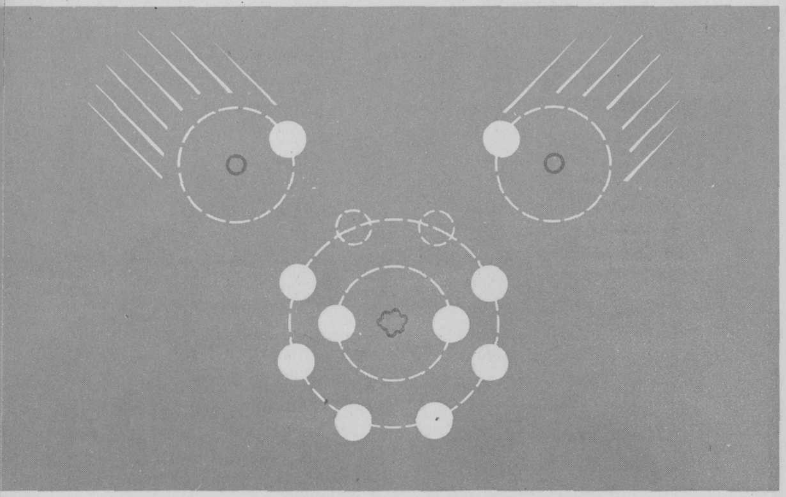


Photo: Bureau of Reclamation

All these striking aspects of water depend on a process called *chemical bonding*. All molecules have an electronic attraction for each other, and in the case of water this force is relatively great and makes for an extremely tight structure. This force results from the fact that oxygen's atom has two unpaired electrons while the two hydrogen atoms lack an electron each. The hydrogen atom with its single electron is eager to obtain another one. The mutual need of the atoms for paired electrons draws them irresistably together, and the bond thus formed is extraordinarily strong. You can see from the diagram that the hydrogen and oxygen atoms share two unpaired electrons.



Strong chemical bonding accounts for water's remarkable ability to adhere to substances (or "wet" them, as we ordinarily say), and thus eventually to dissolve them. Bonding also affects the boiling point of water and is responsible for its freezing process. The importance of this bonding to life processes is very great indeed, for without it water would not have the unique properties already described.

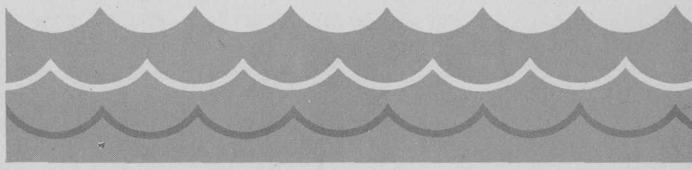
Now your young friend says, "Yes, I understand. But how did water get here? Where did it come from?"

To answer his question you would have to provide some geologic history. At one time the earth apparently was a molten mass radiating heat into space. It was surrounded by an atmosphere of gases and vapors which contained the essential ingredients of water. As the earth cooled and chemical changes proceeded, water eventually was formed.

The early seas probably were fresher water than seas of today, because water had scarcely begun the grinding and dissolving action which eventually carries salts down to the sea. Ever since the seas formed, water has been working away at the earth, trying to mold it into a perfectly smooth surface. Other forces within the earth keep raising up new mountains and hills; otherwise the earth eventually would be covered by one vast, shallow ocean.

There is considerable evidence that the earliest forms of life came into being in the primitive seas—and perhaps this is the most interesting thing of all about water.

What makes us think it happened this way? For one thing, blood plasma is a salty solution very much like sea water. In effect, land animals carry the sea with them, inside their bodies. In any event, life could not have emerged from the sea without water, and without water life cannot exist upon the earth.



In its assigned function as the Nation's principal natural resource agency, the Department of the Interior bears a special obligation to assure that expendable resources are conserved, that renewable resources are managed to produce optimum yields, and that all resources contribute their full measure to the progress, prosperity, and security of America, now and in the future.

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