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Understanding Weather
Michigan State University Cooperative Extension Service
4-H Club Bulletin
Weather Project Unit 1
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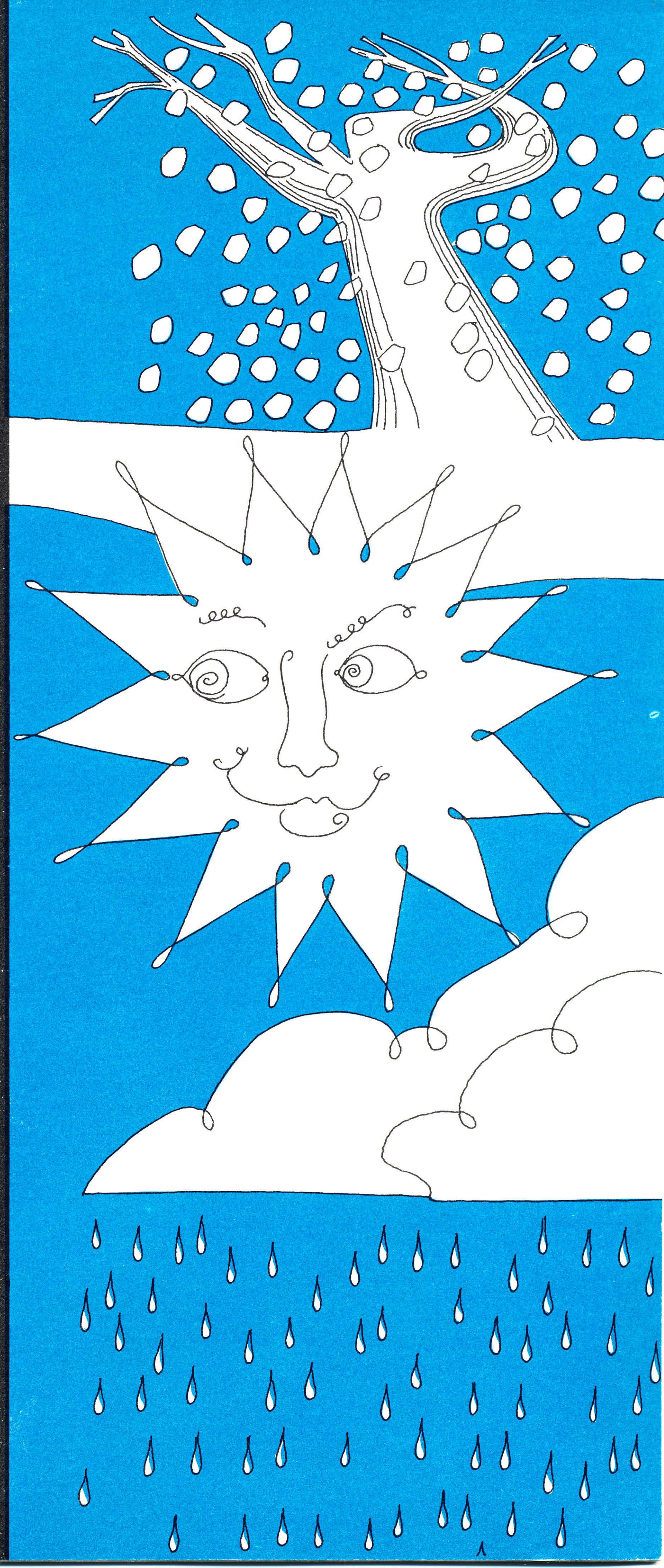
UNIT 1 4-H WEATHER PROJECT

UNDERSTANDING WEATHER



4-H Bulletin 150.2A
Member's Guide

4-H—Youth Programs
and
Agricultural Engineering Department

Cooperative Extension Service
Michigan State University

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WE'RE GOING TO HAVE WEATHER

"Whether it's cold or whether it's hot
We're going to have weather, whether or not."

How often do you think about the weather? "Once in a while" might be your first answer—maybe when there's a blizzard and the schools have to close. Or when you plan to go swimming and the thermometer takes a nosedive. Or when it starts to rain and you're stuck walking home without an umbrella. We're always aware of the weather when it changes suddenly or upsets our plans.

Actually—whether we realize it or not—we think about the weather all the time. It affects what we wear, how we live, what plans we make and even how we feel. If it's cold out, we bundle up. If it's hot and sunny, we get out our bathing suits and head for the lake. A balmy, spring-like day lifts our spirits and makes us feel like singing.

Weather is the condition of the atmosphere, or air outside, at any specific time. We describe the weather by telling how hot or cold or how cloudy or sunny it is outside. We also describe it by telling the direction and speed of the winds and the amount of moisture in the air. Climate, on the other hand, is the average kind of weather a place may have over a period of time.

Our weather changes from season to season, from day to day, and sometimes hour by hour. Generally this is a good thing. People need different kinds of weather. A long stretch of fair sunny days is ideal for summer fun, but makes the farmer unhappy, if his crops need rain. The same snow that adds up to a successful season for the ski resort owner causes all kinds of problems when it falls on the city. There it clogs roads, snarls traffic and creates hazardous driving conditions.

Some weather is bad for everyone. A tornado is weather in its most violent form capable of destroying life and property. Hurricanes and blizzards can be just as fearsome.

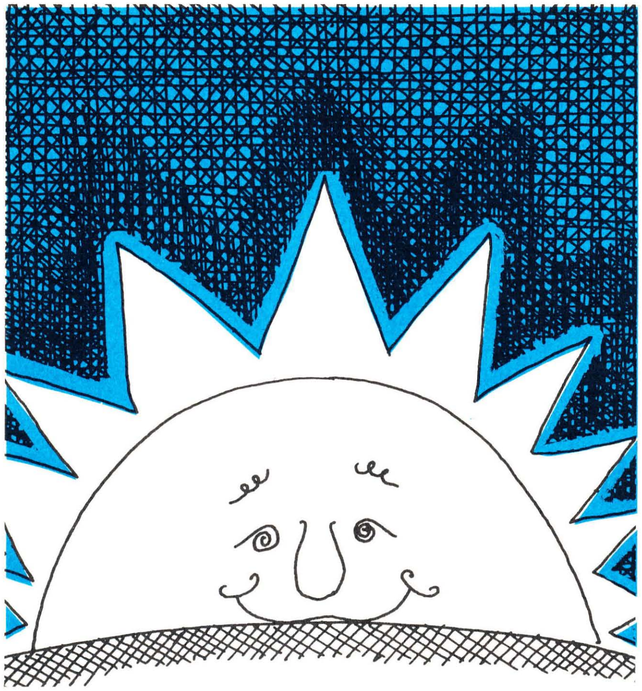
It's hard to believe that the same elements that combine to create a lovely day can brew such vicious storms. But it's true. Part of the fascination of meteorology, or the study of weather, is figuring out what these elements will cook up next. Our weathermen have learned to do just that quite accurately.

What are these elements? There are only four:

AIR
SUN
EARTH, and
WATER

Let's call them weather-makers.

A question to think about: Do other planets have weather like ours?



HAVE YOU EVER WONDERED. . .

What makes our ears "pop" when we climb a high hill?

Why we have to go "south" to get a tan from the sun in the winter?

What makes windows "steam"?

Why grass is wet in the morning when it didn't rain the night before?

Why tires are more apt to blow out on a warm day than a cold?

Why it's cooler at the lake than in the city?

Why snow sometimes melts faster on one side of the street than the other?

The answer to each of these questions can be found in your first introduction to weather. As we come to understand weather, we discover the reasons for many strange and fascinating happenings in the world around us.

But even more important, as we understand the facts about weather, we can learn how to control its effects and make our lives more comfortable and secure.

UNDERSTANDING WEATHER
UNIT I

CONTENTS

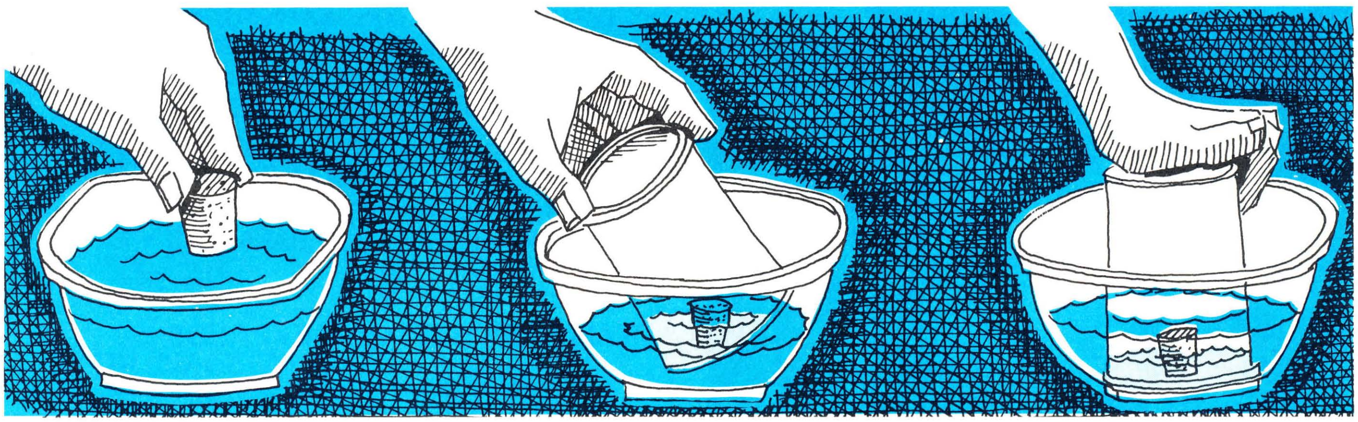
Weathermaker I THE AIR

What is air? We can't see it. We can't feel it, unless a breeze or wind is blowing. But we know it's there. We breathe it all the time. We couldn't live without it.

AIR TAKES UP SPACE

Scientists call air "matter". But then they add that matter is anything that takes up space. Does air take up space? Let's find out.

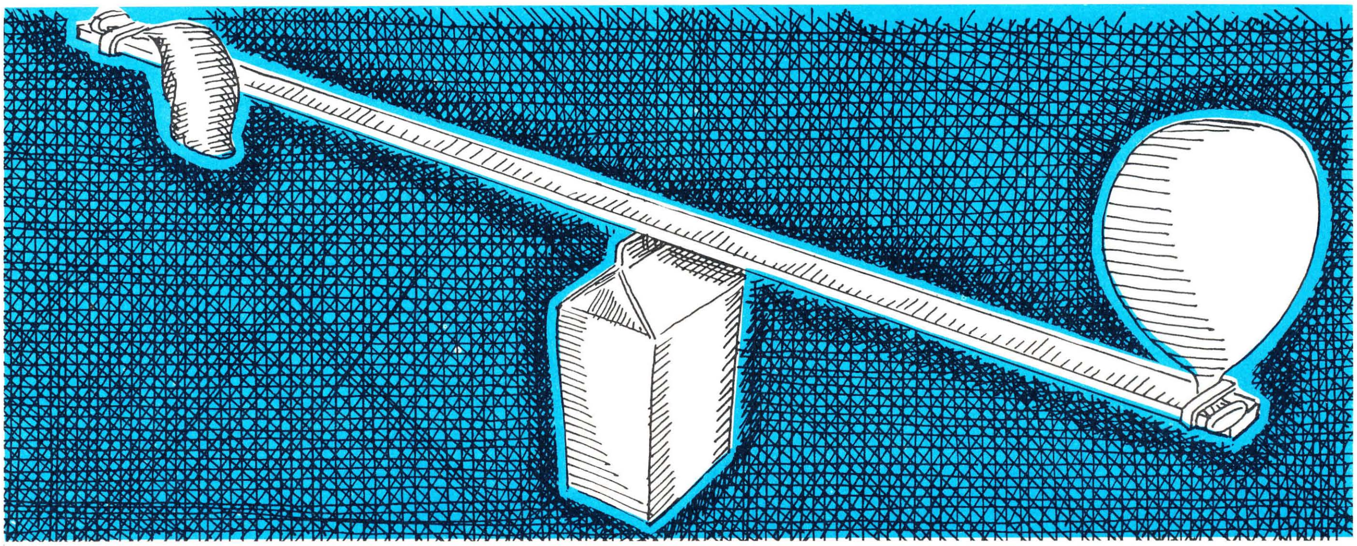
Fill a cereal bowl with water and float a small cork on it. Now turn a water glass upside down over the cork and push the glass into the water. Can you believe what is happening? The water and the cork go right down to the bottom of the bowl—as though something were pushing them. Something *is* pushing them—air.



AIR HAS WEIGHT

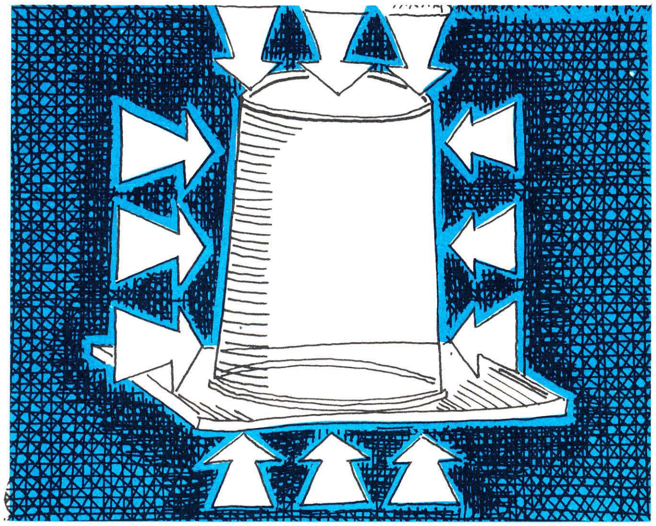
Scientists also tell us that all matter has weight. Does air? If you have a very accurate scale, you can try this test quite easily. Inflate a ball with a pump. You can use a beachball, a basketball, or a football. Weigh it carefully. Now press out all the air you can. Weigh it again. What did you find out?

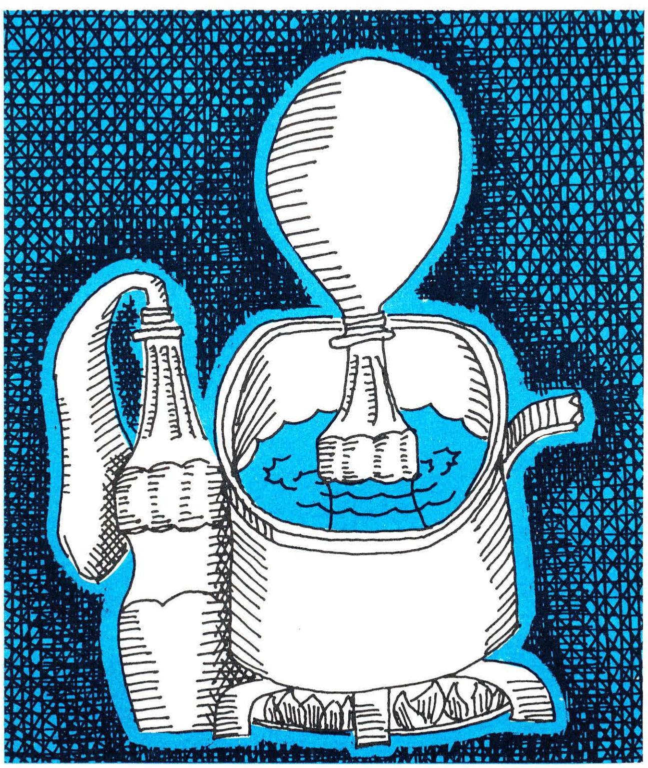
If your scale is not accurate enough, here's another test you can make: Attach a deflated balloon to each end of a yardstick with a rubber band. Balance the yardstick on top of the milk carton. Mark the exact place on the yardstick at which it balances. Now blow up one of the balloons and replace it with a rubber band. Place the yardstick back on the milk carton. Now try to balance it at the same spot. What happens? The inflated balloon is heavier. That end of the yardstick drops.



AIR EXERTS PRESSURE

If air has weight, it must be pressing down on everything it touches all the time. It is. If we measure with a barometer at sea level we find that the air is pushing down on us with a force equal to *14.7 lbs. per square inch.* Why aren't we crushed under all these tons of air? Because the air inside our bodies pushes out with the same force as the air around us pushes in.





Here's a very simple demonstration that shows air pressure at work. Be sure to try it over the kitchen sink in case something goes wrong. Fill a glass to the brim with water. Cover it with a piece of heavy wrapping paper or cardboard. Press the paper to the water with the palm of your hand. Now remove your hand and slowly turn the glass upside down. What holds the paper to the glass? The answer is air pressure. Now carefully turn the glass sideways. This proves that air exerts pressure in all directions.

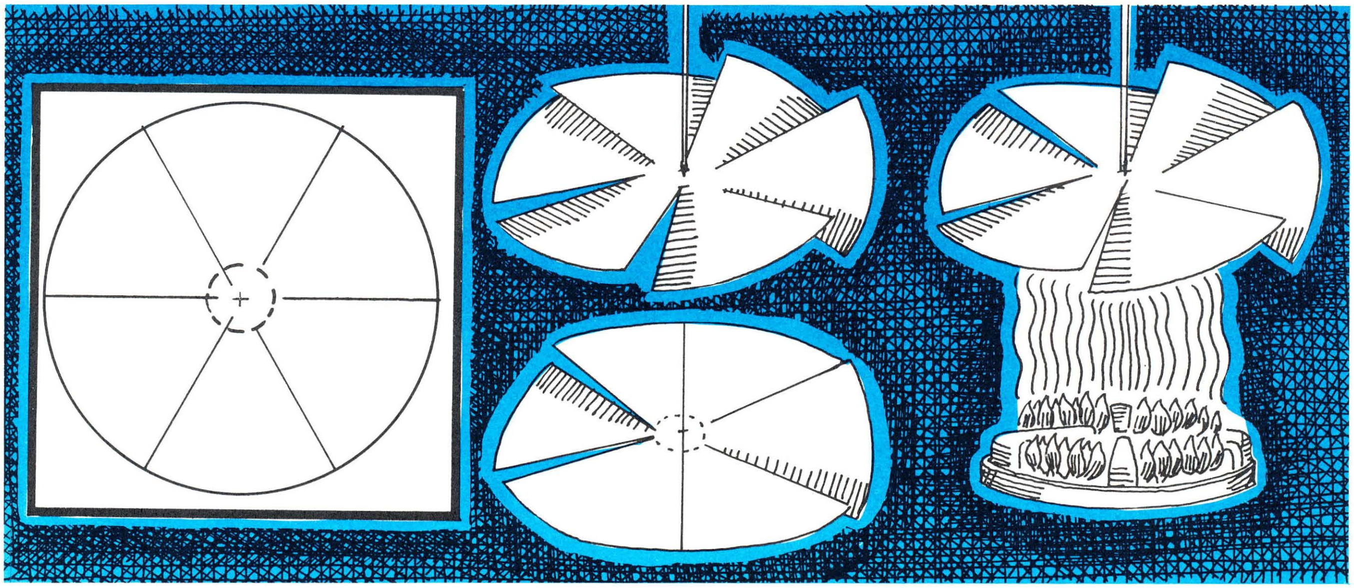
An interesting thing happens as we go up higher. The air pressure lessens. The higher we go, the less air there is above us pushing down. This reduces the pressure. It also explains why our ears "pop" when we climb a high hill or to the top of a tall building. The air inside our bodies has not adjusted yet to the different pressure outside.

WARM AIR RISES AND EXPANDS

All matter is made up of molecules. Like a box full of super-balls dumped out in a room, molecules are in constant motion. Heat them up and they move faster, hitting against each other and bouncing farther apart. Cool them, and they huddle together as though to keep warm.

If air is matter and matter is made up of molecules, let's see what happens when we heat these molecules. You'll need an "empty" pop bottle, a small balloon, a rubber band and a saucepan with water in it to heat. Place the balloon over the top of the bottle. Secure it with the rubber band. Now place the bottle in cool water and then heat the water slowly. What happens to the balloon? As the air molecules in the bottle warm up, they bounce right into the balloon. This is what we mean when we say that warm air expands. It takes up more space. The air that is left in the bottle itself has fewer molecules. If we could weigh just the air that is left in the bottle, we would find that it is lighter than it was before.

Can you guess what happens when you make air colder? Take the balloon from the pop bottle and blow it up. Tie it securely. Now put it in the freezer (or outside on a cold day) and leave it over night. Where did the air go? It's still there, of course, but now all the molecules are huddled together into a smaller area. This makes cold air heavier.



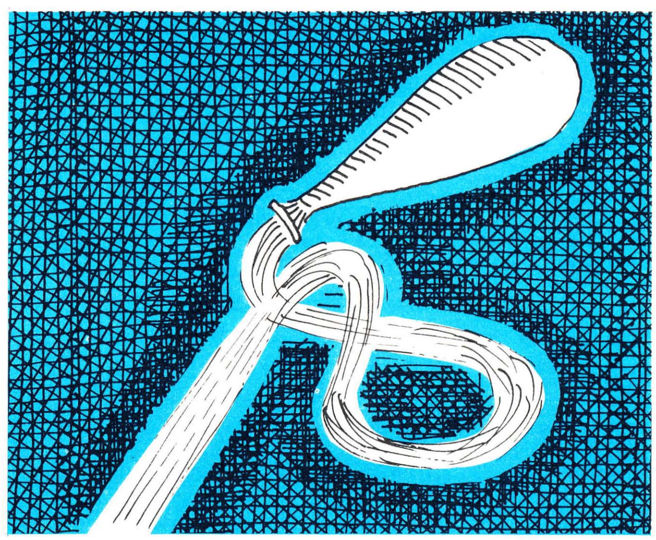
HOW AIR CIRCULATES

Here's a whirling toy that's easy and fun to make. You'll understand what makes it go, but will your friends? See if they can figure out the secret. You'll need a 4" square piece of stiff paper, (about as heavy as a file folder); a compass; scissors; needle and thread. Draw two circles on your cardboard. Make one as big as the cardboard and the other about the size of a nickel in the center of the larger circle. Draw three lines to cut the larger circle into six fairly equal parts. Cut the lines as far as the inner circle. Twist the cut parts down, like the blades of a fan. Pull a thin thread through the center of the cardboard and hold or fasten your toy over a lamp, warm radiator or oven. The rising warm air will make it whirl.

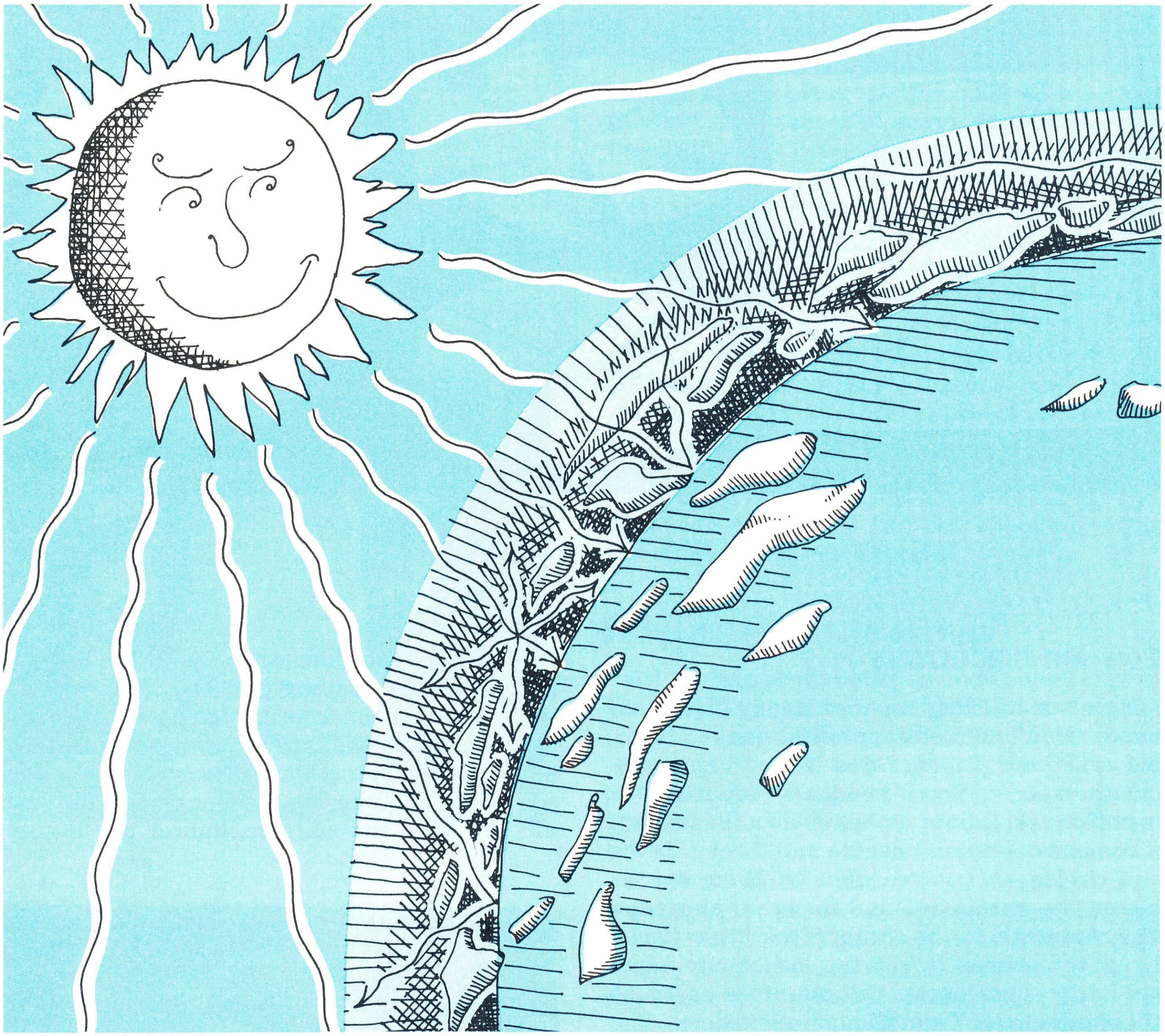
This starts to give us an idea of how air moves or "circulates." The radiator, lamp or stove warms the air above it. The air expands and rises. Then as it cools off, it grows heavier and falls. If we open a window on a cool day, the air inside the room circulates faster because the outside air rushes in and pushes the warm air up. Do you know why?

A balloon gives us the clue. As we blow up a balloon, we force more and more air into it. This makes the air inside denser, increasing the pressure. At the first chance, all those jammed together air molecules will try to escape.

What happens then when we let the balloon go? Instead of staying put, the air inside the balloon rushes out from its high pressure prison to the more open space or lower pressure outside. In the same way when warm air and cold air come together, denser or heavier cold air will force the warmer, lighter air to rise.



Here's a question to think about: If you pump too much air in a tire on a cold day, what could happen when the weather warms up? Why?



AN OCEAN SURROUNDS US

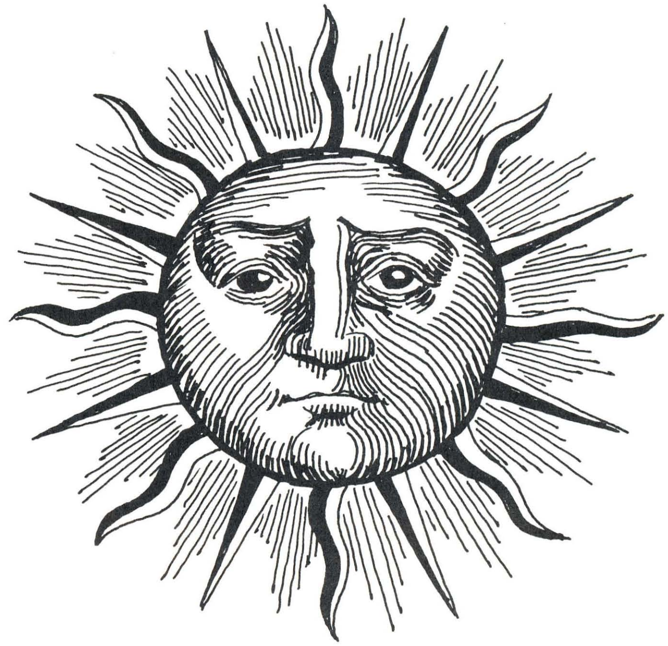
We live at the bottom of a tremendous ocean of air. This ocean of air completely surrounds the earth and is deeper than the deepest sea we know. It stretches more than 500 miles above us. Yet we can only live comfortably in the bottom-most few miles of it.

This ocean or "atmosphere" has a very special effect on our weather. If the earth had no atmosphere we would either burn to death in the daytime or freeze to death at night. During the day when we face the sun, the heat could boil water. At night, away from the sun, temperatures could plunge hundreds of degrees below zero. Of course, this doesn't happen.

Our atmosphere protects us.

First, it shields us from the sun's most harmful rays. Many of these rays hit the molecules of air in the upper atmosphere or clouds and bounce back toward the sun. They never reach the earth. The rays that get through are absorbed by the earth and lower layers of the atmosphere. The earth warms up and gives off heat. Now our atmosphere acts as a blanket. It traps the earth's heat and keeps us warm. This is often called the "greenhouse effect". Can you find out why?

In talking about the atmosphere, we have seen that the energy for our heat comes from the sun. Let's see what else the sun does for us.



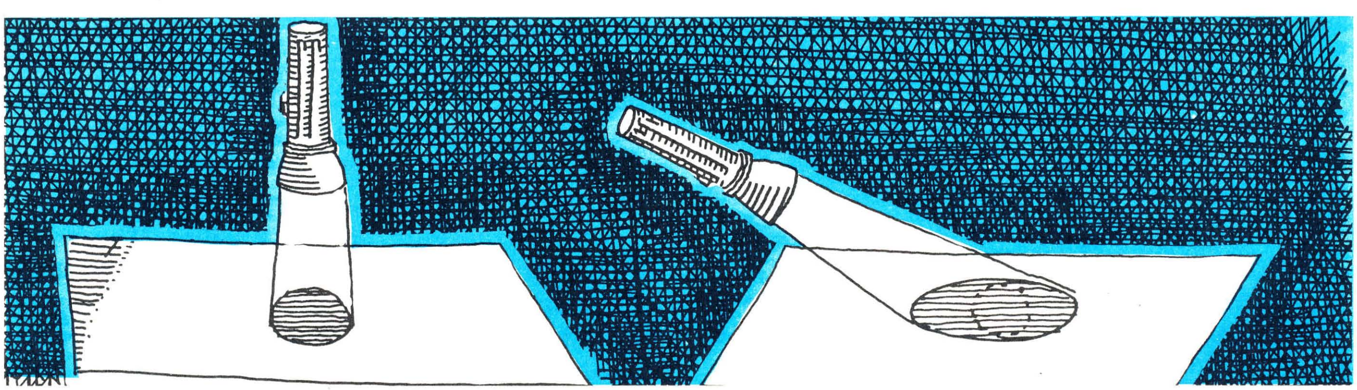
Weathermaker II
THE SUN

The sun warms us. No one has to tell us this. We can feel it. When the rays from the sun touch us, our bodies turn the sunlight to heat and we feel warm.

On a sunny summer's day the sun's rays are strong enough to tan our skin. Around noon on such a day, your mother might say, "Come in out of the sun. You'll get a burn." Does she ever tell you that in the winter? Not if you live in Michigan or some other northern state. It would sound rather silly. Here, even at noon, on a bright winter's day, the sun's rays are much weaker. Have you ever wondered why?

The answer has nothing to do with how close we are to the sun. Actually, the earth is three million miles closer to the sun in winter than in the summer.

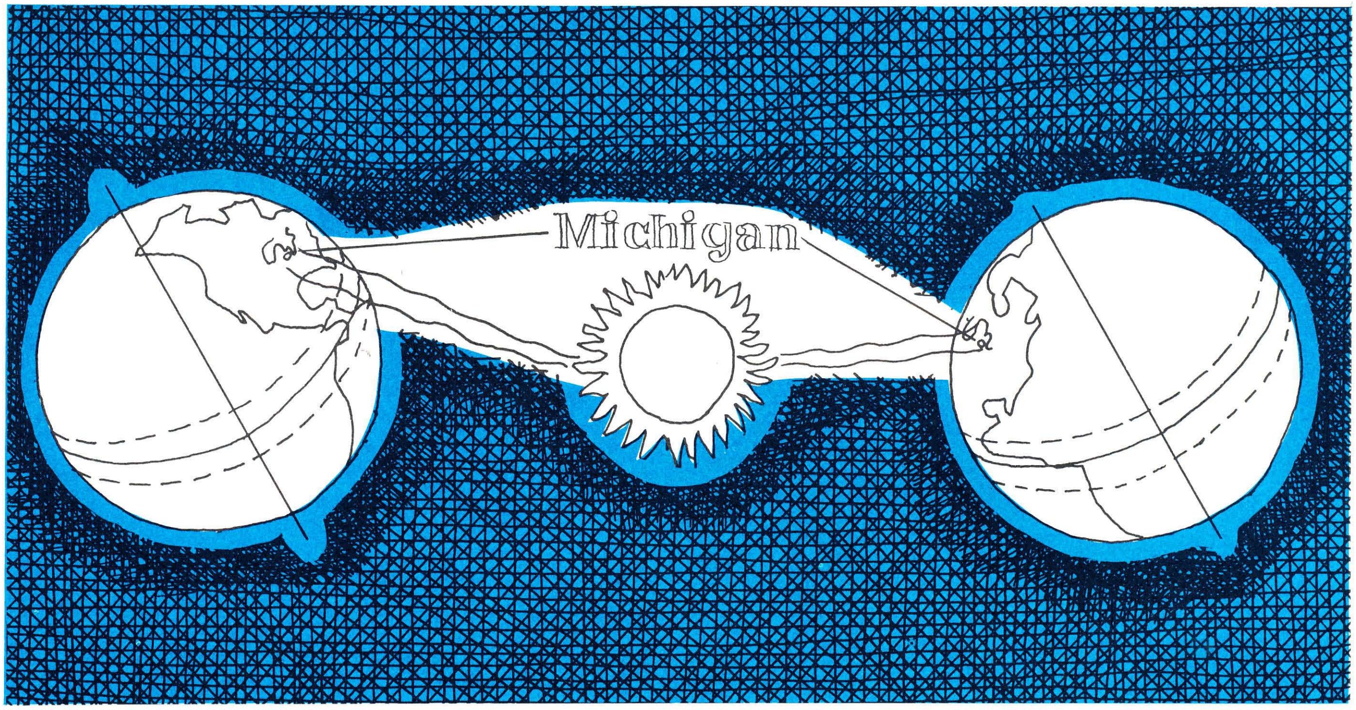
A clue to the riddle can be found in a simple demonstration. Hold a flashlight about six inches above a piece of paper. Shine it directly down on the paper. The beam will make a bright circle. Trace around the circle. Now tilt the flashlight and direct the rays to the same spot on the paper. Again trace around the outline of the beam. You will notice two things. The same amount of light now covers a much larger area. The circle has become an oval. Also the light in the oval does not seem as bright as the light in the circle. It isn't.



DIRECT RAYS ARE WARMER

Direct rays of sunlight are much stronger than slanted rays. This is why we are apt to get a burn at noon in the summer. At noon, the sun is most directly overhead.

Now we can understand why the sun in the summer is stronger than in the winter. In the summer our part of the earth tilts toward the sun. The sun's rays hit us more directly. In the winter we tilt away from the sun. All we get are more slanting rays.



Here we are tilted away from the sun. The sun's rays are much more slanted, and we are having *winter*.

Here we are tilted toward the sun. The sun's rays are quite direct and we are having *summer*.

Did you notice that the sun shines even more directly on some countries all the time? These are the lands around the middle of the earth. They lie just north and south of an imaginary line called the Equator, where it is always summer. We call this area between the Tropic of Cancer and the Tropic of Capricorn the *Equatorial Belt,* and the directness of the sun's rays changes very little over a year.

Now can you find parts of the earth that are always cold? Only the most slanted rays ever reach the Artic and Antartic circles at the far ends, or the "poles" of our globe.

Look again at the drawing and you'll see something else. When we are tilted toward the sun, what is happening to the lands in the Southern Hemisphere below us? They tilt away. While we are having summer, South America must be having winter.

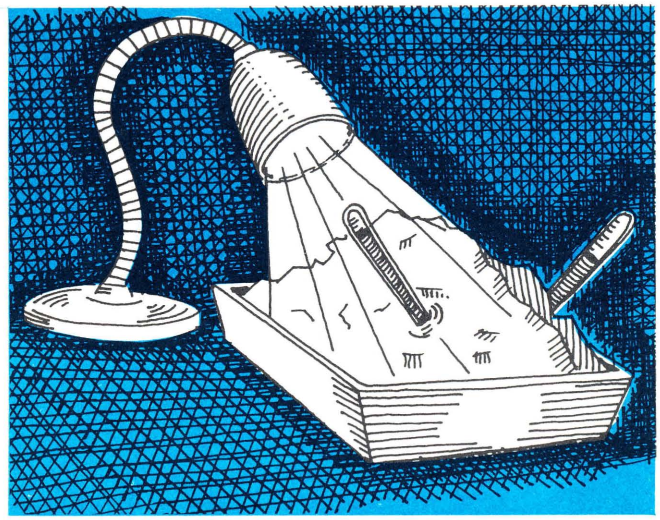
Here's a way to find out:

Draw a map of the Western Hemisphere. Locate Canada, Southern United States, Brazil and Argentina on your map. Now try to find the average temperature of each place for at least two different times of the year. Good places to look for the information are in school or library books such as Atlases, encyclopedias, geography books and books about the individual countries.

Here's another interesting fact. The south side of a house, or road, or hill is warmer in the northern hemisphere. Can you tell why from the drawing? Notice the sun's position in relation to our part of the earth.

Demonstrate the sun's effect this way: Build a mound of soil in a pan. Stick thermometers in opposite sides of the mound, labeling them north and south. Now direct a lamp so that it shines from the south side. Check the difference in temperature after 15 minutes.

The south side gets more direct rays. Perhaps you've wondered why tulips bloom first on the south side of the house, or why snow melts on one side of the road but not on the other. Now you know.



WHY SUMMERS ARE WARMER

We have seen that the sun's rays are stronger in the summer. This is one of the reasons why summer is warmer than winter. Another reason is that summer days are longer.

Have you ever noticed that you feel hotter the longer you stay in the sun? Finally, on a bright summer day, you can feel so uncomfortable that you have to "cover up" or come inside. Otherwise you're apt to burn. If the sun's rays are so "hot", why don't you burn the minute they touch you?

Try this demonstration and you'll have the answer.

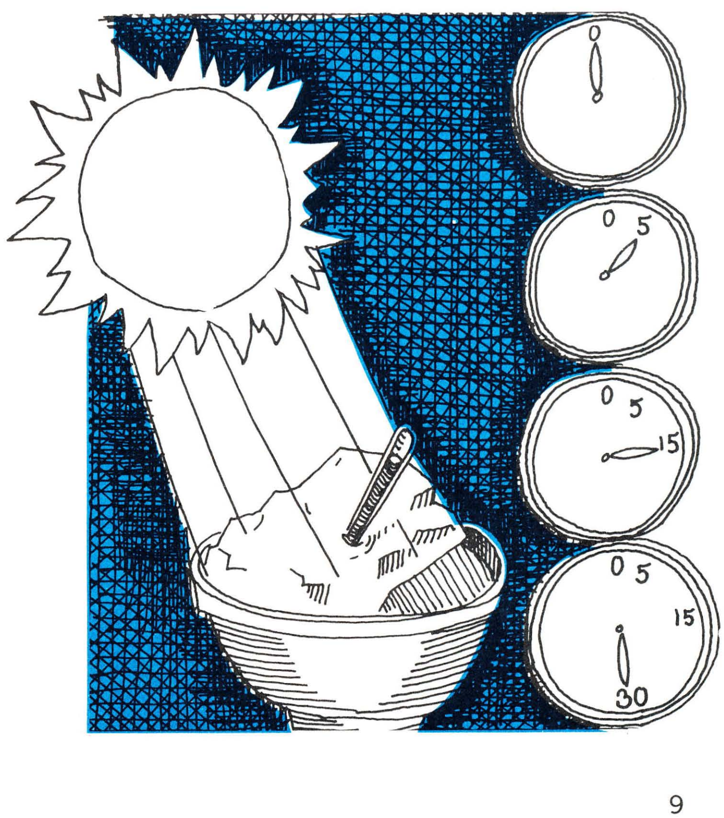
Set a bowl of soil in direct sunlight or under a heat lamp. Stick a thermometer in it. Check the temperature of the soil before you begin and then again after 5 minutes, 15 minutes and half an hour.

Heat builds up. When the sun's rays touch the soil, the rays are turned into heat. This heat is stored and piles up. The soil gets hotter and hotter. Turn off the light and the soil is still hot. If the soil is hot enough you can feel that the air around it is warmer too. In the summer, when days are longer, the earth has more time to build up heat. All this heat from the earth warms the air and helps make summer warmer.

What do you think is the hottest part of the summer? In June, when the sun's rays are most direct? Actually, the warmest month is August. Because heat builds up, the hottest days come later in the summer. Now which do you think would be warmer? Twelve noon or 3:00 P.M.? Which is the coldest time of the night? Around midnight or just before dawn?

LONGER DAYS DON'T ALWAYS HELP

If longer days help the earth build heat, you may be wondering: "Why are the north and south poles so cold when the sun shines there for six months without setting?" We already know part of the answer. The rays from the sun are weak and slanting. The rest of the answer has to do with what happens to those rays when they hit snow and ice. Let's turn to our next weathermaker, the Earth, and find out.



Weathermaker III THE EARTH

As we know, the earth warms the air by turning sunlight into heat. Some parts of our earth, however, build up heat better than others. This makes a big difference in our weather.

DARK LAND IS WARMER

Lay a piece of white cloth and a piece of black cloth in the sun. Feel them after 5 minutes, then 10 minutes. Which is warmer? We say that the black cloth "absorbs" heat and the white cloth reflects it. This means that the light rays soak into the dark cloth and turn into heat. But the rays bounce right off the white cloth. Very few sink in. This is why we wear white or light colored clothes in the summer. They actually keep us cooler. In tropical countries buildings are often white or built of materials that will reflect the light. This makes them cooler, too.

Does the color of the earth make a difference? Fill two pans with dark soil and a third with light sandy soil. Cover one of the dark soils with a white cloth. Make sure all are the same temperature when you begin. Place them under a heat lamp and take the temperatures again after half an hour. Which is warmest? What happened to the soil that was covered with a white cloth? The whiteness reflected the light. This is what happens in the polar regions with their covers of snow and ice. Even with six months of daylight, the sun's rays bounce off the snow. Very little heat builds up. The lands stay cold.

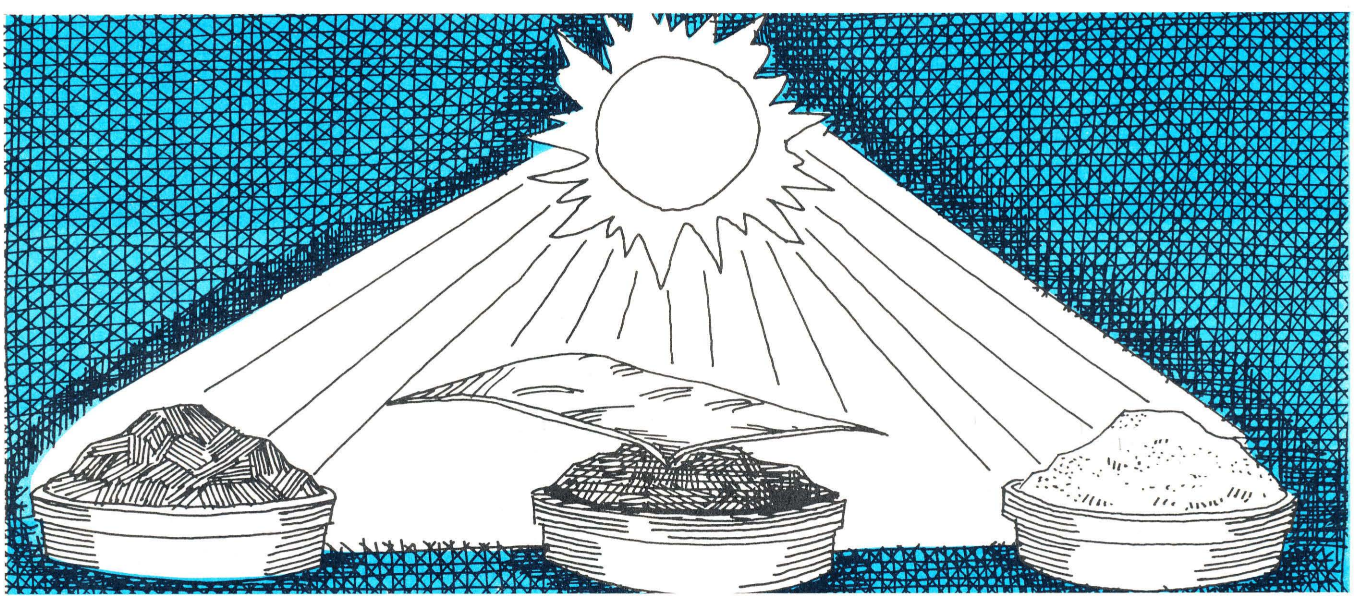
WHY THE LAKE IS COOLER

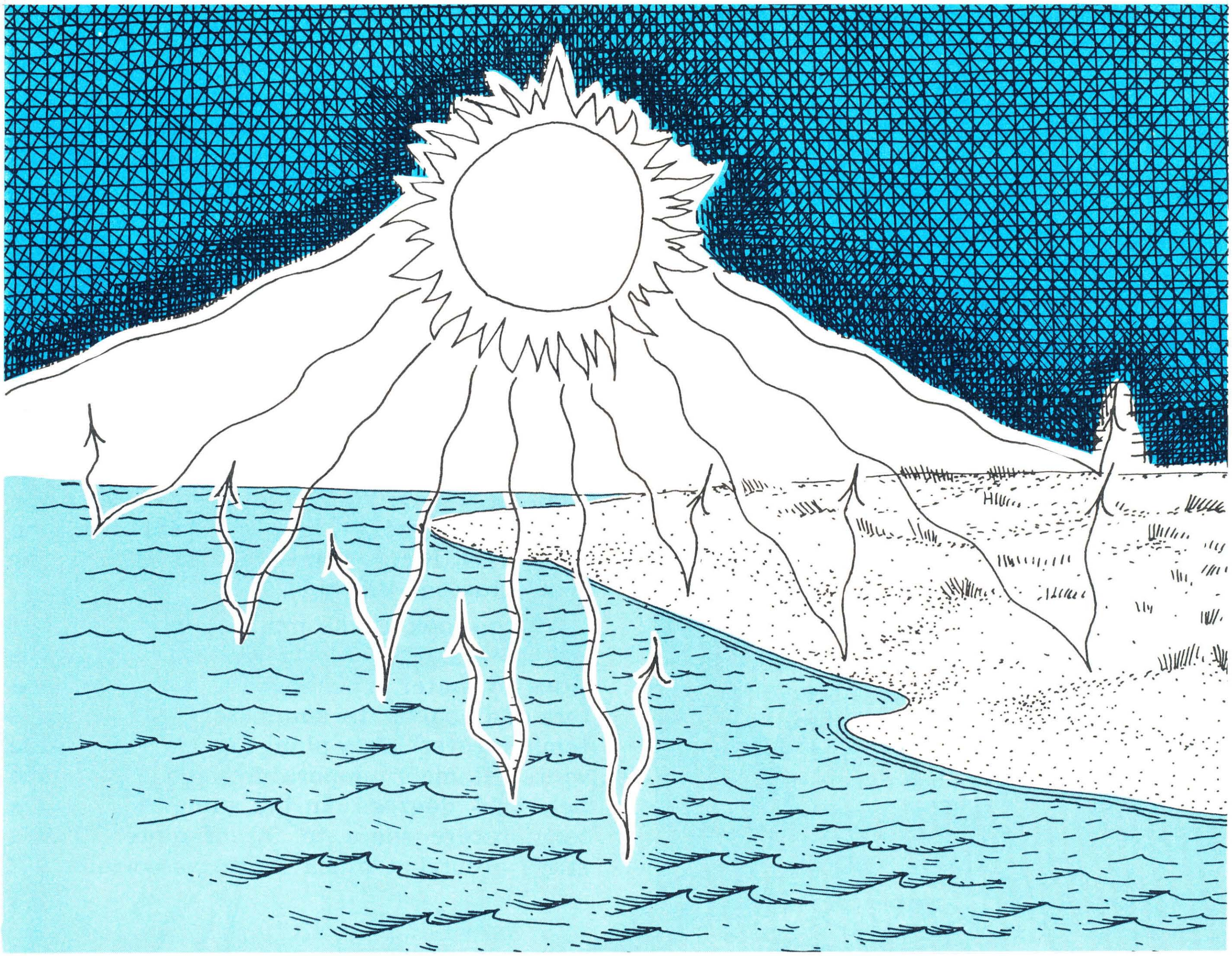
Where do you go to cool off on a blistering hot day? If you live in Michigan, you probably head for a lake. You know that the lake area is cooler, but do you know why? The experiment above gives you part of the answer. Dark city buildings and streets absorb heat. When the sun's rays soak in, the heat builds up. At the beach, the sun's rays are more apt to bounce off sand and water. This helps keep the temperature several degrees cooler.

The water affects temperature in another way, too. Take a bowl of soil and a bowl of water. Make sure their temperatures are the same before you start. Now place them under a lamp for half an hour. Check the temperatures every 10 minutes. What did you find out?

Soil heats faster. The sun's rays never go very deeply into soil. The soil surface heats up quickly. The next time you're at the beach, scratch away the top layer of hot sand. Underneath the sand will be very cool.

Something different happens with water. The sun's rays sink way down, warming a huge amount of water. This takes time, of course. Water heats much slower than land. If you place your bowls of water and soil in the refrigerator, you will find out that water cools slower, too.





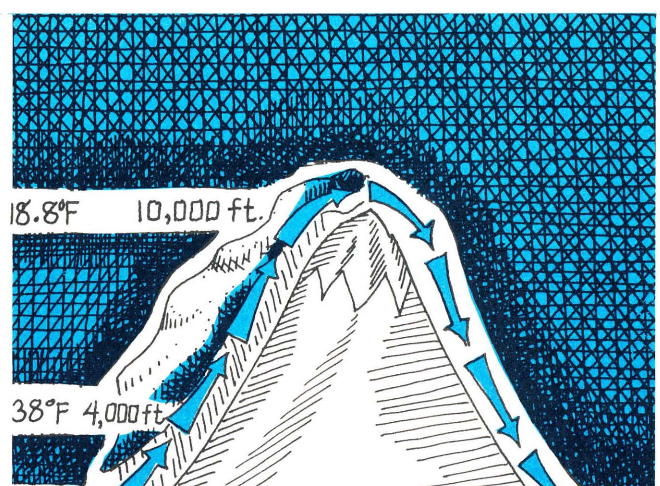
Now we can understand why the lake feels cool and refreshing on a hot day, but warm on a cool night. During the day it warms up much slower than the land around it. At night, it does not cool off as fast.

GO UP TO COOL OFF

The earth has other surprising effects on our weather. The higher we go up, the cooler it becomes. Sometimes you can feel it growing cooler just going up a high hill or a tall building. Can you figure out one of the reasons why? The clue is that heat from the earth warms the air. The farther away from the earth you go (up to an average distance of about 12 miles), the cooler it becomes.

Altitude, then, or the distance up, affects weather. Even at the equator a city can be cool if it is located high enough.

On the other hand, a country—Italy, for example—can be located in a fairly cool or temperate climate zone and have balmy, summer-like days almost all the time. The reason has to do with our final weathermaker—water.



Weathermaker IV WATER

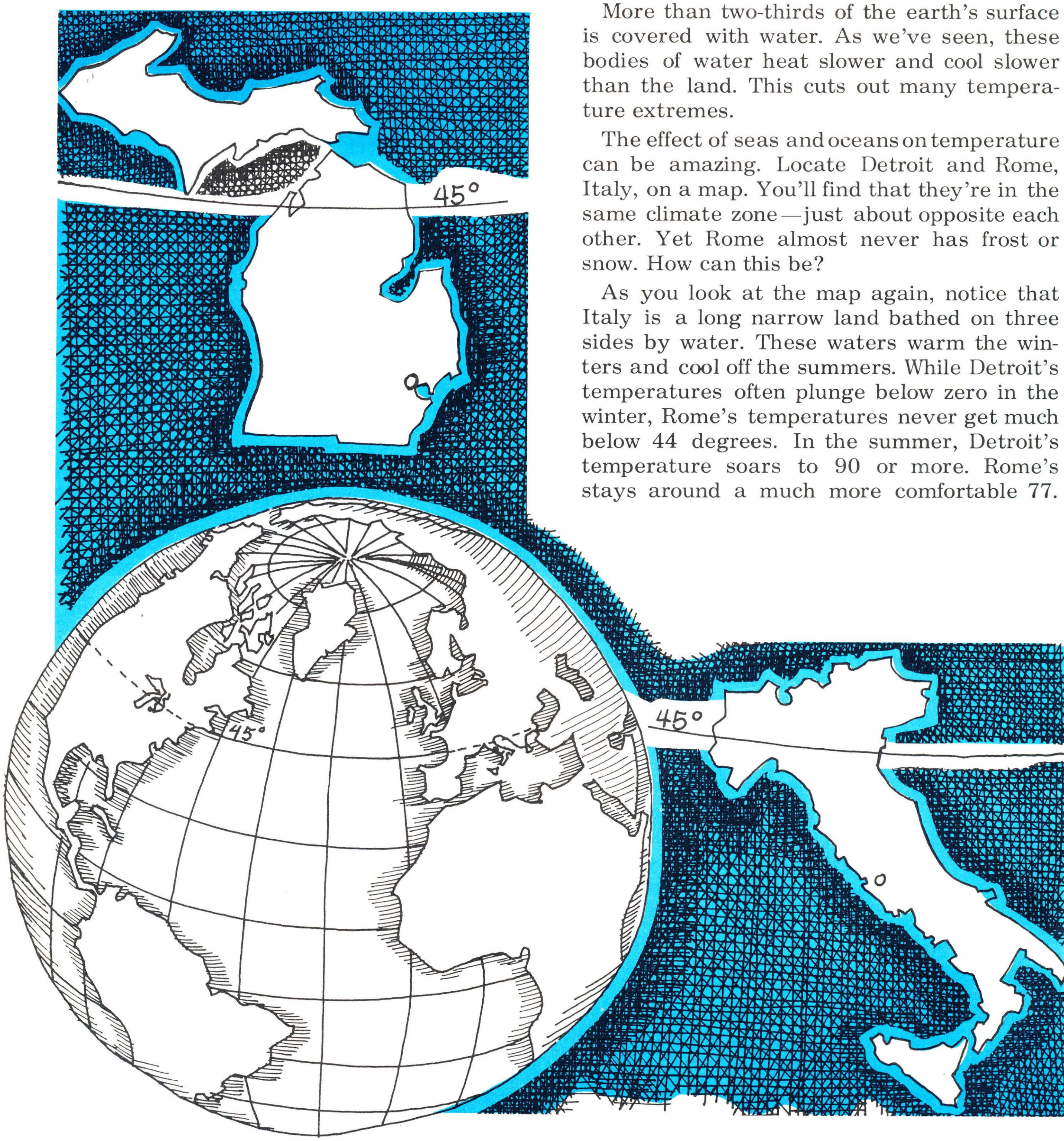
When you think of water as a weathermaker, what comes to mind? Probably a picture of rain, or snow, or some other form of water in the air. This kind of water makes the air feel damp or wet. We say it affects the humidity. Water affects the temperature, too, and this is just as important.

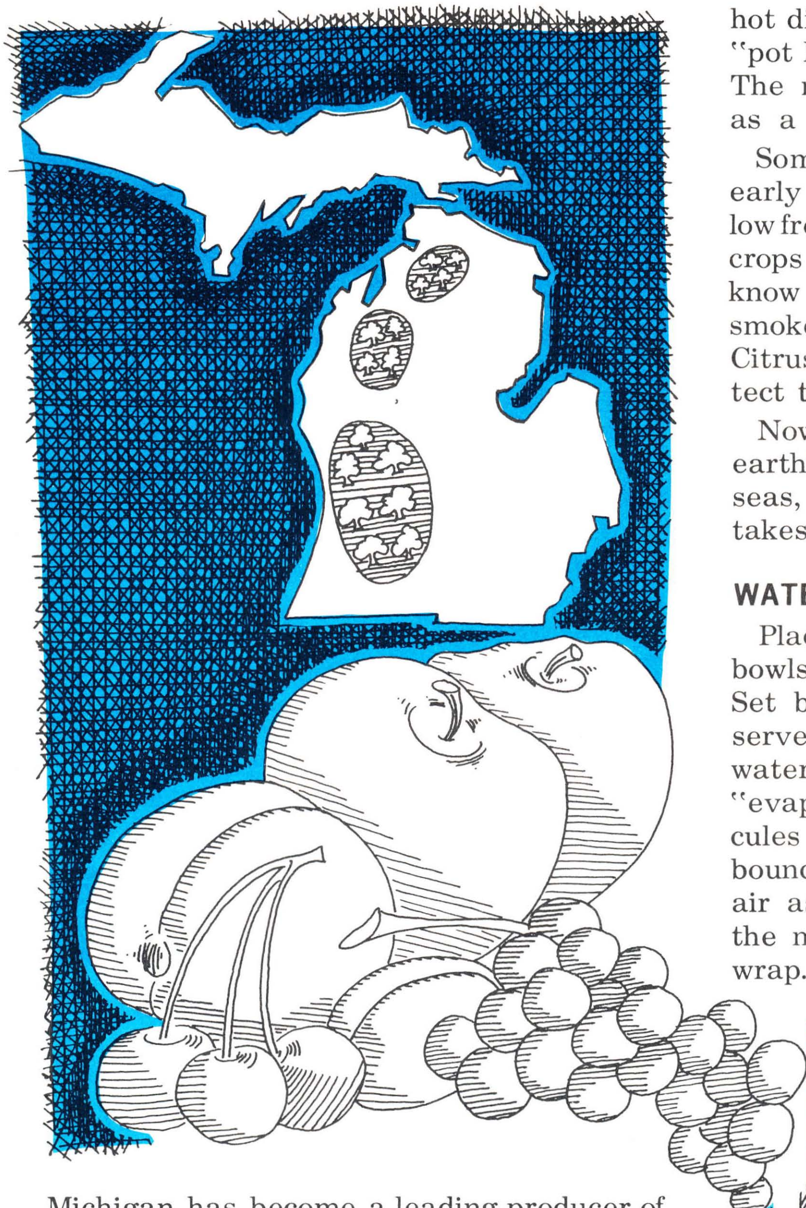
WATER MODIFIES OUR TEMPERATURE

More than two-thirds of the earth's surface is covered with water. As we've seen, these bodies of water heat slower and cool slower than the land. This cuts out many temperature extremes.

The effect of seas and oceans on temperature can be amazing. Locate Detroit and Rome, Italy, on a map. You'll find that they're in the same climate zone—just about opposite each other. Yet Rome almost never has frost or snow. How can this be?

As you look at the map again, notice that Italy is a long narrow land bathed on three sides by water. These waters warm the winters and cool off the summers. While Detroit's temperatures often plunge below zero in the winter, Rome's temperatures never get much below 44 degrees. In the summer, Detroit's temperature soars to 90 or more. Rome's stays around a much more comfortable 77.





Michigan has become a leading producer of cherries, apples and other fruits because of the Great Lakes and their effect on the weather. The map shows Michigan's fruit growing areas. Notice that these areas are east shores of large lakes. Winds coming from the west are warmed or cooled by the lakes. Cooler air in the spring holds back the buds on fruit trees until after the last killing frost. Warm air off the lake in the fall means a longer growing season.

WATER AS A BLANKET

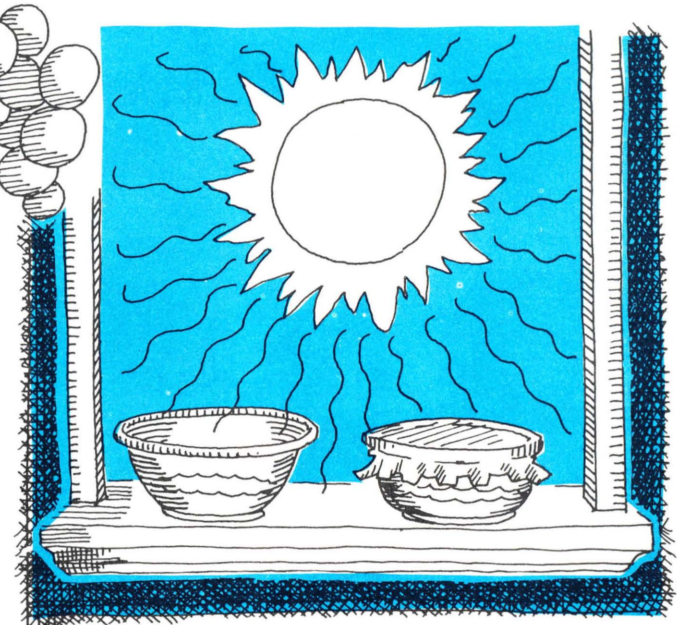
Water affects our temperature in another way. Water, when it appears above us as clouds, acts as a blanket. It traps the heat from the earth. This is why cloudy nights are warmer than clear nights. Have you ever seen your mother wrap a casserole or other hot dish in newspaper to keep it warm for a "pot luck" supper? She is trapping heat, too. The newspaper keeps the food warmer, just as a cover of clouds keeps our air warmer.

Sometimes on a clear night in late spring or early fall, the temperature suddenly dips below freezing. One way farmers can protect their crops is by making artificial clouds. Do you know how? They burn smudge pots and the smoke traps the heat from the warm earth. Citrus growers in Florida often do this to protect their orange crops from unseasonal cold.

Now let's see how water gets from the earth's surface, where it appears as oceans, seas, rivers, and ponds, into the sky where it takes the form of clouds.

WATER — IN THE AIR ALL THE TIME

Place about an inch of water in two shallow bowls. Cover one snugly with plastic wrap. Set both bowls on a sunny window sill. Observe what happens over several days. The water in the uncovered bowl will disappear or "evaporate" into the atmosphere. As the molecules of water warm up, they move faster, bounce out of the bowl and escape into the air as a gas, or vapor. In the covered bowl, the molecules only get as far as the plastic wrap.



Water evaporates into the air all the time. Oceans and other bodies of water and the leaves of green plants give up a tremendous amount of water vapor. Air picks up the water vapor molecules and carries them away. The water molecules may stay in the air as a vapor. We won't see the vapor, but it's there. Or the vapor may reappear in the form of a liquid (rain, dew, fog, clouds) or a solid (snow, ice, hail) which we can both see and feel. It all depends on the temperature.

WARM AIR HOLDS MORE WATER

Try this. Blow into a bottle that is either warm or at room temperature. You won't see much of anything happening. Now chill the bottle in the refrigerator and blow into it again. The bottle becomes cloudy. If you look closely, you'll see that the cloudy look is really tiny drops of water.

When the bottle was warm, the warm air inside could hold the water vapor from your breath. When the bottle is chilled, the water molecules, like air, huddle together and form a liquid. We say the vapor "condenses". We see it as drops of water. What do you think would happen if the bottle had been outside in below-freezing weather? The water vapor in our breath would turn to frost. Water can change very quickly from a gas to a liquid or solid. Again, it all depends on the temperature.

FINDING THE DEW POINT

As warm air cools off, it reaches a point where the water vapor in it will condense or change into a liquid. We call this the "dew-point". When "steam" appears on windows or moisture collects on the outside of a cold pitcher of water, it means that the air touching the glass has been cooled below the dew-point. Would you like to know the dewpoint for wherever you are right now?

You'll need a tin cup, some ice and a thermometer. Fill the cup about three-quarters full with water at almost room temperature. Be sure the cup is dry on the outside. Now place ice and thermometer in the cup. Stir the water and ice with the thermometer. Notice the temperature when moisture starts to form on the outside of the cup. This is the dewpoint.

MAKING A FOG

This time you'll need a pop bottle, some water and an ice cube. Rinse out the bottle thoroughly with hot water. Pour about 2 or 3 inches of hot water in the bottle. Next place an ice cube on the top of the bottle. Warm air rises from the hot water. Water molecules in the air are cooled by the ice cube and condense, forming a fog. This is what happens when a mass of warm air and a mass of cool air come together.

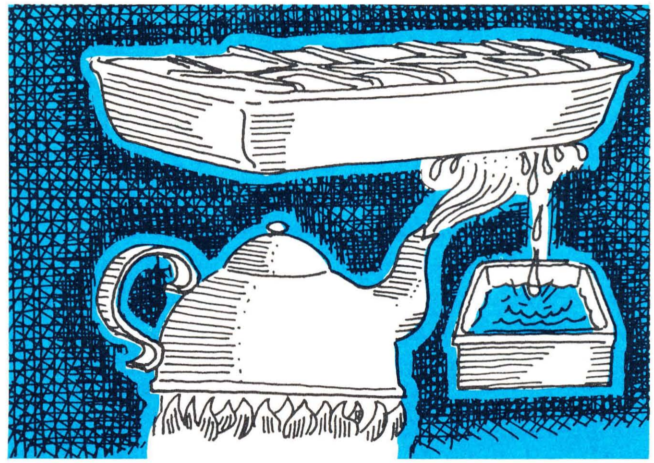
If the masses meet near the ground, the vapor in the warm air condenses and we have fog. If the masses meet higher up in the sky, the same thing happens. Only this time we call it a cloud.

Here's an interesting fact: Water vapor always condenses on or around something. In our experiment, the water molecules cling to the insides of the bottle. Outside, water molecules cling to particles of dust to form fogs and clouds.

MAKING RAIN

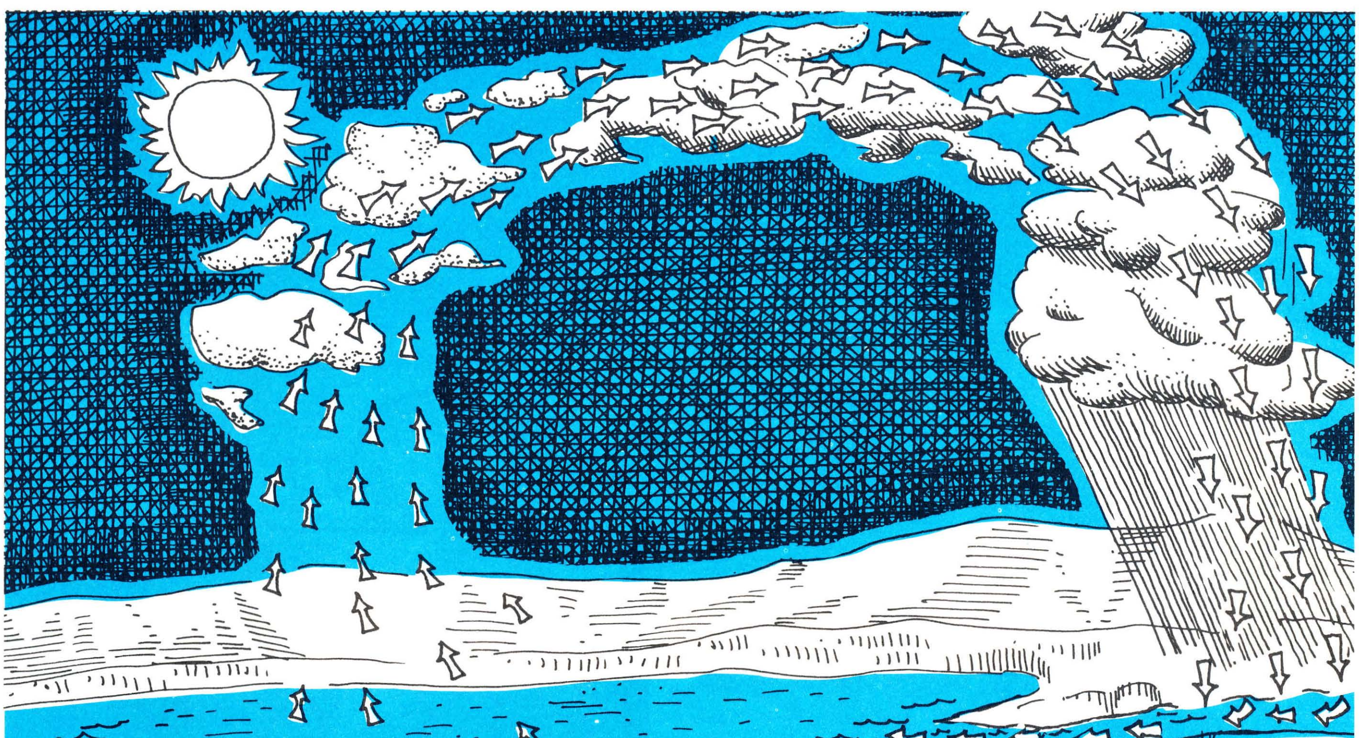
You'll need a tray of ice cubes, a tea kettle of boiling water and an extra pan. As the tea kettle boils, steam or water vapor will come from its spout. If you hold the tray of ice cubes over the tea kettle, the vapor will condense on the tray and collect into drops. As the drops become larger and heavier they will fall. The second pan is to collect your raindrops as they fall.

As a cloud gets colder or perhaps gets jiggled about by another air mass, the tiny droplets come together and form larger drops. Finally, the drops get too heavy and they fall. We say it's raining.



OUR NEVER ENDING WATER CYCLE

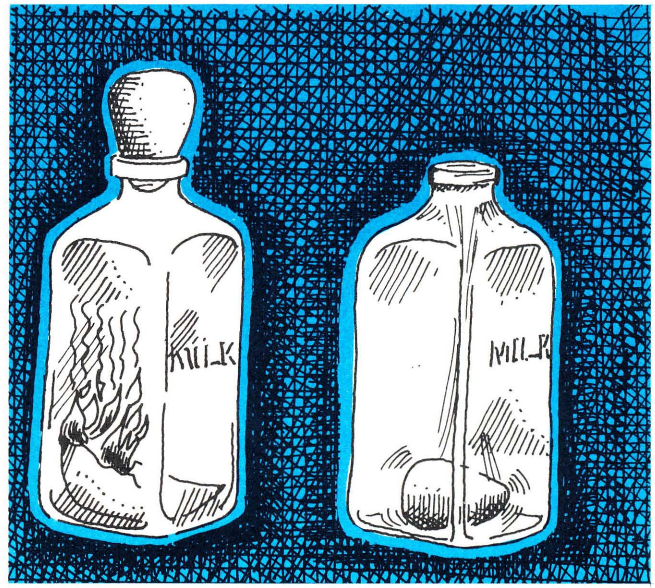
Now that we've talked about evaporation, condensation, and precipitation, or rain, we can understand a process that has been going on for millions of years—the water cycle. Water evaporates all the time from oceans, lakes, rivers, plants, trees and soil. The water molecules escape into warm air. As the warm air rises, it cools and the water vapor condenses into the clouds. When the clouds become too heavy or cold, the moisture drops out as rain, snow, hail or sleet. The earth absorbs the rain and the process starts all over again.



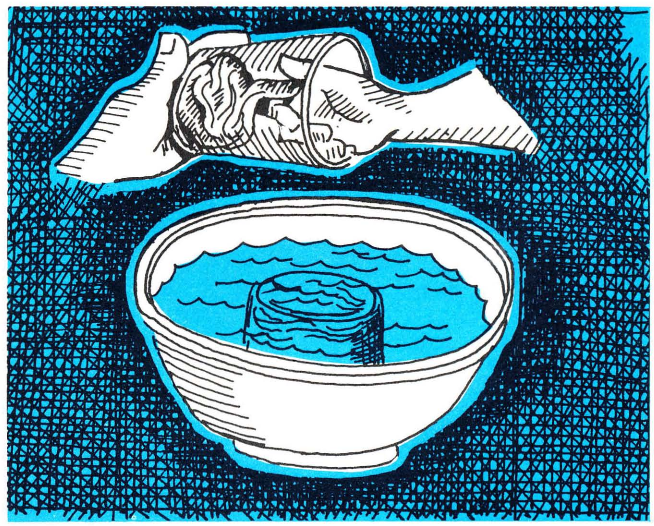
Summing Up...

Now that you've learned the basic facts about weather elements, DON'T STOP.

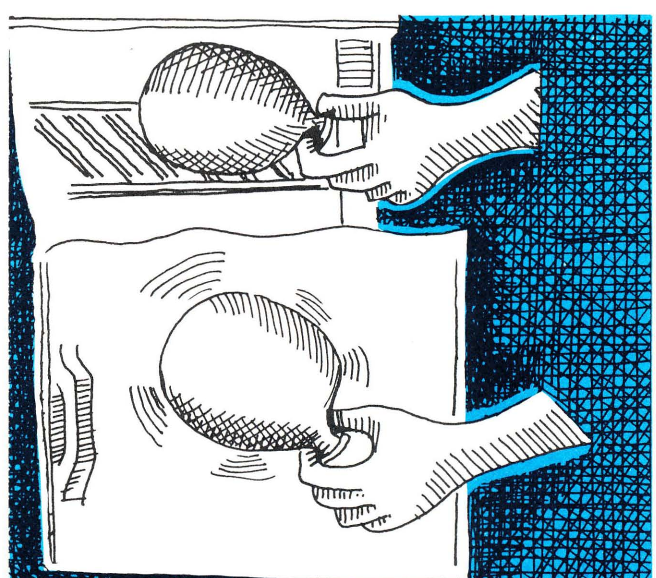
HAVE FUN with what you've learned. Give a magic show for your friends or their younger brothers and sisters. Mystify them with the tricks you've learned. (Let them in on the secrets, and they'll learn too.) Here are three more tricks to add to your magic act:



Egg-in-the-Bottle: The problem is how to get a peeled, hard-boiled egg in a glass milk bottle. The solution: Let air pressure push it in. Here's how: Light a piece of paper and drop it into the bottle. While the paper is burning, place the egg on top, pointed end down.



The-Handkerchief-That-Stays-Dry: Stuff a handkerchief into the bottom of a glass. Turn the glass upside down and push it into a bowl of water. Completely submerge the glass. Bring it back up. The handkerchief is still dry, of course.

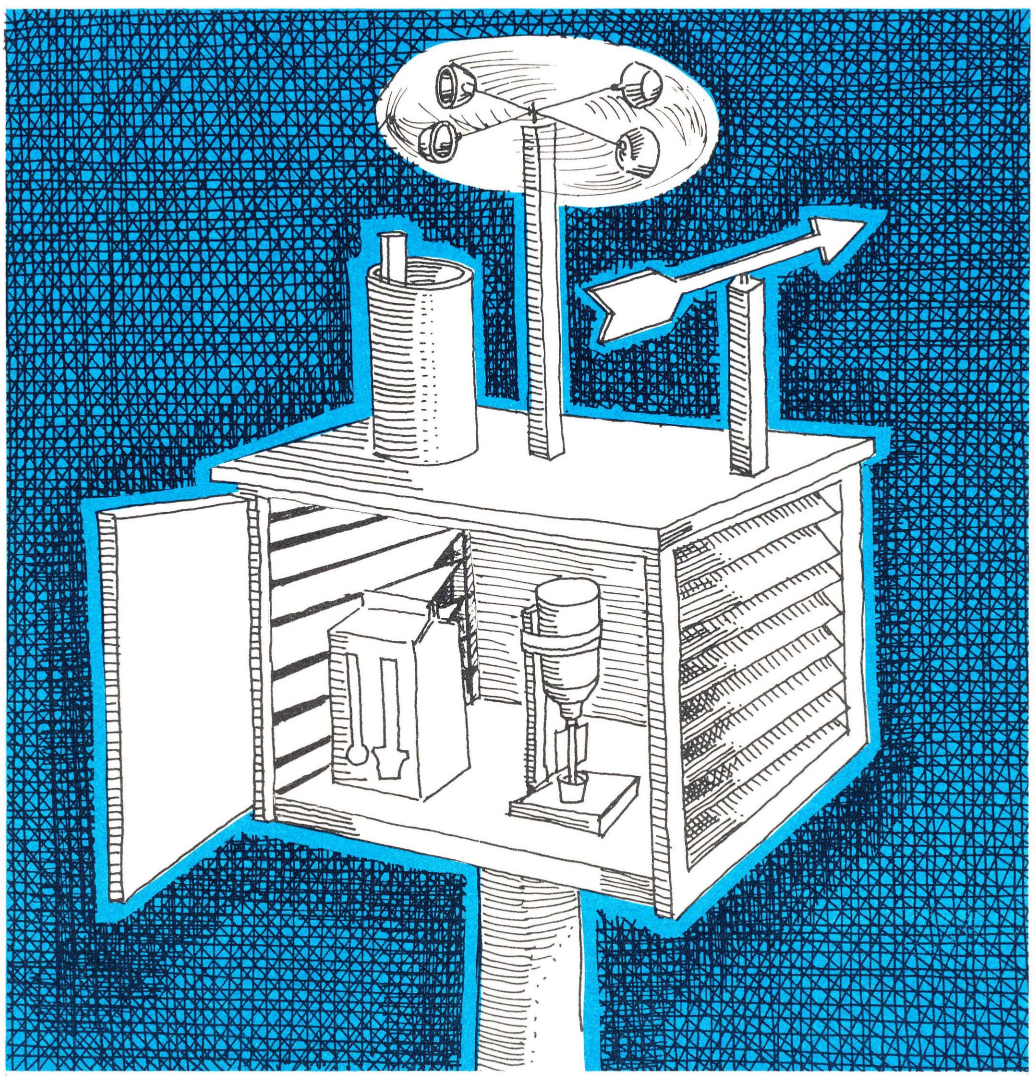


The-Balloon-That-Grows: Blow up a balloon and chill it. Then, to your audience's surprise, let the balloon expand by itself.

BE A CLIMATE EXPERT: Keep a daily record of temperatures for several U.S. cities such as Detroit, Washington, Miami, Denver, Los Angeles or whatever cities you can find listed in the weather section of your newspaper. Include your own local temperatures for comparison. Notice the differences and find out why.

USE WHAT YOU'VE LEARNED. Put weather facts to work for you. Use them to keep warmer in the winter, cooler in the summer. Use them to start a seedbed earlier or to protect crops. If you make an exhibit showing ways to use weather facts, others can be helped by what you've learned.

WANT TO LEARN MORE? Turn to Unit II, where you'll have a chance to build a weather station. With your own instruments, you can keep an eye on our four weather elements and watch them as they stir up a storm—or a peaceful day.



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