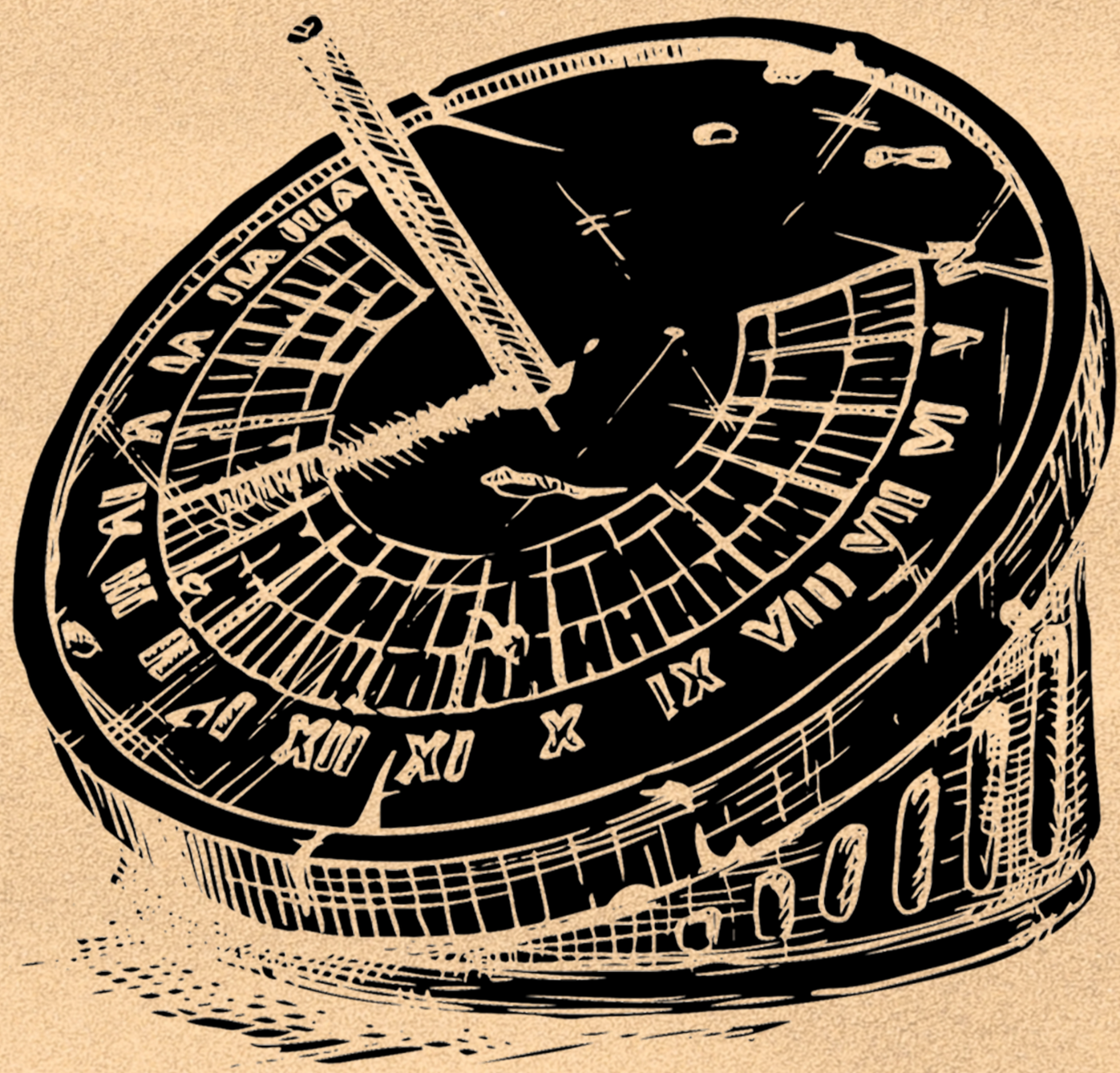
THE FIRST BOOK OF TIME



JEANNE BENDICK

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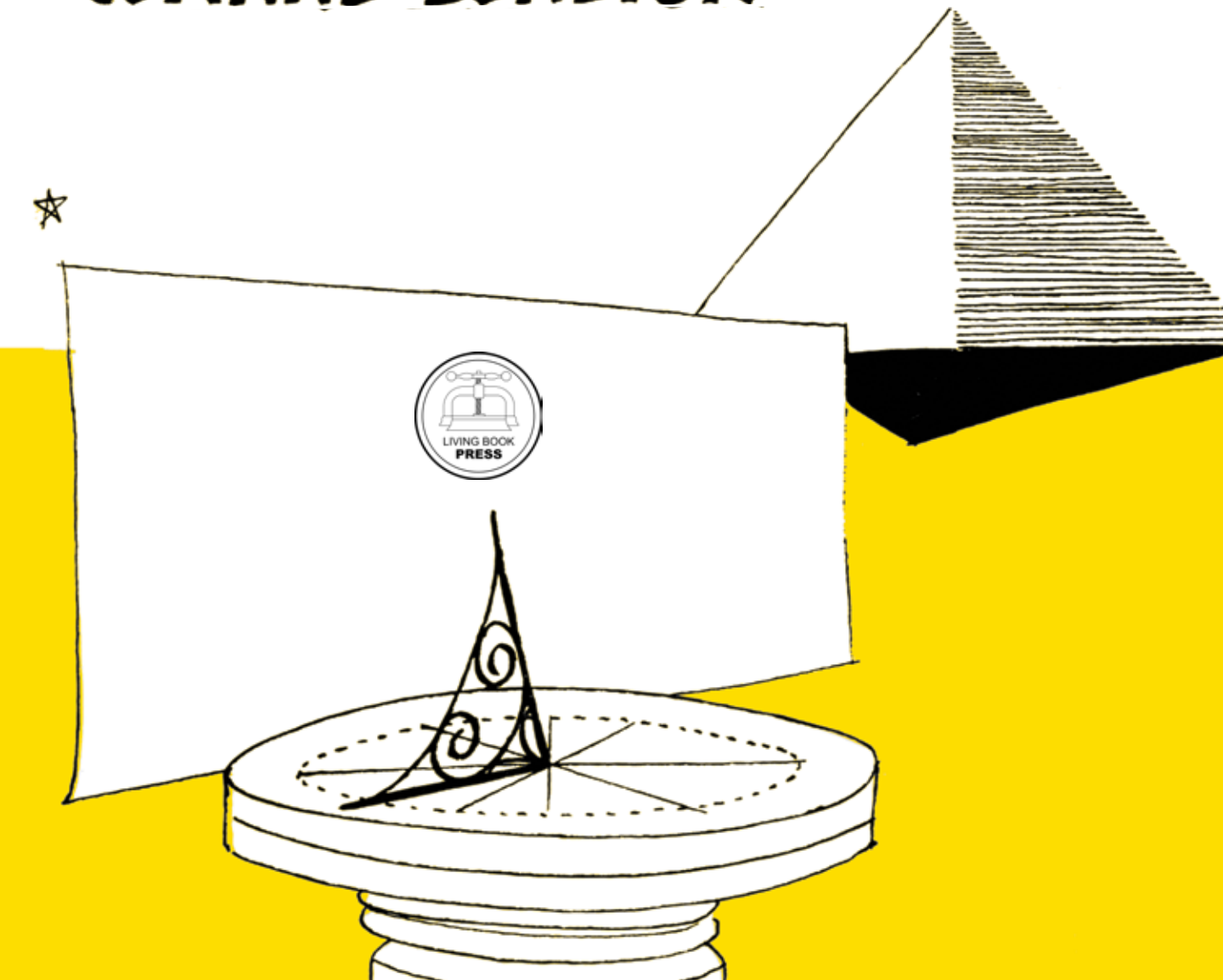


HOW DO YOU THINK ABOUT TIME?

How do you think about time?

Do you think of it simply as seconds and minutes—hours and days?

Do you think that time is something that never changes—that a minute is always a minute, and a year is always a year?

Janus, the Roman god of things beginning, had two faces. One looked back into the past; the other looked ahead into the future.

Do you think that the past has happened—and the present is now—and the future is ahead?

Do you think that there could be time if there were no people to measure it?

Now try thinking about these things.

Try thinking about the past, the present, and the future all happening at the same time.

Try thinking about time going much faster in one place than in another.

Try thinking about a clock that is alive. Try thinking about a clock that can measure a billion years, or four billion years.

Try thinking about a clock that can measure a millionth of a billionth of a billionth of a second.

Try thinking about time beginning, or ending.

Try thinking what the world would be like without time.

Could you imagine it?

WHAT IS TIME?

Everybody knows what time is.

But if someone asked you to explain it, what would you say?

Would you say that time is a way of measuring things?

Or is it a thing itself?

Would there be time even if we didn't measure it—even if there were no people to think about it?

We cannot touch time or see it or taste it or smell it. We cannot cut it up or add to it. We cannot stop it or start it, or turn it around and make it go the other way.

Did we merely invent time, because it's handy?

Or is it something real, like space?

We cannot see or touch or hear space, but we know it is real. All solid things in the world take up room in space. Things occupy space. They exist and move in it. We say space is a *dimension*.

People and things take up room in space. They move through it.

Is time a dimension, too?

We can locate things in the dimension of space by asking the question, "Where?"

Can we locate them in the dimension of time by asking the question, "When?"

If you are beginning to feel mixed up because you cannot find the answers to something you always thought was simple, don't worry. More than fifteen hundred years ago St. Augustine said, "What is time? If nobody asks me, I know, but if I try to explain it, plainly I know not."

For thousands of years, philosophers and men of religion, mathematicians, physicists, geologists, astronomers, and many other people have been thinking and arguing about time. And they still are.

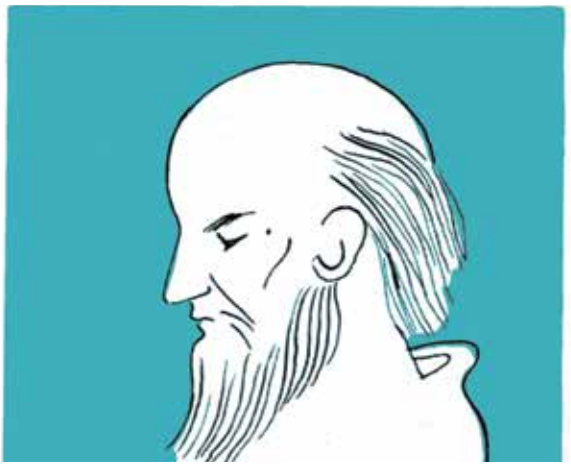
PAST, PRESENT, AND FUTURE

What *do* we know about time?

It doesn't start and stop. As far as we know, it has no beginning or ending. The scientific word for this condition is a continuum. Is time a *continuum*? We do not yet know.

More than two thousand years ago Aristotle, one of the greatest of the Greek scientists and thinkers, said, "Time is a continuous quantity. Time is not itself a movement, neither does it exist without change. *Now* is the link between past and future, but how long is now?"

Aristotle



St. Augustine

Seven hundred years later, St. Augustine wondered, "Does time exist? We can measure it, and we cannot measure what does not exist. But the past does not exist anymore, and the future does not exist yet, and how can we measure the present when it passes in an instant?"

One of the simplest ways we have of dividing time, in our minds, is into the *past*, the *present*, and the *future*.

The past is everything that has happened.

The future is all the time to come.

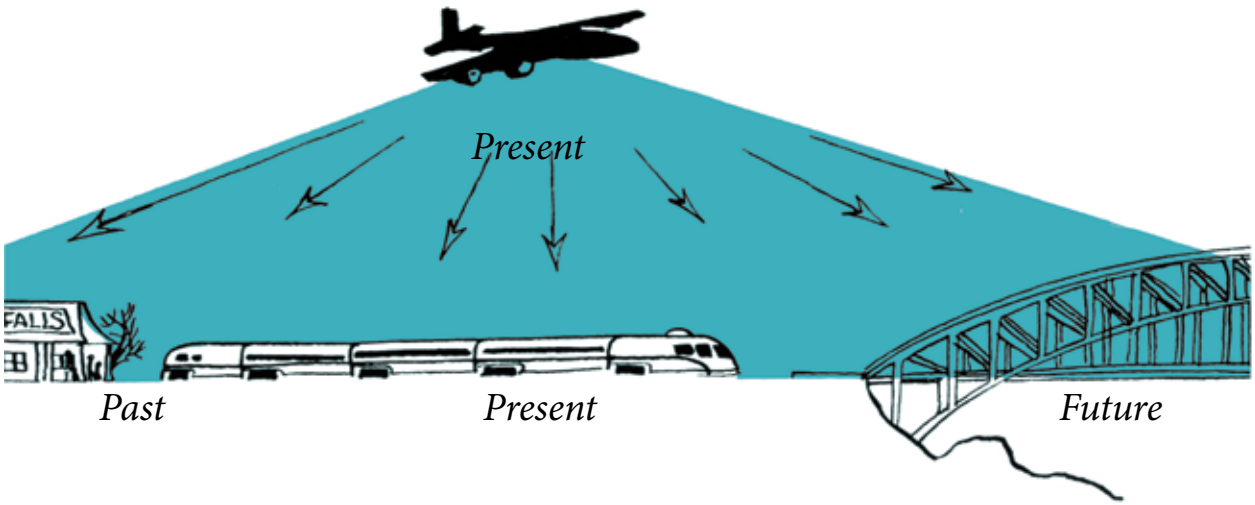
The present is right now.

But, in an instant, the present has become the past. The words you just read are in the past. In an instant, the future has become the present. Time passes. Can you say it moves?

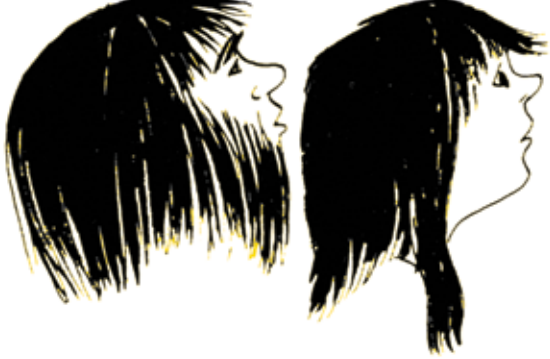
Not exactly.

But we measure time by motion. We measure it by the regular motion of real things—the gears or pendulum of a clock, the flow of electricity, the ebb and flow of tides, the movement of the earth and the moon, the swing of stars across the sky.

Sir Isaac Newton remarked that we measure time by motion, and we measure motion by time.



Are the past, the present, and the future the same for everyone? After all, the same instant is now. Suppose you are in an airplane, watching a train on the ground. To the people on the train, the station they have just left is the past, the bridge they are about to cross is the future. But you are seeing them all at the same moment. Your now is the past, the present, and the future of the people on the train.



MEASURING TIME

It was important for man to learn how to measure time. Everything depended on it.

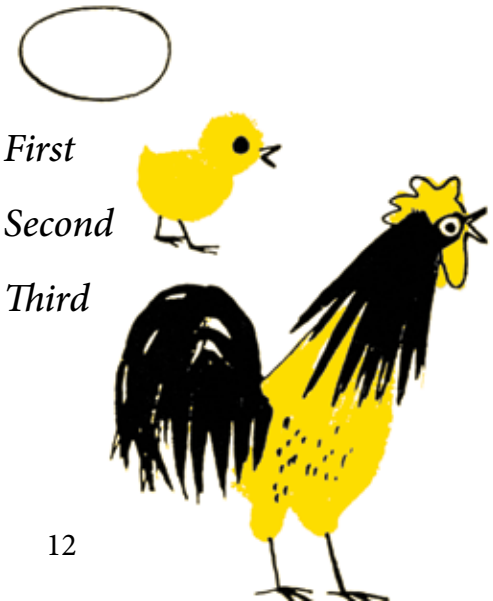
Of course, it was important for him to know when it was going to be day or night—or winter, when the food was scarce—or summer, when the food was plentiful.

But most animals and most plants seem to be able to tell these things without having to think about measuring time. What else depended on it, for man?

Almost everything we know today.

Learning to measure time was the beginning of learning *order*, and all science depends on order. A person cannot even count without order.

When we say, ONE, TWO, THREE or FIRST, SECOND, THIRD what are we doing? We are putting numbers in order so that we can think about them one at a time. But we must have a place to begin. Something has to be first. First how? First in space. First in time.



So, learning the order of things was the beginning of science for man—learning that day follows night, that the seasons follow one another in a regular pattern, and that so do the ebb and flow of tides, that the moon is full and then full again after an exact number of days and nights. Man found order in the movements of the heavenly bodies, and they gave him his first ways of measuring time.

WHAT MAKES A YEAR

We can only measure time by motion. If nothing moved in the universe, would there be such a thing as time? Probably not. The scientist, Dr. Einstein, said that there is no such thing as *absolute* time—time by itself, with no relation to anything else.

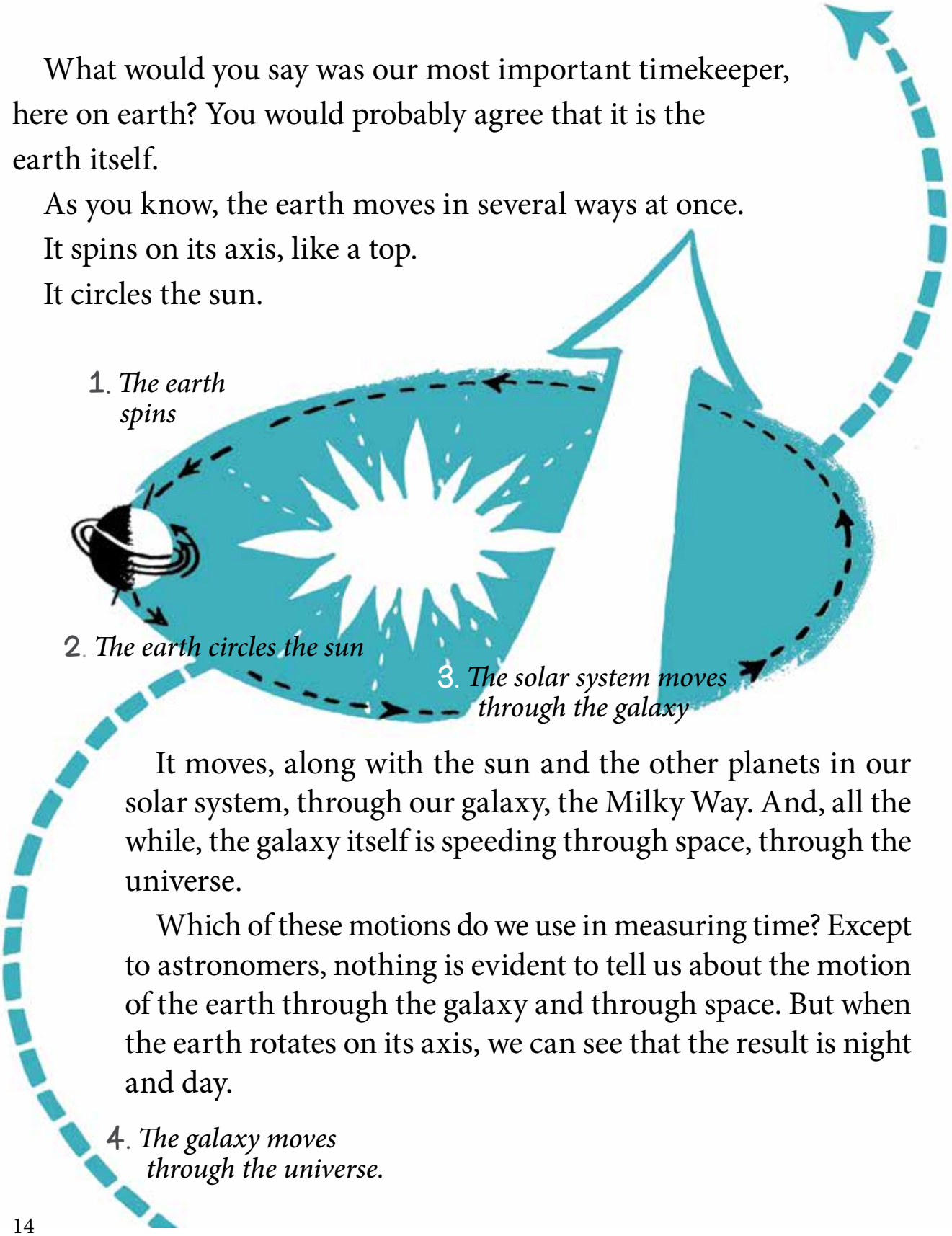
But as long as there is motion there is time, and we can measure it. As long as a clock ticks or a heart beats or spring follows winter, we can measure time.

What would you say was our most important timekeeper, here on earth? You would probably agree that it is the earth itself.

As you know, the earth moves in several ways at once.

It spins on its axis, like a top.

It circles the sun.

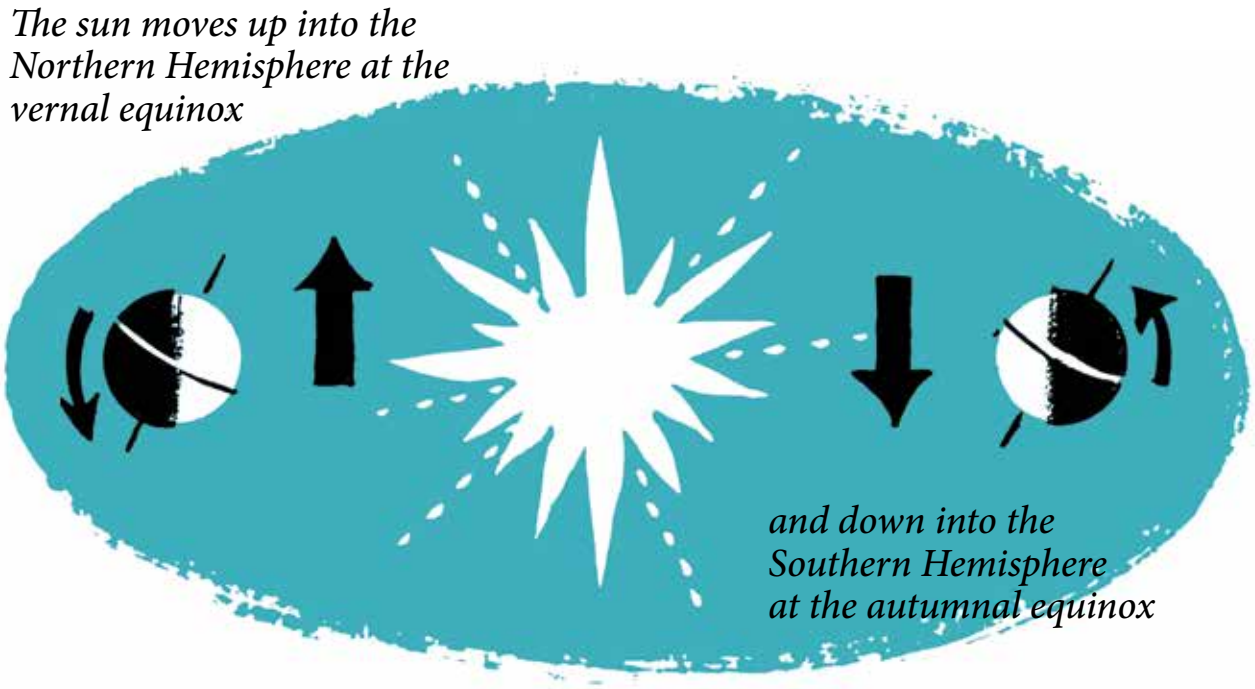


It moves, along with the sun and the other planets in our solar system, through our galaxy, the Milky Way. And, all the while, the galaxy itself is speeding through space, through the universe.

Which of these motions do we use in measuring time? Except to astronomers, nothing is evident to tell us about the motion of the earth through the galaxy and through space. But when the earth rotates on its axis, we can see that the result is night and day.

And when the earth has made a complete orbit around the sun, we notice it as a year.

The *solar year* (*solar* means "sun") is figured from the time the sun crosses the Equator in the spring, going from the Southern Hemisphere to the Northern Hemisphere, until it crosses the Equator the next year, going the same way again.



The scientific name for this time of crossing is the *vernal equinox*. Most of us call it simply "the first day of spring."

At the *autumnal equinox* the sun crosses the Equator again, going south, but the solar year is measured from one vernal equinox to the next.

The solar year is 365 days, 5 hours, 48 minutes, and 45.7 seconds long.

Another standard of time for a year is slightly different, but a little more exact. It is called the sidereal year. *Sidereal* means "determined by the stars." The sidereal year is the length of time it takes the earth to return to an exact place in its orbit in relation to the fixed stars—those stars which always seem to keep their same positions in relation to one another. The sidereal year is 20 minutes longer than the solar year.

A solar year is determined by the sun

Our *calendar year* is 365 days long. But what happens to that extra 5 hours, 48 minutes and 45.7 seconds—the difference between the solar and the calendar year? We save them up for four years and make an extra day of them—February 29. We call that fourth year a *leap year.*

A sidereal year is determined by the stars

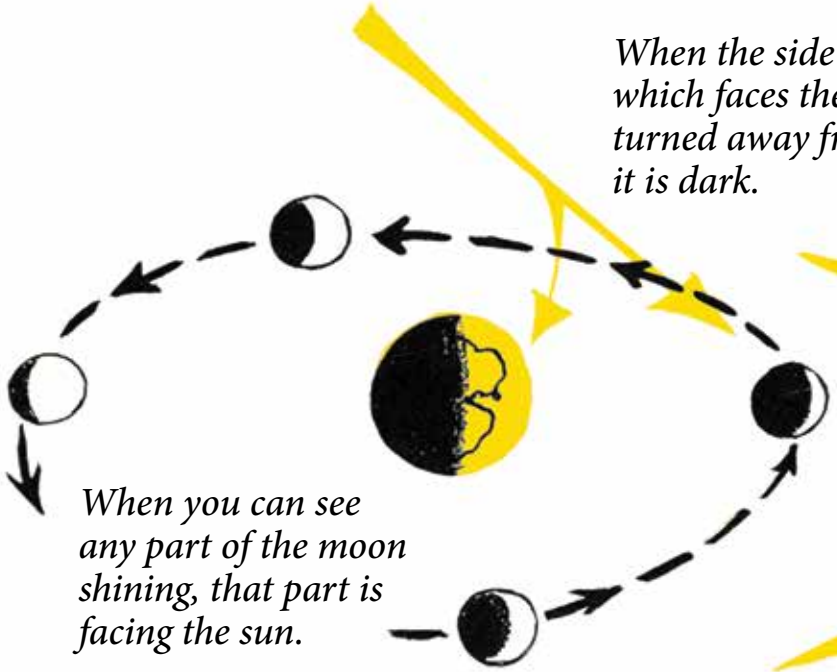
A calendar year is determined by people

MONTHS AND WEEKS

What makes a month? The answer depends on what kind of month we are talking about. The months in our calendar were made by people. These months have no relation to the beautifully exact movement of the moon through the sky, which makes a *lunar month*. (*Lunar* means "moon.")

The lunar month is one of the three natural divisions of time. (The others are the solar year and the solar day.) A lunar month is the length of time from one new moon to the next. It is 29 days, 12 hours, 44 minutes, and 2.8 seconds long.

It starts when the positions of the earth, the moon, and the sun are like this—



And when they reach those positions again, another month begins.

Sometimes a lunar month is called a *synodic* month.

Just as we use a sidereal year, we often use a *sidereal* month, which is figured from the time the moon is in conjunction with a certain star, until it moves into that exact relationship again. A sidereal month is shorter than a lunar month. It is 27 days, 7 hours, 43 minutes, and 11.5 seconds long.

Why don't we use lunar months or sidereal months instead of man-made months, and add them together to make a year?

Add 12 lunar months together,
or 12 sidereal months, and see what happens.

12 lunar months
× 29½ days in a lunar month

365 days in a solar year
− 354 days in a lunar year
11 days short

And a sideral month is even shorter!

WEEKS

Is a week a natural division of time?

Not really. It is a little uncertain how a week of seven days started, but it has been used for thousands of years. Except that it roughly divides the month into four convenient parts, there is no real reason for a seven-day week. The ancient Egyptians had a ten-day week, and so did the French after the French Revolution. The Romans had an eight-day week, and there have been four-day weeks, too.

Sunday is the sun's day.

Monday is the moon's day.

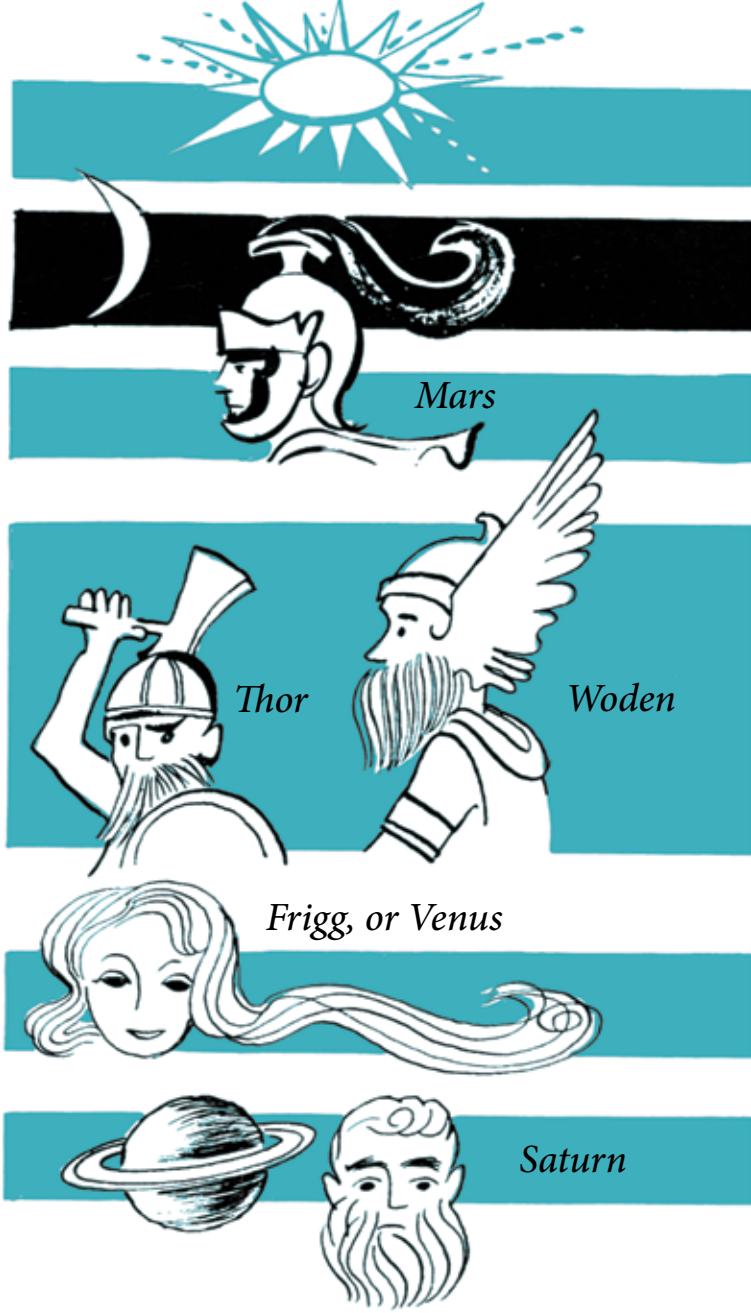
Tuesday is Mars' day. (The Saxons called Mars "Tiw"—hence, "Tiw's day.")

Wednesday is Mercury's day. (The French call it "mercredi"; the Saxons made it "Woden's day.")

Thursday is Jupiter's day. (The Saxons called Jupiter "Thor"—hence, "Thor's day.")

Friday is Venus' day. (The Saxons associated her with Frigg.)

Saturday is Saturn's day.

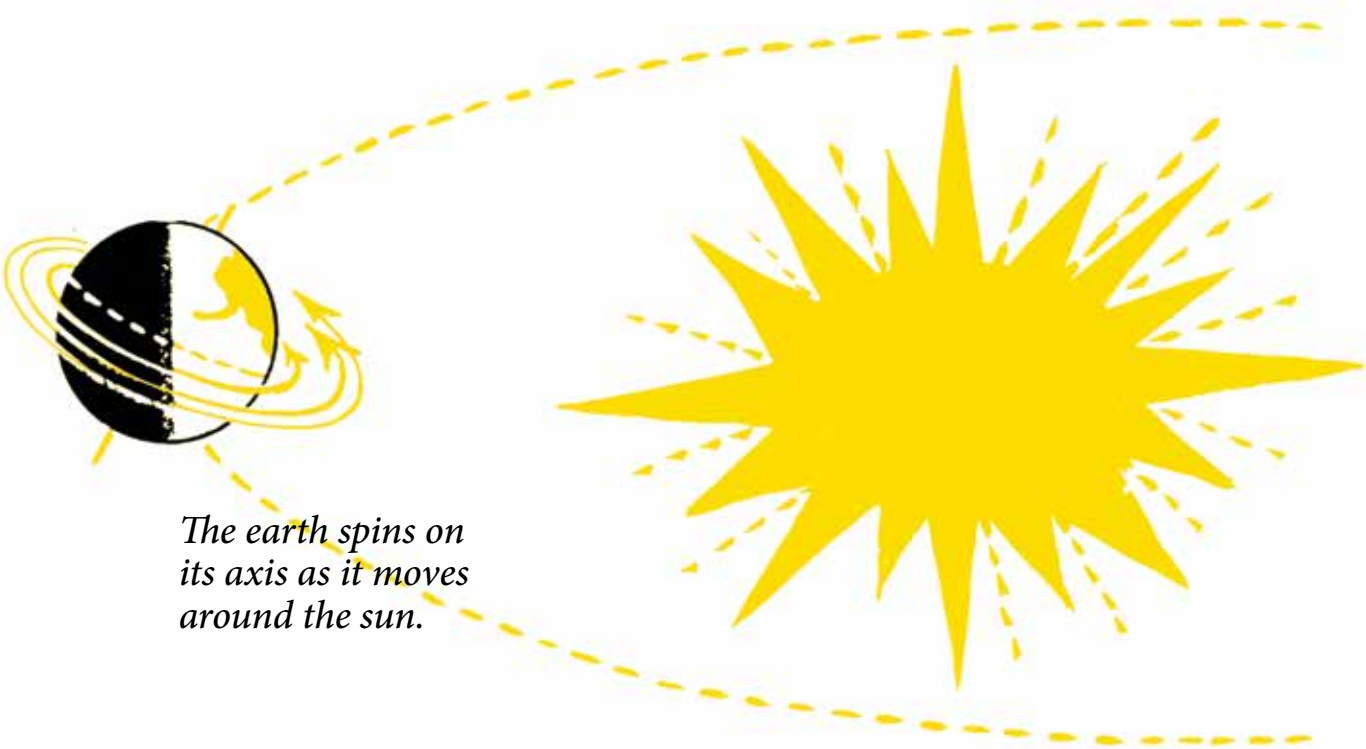


ALL KINDS OF DAYS

The first thing you probably noticed about time was that night always came at the end of your day, and morning always came after the night. This was certainly the first thing that primitive men noticed too, and their first way of measuring time must have been by days and nights.

What is a day?

A day is the length of time the earth takes to turn around once on its axis. A day is 24 hours. Part of a day is light, when your section of the earth is facing the sun; and part of it is dark, when your section of the earth is turned away from the sun.



The earth spins on its axis as it moves around the sun.

The 24 hours that it takes the earth to turn on its axis is called a solar day. Is there a *sidereal* day, too? Of course. It is about four minutes shorter than the *mean*, or "average," solar day of 24 hours.

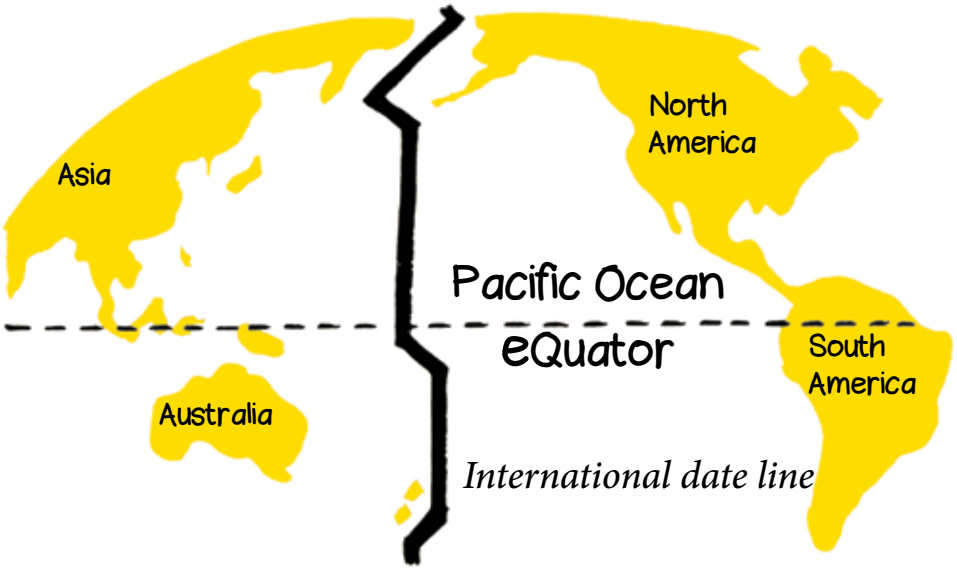
When does a day begin? For primitive people it began at sunrise, and in some places it still does. In most of the civilized world a day begins at midnight. But midnight where? After all, the earth keeps turning, and it is always midnight somewhere.

If you look at a globe which represents the earth, you will see that it is divided, by lines running from the North Pole to the South Pole, like the sections of an orange. These lines are called *meridians*. Geographers invented them to help us locate immediately any spot on earth.

Meridians

We'll talk more about meridians on page 28, but let's think about one particular meridian now. It is the 180th meridian, called the *international date line*.

It is shown by the heavy line on the drawing.

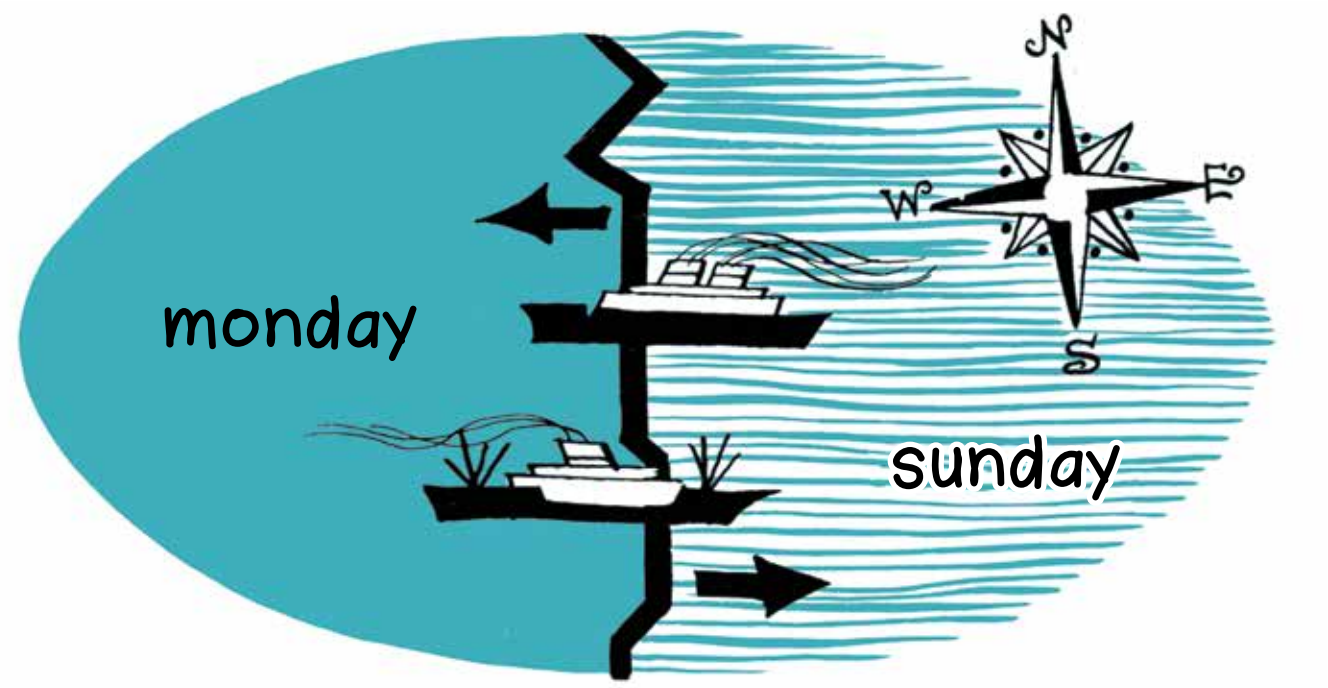


By international agreement, at exactly midnight along the international date line a day ends on the eastern side, and a new day begins on the western side.

Geographers picked this particular place because most of the 180th meridian runs through the open stretches of the Pacific Ocean. If the international date line ran through centers of population, things would be very mixed up. Tomorrow, or yesterday, might be just across the street.

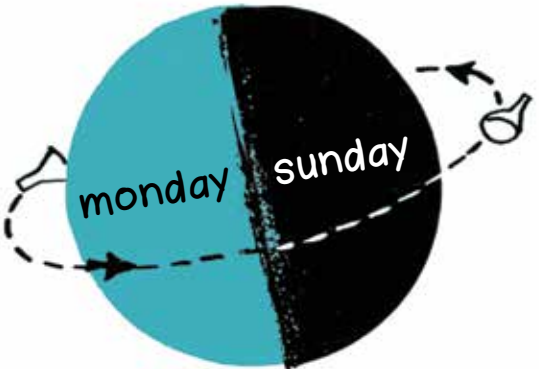
You can see that the international date line has some bends in it. The line is bent so that all Siberia, and all the Aleutian Islands, and all the Fiji Islands will be in the same day at the same time.

Suppose you were on a ship, traveling west across the Pacific to Japan. What would happen when you crossed the date line?



If it were Sunday, you would suddenly be in Monday. You would have lost a day. But if you were sailing east on Monday, when you crossed the date line you would be back in Sunday again. You would have gained a day.

Astronauts go back and forth, from today to tomorrow and then back to today, every time they circle the earth.



When man was first learning to measure time, he realized that during the winter months the nights were long and the days were short. In the summer there were only a few hours of darkness before it was light again. It was thousands of years before he figured out the mean, or average, day of 24 hours that we use now.

Only twice a year are the days and nights equal: when the sun crosses the Equator at the spring *equinox* (which means "equal night"), on about March 21, and again on about September 23, when it crosses at the autumnal equinox. At these times, the sunrise and sunset are twelve hours apart.

Now look at this. When the earth tilts in its orbit so that the North Pole faces the sun, it is daylight at that pole for six months, and dark at the South Pole, which is turned away from the sun. When the earth tilts the other way, it is dark at the North Pole, and daylight at the South Pole.

DAYLIGHT SAVING TIME

What is daylight saving time? Can we really save an hour of daylight, like money in the bank, to use when we need it? Of course not. The hours of sunlight and the hours of darkness stay just where they are. The only thing we can change is what the clock says.

If we want an extra hour of daylight to enjoy in the summer, we move the clock hands ahead an hour. Before we moved them, it was dark in the evening when the hands pointed to seven.

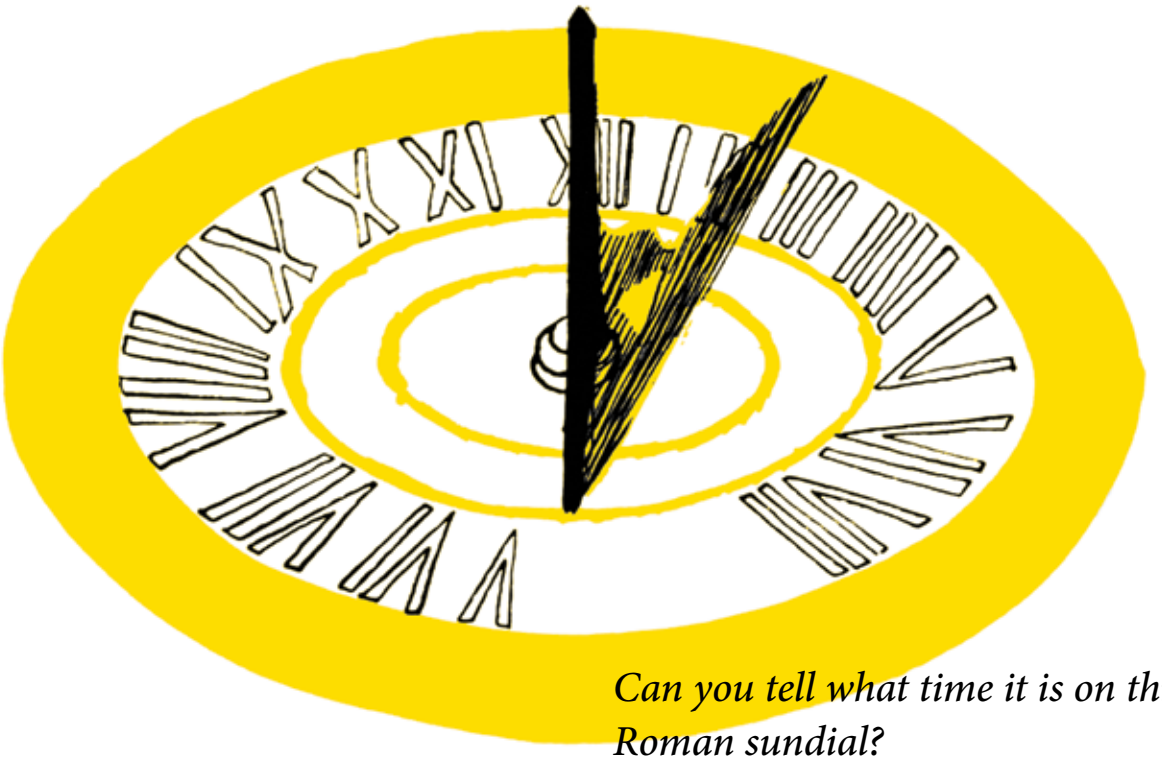
Now it is still light at seven, but dark when the hands point to eight. But we haven't gained an extra hour in the day. What happens early in the morning?

Before we set the hands ahead, it was light when they pointed to 5 A.M. Now they point to 6 A.M. when it gets light. That is why farmers do not like daylight saving time, and many of them do not use it. Cows and chickens do not tell time by clocks.

MEASURING HOURS, MINUTES, AND SECONDS

An hour is a twenty-fourth part of a mean solar day, but only because we say it is. An hour is not a natural division of time. It is only a convenience. *Hour* comes from a Greek word meaning simply "a time of day."

For many centuries, only the daylight was divided into hours, and there was a very good reason for that. Nobody could tell time at night, or even on a cloudy day.



Can you tell what time it is on this Roman sundial?

The first instrument that divided a day into hours was the sundial.

The ancient Romans used the word "hour" to describe a particular time of day—the hour of sunrise, or sunset, or noon. The Romans divided the hours of daylight into five parts on their sundials. Earlier sundials had twelve hours.