SPACE TRIP FOR THE JONESES

Partly described by the Joneses themselves

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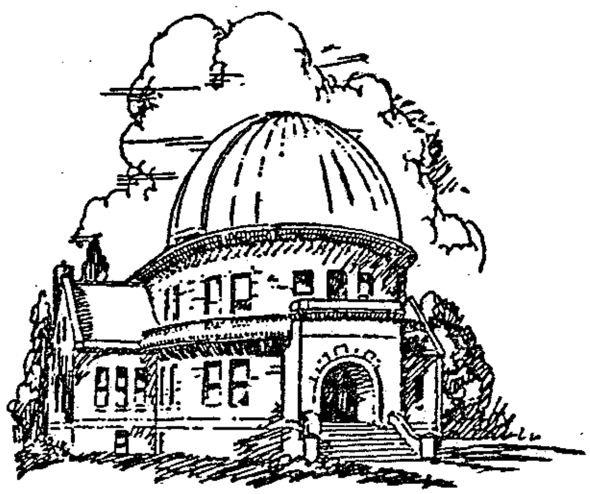

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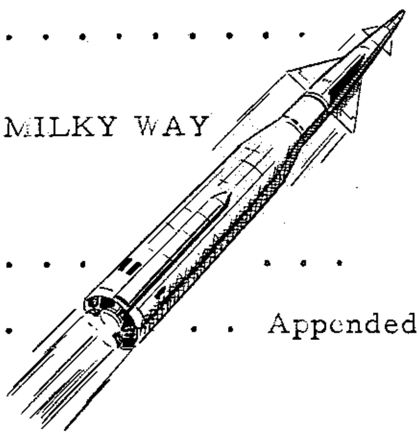

SPACE TRIP FOR THE JONESES
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Chapter I

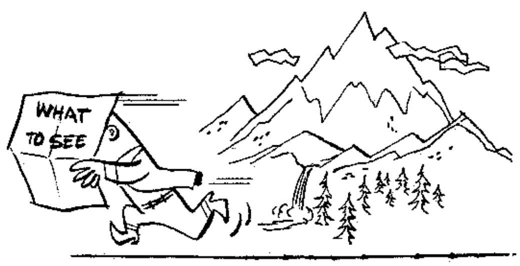
IS THIS TRIP NECESSARY?

Most of us have a casual interest in the sky around us. We can't help noticing the outdoor overhead lighting from time to time. Often we say to our friends, "Aren't the stars beautiful tonight?" We wonder if that bright reddish spot of light up there is Mars. No, that's a plane; it's moving! The changing phases of the moon fascinate us. We see the sun disappear over the western horizon amid the glorious colors of a magnificent sunset. There is no fear that it will fail to rise on the morrow, even though we may not be up to greet it. We take the sun, moon, and stars for granted. Need we be more concerned about them?

WE HAVE EYES AND SEE NOT

Are we earth inhabitants just to make a living, or are we to make a life too? As we go through our allotted three score and ten years, will we find time enough to notice the scenery as we pass by? Do we feel any urge to know more about the rocks at our feet, about the flowers and birds around us, or about the heavens above us? Our friends tell us that we should see Paris in the spring-time, the Alps by moonlight, the glory that was Greece, and the Grand Canyon of the Colorado some summer. "Haven't you been to Yellowstone Park yet? You've missed half your life!" they say.

But when we go there, when we make that scenic trip, what will we see? While we take that Cook's Tour are we so busy reading Cook's directions that we fail to see what Cook describes? Do we go through the trip with a haunted expression, fearful that we will miss something that we should have seen, so as to be able to tell the folks at home about it? Remember the picture of the world traveler seated in the "Seeing the Alps" train with the light coming over his left shoulder, so busy reading Touring the Alps that he hasn't time to look out the window and see them? Or the teenagers riding the family car on a trip through the Canadian Rockies and buying a new comic book at every rest stop? Or the group playing pinochle in the parlor car of a train while its picture windows sweep from Pike's Peak to Mount Evans along the Front Range of the Colorado Rockies? Instead of taking a trip it might be more instructive to sit in an air-conditioned movie-house and watch a colored movie go by. Especially if there is a sound-track guide that knows his way around and can tell all about the things worth knowing in an exciting, unforgettable way. Maybe we should read a travelogue like this!



Most of us have eyes, yet we see not. Many of us sightseers daily go through museums, planetaria, art institutes, and libraries. Yet, if called upon, we could tell very little about what we saw. There is the mind's eye as well as the actual optical organ of sight. We must know

We have even worse hazards now. Let's not try to point out the star Arcturus for our friends from the middle of the street, or even worse, when we are driving on a public highway.

Much of the subject-matter of astronomy is better kept in books. That's the best place for the material because there's not enough room on the shelves of our brains to hold it for long. We may sound educated if we recite parrot-like the facts of science, but we shall go much farther and live with ourselves and our friends more completely and happily if we learn the why and how of science, which holds together what we know by its logical connections. Said a negro mammy to her daughter, "Lor', chile, if you haint got no eddication, you just gotta use your brains." Yes, the bear went over the mountain to see what he could see. But he had to climb the mountain of understanding first. Only then did he get the high view and the deeper appreciation that goes along with it.

For, after all, most of what seems to be a very profound fact of astronomy is merely the application of good common sense. Apparent complexity often yields to ordinary horse sense--good logic applied one simple step at a time. Oftentimes the logic may be clouded with technical lingo, a professional gobbledy-guck which frightens many people away. They eye the scientist with respect and awe, but stay completely away from his work for fear of being burned by his technicality. In this scientific age it is high time that science be explained and learned in round numbers. We have generally paid so much attention to the details of the shrubbery and underbrush of the scenery that we hardly ever find time to scan the wide sweeps and vistas of the forest. And so in the scientific scene we can't see the forest of the great design on account of all those technical trees. Let's take a knowing look at the stars. Let's take a panoramic view of the heavens and leave technical details to the scientist and research worker.

Have you ever really tried to unravel the puzzles of the stars, of the sun and moon, and of the planets? There are among us many who like to read and listen to detective stories. We follow through the clues as they are presented in the mystery thriller. We hope to beat the master detective to the solution of the crime. Instead of the artificial puzzle usually presented by the author in the detective story, why not try to follow the real situations presented constantly by the stars and planets in the skies above us? Why is the moon only half lit up tonight? Why is it in a different place among the stars, compared to where it was last night? Why do most stars rise and set, while the Big Dipper stays up all night? When the sun sets in the west, how can it sneak back so as to be able to rise in the east the next morning? Here are detective stories aplenty, whose plots are natural and a real part of life, and not manufactured and unreal. Imagine the thrills of working out clue after clue, trying to out-guess Mother Nature herself.

Said Alice in Wonderland to the Queen when she was having trouble explaining something: "I could explain this better, if I understood it myself." So could we all--guide and learner alike!

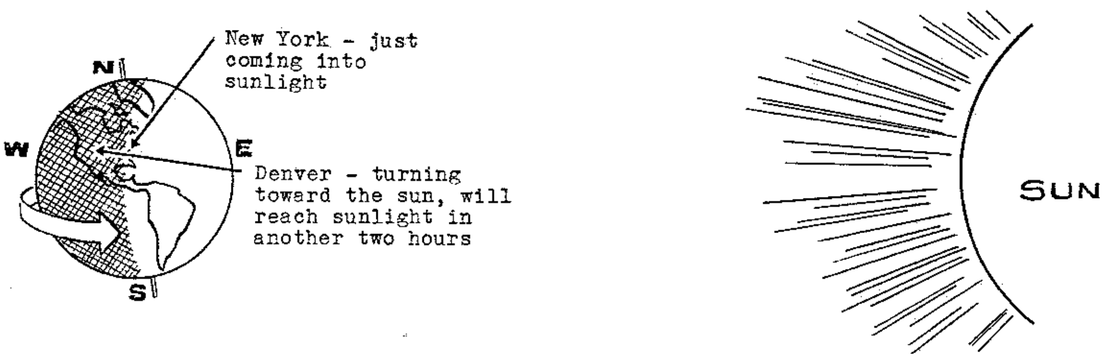
The above quotation from Lewis Carroll's famous story has formed the background upon which this book and its title Space Trip for the Joneses have been built. Over the years students in our astronomy even when they are not quoted directly it will still be astronomy for the Joneses by the Joneses. For the author has unconsciously acquired from his students and from visitors to the Chamberlin Observatory new ideas for explanations. The present astronomy course therefore must certainly be much better outfitted with ingenuity of explanation and illustration than was that first threadbare course taught a quarter century ago. The explanations by the author of this book are merely the explanations of the students which he paraphrases. With all this talented help the reader now should be in a better position to say in all sincerity, "I can explain this better now, because I understand it myself."

EXPLAIN UNTO OTHERS AS YOU WOULD HAVE THEM EXPLAIN UNTO YOU

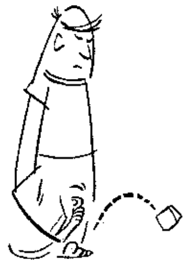
There are many tricks of the trade that a good guide and explainer should know. A great speaker has said that you must tell a person what you are going to tell him, then you tell him, and finally you tell him what you have told him. But that person will be completely bored unless this is done in three striking ways, all different. Too often the guide stops explaining at the point where he thinks anything more he might say would be obvious. But often he is too optimistic on this point. The idea is not really obvious until conclusions are clearly drawn, and not left hanging fire. Or until some example of a similar nature common to the experience of all of us is used as an illustration.

For instance, you ask why clock time at a given moment is later in New York than in Denver. "Because the earth turns, of course," is the answer. But that doesn't really explain it at all. The earth must turn east and carry the eastern part of the United States into the sunlight first. How do you know the earth turns east? Look about you. When you are driving in a car, as the car goes one way, the scenery appears to go the other way. Which way is the earth-car going? The sky scenery, sun, moon, and stars drift west as time marches on; it must be that we are going east with the earth.

Now that we have the direction of motion right, it will be better to illustrate further by imagining the globe of the earth turning toward a light. The United States turns east--New York first--into the sunlight,



and then turns western United States and Denver into the sun. But the idea of time's being later in New York will still not catch hold until the conclusions are drawn. Point to Denver when it is still in darkness on that side of the globe, after the earth has turned New York into the sunny half of the earth. Now say by the time that the earth turns Denver into the sunlight and it is therefore sunrise for Denver, the sun will have



When I was a boy a stone was to me a stone, and that was a bit of worn-down rock that could be kicked about or thrown at things. And earth was earth, and that was inert crumbly stuff in which things crawled and grew. Everything was what it was. Things were just what our sense said they were.

I learned in time that the stone had a strange history over millions of years. I learned that mighty forces had formed and baked it, buried it and smoothed it. Then I learned that the dead stone was composed of infinitesimal atoms.

I learned that the inconceivably small atom was itself a system and that its constituents whirled in their orbits with incredible swiftness.

In short, everything turned out to be more and more different from what it seemed to be. It was my ignorance that made me think things common and ordinary, for they are strange and wonderful.

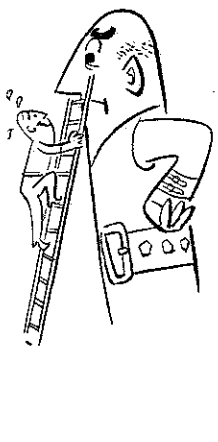
What has all this to do with beliefs? It certainly has a lot to do with mine. Let me draw a moral or two which may explain what I mean. One is that in learning about things we never learn the causes of things. We learn more about things, and the things change amazingly as we learn, but we never learn to explain their being.

We discover the atom and it becomes another form of energy. But what is energy? And if some day energy turns out to be something else again we are no nearer to explaining it than before.

We will give Dr. McIver's solution to his problem in the final chapter.

But had scientists stopped trying to understand and explain things, scientific progress would have stopped also, long ago. Remember what the head of the U.S. Patent Office said back in 1830? In his opinion, expressed at that time, there was no value in continuing the patent office longer, because all things that could be invented had already been invented. Chemists not so long ago had the wrong notions about atomic structure, thought atoms were tiny solid bouncy billiard balls; but they nevertheless still went ahead making a good grade of sulfuric acid. They knew chemistry only in round numbers but nevertheless got good efficiency out of chemical processes by using the best approximate theories they knew. 'Twas ever thus. Science travels apace despite lack of knowledge of first causes. Color TV is a success, and yet scientists are still not sure what electricity really is.

WE CAN STAND ON THE SHOULDERS OF GIANTS



With the world so completely involved in science, its industrial and military applications, and its relation to general living, an education cannot be well-rounded unless it includes a fair amount of knowledge of science and the application of the scientific method. But this scientific material should be presented for the Joneses. It should not attempt to be an overall coverage of any particular science intended for the professional scientific worker, but should make the citizen apply the scientific method to all his logical thinking and he should be made to explain the common phenomena of science in terms that the layman can understand. Such a study of general science should be part of the

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Chapter II

BEYOND THE FAR HORIZON

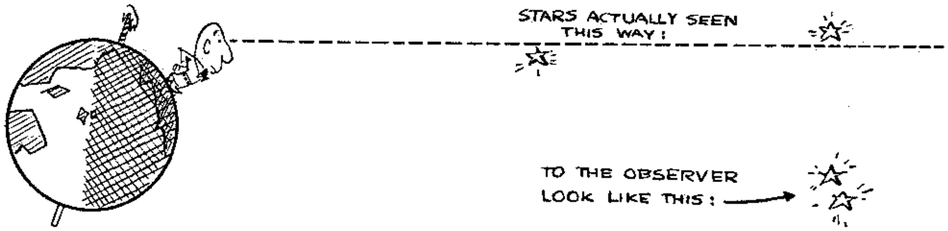
I remember, I remember, the fir trees straight and high,
And how I thought their slender tops were close against the sky.
--Thomas Hood (quoted by Luebke, 51-2)

Some of us Americans live like modern cliff-dwellers in apartment houses along the canyons of city streets. Many of us live in large communities where starlight and even moonlight fight a losing battle with the neon lighting of our technicolor nights. But nearly all of us either live in the country all the time or have opportunities to go on vacations and trips out to the open fields and hills and see the starry sky in all its sparkling glory. Haven't there been nights when you felt you could almost reach up and touch the stars? Were you ever in the Rocky Mountains above timberline on a moonless night? More stars than you ever saw before are virtually massed together and hanging just over your head. But whether you live in town or country you can still make an imaginary trip into space without even looking at the stars.

Have you ever dreamed, as you looked into space, of being transported to the stars--perhaps on a flying saucer? Have you built not only air castles but also star castles in the great beyond? Let's go visit the stars.

I wonder if you are really prepared to make such an unusual trip on the wings of your imagination. You must needs have a concept of the depths of space. You must try out your wings on short trips first. You will find yourself in need of new units of measurement to sound these depths. It will help to realize that the sky reaches out to the stars both on the daytime and night-time sides of the earth. Are these two sides so very different? But of course, one is the shady side of the earth and the other is the sunny side--the sun's side. Let's show you in a sketch.

The great Chinese philosopher Confucius said that one picture is worth ten thousand words. Do you remember what Confucius's brother is alleged to have said about him? Said he: "Confucius, he talk too much. He ought to show more pictures." Here is an explanation in a sketch:



But that isn't the only way that stars seemingly adjacent might still be a great distance apart. Because of perspective the rails of a train track look separated up close, but seem to meet in the distance.

> As planes in formation appear to collide at a great distance from the eye, so widely separated stars appear to converge at a great distance from us.
>
> (Winans, 48-3)

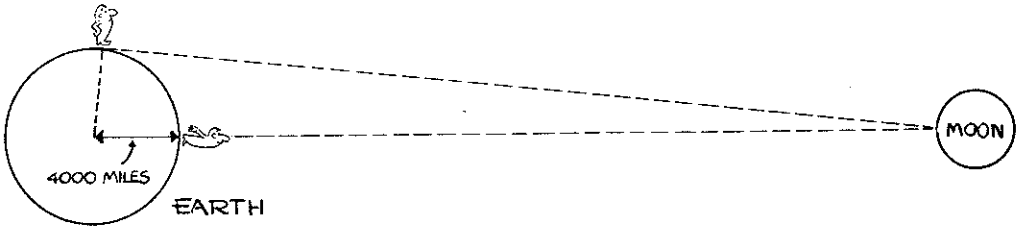
> As the distance from two objects increases the closer they appear to each other. For example, from Denver the peaks of some of the mountains seem only a few feet apart, whereas actually they are many miles apart.
>
> (Patnode, 50-2)

> For the same reason a pair of automobile headlights a mile away may appear to be one.
>
> (Ludington, 50-4)

DIMNESS A MEASURE OF FAR-NESS

As you look into the sky don't you get the idea that the fainter stars are farther away? You should, because past experience has shown you time and time again that the dimmer street lights are farther away. You realize as you look down a row of street lamps that they are all probably 1,000-watt lamps. In fact if they were all a block away they would appear of equal brightness. Instead, see how much fainter that light ten blocks down the avenue appears.

Therefore ordinarily we would expect dimness among stars to be a measure of their far-ness, presuming that they were all lamps of about the same wattage or candle-power. We would suppose that the brightest stars appeared bright mostly because of their nearness. Actually, however, as we will find out later, some of the most brilliant stars are great high-powered suns shining from way back among the suburban communities. Their overwhelming brilliance makes up for their remoteness. On the other hand that little faint star in the handle of the Little Dipper which is just barely visible, must be sending its rays from a long distance. It could be a high-powered star, but shining from the backwoods of space.



One man looks at the moon directly over his head. The man at the top looks at the moon sidewise toward his horizon. It is clear from the drawing that the man looking over his head is looking at the moon from a smaller distance--smaller by the distance from the center of the earth to the surface at his feet. Since he is closer by 4000 miles to the moon, he will see it about one-sixtieth larger overhead than it was on his horizon. Precise measurement will confirm this fact. Even though we know this to be true, the moon still looks bigger when it is near the horizon.

This apparent enlargement near the horizon is also noticeable in the shape of the constellations. The constellation of Orion appears much longer when it is near either the eastern or western horizon, than when it is high in the south. In the early evenings in December the Big Dipper is a much bigger dipper near the northern horizon than in April when it is high in the northern sky.

This optical illusion is explained by some with the suggestion that the apparent sky dome seems flattened and distances between stars appear shortened overhead. Others suggest that things look bigger along the edge of the sky because we have objects on the horizon to compare with them. Yet when an apparent horizon is raised high in the sky as part of a nearby mountain, the moon does not seem larger on that account when it rises above or sets below it. But some observers allege that they can make a full moon on the horizon shrink to its proper size by looking at it without its surroundings through a long cardboard tube.

Here's how Russell, Dugan, and Stewart's Astronomy (Ginn and Company) explains this phenomenon:

> These illusions are directly traceable to the unconscious habit, developed from an early age, of interpreting apparent size by the aid of our familiarity with real size. This perspective adjustment is strongly adjusted in the horizontal plane, to which our experiences are largely confined, but is very imperfect in the vertical direction. It is worth remarking that a ship seen below an airplane looks much smaller than one seen on the horizon at the same distance.

With regard to this last point, aviators claim that when they look down upon an airfield it often looks too small to land in. Yet automobile drivers never fear that the fences along the highway will not let them by, even though they seem to meet in the distance. Maybe it is something like the illusion of the two equal lines, one straight up from the middle of the other. The vertical line looks longer than the divided one. Perhaps the division of the line makes the two halves look smaller.

You will notice how inadequate the mile becomes as a unit of length when we use it to span the distance to the nearest star. It's somewhat like measuring the distance to Timbuctoo in inches--only worse. The astronomer has designed two new units for more comprehensible measurement of distances in space. First, there is the astronomical unit--the earth's average distance from the sun. This is used for measuring distances in the solar system more comfortably. Thus the distance of Pluto from the sun is about 40 times the earth's distance, or 40 astronomical units; also, Jupiter's closest approach to the earth is about four astronomical units. Second, there is the light-year, used to measure distance to the stars and other far away celestial objects. A light-year is the distance that light travels in a year at about 186,000 miles a second.

The number of miles in a light-year can be obtained by multiplying the number of seconds in a year by the number of miles that light travels in a second. But who wants to multiply it out? Let's take the astronomer's word for its value--5,800,000,000,000 miles or nearly six million million miles. The national debt in the United States is beginning to reach these astronomical figures; the number of miles in a light-year is about twice the number of dimes in the national debt. The mere comparison of these numbers hardly helps us to comprehend either the distance or the amount. But with this new unit the distance to the nearest star turns out to be about four light-years, and the distance across our Milky Way system is about 100,000 light-years. It now becomes apparent that the light-year is a better "thinkin' unit" than the mile to sound the real depths of space. But even this lengthy yardstick becomes hopelessly inadequate when we learn that the 200-inch Hale telescope on Palomar Mountain is reaching more than two billion light-years into space.

Let us put all these depth-reaching distances into a table for neater comparison and for easier reference:

Stairway to the Stars

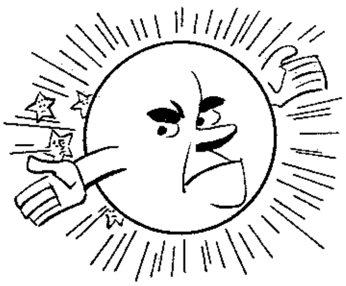
8 trips across the United States		equal a round-the-world trip
10 round-the-world trips		equal a trip to the moon
400 trips to the moon		equal a trip to the sun
40 trips to the sun		equal a trip to Pluto
7000 trips to Pluto		equal a trip to the nearest star,
	or	equal a billion round-the-world trips (4 light-years)
25000 trips to the nearest star		equal a trip across the Milky Way (100,000 light-years)
40000 trips across the Milky Way		equal a trip across the cosmos of the 200-inch Hale telescope (4 billion light-years)

Which will you wear to ascend the stairway to the stars--your golden slippers or your seven-light-year boots?

STARS IN THE DAYTIME

Someone objects immediately to this topic by saying, "If there are stars on the sunny side of the earth, you would be scorched by the sun trying to reach these stars." Hurray for him! With an imagination like that he has already passed his space-traveler test. In trying to go past the sun one might meet the fate of Icarus, whose close passage to the sun melted the wax which held his wings to his body. Let us admit that this topic tests not so much the conception of space as it does the logical allegedly to make it hotter than usual, so that only "mad dogs and Englishmen go out in the midday sun!"

If you ever lose faith in the daytime presence of the stars, just notice how the stars appear one by one in the twilight sky after the sun has set. There really isn't a celestial lamp-lighter that goes from one to another to light them up. They must have been there all the time ready to shine forth just as soon as the bright bully of a sun disappeared from view. Or maybe you have had that rare early-morning privilege of seeing the stars fade one by one as the dawn-light blotted them out. But you know they are still up there in the sky, shining with all their might even after the sun has risen.



We are reminded of William Cullen Bryant's Hymn to the North Star and its first two stanzas. Poets especially would know there are day-stars.

The sad and solemn night
Hath yet her multitude of cheerful fires;
The glorious host of light
Walk the dark hemisphere until she retires
All through her silent watches gliding slow,
Her constellations come, and climb the heavens, and go.

Day too hath many a star
To grace his gorgeous reign, as bright as they;
Through the blue fields afar,
Unseen, they follow in his flaming way;
Many a bright lingerer, as the eve grows dim,
Tells what a radiant troop arose and set with him.

Let us see now how astronomy students have explained the stars of the daytime to the Joneses. While some of these quotations are repetitive, they are all worth reading. For they give a great variety of ingenious responses to the request: Explain in a convincing way how it is known that the stars are up in the sky in the daytime. If you can follow these explanations you are well on the way toward receiving your wings as a space-force cadet.

An eclipse of the sun will reveal that the stars are up in the sky during the day. It is also possible to look up a chimney or from the bottom of a well and see some of the brighter stars, especially those near the zenith. When one stands in the darker spot, such as the bottom of a well, the pupil of the eye opens up and the eye gathers in more of the starlight in the manner of a telescope, and it is then possible to see the star. The sky will appear no brighter since each reflecting dust particle or air molecule scatters the sun's light and the sky as a whole is not a point source from which the light can be focused. A telescope may also be used to see the brighter stars during the day. A fourth convincing argument is that as the sun comes up all of the stars disappear more or less simultaneously, and as the sun goes down the stars appear in their places very quickly. It is not logical to assume that the stars are lighted or extinguished very quickly or that they suddenly rush into place, and therefore they must be up in the sky during the day.

(Anderson, 48-2)

on the spot where it once had twinkled (just as if it merely turned out its light to conserve electricity while the sun lighted the sky). Within the next few hours I was to behold the wonder of my lifetime, when the moon passed directly in front of the sun and erased its light into a total eclipse, while the stars simultaneously switched on their lights to check this unusual situation--just in the position I had watched them fade. I knew that they had been there all the time but had timidly backed away when competing with the sun's rays. When the sun had passed away from the moon (as it would seem to an observer) the stars were gone, but I left the deck that afternoon knowing that they had been with me all day and would again shine forth, each in his own position, that night.

(Porter, 51-2)

EXPANDING OUR HORIZONS

Now that we have finished our space indoctrination let's make our first test flight. Let's plan to make a fast trip out to the ends of space. We will get a panoramic view of the universe to form a skeleton framework upon which to hang our future astronomical ideas. We will find our horizons expanding with great rapidity.

There is the story of the high school girl at a banquet, seated next to a college professor, who asked him what he did. The professor replied that he was studying astronomy. Whereupon the high school girl, with all the assurance that young people have at that age, said: "Astronomy? Why, I finished that last year!" As if one could! But here we are, planning to finish off a survey of the cosmos in the next few minutes.

Whenever we take a sea voyage we are advised to take some pills along to prevent seasickness; perhaps we will need some space-pills for this fast trip. For in doing it so rapidly we may give our readers not gastronomical, but perhaps astronomical, indigestion. Remember the astronomer's son who asked his mother a question in astronomy. Mother was perplexed. "Why do you ask me, son," said she. "Why don't you ask your father? He's the astronomer." Whereupon the boy responded, "I don't want to know that much about it."

To stretch our imagination we will begin by using a quotation from one of George Bernard Shaw's scientific plays. Says one character to another: "Who the deuce was Pythagoras?" Whereupon the second character says, "Why, don't you know? Pythagoras was a wise man, a sage, who held that the world is round and that it goes around the sun." Whereupon the first character replies, "What an utter fool! Couldn't he use his eyes?" That doesn't make much sense until you think about it a little. Of course, if you live on the plains of eastern Colorado or of Kansas, you know the world is flat; just as far as you can see it in all directions it's flat. It's silly to assume it has any other shape. And as for the earth's being in motion, why, that's crazy too. For if the earth were going around a curve around the sun, you could feel it. When Dad drives the car on two wheels around a curve, it practically throws you out the side door. So if the earth were going in a circle you could tell. But everybody knows that the earth is stationary. It isn't moving. It may shimmy a little bit in southern California, but around here it's perfectly motionless, isn't it? What an utter fool! Couldn't he use his eyes? It's perfectly obvious that the earth is flat and stationary.

And yet the fourth graders these days know better than that. I mention fourth-graders because I have a book written by the fourth grade supported him! That version brings the conception right up to date because the women are more than ever supporting their men these days. Here is one sample that shows how.

At a summer convocation when there were a great number of men being graduated under GI Bill privileges at the University of Colorado, their wives were asked to sit up on the stage in front of the men. Before the husbands had been awarded their proper degrees the wives were also given their degree, the same degree for all of them. This, you may remember, was a very appropriate degree--PHT, Putting Husband Through--because they had all helped by baby-sitting, secretarial work, and various other means, when the subsidies of the GI Bill proved inadequate for support. Thus you see how women support their men these days.

The ancients had their universe worked out fairly well as you can see--at least the fixtures of the universe. How did they take care of the moving parts? Do you recall how they got the sun across the sky? It was Apollo, the sun-god, who drove the sun chariot across the sky. That must have been a hot job; he would have to use his asbestos suit for that. Do you remember how his son, Phaeton, who always wanted to drive the sun horses, got up one morning before Apollo's alarm clock had gone off and started those horses across the sky? Because he hadn't driven them before, he couldn't control them, and so he got the sun too far away from the earth. As a result we still sing on Sunday mornings about "Greenland's icy mountains." That's how they got that way. Frozen up, just like that, when Phaeton's sun horses ran away. Then, like all poor drivers that wander from curb to curb, Phaeton drove the sun too close to the earth. We still have a burned place--a seared place--a place where the grass never grew again--the Sahara Desert. One can't help admiring the ingenuity of these explanations of earthly phenomena.

But there was a problem that ancient scientists had difficulty in explaining--how could the sun be driven into the west in the evening and still reappear in the east the next morning? There were some who were tunnel-minded who thought there was a tunnel down between the elephants through which the sun was driven, probably scorching the elephants as it went by. There were others who were navy-minded who thought that there was an old sailor with an old ship who had nothing else to do but to row the whole outfit--sun, chariot, horses, driver--around the edge of the earth during the night when nobody was looking. Now in those days of curfews when people went to bed with the chickens, you might have been able to sneak the sun past, but in these days of graveyard shifts and college students that study all night, it just couldn't be done. I can remember a former student in my class, Dorothy Donovan, who explained this very nicely by saying that if you stay up all night wondering where the sun went when it set, suddenly it will dawn on you! Remember how ancient mythology took care of the moon? Diana, the goddess of the hunt, had charge of hanging the moon in the sky. So whenever there was no moon in the sky, it was presumed that Diana had gone a-hunting and had forgotten to hang the moon in the sky.

That was the world of the ancient theorists, satisfactory to most of them. However, there were critical scientists even in those days, snoopers we might call them, persons who are always looking behind appearances to see whether or not they are deceiving. It is this type of person that has helped us to make so much progress in science. They noticed that the stars didn't stay put as good diamond-studded tacks should, but gradually crept across the sky. That would be hard on old of the planets were accounted for by putting circle upon circle upon circle until Alphonso of Spain cried: "If I had been present at the Creation I could have rendered profound advice." The horizons that had been stretched by the crystal-sphere and Ptolemaic theories were extended still farther by Copernicus whose suggestion that the sun be put at the center of things rather than the earth greatly simplified the theory of the motions of the planets. Because there were no telescopes in his time, Copernicus could give no positive proof that his theory was right. But it seemed more logical to him and to us now to have the tiny earth do the turning rather than the immense starry sphere.

But the real expansion of the universe, almost its explosion, came with the discovery of the telescope in 1610. The term discovery is used here instead of invention, for tradition has it that the principle of the telescope was discovered by accident by the nine-year-old daughter of the Dutch spectacle-maker Lippershey. She was playing once with some of her father's left-over spectacle lenses. Now all women, even nine-year-olders, have that sixth sense, intuition. It must have been as a result of this attribute that she happened to hold two of these lenses so that the distance between them was the sum of their focal lengths and thereby made herself a telescope. For when she looked through these two lenses at a distant church steeple it looked much bigger. It was upside down, but it was much bigger. She rushed in and told Dad about it, and Dad Lippershey took the credit. When Galileo down in southern Italy heard about it, he made a telescope of his own with a paper tube, one that magnified about 30 times. With it he dared to look at the objects in the sky, and thereby committed heresy. For the people of that day thought that if the good Lord had intended for us to see the heavenly bodies up close, He'd have brought them closer.

But Galileo took that chance. He looked at the planet Venus and found that it went through phases like the moon, proving that Venus went around the sun rather than around the earth as people had imagined until that time. He also looked at the planet Jupiter and found four moons going around it. These four brightest moons have since been called the Galilean moons; eight others have been discovered since. Galileo even looked at Saturn, and found that, in his telescope at least, the planet looked as if it had ears on it. It wasn't until 1675 that Cassini with a better telescope was able to recognize the true shape of the rings of Saturn. With the advent of the telescope came the rapid expansion of space--first, of course, the extension of the solar system. Three new planets have been discovered: Uranus, Neptune, and most recently, in 1930, Pluto. There may be more planets out there, but that's as far as the expansion of the solar system has gone to date. With the invention of the spectroscope has come knowledge of the constitution of the atmosphere of the sun, the stars and the planets, and of the nature of comets. The telescope made possible the observation of sun-spots and the discovery of asteroids or planetoids, those little pieces of celestial real estate mostly located between Mars and Jupiter.

While the astronomers were expanding the solar system, they were also expanding the stellar system. They found that our sun is only one of some 100 billion of stars that form the Milky Way system. And it is a star of less than average size too; that's hard for Americans to take--Americans that are used to having the biggest things in the world. The Milky Way system of stars is shaped like a watch, which would be, however, a tremendous watch that is 100,000 light-years across and 10,000 light years through from back to face. Most of its hundred billion stars moon, then to the sun, and to the planets in their order out from the sun. From the planet Pluto we would go off to the stars, first to the stars of our own Milky Way, and then to those beyond the Milky Way. Doesn't that "beyond the Milky Way" have a far-off sound? In order to make this trip in a reasonable period of time, we shall have to travel at a tremendous speed.

There is a picture in the Book of Knowledge--maybe some of you have seen it--which shows planes taking off from the earth to go to the sun, moon, and planets, and to the nearest star. It lists the times required to make the trips if planes could fly the space between them at 200 miles per hour. Do you know how long it would take to reach the moon at that speed? Almost any Cub Scout could tell you that it would take seven weeks. Let's call it fifty days to reach the moon. At that same speed it would require fifty years to reach the sun, 500 years to get out to Saturn, and 2000 years to reach Pluto at the edge of the solar system. Then if you still wanted to travel to the nearest star, at the same speed of 200 miles per hour, the trip would require nearly 13 million years. The Cub Scouts will tell you that last figure too; they've read the Book of Knowledge.

It appears that a speed of 200 miles per hour is much too slow to make our trip in a reasonable period of time. Almost immediately someone will suggest the speed of light instead--186,000 miles a second. That speed would carry you 7 1/2 times around the earth while you count one. Such speed should take you places soon. In fact it will take you to the moon in a little more than a second--now that's going, isn't it? The speed of light will transport you to the sun in eight minutes--do you have your asbestos suit with you? It's really hot up there. It will carry you to Saturn in an hour and a quarter, to Pluto in five hours, and to the nearest star beyond the sun in four years. At 186,000 miles a second it would still take you 100,000 years to span the distance across our Milky Way system of stars and 1000 million years to reach the most remote galaxies that can be sighted with the 100-inch Mount Wilson telescope. Even at the terrific speed of light the trip would take us much too long. We're going to have to travel faster than light. But Einstein says nothing can go faster than light, because if it does something very queer happens.

There was a professor named White
Who traveled much faster than light.
He went out one day
In a relative way,
And returned on the previous night

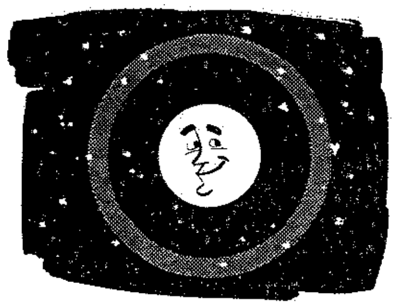
For if one goes faster than light time unelapses. You can get the idea in this way. Imagine a clock going away from you at the speed of light. Now, of course, light comes from the face of the clock also at the speed of light, and if you could see so far the hands of the clock would stand still. This would be true because it's a tie race, and the speed of the light toward you is just cancelled out by the speed of the clock away from you. But suppose that the clock were going away from you at a speed greater than the speed of light. Then you would be seeing the hands of the clock by old light, because the clock is going away from you faster than the light from the face of the clock can travel back to you. As a result the hands of the clock would seem to go backward. Have you been able to follow us? If you haven't, no matter; we can't all be Einsteins. Actually if a source of light were going away from you at a speed greater than that of light, you could never see it because it is going away faster

SPACE TRIP FOR THE JONESES
Partly Described by the Joneses Themselves

Chapter III

TAKEOFF POINT: THE EARTH

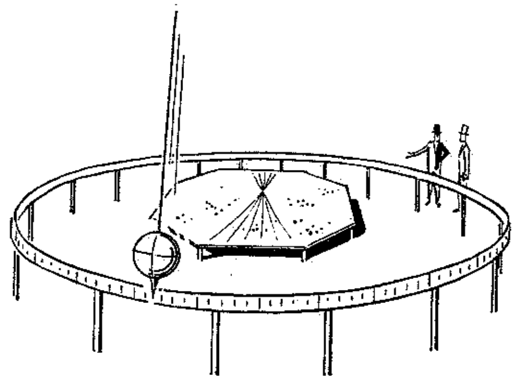
Since appearances are so deceiving, we will need to be careful in our observations of space from the earth. Are the motions of the sun, moon, and stars across the sky to be interpreted as motions of those celestial bodies themselves, or are they only apparent motions caused by a moving earth, or are they perhaps a combination of both? That is one of the 64-dollar questions that we will attempt to answer in this chapter. Is the ring around the moon out there, or is it in the earth's atmosphere? Does the poor power and light service on the stars make them flicker so, or do heat waves in the air make the stars twinkle?



You all have had the experience of sitting in a train in a station and noticing that the train next to you is pulling out. Suddenly you feel a bump, and you realize that it is your train that is pulling out instead. Again we ask, does the sun move across the sky, or does the earth turn past the sun? I don't feel any bumps. Do you? When the moon goes racing through the clouds on a windy night, is it really moving or are the clouds skidding by? We must be extremely careful of our interpretations of relative motions.

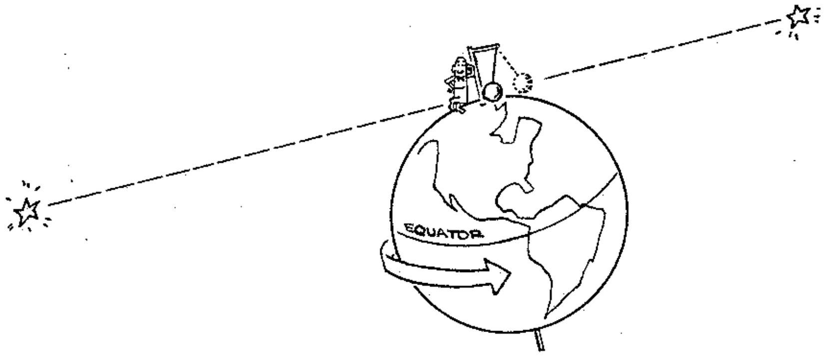
The scientists of ancient times didn't feel any bumps either, but they had another good reason for keeping the earth stationary. Said they, if the earth did spin once a day, its turning past the atmosphere at several hundred miles per hour would produce such a big wind that everything would be blown off the face of the earth. They felt more at ease when they let the sphere that carried the stars do the turning. But here is a case in which the cure was worse than the disease. They little realized that the stars were so far away that if they were flung around such wide circles they would have to move at inconceivably high speeds to make the big round trip each day. Had these scientists had even an elementary idea of mechanical forces, they would have realized that the tremendous crystal sphere carrying the stars would have to be made of very durable plastic, braced with great transparent girders, to stand the spin-off of that once-a-day turning. Even a child on the edge of a playground merry-go-round or on the end of a crack-the-whip chain knows how hard he must hold on to avoid being spun off into space.

Before we take off in our rocket ship, let's make sure that our earth doesn't give us an unexpected top-spin as we start into space. But even if we are hitch-hiking in imagination only, we shall need to make our earthly



long. The heavy weight was fastened by a cord to the side of the hall, left in that position for a day to avoid any extraneous vibration, and then the cord was burned to start the weight swinging across the floor like a pendulum. On the bottom of the weight was a steel pin that scratched marks with every swing in a ring of sand at the center of the hall. After some time it became apparent that the lines in the sand ring were being skewed around in a clockwise direction. In fact, there was a change in the direction of the swing of the pendulum of about ten degrees an hour, while a large crowd of people watched the experiment.

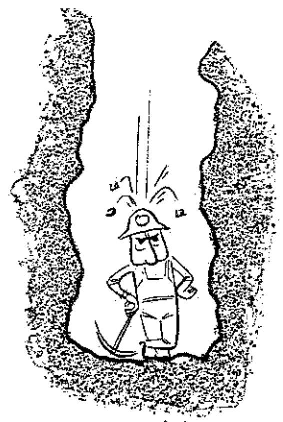
Here was amazing evidence that the earth was turning the floor of the Panthéon under the invariable plane of vibration of the pendulum. For if you swing a weight on the end of a string, it will keep swinging in the same direction no matter how much you twist the string. That is one of the properties of a pendulum; it will maintain a fixed plane of vibration and swing in the same direction in space, provided that it is suspended from an almost frictionless point and is not disturbed in any way. To see how the action of the pendulum proves the rotation of the earth, it is best to imagine the Foucault pendulum located at the North Pole. It surely is



cold up here, isn't it? Now as the pendulum swings back and forth the earth will turn under its plane of swing once every 24 hours--if the pendulum can be made to swing so long. Actually it will appear that the pendulum is changing its direction of swing in a clockwise direction, just as it did less rapidly in Paris. If it happens to be the long night at the pole, we can line up the direction in which the pendulum is swinging with stars on the horizon. We will find that it keeps swinging on a line between the same two stars on opposite sides of the sky. Therefore the pendulum must be swinging in the same constant plane with reference to starry space. Clearly, it must be the earth that is turning under the pendulum, while the pendulum swings in its constant plane in space.

Now imagine ourselves and our pendulum transported to the equator of the earth. Better take off that parka; it's too hot for this place. Suppose motion. Similarly when a bombing-plane releases bombs one after the other, these bombs will form an almost vertical line below the bomber, because they are still moving forward at the same speed they had in the bomb bay before they were released--that is, the forward speed of the plane. No wonder they maintain a tie race with the plane as they drop. And if it were not for the friction of the atmosphere, the bombs would hit the ground directly below the plane as it continues in the same course.

Suppose we let some of the Joneses explain it from here. These explanations are in response to the question: Why does the rotation of the earth make weights dropped down a vertical mine-shaft tend to strike the east wall?



> As the hub of a wheel turns more slowly than its rim, and the hub-ends of its spokes more slowly than the rim-ends so the bottom of the mine-shaft moves more slowly than its top. It has a smaller circle to turn in in the same length of time. A stone, dropped from the top of the shaft, maintains its surface speed eastward as it drops. Thus, it gains on the slower bottom, and tends to catch up with the east wall near the bottom.
>
> (Vander Jagt, 50-2)
>
> The top of the mine-shaft is traveling from west to east, due to the rotation of the earth, at a slightly faster rate than the bottom of the shaft, because it is describing a larger circle in space per day. An object dropped from the top of this shaft has this faster speed as its initial speed when dropped. It keeps this initial speed as it falls to the bottom of the shaft, and is in reality going faster toward the east than is the bottom, therefore tending to strike the east wall of a deep shaft rather than the bottom at a point directly below the dropping point.
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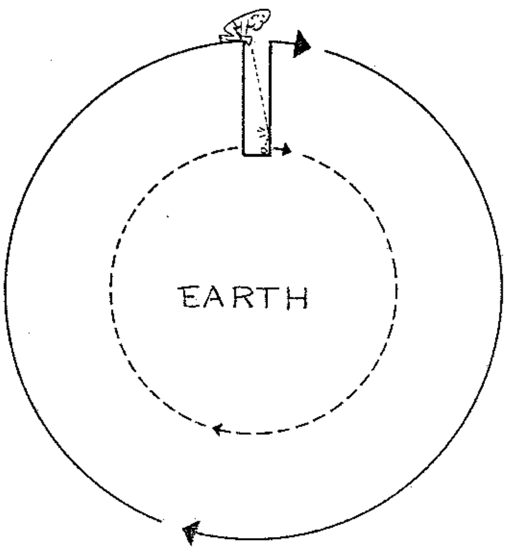
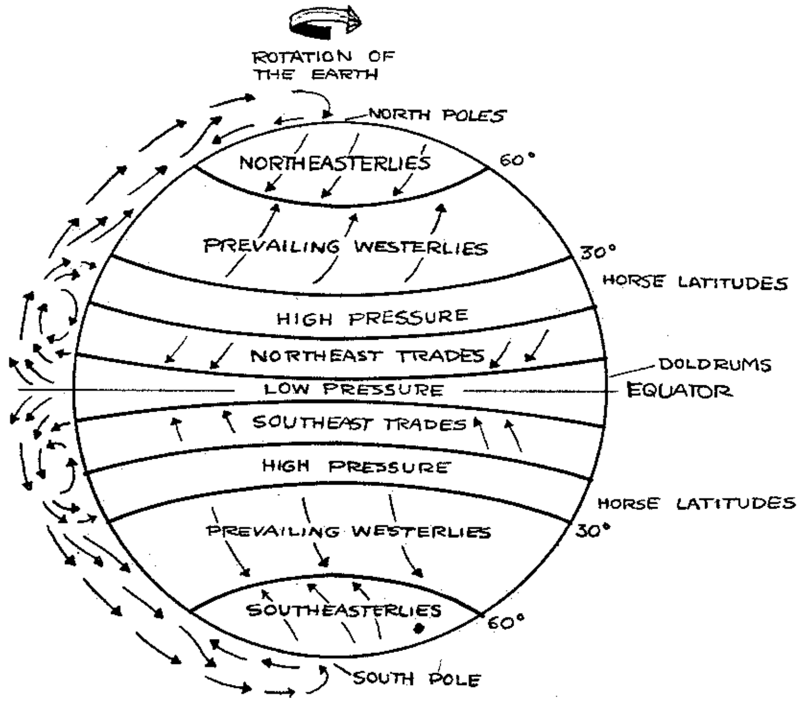
> (Ludington, 50-4)

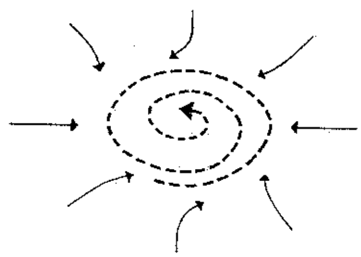


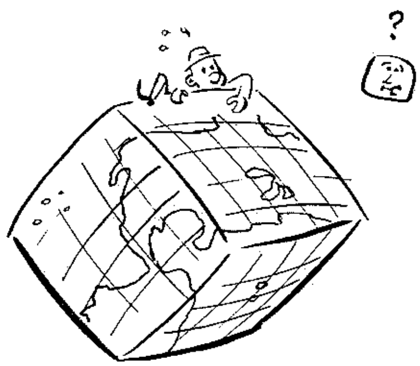
> Since the top of a mine-shaft is farther from the center of the earth than is the bottom, it travels a greater circle per day, that is, it must have faster speed. A body dropped from the top of the shaft will retain its original speed, just as bombs dropped from a plane retain the forward speed of the plane from which they are dropped. Since the falling body is traveling to the east faster than the lower portion of the shaft, it will therefore move towards the east wall of the shaft and will strike it if the shaft is deep enough.
>
> (Quigley, 51-2)



the air coming from many miles north and south of the equator will have the smaller rotational velocity of the earth at these points and maintain this slower eastward speed as it goes toward the equator and will lag to the west as explained above. So the prevailing winds will seem to come from the east of north and south--hence the northeast and southeast trade-winds. These were long-winded winds; do you want us to blow them again? Maybe if you read this part again, it will make more sense!

In a similar manner hot spots anywhere on the earth will pull air in from all sides. In the case of a hot spot in the northern hemisphere, the air coming from the north would, as before, lag behind the hot spot, as you can see in the sketch, but the air coming from the south would be coming from a place nearer the equator where the air does a bigger circle per day, and would therefore move ahead of the spot. Diagonal currents of air coming in from the east and west would be deflected less ahead or less behind according to their degree of north-south motion. There is no deflection for due east or west winds because their air is not moving between zones of different sidewise velocities. As we can see from the sketch, the hot spot will produce a whirling mass of air known as a low or a region of low barometric pressure. The sketch shows only the case for the northern hemisphere where the swirl will be in a counterclockwise direction; in the southern hemisphere it would be clockwise. In both hemisphere highs--regions of high barometric pressure--would spin in the reverse directions respectively. If we look at the weather maps and trace the directions of the wind arrows around the lows and highs, we will find that in general they pursue the indicated patterns. Here is constant evidence of the rotation of the earth as its effects swirl eddies of weather across our country. We are told that there is also





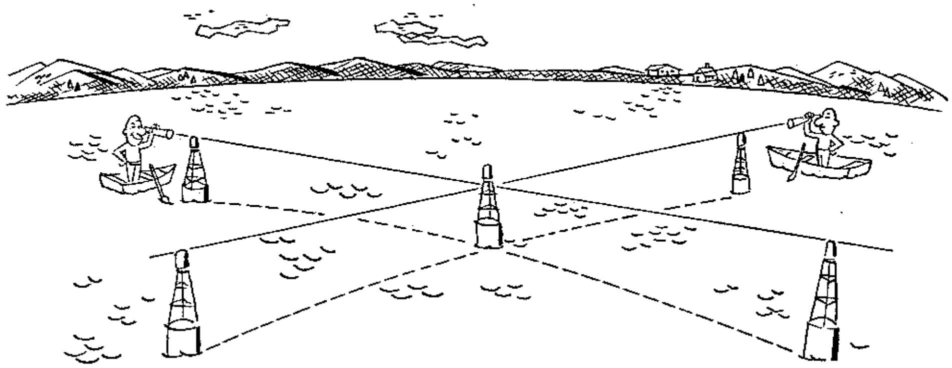
glass, instead of around a grapefruit. But a traveler could verify the spherical shape of the earth by going first around the equator of the earth and then at right angles to the equator around the poles. This round trip in the direction of the poles of the earth has never been made in a single continuous trip, but all parts of it have been made, enough to show that a traveler could return to his starting-place by going in that direction too. Comparison of the lengths of the two round-trips--via the equator and via the poles--would indicate whether the earth was shaped like a basketball, a discus, or a football.

One of my colleagues, Dr. Frank W. Dickinson of our department of philosophy, has called my attention to an odd circumstance with regard to this matter of going around the earth. Says he, if you go around the earth in a westward direction, you can get back to the starting-point without changing direction, but if you go north you will find the earth built differently in that direction. For to get back to your starting-place you will go north for a while, then south for half the way around, and finally north again. In other words you get around the world one way by going in one direction only, but the other way around requires you to reverse your direction of travel twice.

As an illustration of how the world is built bilaterally in one sense only, our philosopher imagines a man standing in front of a wide, full-length mirror. As he moves his right hand, the left hand of the image moves; if he now moves his left hand, the right hand of the image moves; yet if he kicks his foot, the head of the image doesn't nod. And the head should nod, says the philosopher, if the world were built up and down just as it is built sideways. You may tell the philosopher that his problem is just one of using improper phraseology. For if the man wore a ring on his right hand only and this hand were moved, it would be the ring-fingered hand of the image that would move. Just calling the moving hand the left hand of the image need not confuse us, because we could always make it the right hand of the image if we imagined the man standing behind the mirror.

But when one thinks of another example of this problem, one can begin to believe that the philosopher has a good point here. In the United States we have the rule of the road of keeping to the right on highways and of passing oncoming vehicles on the right. In passing, the drivers of two vehicles both obey the simple rule, turn to the right, and they generally pass successfully, perhaps occasionally scraping a fender. But now suppose we imagine two planes flying in opposite directions in a very narrow canyon, both at the same height. Suddenly they meet as they come around a quick bend in the canyon. Here they are at the same level in a place too narrow for the planes to pass by on the side, using the regular rule of the road, that is, turn to the right. If they are to pass at all, one will have to pass under while the other passes over. If they both go up they will collide; if they both go down they will collide. In an emergency like this can you think of a rule so simple and automatic as turn to the right which will tell both pilots immediately which one is to go up and which one is to go down?

nearly straight line as illustrated in the sketch. Then it will be found that the line of sight across the tops of the first and third buoys, observed



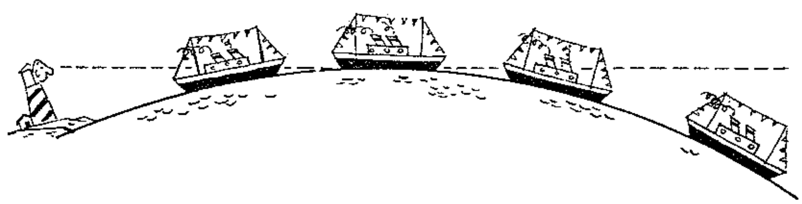
with the help of binoculars or a telescope, is about eight inches lower than the top of the middle buoy. This means that the center buoy is riding high because of the upward curve of the water surface. Essentially the same curvature will be found no matter what water area of the earth is used for the experiment and no matter what the direction in which the buoys are lined up. So here is a quick approximate way to show not only that the earth's surface is curved, but also that it is curved nearly uniformly in all directions like a sphere. Of course longer sights would give more decisive results.

AS SHIPS SAIL AWAY, THEY TELL US EARTH'S SURFACE IS CURVED

We would disappoint a number of our readers if we did not bring in the traditional method of proving the earth round by watching a ship disappear in the distance. Although many of us have heard of the method, very few of us can give a clear account of the manner in which it demonstrates the curvature of the earth. Here is one version:

> Another evidence of the globular shape of the earth is the manner in which a ship disappears from sight when it sets out to sea. If the earth were flat, we should expect to see the hull of the ship long after the slender masts and rigging had been lost to sight. In that we first see the ship's hull apparently sink gradually from sight, then the funnels and masts disappear, and finally we see only smoke on the horizon, it must be that the ship has passed over and disappeared behind the curve of the earth.
>
> (Shjelderup, 50-2)

I would make only two suggestions to improve this excellent account. First, the description should also call attention to the fact that if the



motion of a bus causes a by-"stander" to appear to be a "passer"-by to an observer on the bus.

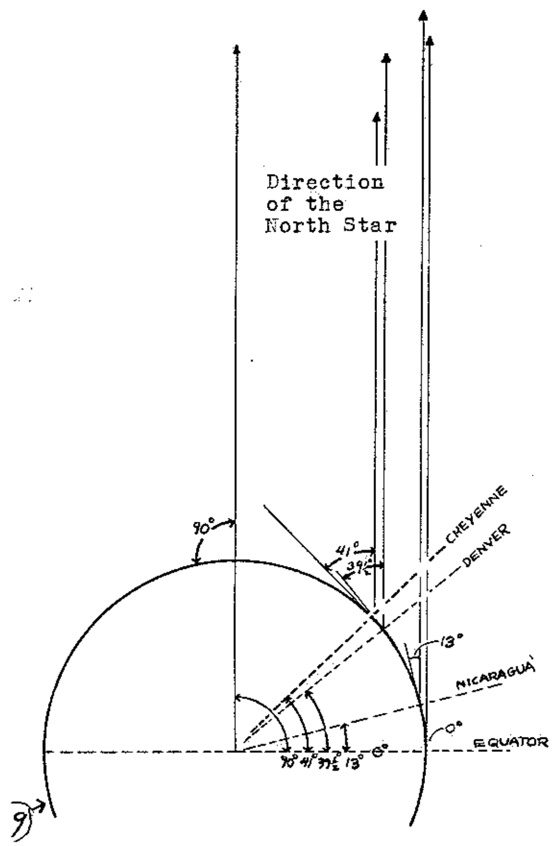
(Barker, 51-3)

The earth rotates from west to east, but it makes the stars appear to move west. When we travel on a train, although we know that the houses, trees, barns, fences, posts, etc., are all stationary, they appear to be moving in the opposite direction from the way we are traveling.

(Snell, 51-3)

I have listed these quotations here partly to remind us again what a novel variety of illustrations can do to make a principle crystal clear, but mainly to emphasize that this type of apparent motion of the stars is NOT what we are concerned with now. It is at times a good device to explain what a thing is by explaining first what it is not. This westward drift of the stars could not easily be used as proof of the earth's roundness, but the change in position of the stars, especially the North Star, as we move north and south on the earth's surface, can help us here. From Denver, Polaris----

Teacher's question: "Which is brighter, Polaris or the North Star?"
Student's answer: "Why, I'm brighter because I know that they're the same star!"



As we were saying, from Denver the North Star appears in the northern sky, almost due north, the brightest star at a point nearly half-way up from the horizon to a point directly overhead. More accurately its average altitude is about 40°, which is also the north latitude of Denver. I have often seen Polaris from Cheyenne, Wyoming, just a hundred miles north of us, and have found the altitude of the star noticeably higher there. At one period of my life I saw the North Star from Nicaragua in Central America, where it was barely above the line of the jungle-covered hills. The latitude of this place in Nicaragua was about 13° north. Perhaps we should remind ourselves, in passing, what latitude is. It is generally defined as the distance in degrees measured north or south from the equator to a maximum value of 90° at the poles. We have all seen the circles of latitude on maps or on globes, generally spaced at intervals of 5° or 10°, from 0° at the equator to 90° at the poles.

With the help of the figure we can visualize the apparent altitude of the North Star as observed from the latitudes of Denver, Cheyenne, and Nicaragua. It is not hard to imagine yourself at the North Pole with

> He can never see it because Mother Earth does not have a pane in her back.
>
> (St. John, 50-3)

Let's go back to the salt mines. Where were we? Oh yes, we had just made a trip from the equator around the curve of the earth up to the North Pole and had found that the North Star had climbed as fast in the sky as we had increased our latitude, until the North Star was directly overhead when we reached the North Pole. You may remind us now that all along we have assumed that the earth is round to start with and have proved nothing more than we knew before. But we are really doing something additional this time; we are trying to prove the earth really spherical--that its surface is like that of a sphere, uniformly curved in all directions. We did this sort of thing when we discussed the floating of three buoys in a straight line on any body of water, in any direction, to prove the earth approximately spherical. But here we are doing the same sort of thing on a grander scale by checking the true shape of the earth by using the stars as reference points.

For if we find as we run around the curve of the earth at constant speed that this action makes the North Star appear to rise in the sky also at a constant speed, then we are forced to conclude that our path on the earth's surface is part of a perfect circle. On the other hand, if the North Star changes altitude in the sky faster than we change our relative position on the earth or vice versa, we will know that the earth's edge is irregular. Of course if we do this trip on land, we will need to rule out the hills and valleys by using a level surface as a base. For this reason it may be better to go from the equator to the pole by sea and thus have the more uniform water line on which to base the real figure of the earth.

The mental maneuvering that we are doing here will help us greatly in our later efforts to look out from the earth at the constellations and to project the motions of the sun, moon, and planets upon the background of the stars. We might be helped even more if we had a planetarium to which we might go whenever words, sketches, and the tools for imagery that are found in the average home seem to fail us and we seem to need a moving picture in 3-D to give us a realistic view of astronomical events. Perhaps it will be better in the long run not to use such a crutch but to depend upon our own power of visualization, which can be renovated by occasional visits to a planetarium or an observatory.

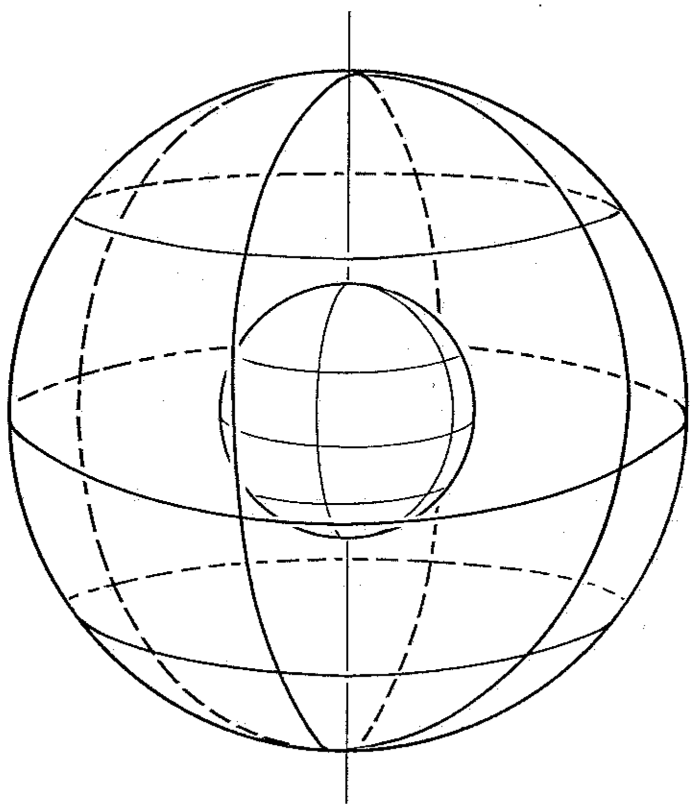
Let us summarize in a systematic way this whole problem of determining the shape of the earth by the apparent changing positions of reference stars as we move north or south on the earth's surface. First let's list the alternatives: the stars are either near or far; the earth is either flat or curved. Then we can eliminate one by one the conceptions that prove inconsistent with the facts. Suppose we assume first that the earth is flat and the stars are near.

> The stars would seem to shift if the world were flat, only if the stars were near, but they would seem to shift at different rates in different regions in the sky. This can be likened to the shifting of telephone poles past the observer in a speeding car. A pole in the distance seems to move towards you slowly, then faster and faster, finally flashing by.
>
> (Cuthbertson, 49-4)

You would experience the same effect walking across a large room with many lights in its ceiling. You would notice the lights overhead

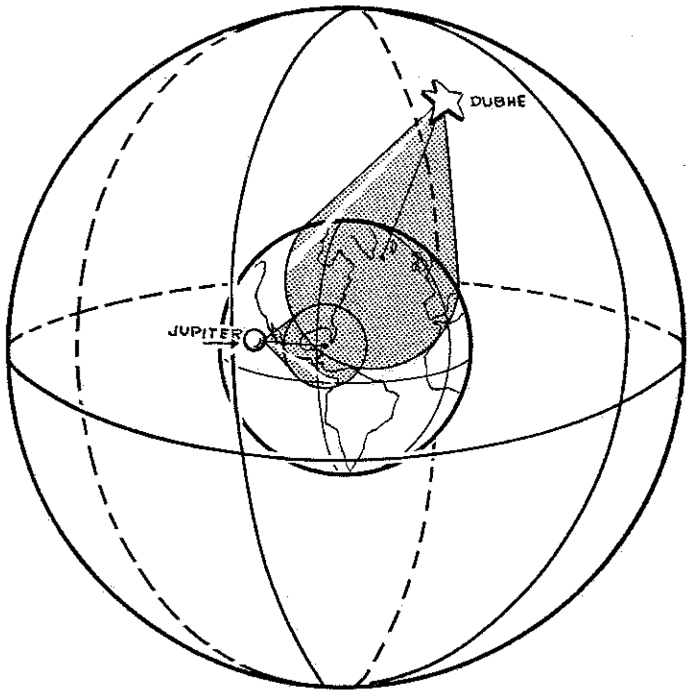
Already we have learned almost enough to read the signs in the sky. Let's try to learn more, and thus appreciate how problems in navigation are greatly simplified because of the spherical shape of the earth. Stars are located in the sky by the astronomer on a network of imaginary latitude and longitude lines similar to those pictured on any globe of the earth and shown in the sketch, obtained by extending the earth lines out to meet the sky.

Thus the poles of the sky globe so obtained are merely the two places among the stars where the axis of the earth extended north and south meets the sky. Our North Star is within a degree of the north sky pole. The sky latitude lines (called declination) are made by stretching out the circles of latitude in a direction away from the center of the earth until they make



similar circles in the sky globe. In this way the sky equator is the biggest circle around the sky, midway between the poles, and is the extension of the earth's equator out into space. The vertical circles of longitude, which run north and south and are used to measure distances east and west around the earth from the prime meridian of Greenwich, can be stretched out to the sky to produce what are known as hour circles (of right ascension).

Because the earth turns eastward daily, the lines of longitude on the earth and sky spheres will match their original line-ups only once a day. However, if you have the correct time, you will know the relative displacement of the two sets of lines. Also as the earth turns the stars will seem to retrace their own sky circles of latitude each day. It is important to realize that stars are located on this network of sky circles in very much the same way that cities are located on the earth with regard



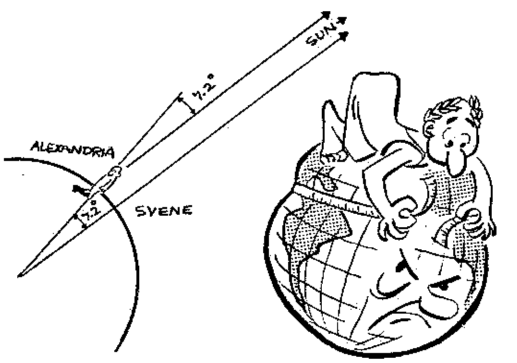
of 66°, to make it climb to a point directly overhead we have to be transported 24° toward Jupiter, that is, toward Cuba, around the curve of the earth. Therefore our location on the earth's surface must be at a point which is simultaneously 51° from Iceland and 24° from Cuba.

In this description of the determination of position on the earth's surface we are giving the measured angles only to the nearest degree; actually they were read to the nearest minute. Since there are 60 nautical miles to the degree of latitude on the earth's surface, the nautical mile becomes a very convenient unit of distance for the navigator. For a change of one minute in the altitude of any object observed in the sky means a change of one nautical mile in the location of the observer's position on the earth's surface. Positions at sea are generally known to the nearest nautical mile; medium speeds and comparative steadiness of ships make accurate observations possible. Positions obtained from planes in fast flight through unsteady air are obtained with much less precision. In fact, often the navigator is far past a position before he determines where he was when he made an observation. So a rule of the air force used to be to know one's location "within five miles in five minutes."

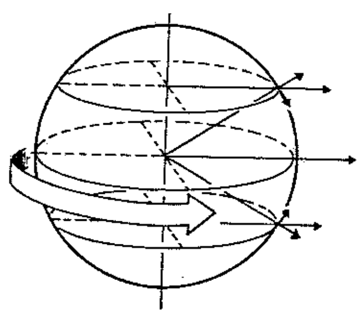
As we noted above by observing the star Dubhe at an altitude of 39°, we knew we were about 51° from Iceland; and by observing the planet Jupiter at an altitude of 66°, we knew we were approximately 24° from Cuba. We find the point on the earth that meets both of these conditions by first putting a pin in the earth globe at the proper point near

IT'S NOT A SMALL WORLD; IT'S A BIG ONE!

It is interesting to recall that away back about 250 B. C. the Greek scientist Eratosthenes measured the distance around the earth at a time when everyone, except a few Greek scientists like him, believed that the earth was flat. The big earth seems a bit unwieldy to get a tape measure around, but Eratosthenes found a way to estimate the whole distance around it by measuring only a part of the way around. He had been told that at noon on the longest day of the year at Syene, in southern Egypt, the sun was directly overhead and vertical objects would cast no shadows. He found, however, that where he lived in Alexandria, in northern Egypt, at noon on the same day objects cast a shadow which indicated that the sun was about 7° away from the zenith, the point directly overhead. He reasoned correctly that the difference in direction of the sun as observed from the two places was caused by the curvature of the earth between them. In other words, vertical poles at these two places although aimed downward for the center of the earth would nevertheless point out into the sky along lines differing by about 7 degrees. This indicated to Eratosthenes that the curve of the earth between Syene and Alexandria amounted to one-fiftieth of the earth's circumference. The distance between the two places was measured by runners; the unit used was the stadium, whose value is not accurately known. According to one historian's value of the stadium, the circumference of the earth comes to about 24,000 miles, only 900 miles short of the truth. To avoid the uncertain unit let us note that the actual angle used by Eratosthenes was 7.2° (one fiftieth of 360°), which compares favorably with the modern value of the 7.1° difference in latitude between these two cities and shows clearly the high degree of accuracy that this ancient scientist obtained.



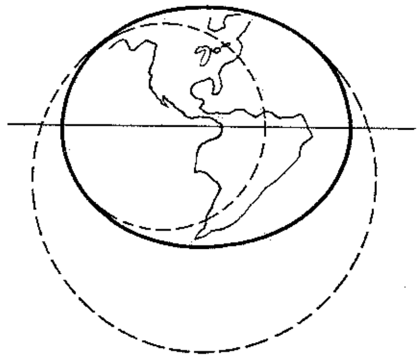
In recent times a number of other arcs on the earth's surface have been measured very carefully by modern surveying methods. These indicate that the earth is nearly 24,900 miles around, that its distance from pole to pole is 7900 miles, and that its thickness through its midriff at the equator is 7927 miles. The fact that the earth has this middle-age spread--is wider across by 27 miles than it is from north to south--can be explained by assuming that the earth was at one time less rigid



The combination of greater distance from the center of attraction and the greater throw-off makes a person who would weigh 176 pounds at the poles weigh only 175 pounds at the equator. It's hardly worth a trip of 6000 miles to reduce one's weight by only a pound. And even that pound might not be lost in the place one needs to reduce most! At any rate we have learned how the earth throws its weight around.

IN A MANNER OF SPEAKING THE MISSISSIPPI RIVER FLOWS UPHILL

Measurements of the earth indicate a gradual change of curvature of the earth's surface from the pole to the equator. As can be seen in the exaggerated drawing, the earth is most flattened at the poles; the curvature would be least there and would form the largest circle if extended. Also the earth is most bulged at the equator; hence it curves fastest there and makes the smallest extended circle. Since a degree of a circle is always one 360th part of it, we can be sure that a degree of the larger circle of curvature will be longer. Actually there isn't much difference. Some values of a degree of latitude on the earth are:



69.4 miles near the poles
69.1 miles at latitude 45°
68.7 miles at the equator

So the value of 69 miles per degree that we used in our navigation problem was a good average value.

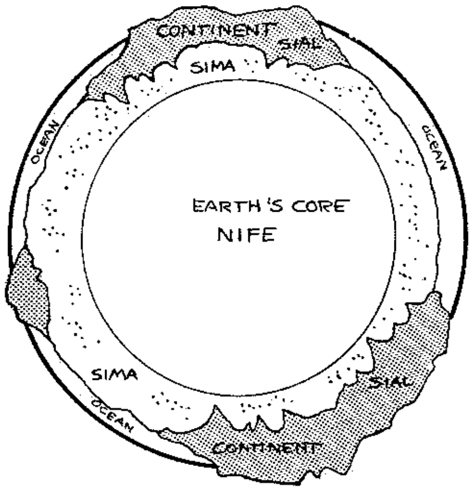
This out-of-roundness of the earth is quite insignificant for many purposes. If the earth were reduced to the size of a bowling ball, it would be about 30 thousandths of an inch wider than it is high, perhaps no more out of round than many bowling balls.

We have mentioned the uniformity of the change of curvature of the earth for another reason. Just as the pole of the earth is closer to the center of the earth by 13 1/2 miles than the equator of the earth, so the source of the Mississippi River in Minnesota is closer to the center of the earth by several miles than the mouth of the river as it flows into the Gulf of Mexico. As the so-called Father of Waters flows from Minnesota to the Gulf, it is flowing farther and farther from the center of the earth. Hence in a manner of speaking it flows uphill. Here's how a couple of the Joneses put it:

> In a sense it flows uphill because it rises farther north and flows south. The northern part is closer to the center of the earth; therefore the river flows away from the center toward the bulge of the earth. The earth's rotation speed forces it "over the hump"; thus, figuratively speaking, the river flows up.
>
> (Cochran, 48-4)

> The earth is like a pumpkin, flattish at the poles and bulging at the equator. The equator therefore is farther from the center of gravity than the poles are. The Mississippi River is like water

The German geologist Suess has an informative way of showing the layers of minerals that form the earth's sphere. He calls the material of the continents of the earth sial, abbreviated from the chemical symbols of two of its main ingredients, si for the silicon in the sand and al for the aluminum in the clay. This layer of sial, from 25 to 80 miles thick, forms the outer crust of the earth. A 1000-mile thick layer below this is called the sima--si for silicon again and ma for magnesium--important ingredients of the basaltic rock there. This layer is made of minerals which are ordinarily heavier than the sial when cool. But when they become heated, perhaps by radioactivity according to Joly's theory, they tend to melt and expand, permitting the then almost equally dense solid material of the continents to sink into this layer. Thus there are "sinking continents" which form a chapter in geological theories. Finally, according to German geologist Suess, the central core of the earth is called nife, named after its supposed two main ingredients, ni for nickel and fe for ferrum, Latin for iron.



You cannot help noticing that geologist Suess arranged the earth's matter so that the heaviest material was at the center. Of course it seems logical to assume that if the earth were at one time of liquid or jelly-like consistency, the heavier matter would be pulled by gravity more strongly and would sink to the core of the earth, just as sediment in muddy water eventually sinks to the bottom. But borings of the earth's surface have penetrated only a few miles of the 4000 miles to the earth's center. How can scientists know or even surmise the constitution of the earth's core when they have samples only of the outer continental layer to a depth of at most ten miles?

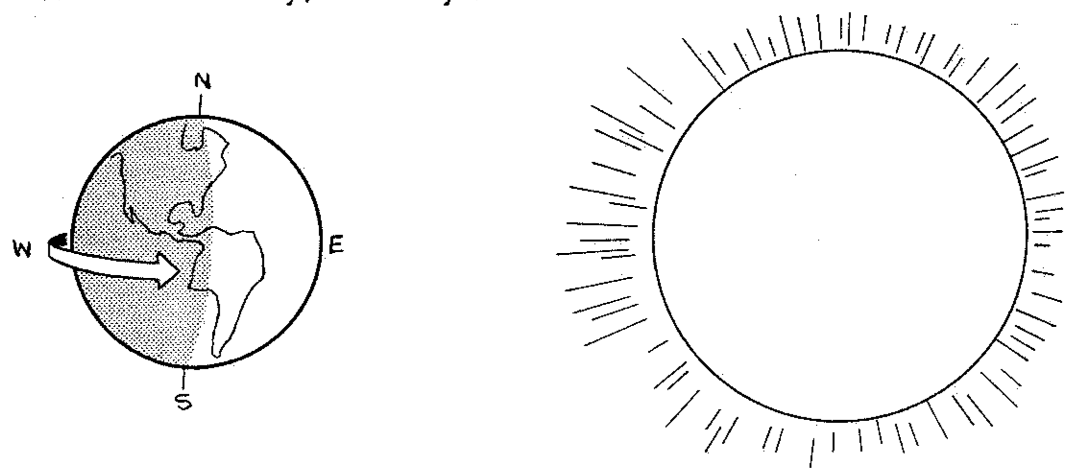
This question brings us back to the original title of this section--the weight of the earth. Now that the earth has been measured and weighed we have enough information to determine the average consistency of its substance. By dividing the weight of the earth by the space it occupies, using the proper units for both, one finds that the material of the earth averages 5 1/2 times as heavy as water, that is, its density is 5.5. In other words, if a bucket filled with water weighs 30 pounds, it would weigh 165 pounds filled with average earth-stuff. Compare this density of 5.5 with that of iron, 7.8; of lead, 11.3; and of gold, 19.3. In the case of the earth the density of only the surface rocks is known for sure. These surface rocks are mainly granitic in nature with a density of 2.7, only half as dense as the average for the earth as a whole. Consequently it stands to reason that the central core of the earth must be much heavier than the average in order to make up for the lightness of the surface materials. As expressed by students:

> The weight of the earth has been calculated by various means and the density of the rocks on the surface is known. The average density of the earth, determined from its weight and size (both known), is so much greater than the density of the rocks at the surface that the density in the center (unknown) must be large to achieve this average.
>
> (Jenkins, 48-4)

distributed over this bulged shape ans has kept shoving the waters of the Mississippi over the hump. We come now to the greatest application by far of the rotation of the earth, its use as a time-reckoner.

It is not likely that the Dark Ages were called so because of a lack of artificial lighting. However, through all ages, including the Dark Ages, the presence and absence of the sun's light has had much to do in the determination of plant and animal life on the earth. Not so many years ago man arose and retired very much according to the schedule followed by the chickens--rising and setting with the sun. Only recently have electric-lighting and night-life greatly modified man's habits. Essentially the daily rotation of the earth with respect to the sun has been Mother Nature's most fundamental unit of time. It is true that the day has been subdivided by man into artificial units of hours, minutes, and seconds kept track of by sun-dials, hour-glasses, water-clocks, watches and clocks of sundry types, and most recently by quartz-crystal oscillators and atomic clocks. Nevertheless, nature's basic unit of time remains the average time required by the earth to turn once with regard to the sun. In Chapter VI, with more background, we shall discuss several other varieties of time, including also nature's other fundamental unit of time, the year of the seasons.

As the earth turns, like a roast on a spit, places on its surface will be turned in and out of the sun's rays at different times. Thus the day by the sun will begin for various localities at progressively different times. In order to appreciate this situation more fully let us read answers to the question, "For which part of the United States does the sun rise first each day, and why?"



The sun rises on the eastern coast first, because the earth rotates from west to east, thus turning the eastern coast into the sun first.

(Anderson, 48-3)

It rises first on the extreme eastern part. The curvature of the earth prohibits all parts of the United States from coming into view of the sun at the same time, and the eastward rotation of the earth brings the eastern parts of the United States into view of the sun before the western parts.

(Creese, 48-3)

As a great ship on night patrol returns eastward to its base, so Maine, the prow of our nation's vessel, glides into the port of dawn first each day.

(Lyster, 48-4)

Hawaiian time is always earlier than Denver time because the earth, spinning towards the east, swings Denver into the sunlight first and back out of it first.

(Cuthbertson, 49-4)

STANDARD TIME ZONES

In the preceding section we have already indicated different time zones all over the world, usually at one-hour intervals, but occasionally for convenience at intermediate values. The need for standard time zones became urgent first when people began to communicate by telegraph or telephone and had faster means of travel by railroad. It became a nuisance to take account of differences in time, generally in odd minutes, because most large communities kept their own local times, entirely regulated by the noon position of the sun for their particular spot, and let the rest of the world fend for itself.

In 1884, by international agreement, standard time zones were organized for the first time, with some modifications since. Thus in the United States we have Eastern, Central, Mountain, and Pacific time zones, respectively with clocks reading 5, 6, 7, and 8 hours earlier than Greenwich, or London, time and centered at the key cities of New York, Chicago, Denver, and San Francisco along the 40th parallel of latitude. The boundaries for these time zones are irregular and are established by commercial convenience at railway terminals and the like. For instance, as one goes east from Denver, the change to Central Time occurs at McCook, Nebraska, on the Burlington Railroad; at North Platte, Nebraska, on the Union Pacific Railroad; at Ellis, Kansas, on the Greyhound bus line; and at various other points, depending on the route taken. Special adjustments occur at some points. El Paso, Texas, is farther west than Denver and does keep Mountain Time like Denver. But all the rest of the great state of Texas keeps Central Time, despite the fact that most of Texas would normally fall in the Mountain Time belt.

For comparison of time in these standard time zones, a simple rule can be applied. As one goes east time becomes later, usually one hour later for each zone; and for zones to the west time is always earlier--all comparisons instantaneous, of course, perhaps most easily made on TV network newsroom clocks. But as you compare clocks all over the world, you will soon think of this problem. As you transport yourself in your imagination instantaneously east-er and east-er and east-er, time will get later and later and later until, after a complete circuit of the earth's time zones has been made, you pass your original time zone a full 24 hours, or a day, later. In the same fashion, as you mentally transport yourself west-er and west-er and west-er, time gets earlier and earlier and earlier, and after making the full circuit instantaneously again, you will find yourself back home on the previous day. With a two-day disparity produced by the two mental round-trips of the earth, obviously something is wrong here; there ought to be some place on the earth where the date changes by one day per circuit to keep the date and time of day consistent all the way around the earth.

This dilemma was originally encountered by the sailors of Magellan when they made the first trip around the world. Magellan himself did not complete the circuit because he was killed in the Philippines. But his crew kept track of each sunrise and sunset as they went around the earth and returned to Portugal one day off in their count. Let's try to figure out why. As you go west toward the setting sun as they did, you delay time will be nearer 31 days because of the day you had twice, even though you lost seven or eight hours as you changed time zones going east--the same ones you gained on the way over. Anyway you get an even break on the round trip. But how about those people that went across the Pacific to China and then returned home by continuing west via India, Europe, and New York? They will probably worry the rest of their lives wondering if they will ever get back that day that they lost in mid-Pacific. Or did they get most of it back already hour by hour as they entered new time zones going west?

In this connection we are reminded of Professor C. A. Young of Princeton University, who proposed the conundrum, "What is the greatest possible number of Sundays in February?" and astounded everyone by his answer, "Ten!" This answer is rather easily explained, as he did it, by taking a leap year when February already has five Sundays--February 1, 8, 15, 22, 29--as it had in 1880, 1920, and 1948, and will have again in 1976. Then imagine a ship making weekly round-trip sailings from Siberia to Alaska, and leaving Siberia on Sunday, February 1, just in time to arrive at the date-line at midnight ending Sunday, only to have Sunday again on Alaska's side of the International Date Line. Of course on the way back during the week the ship will lose a day, perhaps parts of Wednesday and Thursday, but it can continue to double its Sundays on February 8 and on every other Sunday in February--in fact on each successive trip back to Alaska. Thus by following this schedule, the ship will have produced ten legal Sundays in February--believe it or not!

But perhaps the most fascinating idea of all is to imagine a house built across the International Date Line so that its kitchen is on the American side of the line, while its living-room is on the Asian side. Of course, the date-line actually crosses no land areas, but we could imagine a volcanic island being elevated in the Pacific, so that we might build our mythical date-line house upon it, facing it toward Asia. Then you could imagine yourself working in the kitchen on a Saturday morning. You got up at seven; you've been working hard for two hours; you feel the need for a rest. All you have to do is to walk into the living-room and you have the best excuse in the world for resting, because it is Sunday, the day of rest, on that side of the house. You can loll about the living-room for the rest of Sunday there, and by tomorrow it will be safe for you to return to the kitchen. For by that time it will be Sunday in the kitchen; you need no further excuse for resting even in the kitchen.

Here are several novel ideas that come directly from the Joneses in response to the question: What day and time is it in the kitchen when it is 10:00 a.m. Saturday in the living-room (same house)?

It is well to recall here too that when the path of a total eclipse crosses the date-line, since the moon's shadow travels east over the earth's surface, you will have the unique situation in which the eclipse ends for a place on the earth's surface where the time is earlier than the place for which the eclipse began. In other words, here is an eclipse that ends before it begins!

SPACE TRIP FOR THE JONESES
Partly Described by the Joneses Themselves

Chapter IV

OVER THE RAINBOW: THROUGH THE EARTH'S ATMOSPHERE

As we look into space through the earth's atmosphere we will need to be careful to make sure that the air we breathe and live by and the light we see by are not playing tricks on us. Dr. Donald H. Menzel in his excellent book on Flying Saucers* makes the general statement that 80% of the observations of flying saucers are real, that is, they are observations of real phenomena in the sky, but are misinterpretations usually. He also calls attention to the general idea that in these days of hysteria and fears about atomic energy anything that is observed more than a few feet from the ground is interpreted wildly either as a guided missile being tried out by our own air force or sent our way by our enemies or as a space-ship hailing from Venus or Mars. The possibilities of the use of atomic energy give exaggerated and fearful ideas to our imagination. Nevertheless it will be a sad day for future scientific progress when earth-men no longer see flying saucers in our sky. The disappearance of flying saucers from our skies will be a sign that human imagination is dying. One disturbing thing, however, is that the men who scan the sky frequently, the astronomers, whom we expect to sight flying saucers most, actually see them least. Is this a sign that astronomers are losing their scientific imagination?

We can touch, examine, and see up close the things of this earth--not so with the things of space. The meteorites which rain down upon the earth are the only tangible samples of outside space that we have. They are the only space-travelers that we can hold in our hands. With regard to other objects in space, they are too far away for holding. We can examine the details of the closer ones only with the help of high-powered telescopes by means of the light reflected by them from the sun. For the more distant celestial objects we are limited to determining their nature by the quality and direction of their light. It behooves us to know something of the properties of light and of the manner in which the earth's atmosphere affects and transmits the "signals from the stars." Let's begin with

RAINBOWS IN THE SKY

Rainbow in the morning, sailor's warning;
Rainbow at night, sailor's delight.

Some think that the quotation above is completely a superstition or an old wives' tale. However, there is some basis of scientific fact in the rhyme. The fine spray that you use for watering the lawn will make a perfect rainbow if you observe it with the sun at your back. For the small drops of water in the spray act like the raindrops in the sky to form little prisms of water to reflect the sunlight once or twice within each drop and also to spread the light out into its different colors, often producing another rainbow with the second reflection.

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* Donald H. Menzel, Flying Saucers, Harvard University Press, 1953.

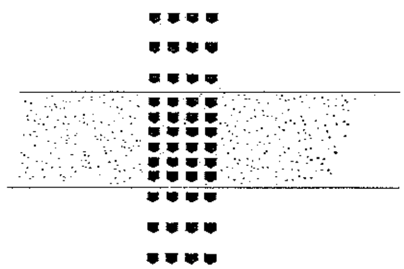
to make unusually deep valleys and high mountains of waves; or when a trough meets crest to cancel out a wave and transform it into an area of only slightly troubled waters.

The refraction or bending of light, caused by differences of velocity as light travels through different substances, deserves a fuller explanation. First of all, let us say that ocean waves and ripples do not give an exact picture of the manner in which light waves travel, but are close enough in principle to be used as illustrations. Actually light waves move along a wave-front, and each point in the wave-front becomes a source for more waves. If this were not so, rays of light coming from a point source would have gaps between the waves. If you were far enough away from the source of light, the waves of light might pass by both your ears and completely miss your eyes. Instead, light waves from a point seem to form a solid front or shell of waves like a big quivering soap bubble, but expanding at 186,000 miles a second.

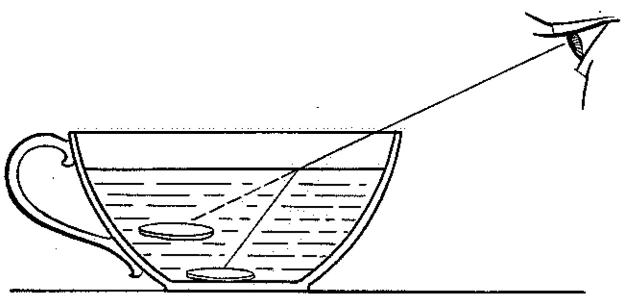
It might be well to mention here that it is just not possible to find any mechanism that is a part of our common experience that will illustrate all the properties of light, for light is a most uncommon thing and acts in rather wondrous and puzzling ways. This dilemma that we find ourselves in is very like the thing that Dr. McIver describes on page 7 of Chapter I; no one can take anything completely back to its fundamentals and stay with ideas that are fully understandable. All great scientists have found that there is a limit to which mechanistic ideas can be taken, and beyond that limit only operational mathematics applies, with no conceivable way of picturing what is actually happening. It's something like throwing a ton of pennies into the air and trying to keep track of all the forces that operate on all the pennies until you see clearly why just a half ton of the pennies turn up heads--only much worse.

Sir James Jeans has expressed the dilemma very well in what he says about the electron and the principle of uncertainty: that the more one tries to pin the electron down, the more he finds that it is not there. Our devices to explain light phenomena are always makeshifts, and all of them have bad flaws in them. But it is only by successive approximations like these that we can come believably ever nearer to representing the facts. As we will say again in the last chapter just as we need to say it here: it is better to have tried to explain and to have failed than never to have tried to explain at all. Pardon the interruption!

In order to explain what happens to light when it goes through a sheet of glass, suppose we use an illustration of a marching column of soldiers for the ray of light and a sandy road for the thickness of glass. Suppose that we have the marching column, four men abreast, reach the sandy road head-on--directly at right angles. You can see that when the four men of the first rank encounter this sandy road they will be slowed by the harder going through the sand. The second rank will therefore gain on the first rank because it hits the sand later and will close in somewhat on the first rank. It is clear



the dime. Now pour water into the cup and the dime will be lifted up into view in the manner shown in the sketch. The bending of the light from the dime toward the surface of the water as this marching column of light comes out of the water makes it possible for you to see the dime around the edge of the cup. An effect similar to that of the water in the cup is produced by the earth's atmosphere upon the light of the sun and moon. Instead of the dime we see the sun and moon over the brim of the horizon.

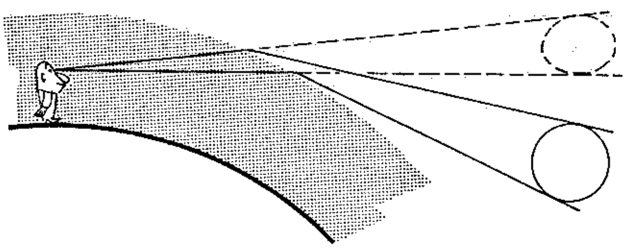


Let's notice now the explanations of the Joneses in answer to the question, "How does refraction in our atmosphere affect the position of a star in the zenith? Why?" We need a breather anyhow!

> Refraction in our atmosphere doesn't affect the position of the stars in the zenith at all. Light, in passing from a less dense medium (outer space) to a more dense medium (earth's atmosphere), is bent toward the vertical. Since light from a star in the zenith is coming straight down, it can't be more nearly vertical, and therefore the star is where it appears to be. (This statement neglects the earth's rotation and revolution while the light travels to the earth. Also it neglects the distance to the star. Actually the star may be in a completely different place or have ceased to exist while the light is traveling from where it was originally.)
>
> (Anderson, 48-3)
>
> A ray of light is bent toward the perpendicular to a surface by refraction at that surface. However, the star at its zenith is straight up anyway, so it could not be bent any more toward the perpendicular, even if it bent over backward.
>
> (Trout, 48-3)
>
> It is affected not at all. The wave-front of light hits the air squarely, so it is not thrown out of line by a first-rank pivot striking slow going ahead of the rest.
>
> (Mote, 48-4)
>
> Refraction does not affect vertical rays of light because they enter the atmosphere perpendicular to it, and all parts of the ray are slowed down equally. It is only when light strikes the atmosphere at an angle and part of the wave-front is slowed ahead of the rest, that the wave-front or ray is bent.
>
> (Wilson, 49-2)
>
> There is no effect at all as far as the position is concerned, because all parts of the wave-front strike the denser air at the same time. Hence there is no tendency to wheel the wave-front around, changing its direction.
>
> (Cuthbertson, 49-4)

You can see from John Cuthbertson's drawings that the light of the stars will always seem to come from the last direction the light waves took through the air and thus the stars will nearly always appear too high in the sky. The greater the angle from the perpendicular at which the wave-front strikes the earth's atmosphere and the greater the depth

Some budding scientists, observing this apparent widening effect, will seize upon this fact as a clue that it is refraction that makes the sun and moon look bigger near the horizon. But any feelings of elation at this discovery are doomed to early disappointment, for the results of refraction are just the reverse of the desired effect. Indeed, the disks of the sun and moon are really made smaller because, while their width sideways remains the same, their height is actually made smaller by differential refraction which lifts the bottom more than it lifts the top, and squeezes the disk into a football shape.

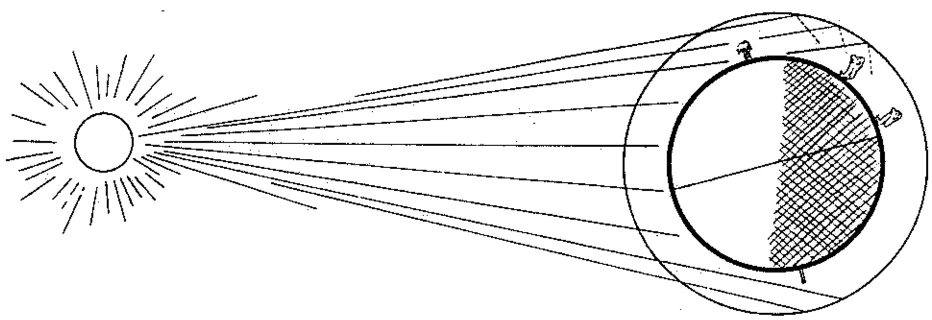


Now twilight lets her curtain down
And pins it with a star.

--Lydia Maria Child

Inasmuch as we have discussed in this section the lengthening of the period of daylight caused by the bending of sunlight around the curve of the earth's surface, it is appropriate to discuss another effect which also lengthens somewhat the period of daylight by adding twilight to both ends of it. Before sunrise and after sunset, even though the sun is below the horizon for observers on the earth's surface, it is nevertheless illuminating the atmosphere above the earth. Much of this light diffused through the air reaches the earth's surface by reflection from water vapor and dust particles and by other means, and adds generally several hours of twilight to the period of possible sunlight.

In the polar regions because of the slow spiral setting of the sun these twilight periods may ameliorate the darkness of the long polar night by as much as a month at its beginning and at its end. On the other hand, at the equator the shades of night are pulled down fast because the



sun sets straight down there and reaches sooner a depth below the horizon where its light can no longer shine on the upper atmosphere. In the states along the northern border of the United States, like Montana, there can be twilight all night long. At the summer solstice the sun is above the horizon for 16 hours there, sets far in the northwest and rises far in the northeast, and in between setting and rising is so little below the northern horizon that it shines on the upper atmosphere all during the short nights.

acts like air to scatter the blue rays through it. Its color cannot be due to a reflection of the blue of the sky, because even on a cloudy day ocean water has a deep blue color. The blue coloring seems so much like a dye that when I was crossing the Gulf of Mexico on my way to Nicaragua I poured a bucketful of sea-water into the ship's bathtub only to find that the water had lost its magnificent blue color.

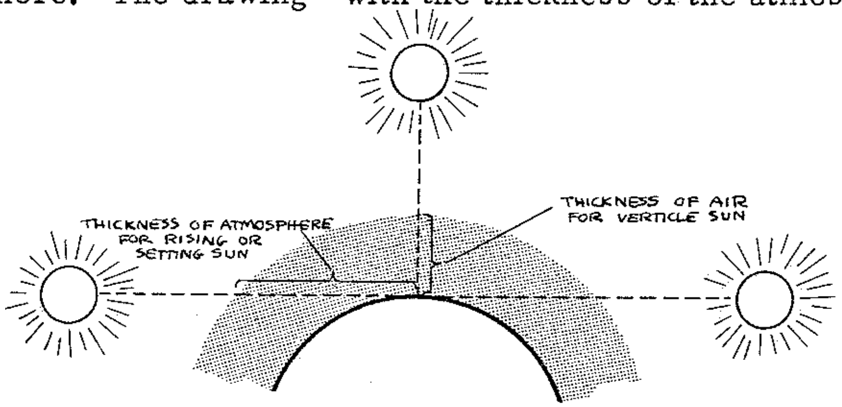
Let's see now how the college Joneses explain to all of us Joneses why the sky is blue:

> When a ray of light enters the earth's atmosphere the ray is bent and, in bending, it is broken up into the colors of the spectrum. The shorter violet rays are interfered with more greatly in our very interfering atmosphere than are the longer red spectrum rays. Caught in the atmosphere the violet and blue rays go bounding back and forth, turning our atmosphere into a beautiful sky-blue.
>
> (Floyd, 48-2)

> The blue waves are shorter than the red waves and are more easily scattered by the atmosphere. They hit the atmosphere and bounce back into the sky while the longer red waves come on through. Since the blue waves can't get through they leave the sky true blue. In other words, Jonesey, the blue waves are shorter than the red waves, so when they hit the blanket of heavy air covering this mundane sphere, they can't get through, they don't have enough length to sidestep the air obstacles. The red waves are longer; they come right on through by stepping over the obstacles. They hit the earth and are absorbed by it. Meanwhile, the blue waves stay up there in the sky most of the day looking for a place to get through.
>
> (Minor, 48-2)

> The sky is blue because the short blue light waves cannot well leap over the particles of air around the earth. They got tangled up, scattered, and separated from other colors--so we see them staying up in the sky.
>
> (Vander Jagt, 50-2)

Sunlight at noon comes through less atmosphere than at any other time during the day, this depth varying greatly from summer to winter in the middle latitudes. However, when the sun is near the horizon, rising or setting, its light is coming through a much greater depth of the earth's atmosphere. The drawing--with the thickness of the atmosphere greatly



exaggerated--shows the sun directly overhead for an observer and also on the horizon in its rising and setting positions. It is easy to see from the lengths of the lines of sight in the air that for the vertical sun the light is coming through only one atmosphere--straight down through it--

for the blue rays. Finally they give up, for theirs is a losing battle, and the red rays march out in front leaving the blue fellows behind, scattered in every direction.

(Albers, 50-3)

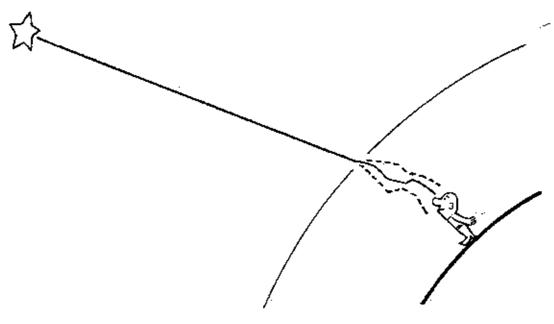
Some people will say, after explanations like these, "I understand why the light that comes directly from the sun would be red. But last evening at sunset the clouds directly above me were red too, and not blue like the sky almost everywhere else was. How do you explain that?" Of course we can't begin to explain all the different colors to be found in a sunset, but this question seems easy to answer. The light from the sun that shone on that cloud up there had to come through almost as much atmosphere as the light that reached you directly from the sun, and thereby had most of its blue waves scattered out too. Only the red waves were able to reach either you or the cloud above you. Even clouds seemingly near the sun but actually above your distant horizon would seem red to you, not because they are actually red, but because the light from those distant clouds could have lost its blue in the long atmospheric path on its way to you.

TWINKLE, TWINKLE, LITTLE STAR ----------

(How I wonder what you are,
Up above the world so high
Like a lamp in a socket!)

Although most of the stars that we see in the sky are actually larger than our sun, all stars are so far away that even in the world's largest telescope they appear only as single points of light--except the sun, of course. No magnification at present possible will make stars any larger than points. Consequently, any disturbances in the atmosphere encountered by the single ray that comes from a star may contrive to blot it out or deflect it so that the star's light is unsteady--it twinkles or misses your eye now and then. Most of us have noticed on a hot day how the horizon quivers with heat waves. We have observed also how heat waves in the air above a hot radiator put wriggles in the objects seen through them. Or perhaps you have noticed the spots of sunlight dancing on the bottom of a clear stream as swirls of water pass by.

It would be too tedious to try to explain all factors that make a star twinkle. Most of the unsteadiness of starlight is caused by the variable bending of light through restless air currents. Some variation may result from random reflection or obstruction by particles in the air. Complete obliteration of starlight is explained by interference of the light as it is buffeted about when crest of wave cancels trough of wave and light disappears for an instant. You can easily observe the effects of interference if you use two adjacent fingers to make a very narrow slit between them, and then hold them close to your eye in the direction of a light source. You will be able to see several alternate black and white lines spread across the slit, parallel to its edges, where light waves have accentuated one another or have matched crest with trough to annihilate the light. Here



disk of a planet twinkle like the single ray that comes from a star, their rays take slightly different paths through the unruly air and therefore do not encounter the same irregularities but are affected differently. The twinkles of these different points are not generally synchronized and, although the planet is made somewhat less bright by the fact that a number of its points are always twinkling out, the planet's disk as a whole maintains a good, average, steady brightness. Let's find out the opinions of collegians with regard to the question, "Why do not the planets twinkle, except occasionally when they are near the horizon?"

> The light rays coming from a planet are not coming from a single point source, as is the case with the stars, but rather from an infinite number of point sources scattered over the disk of the planet as it appears in the sky. The planet will shine with a steady light because, although each of the individual point sources is twinkling, due to the changing refraction of the air layers through which its light rays come, all these point sources are not twinkling in unison. While some of them are winking out, others are winking on, with the result that there is a steady flow of light to the observer. It is like a choir of voices holding a tone for a long time. Every member of the choir may pause from time to time to catch his breath, but as long as the whole choir doesn't stop for breath at the same time, there will be a steady tone produced.
>
> However, when near the horizon so that the light rays from a planet are penetrating a much thicker layer of the atmosphere than when overhead, the rising air currents of various temperatures may be of sufficient variability in their refraction to bend all the rays coming from the disk of the planet at the same time so that the light disappears and then appears again and the planet as a whole twinkles.
>
> (St. John, 50-3)

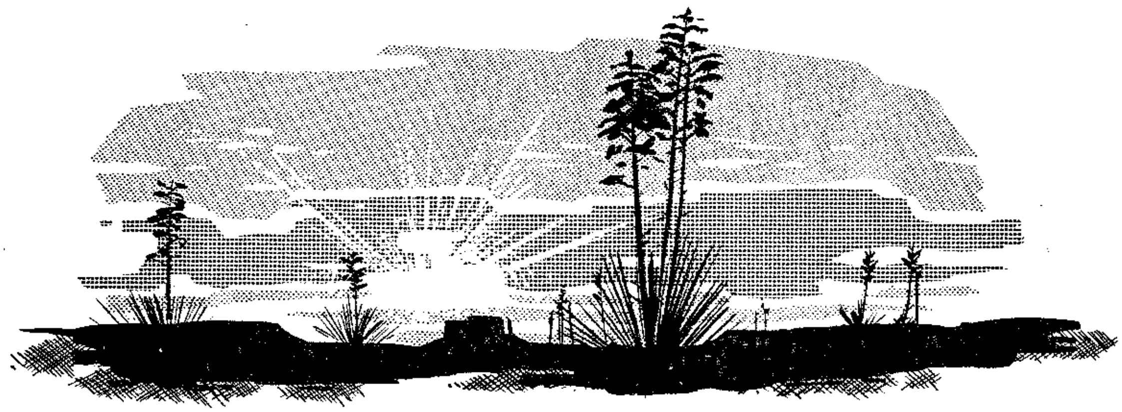
> Planets do not generally twinkle because they are near enough so that they present a real disk to the earth and every point on the disk sends out separate rays, like a cluster, toward the earth. The individual rays twinkle, but while one is off another is on, and so forth, so that the planet may be dimmed, but its points do not generally twinkle all together. Near the horizon, where the amount of heat disturbance in the atmosphere is larger--the more atmosphere, the more disturbance--the entire cluster of rays may be off at the same time--the more places, the more rays dispersed.
>
> (Creese, 48-3)

> The planet's light rays act as many points of light, and if some of these points should be off for a while, the others have sufficient brightness to cover up their absences.
>
> (Koenig, 48-4)

ICE CRYSTALS PUT CROWNS AND HALOS IN THE SKY

A common belief is that if the moon is surrounded by a coma or crown of hazy light, generally colored red on the inside, it is a sign of a storm to come. The size of the crown also carries significance for the dopesters. They say that the number of stars that can be counted within the crown of light is the number of days before the storm will arrive. There is a small element of truth in what these amateur weather prophets tell us. The coma, or crown, around the moon is caused by moonlight shining through ice crystals high in the sky. There are some celestial objects observed through the earth's atmosphere are not deceiving. We are now ready to look toward the starry heavens as a whole, preparatory to making some imaginary trips to specific destinations out toward the stars.

Before we go to Chapter V, let us read again Gene Lindberg's poem at the beginning of this chapter. We may be surprised to find that it means more to us now that we have read this chapter, because we are approaching the earth and the sky with a new light and color in our eyes. Shall we say that we are looking at earth and sky in 3-D through rose-colored glasses--glasses colored with new astronomical understandings?



SPACE TRIP FOR THE JONESES
Partly Described by the Joneses Themselves

Chapter V

OUT OF A CLEAR SKY: THE CONSTELLATIONS

> Pointing out the heavenly bodies has always impressed me as one of the most idiotic of human follies. On a vast expanse of celestial dome such as one beholds from a beach, uninterrupted by any terrestrial landmark, not even a water tower, it is as impossible to point out and identify stars as to recognize one's aunt's chauffeur in the newsreel picture of the Sunday crowd at Coney Island.
>
> --Cornelia Otis Skinner in Seeing Stars.*

A dizzy young student named Moore
Said, "Astronomy's really a bore;
Each time we go round,
The stars I have found,
Are the ones I saw there before!"
--Leverett L. Chapin, 51-4.

Many students in our astronomy classes are initially fascinated by the novelty of learning the names and locations of the most prominent stars and groups of stars--constellations--in the sky. They quickly locate and identify the most familiar of the stars and constellations, some that they knew already, and then the going gets rougher. Many of the new groups of stars have names that are hard to spell and even harder to pronounce. They find difficulty in matching the star groups with the star maps; it is hard for them to get the right scale of distance between stars. They find the constellation figures twisted at such odd angles--the winged horse, Pegasus, is upside down in the sky; or they have to look at the constellation so high in the sky that they get a pain in the neck from trying. Then again, if they observe them on another night at a different time, they are shocked to find that the star groups have changed their positions, and even have changed their orientation in the sky, so that they don't look the same any more. Or they may be nearer the horizon than they were before, and therefore appear to be much more stretched out because of the same effect of optical illusion that makes the sun and moon appear larger when they are near the horizon.

Perhaps the greatest common complaint these students have is that in very few cases do the star groups do justice to the figures of heroes and animals that they are supposed to represent. For instance, how can anyone be expected to make a whole ram out of the three stars that form a small flat triangle that is supposed to represent part of Aries, the Ram, the first sign of the zodiac? These students even cast aspersions on the intelligence and imagination of the ancient shepherds of Babylonia, Arabia, and Greece who wove these figures and legends into the stars. We remind the students that nights were darker in those olden days, that there were no street lamps and other artificial means of lighting up

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* Good Housekeeping: 101:182, August, 1935

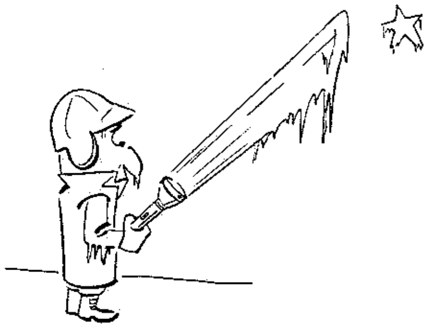
cloudy night. But even then we know that light from the stars whose patterns are well-known to us are making a silver lining for those clouds, at least on the other side.

Knowledge of the stars has other than philosophical values. There are some 55 navigation stars that are used by navigators all over the world. It is true that there are star-finder charts that will enable navigators to locate these bright stars in the sky without the need of tracing out their constellations, if they know the time and their approximate position on the earth. Yet the actual knowledge of the constellations will help most of all for fast work in navigation. A few of our astronomy students who became navy fighter pilots in World War II have reported that their knowledge of the constellations, even though learned in the northern hemisphere, has been adequate in emergencies to bring them home to their flat-tops in the South Pacific. There must be others too who were helped who have not reported back yet.

Also there is the story of J.P.M. Prentice, amateur astronomer, watching the Geminid meteor shower one December early morning in England, who saw that the head of Draco, the Dragon, had one too many stars in it, and thus early discovered Nova Herculis of 1934, one of the greatest exploding stars of all time. Both he and the nova were front-page news for several weeks because he knew his constellations. A dozen or more astronomers, Dean Herbert A. Howe of our observatory among them, discovered Nova Aquilae independently in 1918 because of their knowledge of constellations and their propensity of watching the stars. Observers of meteor showers project the trails of these so-called shooting stars on maps of the constellations and thus learn the heights of their fiery paths above the earth.

Boy and Girl Scouts earn merit badges by tracking the planets among the stars. They also earn badges of honor when they track themselves and lost parties of scouts back to camp with the aid of their knowledge of the North Star and its surrounding constellations. We are reminded here that the Phoenicians were the best navigators of olden times probably partly because they steered by the faint Little Dipper, which held a steady place close to the north pole of the sky, instead of by the brighter Great Dipper, used by the others, which described a bigger circle around the pole and made for less accurate sailing. Like the Boy Scouts, we too learn much of our astronomy by watching the changing positions of the planets among the stars and the more rapid progress of the moon as it forges eastward among the constellations, a round trip each month.

Whether we use our stars for a philosophical or a practical purpose, let us repeat that a knowledge of the figures in the sky and the stories behind them help us to remember the constellations. The seasonal changes of the aspects of the stars make a constant source of enjoyment for ourselves and our friends as we renew each year our acquaintance with the constellations on many clear nights, preferably in the open country or in the mountains. Oftentimes several may observe the sky together--two is a nice romantic number--with the help of star-charts and a five- or six-cell flaslight that points out the stars with a thousand-foot beam easily followed by parties up to fifty persons. The best of these flashlights is a six-cell raccoon hunter's flashlight sold by the Dog Supply House, Detroit, Michigan. A good inexpensive star chart to begin with, for latitudes near 40° North, is the Star Explorer, which can be obtained from the Junior Astronomy



warm room with the illuminated arrow of a planetarium pointer. Maybe some day we will when some sky-minded benefactor endows a planetarium in Denver to fill in the only missing link in the chain of planetaria across this land of ours. Until such a time we will limit ourselves to dreams of pointing out on a planetarium dome stars that are never dimmed by street-lamps or moonlight or hidden by the passing clouds of stormy weather.

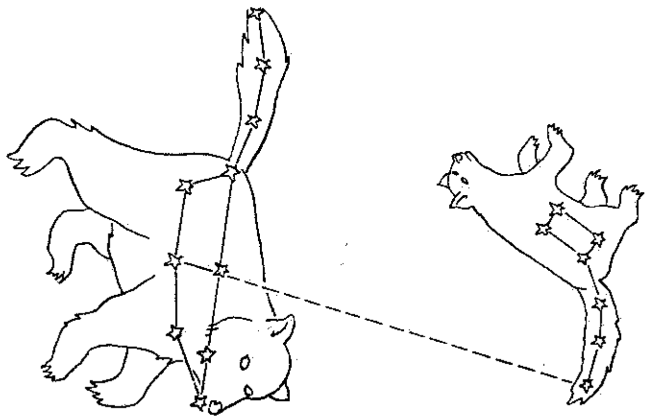
A rather detailed account of our star study program has been given here because many of our readers may want to follow some systematic plan of tracing out the constellation figures. There may also be some who as scout leaders or as sponsors of cub scout dens have had star study as one of their activities. This has been only one approach to the problem. Much could be said for perforated black paper or cardboard models, illuminated by lights, to take the place of planetaria, and the many other ingenious ways that have been devised for becoming acquainted with the star patterns in the sky. Let us now describe the newest device of all.

In 1954 Armand Spitz, of Spitz Planetarium fame, designed the Spitz Junior Planetarium, which is bound to expedite greatly the learning of the star groups. It is a mounted plastic globe, perforated with holes through which the light from a 3-cell flashlight bulb shines, to project the main constellations on the walls and ceiling of any well-darkened room. Only about 450 stars are shown but a reasonably wide coverage of the sky is given, although some groups, like the Pleiades, have to be distorted out of scale to show them at all. Even in this small model there is a horizon operated by gravity, which cuts out the light from the bottom half of the globe. The Spitz Junior also has a means of changing the latitude of observation to show how the stars would look from all latitudes of the northern hemisphere. The purchase price of $14.95 includes a 40-page manual for study of the constellations, carefully written by Armand Spitz himself. Although it does not show the planets, the sun and the moon, and though the turning of the sky has to be done by hand, what should one expect for fifteen dollars! Just remember that the Zeiss planetaria cost a half million dollars apiece.

At this writing the Spitz Junior Planetarium has been demonstrated to more than five thousand visitors at the Chamberlin Observatory, and has been enthusiastically received. It has been used very effectively with one college class in astronomy so far, and proved to be a very helpful transition between the showing of the constellations on Dr. Menzel's National Geographic star charts and the actual pointing out of the star groups in the sky with the long-beamed flashlight. And no wonder, because as the boy said when he looked at the sky, just after a planetarium demonstration, "Mom, it looks just like the planetarium!" There could be no higher recommendation.

Perhaps the most interesting story that came out of our star-gazing experience is the one about the student who told his six-year-old sister that he was going out to the observatory. When she asked him why he was

These same American Indians tell the story about a party of hunters who lost their way, and prayed to their gods for guidance. A child appeared in their midst and, proclaiming himself the spirit of the Pole Star, guided them safely home. Thereafter they called the Pole Star the star that never moves. When the hunters died, they were carried up to the heavens, where they became the stars forming the Little Dipper, so that they might forevermore follow the North Star at the end of the handle, faithfully night after night. So here we have the Greek and Iroquois versions of the stories of the stars that both peoples resolved into the now notorious Big and Little Bears. How about the Middle-Sized Bear? Oh, that's the bear that isn't there!



The two bears are quite often pictured with long tails. Out of this tendency toward long-tailed-ness for the sky bears, other tales have developed. The Greeks realized too that bears no longer have long tails. Their suggestion was that Jupiter, after learning that his lady love had been transformed into a bear, insisted immediately upon enshrining her among the stars. Confronted with the problem of throwing her up into the sky, he had to grab her somewhere and chose to grasp the bear by the tail. But the Great Bear was so heavy and the distance to the sky so great, the mighty fling that was required irretrievably lengthened the tail.

Dean Howe, former director of Chamberlin Observatory, took care of the Little Bear in a somewhat similar way. He suggested that when the Little Bear was first hung in the sky and pinned with his tail at the position of the North Star, he originally had a short tail. But because of the apparent daily rotation of the sky the little fellow was whirled around once a day hanging by his tail from the nearly immovable Pole Star. After several centuries of this treatment it is not to be wondered at that his tail has become permanently stretched. Dean Howe called this lengthening of the tail a sort of evolutionary adaptation to environment. It is fitting too to represent this bear as a polar bear, because there could be no bear more Pole-er!

Apparently there were some persons who did not know of the emergencies which put these bears into the long-tailed class. Instead these others said that once upon a time all bears had long tails. But there came a long winter for which the bears had not provided properly. They were forced by the pangs of hunger to come out of their caves of hibernation while winter weather still prevailed. To keep body and soul together they all scratched holes in the ice of the lakes and lowered their tails in the icy waters for bait to catch the fish that were hungry he looked at the head of the Medusa, turned promptly into stone and immediately sank. Meanwhile Perseus loosed the chains from fair Andromeda, asked for her hand in marriage, was accepted, and they lived happily forever after, being immortalized in the stars even before they died. Now wasn't that a thriller-diller, Joneses?

There is not space here to go more into the mythology of the constellations. This can be done better by reading the stories by Olcott, Grondal, and others. We will conclude this section by mentioning that the original number of constellations established by Hipparchus and Ptolemy was forty-eight. Since Ptolemy's time, second century A.D., more groups have been added--most of them recently--until a total of eighty-eight constellations are now recognized. Most of the new constellations are located in the southern sky which, of course, was not visible from Greece where the early star groups mainly were originated. A few of the new groups filled in spaces in the northern skies where stars were generally too faint or too few to form outlines of heroic figures of the sky. The boundaries between star groups had always been rather irregular and confusing until 1928 when the International Astronomical Union established the eighty-eight areas of the sky by bounding them by lines parallel or perpendicular to the celestial equator. Thus there are now eighty-eight well-defined states of the United Heavens.

DID YOU EVER TRY TO COUNT THE STARS?

In the comic series PEANUTS by Charles A. Shulz, Charley Brown comes across Lucy, one of his girl playmates, counting and looking up at the night sky. He asks her what she's doing; she replies that she is counting the stars. But she also says, "The whole trouble is, I'm too far away. I can't see some of the teeny-weeny ones." But she has an idea, goes into the house and returns with her play chair, stands on it, and then says, with a satisfied air, "Say, this makes all the difference in the world!"

Perhaps you had the same trouble when you tried to count the stars. Also, in the region of the Milky Way, it was hard to tell where the fog left off and the faint stars set in. If any of us have tried to count the stars, we found that one of our biggest headaches was to keep track of the areas we had already counted. Most of us have stopped before we got up to two hundred and decided that the stars were countless. The idea that it is impossible to count the stars comes even more quickly if we try to enumerate them on a moonless night high above timerline in the Rockies. For the stars seem massed together in layers; we can imagine depth in the sky, with the fainter stars disappearing into the distance.

The best way to have the stars counted for you is in an astronomer's star catalogue which tabulates the stars down to naked eye visibility. Of course, the limit of visibility varies with the quality of the individual's eyesight, but a good average can be struck at magnitude 6.5, an expression that we will explain soon. This average value leaves us with about

BRIGHTNESS AND COLOR OF THE STARS

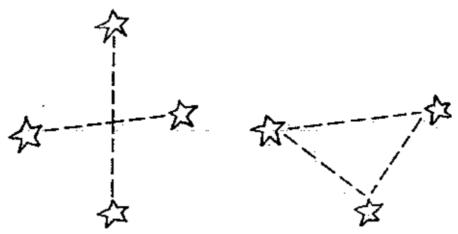
Perhaps the most striking thing about the stars in general is not their number and crowdedness, nor even their odd patterns in the sky. Just as in the theatrical world the biggest stars get the most notice from the general public, so in the sky the brightest stars make the strongest impressions on the novice observer. Of course with more watching the numbers of the stars, their arrangement, and their colors become more important to the discerning eye of the more experienced observer.

When Ptolemy catalogued the stars in 140 A.D. he arranged his 1028 stars into six magnitudes of brightness. Just as we have diamonds of the first water, so he classified the twenty brightest stars in the first magnitude. His sixth magnitude included those stars that could barely be seen on dark nights. Later investigation has revealed that his scale of difference in brightness was a factor of about 2 1/2 for each magnitude; that is, his first magnitude stars, on the average, were 2 1/2 times as bright as second magnitude stars, those in turn were 2 1/2 times brighter than third magnitude stars, and so on down. This meant that the first magnitude stars in general were about a hundred times as bright as the sixth magnitude stars--those that were barely visible. A little approximate multiplication will demonstrate this fact: 2 1/2 times 2 1/2 that is, 5/2 times 5/2, gives 25/4, or about 6; 2 1/2 times 6 is 15; 2 1/2 times 15 is about 40; and 2 1/2 times 40 is 100. Hence a range of five magnitudes means a 100-fold multiplication in brightness.

Since the number 2 1/2, or 2.5, used as a multiplier five times does not give exactly 100, modern astronomers have adopted the number 2.512 for the magnitude ratio, for $2.512^5 = 100.0$. The brightnesses of stars are generally listed to the nearest one-hundredth of a magnitude. For instance, the magnitude of Polaris is 2.12. The trained observer can tell a difference in brightness down to about one-tenth of a magnitude, although the photoelectric photometer can be depended upon to measure to an accuracy of the order of a few thousandths of a magnitude.

When new magnitudes according to this more precise scale of brightness were assigned to Ptolemy's original twenty first-magnitude stars, it was found that their brightnesses actually ranged through some three magnitudes. To take care of the brightest of these stars the scale had to be extended from the first magnitude to the zero magnitude, and then to negative magnitudes. Thus the magnitude of the blue star Vega is 0.14, and that of the brightest star of all, Sirius, the Dog Star, is -1.58. In this way the magnitude scale has been extended now both ways, to brighter and to fainter telescopic objects. For example, the planet Venus has a maximum brightness of magnitude -4.3, the full moon can become as bright as magnitude -12.6, and the sun can reach a magnitude of -26.7. In the direction of fainter objects we may cite the limiting magnitude to which the Chamberlin 20-inch telescope can reach as 15.5, while the 100-inch Hooker reflecting telescope at Mt. Wilson can observe visually stars down to magnitude 19, and the Hale 200-inch reflector on Palomar Mountain can photograph stars and galaxies as dim as magnitude 22.

Suppose we make an interesting comparison between the brightest star in our night skies, Sirius the Dog Star, and the sun, which is, of course, the most important star as far as we are concerned. Since the magnitude of Sirius is about -1.6 and that of the sun is -26.7, with the help of only a little algebra, we can see that our sun is about 25 magnitudes



photograph of the romantic Southern Cross is made. The cross, as can be seen from the sketch, already labors under the handicap that it has no star at its cross-point as does the Northern Cross. So when a photograph is made and one of the four stars disappears because it is a red star on a blue-sensitive plate, the Southern Cross goes too, and all that is left is a triangular disappointment.

HOW CAN THE ASTRONOMERS READ THE NAMES ON THE STARS?

A favorite question in final examinations in our astronomy classes has been: Considering the enormous distances of the stars how can the astronomers read the names on them, even with the largest telescopes? The best answer ever received for this question was given by a student so far back in time that we cannot recall her name. But we shall never forget her answer. Said she: "If the astronomers have found a way to put the names on the stars, they'll find a way to read them." What a vote of confidence in the integrity of scientists! Here are some other answers by students who enjoy firing back at questions like this one--students with a sporting sense of humor that will rise to a challenge:

> If you have an imagination like the one that the study of astronomy requires, you will have no trouble reading the names.
>
> (Branch, 50-2)

> I suppose you want us to say that the telescope uses bifocals in its lens, but that isn't the best answer. It seems rather, since we can't read the names, we humans have merely to put names on star maps, and anyone can read a star map.
>
> (Calvin McConnell, 50-2)

> It isn't hard. They just write them on the lens--so much more practical.
>
> (Vander Jagt, 50-2)

> They don't have names, only positions.
>
> (McWhorter, 50-2)

> The stars are not printed in the sky with their names, but instead have such constant positions that astronomers can name them because they know them for where they are and not for what or who they are.
>
> (McGrew, 53-2)

> Maybe they have publicity agents. All stars do, you know! In reality, the skies are mapped, and the astronomer can momentarily turn the telescope to any given star and the name of it is on his chart.
>
> (Perry, 53-2)

> When you realize that astronomers see horses, dancing girls, snakes, goats, and stuff like that all over the sky with their naked eyes, I'm sure they'll have no trouble at all seeing a well-lighted name-plate on a star with a telescope.
>
> (Claude H. Studebaker, 54-4)

> It helps to have a grand imagination, a knowledge of history and of Greek mythology, and about six Tom Collinses.
>
> (Caldwell, 53-2)

Let's end this section in high spirits!

As was mentioned earlier the 88 areas in the sky are like 88 states of the United Heavens. If you wanted to give the location of a person in the United States, you would say his address is Los Angeles, California, or something similar. In like manner Bayer in his star atlas (1603) started giving the address of particular stars in the sky by using the letters of the Greek alphabet, in the order of the stars' brightness, along with the possessive form of the name of the constellation. Thus Alpha Cygni became the name of the brightest star, Deneb, in the constellation of Cygnus the Swan. In case the stars of a given group were of nearly the same brightness, like the stars of the Great Dipper, the stars were lettered in order as they appear in the sky brim of cup first: Alpha, Beta, Gamma, Delta, Epsilon, Zeta, Eta. Thus the star Mizar in the bend of the handle of the Big Dipper is also known as Zeta Ursae Majoris. Of course, since there are only 24 letters in the Greek alphabet, the two dozen brightest stars in a constellation carried the Greek letters, while additional visual stars were assigned letters of the Roman alphabet until the Flamsteed numbers were introduced. In 1729 Flamsteed started the idea of numbering the stars, assigning numbers to the stars in any particular constellation in the order in which they successively crossed the meridian of the sky. The meridian is the imaginary line passing across the sky from north to south, which the sun crosses at noon every day.

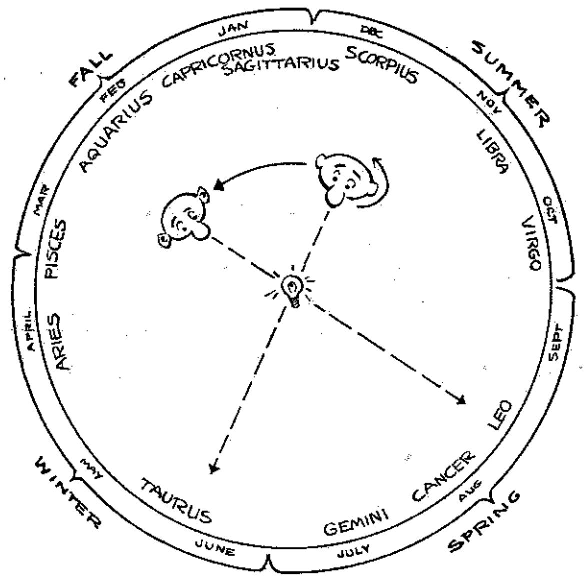
Modern practice is to name all the visual stars by the Bayer letters as far as they go and to use the Flamsteed numbers for the other stars of naked-eye brightness. The brighter stars are generally named by both methods, along with their specific name, if they have one. Thus the brightest star in the constellation Perseus is called 4 Alpha Persei, Marfak. All the visual stars and many thousands of fainter stars have catalogue numbers in various star catalogues and in the photographic charts of the sky. For instance, 4 Alpha Persei, Marfak, is also BC 49^{8}917 (Bonner Durchmusterung), HD 20902 (Henry Draper Catalogue), Bonn A.G. 2828 (Astronomische Gesellschaft), and also Boss 4041 (Boss General Catalogue). Now, don't you feel like a well-organized astronomer, with all your stars properly named and numbered, and filed away according to the 88 states of the United Heavens?

STARS MAY COME AND STARS MAY GO, BY SEASONS CHANGING EVER

As we observe the stars night after night, over the weeks and months, we can't help noticing that the old constellations keep disappearing gradually into the west, while new constellations are appearing in the eastern sky. To explain how this happens we will need to steal a march on the next chapter, which shows more fully the effects of the earth's revolution about the sun once a year. Let's pretend that we are not Missourians yet, and do not therefore need to have this motion actually shown to us. Suppose we imagine the sun as a globe in the center of a room, and that the constellations of the four seasons are displayed on its four walls. Now, let us imagine that we are circling the room inspecting the constellations, much as we would examine the master works of artists in an art gallery. Now, as we circle the room, keeping our back toward the globe or make-believe sun in the center of the room, we will face successively the four walls or the four seasons of constellations. Let us remind ourselves that our back is our sunny or daytime side, and our face will always be looking out from our shady or night-time side at the stars on the wall in the night-time sky. So as we make a complete

> the earth and the sun are between us and the winter stars. They are then in the daytime sky, still not visible to us because of the sun's overpowering light.
>
> (Cuthbertson, 49-4)

Now that we have had our space exercises let us take a final swing at this problem of the constellations in their seasons. Suppose we imagine ourselves back in the room with a light bulb at eye level in the center of the room, representing the sun. But instead of a square room, let's make it circular and paint on the wall around the room only the constellations of the zodiac, that ring of animal constellations through which the sun apparently passes each season, because of the annual journey of the earth about the sun. Now imagine yourself as the earth walking around the central light bulb, the sun. Of course, for realism purposes you should turn 365 times as you go once around the sun, but that would make you dizzy and besides would be of no help in explaining the present problem.



Now again, as you, the earth, go marching around the room you will notice the constellations passing behind the light bulb sun. This situation could easily be duplicated in a planetarium where a dim sun could be projected directly upon the stars. As you stand at the position indicated by the beginning of the large curved arrow in the sketch, you can see the imaginary sun projected on the stars of Taurus. This is where the sun is in June. As you do a quarter turn to the point of the curved arrow, you make the light bulb sweep past the star groups of Gemini and Cancer and end up in front of Leo. This corresponds to the sun's position in September. Thus you can see how the sun appears to move among the stars during the summer season.

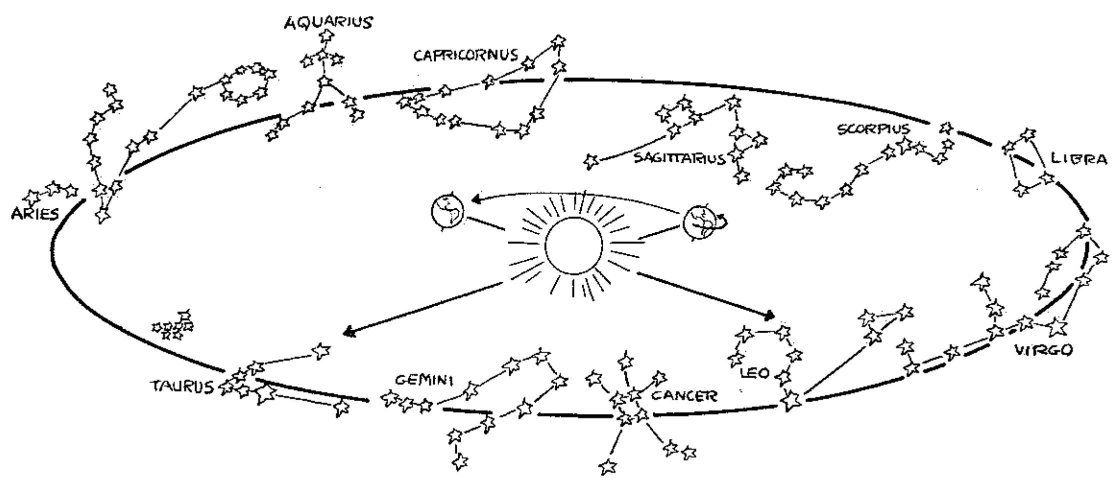
You have only to imagine a very bright lamp for the sun in the center of the room to realize how the sun could successively hide from view the twelve star groups of the zodiac during the twelve months of the year. Not only would the single constellations be lost to the daytime sky, but the neighboring groups on both sides would also be hidden in the sun's glare. Now, of course, the stars that you see most conveniently in the summer must be visible in the night-time sky, perhaps around 9 p.m.

back to the 9 p.m. position. Then your nose would be pointed toward the sky midway between Virgo and Libra, each of which is adjacent to Leo and Scorpius. These constellations of the zodiac would then be appropriately called summer constellations, along with the other star groups that are suitably high in the rest of the sky at that time--that is, around 9 p.m. in the summer. And aren't these stars just too romantic in the good old summer-time!

The following table lists the constellations of the zodiac that are best visible at 9 p.m. during the four seasons of the year. The constellations above and below these that can be best viewed during the same seasons can be obtained from star charts with the help of the Spitz Junior Planetarium, or by the star charts published monthly in the Sky and Telescope Magazine or Monthly Evening Sky Map.

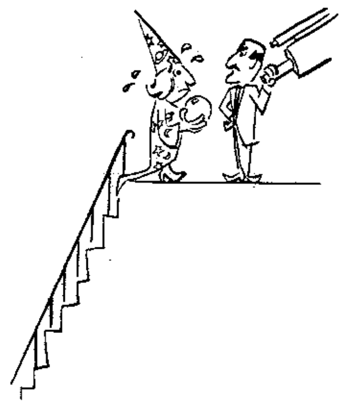
Summer	(Virgo (Libra (Scorpius	Fall	(Sagittarius (Capricornus (Aquarius	Winter	(Pisces (Aries (Taurus	Spring	(Gemini (Cancer (Leo

Let's take a comprehensive look at this whole matter of the stars in their seasons before we go out and look at the sky again, this time with what's bound to be a new light in our eyes. It may be best to do our act all over again in 3-D, back in the circular room with the stars of the zodiac painted on the wall. As we walk around the room again, the idea of how the sun reaches one after another of the twelve zodiacal groups as each of the twelve months of the year go by becomes clearer. Thus a constellation of the zodiac is subtracted each month from the night sky by the sun's encroaching light, while a new constellation, recently left by the sun, is added back to the night sky in the wake of the sun. This is true not only of the stars of these constellations, but also of their neighbors in the sky. As the earth circles the sun, the sun is made to circle the background of the firmament of stars, and give each seasonal set of stars the chance to occupy the stage of the night during the popular hours. To get the complete picture of the earth spinning and going around at the same time, just pirouette as you walk around the room and yours will be full understanding with no more dizziness of confused ideas.



SO YOU DON'T CAST HOROSCOPES?

As I come to the end of this section dealing with the study of the stars, I am reminded of a cartoon I saw several years ago. Pictured is a rather stout lady in the dome-room of an observatory, where she has finally found the astronomer at his telescope. She has evidently made a long climb up the spiral stairway to reach her objective, has apparently asked the astronomer her important question, and is obviously discouraged with his answer. For she says, "So you don't cast horoscopes?" All that terrific climb toward the heavens for nothing!



I know my readers will want to know my opinion of astrology. I shall admit at once that I am no expert in the field, and generally claim ignorance of it, although I have been called astrologer by many visitors who apparently saw little difference between astronomy and astrology. Most of us realize that astronomy owes much to astrology, which attempted to find clues to man's destinies in the stars and thus built up indirectly a background of knowledge of the stars from which the science of astronomy has grown. In a similar way, alchemy, the search for the philosopher's stone that would help transmute a base metal like lead into gold, furnished the foundations for the modern science of chemistry. Just as alchemy died, so too should astrology have passed on, because there is not a shred of evidence that the big stars and gorgeous planets are concerned with the destiny of puny man and that their varying line-ups have anything at all to do with what the future holds in store for us.

The Scriptures say it very well when they state "When I was a child I spake as a child, I understood as a child, I thought as a child: but when I became a man, I put away childish things." Astrology has grown up into the science of astronomy. Man will not really be mature until there are many more readers of magazines like The Sky and Telescope and of astronomy books, than there are readers of and believers in the daily horoscope column in the newspapers and in the widely circulated astrological magazines of the present time. There is plenty of evidence that our destiny is determined by the parents we pick to be born from rather than the stars we choose to be born under. There is much more of predestination in the chromosomes of our human germ cells than there ever could be in the horoscopes cast for us. For after all, what we become is dependent upon how we develop our raw talents. As the Denver head woman of the National Youth Administration (NYA) said once to a young job-seeker who was looking forward hopefully to security: "There is no job with a future. You take the job and you make the future."

As I shall say again in the chapter on the sun, when people ask me whether I believe that the stars determine our destiny: I will agree with your statement if you change the word STARS to STAR. For there is one star that completely determines our existence and hence our destiny, and that star is the sun. But there is also something to be said for the philosophical value of studying the stars. When we hitch our wagon to a star we are aiming toward high ideals, morally as well as physically, for also, again according to the Scriptures, "As a man thinketh, so is he."