Glory of The Stars

by

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Preface and Acknowledgment

To write a book on astronomy without the knowledge of a trained scientist in that field may seem presumptuous. However, the study of the stars and the advance of astronomy has been my hobby since the days 1 studied under Professor M. W. Newton. In this volume 1 have endeavored to bring the most up-to-date, authoritative findings about the starry heavens into a popular form that will inspire greater love for the subject and at the same time increase faith in a personal God who created all things.

There is no subject that should inspire the Christian more than the study of the universe. We are beginning to put the alphabet of the starry heavens together, and they spell the words, "God is here." In the dark hours of our bewildered generation may we learn to look up, for the stars still shine in eternal splendor!

1 wish to thank the following publishers for their co-operation in allowing me to quote from books bearing their imprint. Quotations are used with their special permission.

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"Christ in the Universe," Charles Scribner's Sons, New York City.
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Galaxies, Harvard University Press, Cambridge.
WATSON, FLETCHER G
Between the Planets, Harvard University Press, Cambridge.
WHIPPLE, FRED L
Earth, Moon, and Planets, Harvard University Press, Cambridge.

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THE AUTHOR.

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“The Thunder of His Power”

ON ANY CLEAR, MOONLESS NIGHT turn your back on the gaudy lights and the neon signs of the busy city and go into the open country. If you thrill as 1 do to the glory of the stars you will be impelled to gaze with wonder at the serene and silent pin points of light that hold their ceaseless vigil impervious to the hates and fears of men. There is nothing in Nature’s “blackout” to strike terror to the watcher, for the heavens reveal the majesty and love of the Architect who created the universe.

To the child these spots of blazing glory seem to be what Longfellow called them, “the forget-me-nots of the angels” that shine in “the infinite meadows of heaven.” To the adolescent they are stars; to the mature student they are giant suns, galaxies, and nebulae traveling through the universe in complete harmony with natural law. To the thinking Christian they are all of these and more, for the planets and their satellites, the suns and the galaxies, are an eternal testimony of the omnipotent God who created all things. In The Divine Comedy Dante declared:

“1 raised my eyes aloft, and I beheld The scattered chapters of the Universe Gathered and bound into a single book By the austere and tender hand of God.”

Modern astronomy tells a dramatic story of how the boundaries of the universe have been pushed back by long and arduous research in various fields of science. The physicists, who discovered how to release the power of the atom, have helped to give us a new conception of the starry heavens. The chemists who have learned how to identify elements and their compounds by unique means, have helped solve some of the mysteries of our solar system.

A Growing Science

The universe that the ancients knew was vastly different from the one we are acquainted with today. In the days of Abraham only five planets could be seen by the eye of man, and it was not until late in the eighteenth century that the sixth planet, Uranus, was discovered. Mathematical calculations and great telescopes made it possible to bring another planet, Neptune, to the gaze of astronomers, in 1846. However, it was not until the third decade of our present century that painstaking research brought Pluto into view, a planet twice as far from the Sun as Uranus. Therefore, an expanding solar system swings into our view today, for we have nine planets, including our Earth, to study.

The Egyptians and Babylonians observed the stars, charted the courses of the planets, and correlated the motions of heavenly bodies with the calendar; but they did little more. They were content to enjoy the pageant of the heavens without troubling themselves with the “how” or “why” of their existence or the laws of their movements.

Naming the Stars

The Greeks recognized the difference between the "fixed" stars and the planets; but when they looked at the heavens they imagined they saw strange figures in the groups of stars, or "constellations," and they gave them romantic names. Some of the eighty-nine constellations were named after common objects, such as Crater (the Cup), or Lyra (the Harp). Others were named after animals, such as Canis Major (the Great Dog) and Taurus (the Bull); while yet another group was honored with the names of Greek heroes and legendary characters, such as Perseus, Andromeda, and Cassiopeia. Many of the individual stars also received names and some of these appellations have persisted to the present for such, as Sirius, Arcturus, and Capella.

But when telescopes were perfected, astronomers found the number of stars so immense that the task of naming all of them became impossible, therefore they tagged the principal stars of a constellation with the letters of the Greek alphabet, Alpha (a), the brightest; Beta (b), the next brightest, and so on. But since there were not enough letters in the alphabet to attach to all the stars that have been discovered, astronomers, in recent years, have catalogued and numbered the stars according to their position. Thus 61 Cygni refers to Star 61 in Cynus (the Swan). Fainter stars are designated by numbers ill star catalogues, such as the Henry Draper Catalogue, an example of which would be HD 12953. Although men are not able to name the myriad suns, it is awe-inspiring to remember that God "calls them all by names by the greatness of His might." Isaiah 40:26.

The general conception of the universe in the days of the Greeks was confused, to say the least. Thales, who lived six hundred years before Christ, told his fellow citizens of Miletus that the Earth was a flat disk floating on water. According to him, the Sun, Moon, and stars simply moved across the dome of the sky as flies walk on the ceiling. The Pythagoreans, a school of philosophers, were correct when they taught that the Earth and the other planets were spheres whose light was reflected sunlight; but they added the fantastic story that there were animals on the Moon fifteen times as strong as those on the Earth. Some of the ancients caught a glimpse of the meaning of the universe, however, for Okellus of Lucania said, "The stars must be worlds like ours with animals and plants on them and possibly even people."

Plato realized there was order in the universe, for he asked: 'What are the circular and perfectly regular movements which we should suppose so as to be able to save the appearances presented by the wandering stars?" Aristotle believed that the Earth was round and that it revolved. He, too, thought that there were great spheres which filled the space between the heavenly bodies. A new idea was supplied by Heraclides of Pontus, a philosopher who noticed that the planets Mercury and Venus did not move very far from the Sun. Because of this, he suggested that they might actually revolve around the Sun, and the Sun in turn revolve around the Earth. However, no one in his day took his suggestions seriously.

Aristarchus of Samos, who lived in the third century before Christ, proposed a simple and daring view of the heavens. He suggested that the Sun was the center around which the planets revolved, and he went so far as to make an attempt to measure the distances from the Earth to the Sun and the Moon. His reasoning was correct, but his instruments for measurement were too crude to give him accurate results. It was actually the Copernican system eighteen centuries before Copernicus.

Claudius Ptolemy, the last of the great ancients, who lived in Alexandria about AD 150, gave Greek astronomy an organized system of thought about the universe which prevailed in man's thinking for over fourteen hundred years. He extended the ideas of his predecessors who said that the Earth was motionless in the center of the heavens and that the planets moved in small circles, whose center moved in turn about the Earth. The Ptolemaic system was based upon the obvious appearance of the starlit sky, and it was adopted by thinking and unthinking people alike. Upon this view of the universe was based the religious and scientific thought of the Middle Ages. Dante's The Divine Comedy and Milton's Paradise Lost were written around this concept of the heavens Mid the Earth.

Nicolaus Copernicus upset the Ptolemaic theory when he published his views in the middle of the sixteenth century. His epoch-making treatise appeared in Latin, and its English title is "Concerning the Revolutions of the Celestial Spheres". This Polish scientist, churchman, painter, poet, physician, and soldier found time to work out an entirely new system of astronomy which completely changed man's ideas about the universe. He taught that far out in space there were fixed stars that were immovable. He said the Earth was not the center of the universe, but that it rotated on its axis and moved in an annual orbit around the Sun. The other planets, according to Copernicus, also moved around the Sun, and the various phenomena of the heavens could be explained in harmony with these assumptions. Thus, our world, formerly thought to be stationary, was sent spinning through the heavens, and new vistas of the universe

were opened to the mind of man.

But Copernicus did not live to see his view accepted, for the manuscript of his book was not sent to the printer until the author was almost seventy years of age. Before the printing was completed, the scientist became seriously ill. It is said that a messenger brought the first copy to the sick man only a few hours before he died. Alfred Noyes has dramatized this incident in his poem, The Torchbearers-Watchers of the Sky:

"A shadow moved towards him from the door. Copernicus, with a cry, upraised his head. "The book, 1 cannot see it, let me feel The lettering on the cover. It is here! Put out the lamp, now. Draw those curtains back, And let me die with starlight on my face. An angel's hand in mine."

When scientists read the book by Copernicus, they immediately raised a number of objections to his theory. Some of the doubters said that Venus should show phases similar to those of the Moon if the planets actually revolved around the Sun. Copernicus was aware of this problem, and he had said, "God was good and someday He would show the phases of Venus to someone." His prophecy came true, for in succeeding centuries the phases of Venus have been carefully observed many times through telescopes.

Other critics declared that if the new conception of the universe were true, the remotest stars in the sky should show some small annual change in direction, or parallax, because of the altered position of the Earth as it moved in its orbit around the Sun. Copernicus answered that the stars were so far away that his small instruments could not measure any apparent change. This was correct reasoning, and it was not until almost three hundred years after his death-in 1838, to be exact-that the first apparent motion of a fixed star, 61 Cygni, was discovered.

The Observations of Galileo

Galileo and his successors proved the truth of the Copernican view by scanning the night sky with telescopes. With his "optic tube," as he called it, Galileo, in 1610, saw four moons revolving around Jupiter, the first objects in the solar system to be discovered by man beyond what his eyes alone had seen. His telescope also brought the Moon close enough to be studied easily. In fact, the astronomer made some preliminary sketches of the Moon's surface and attempted to prepare a map of what he saw. Since Galileo's time our knowledge of the universe has continued to increase, until today man attempts to fathom the immensity of space and to comprehend the almost infinite number of blazing suns, the nebulae, and the galaxies that move through the universe.

How can we visualize the solar system of which our Earth is a member? Dr. Fletcher G. Watson has set up a scale by which we can compare the size and distance of the Sun and its planets. If we take an orange to represent the Sun, our Earth would be a tiny pinhead 27 feet from the orange. Between the Earth and the Sun is a shining grain of sand Mercury, and Venus, another tiny pinhead. Look out 14 feet beyond our speck of Earth and we find another grain of sand, Mars. Now we shall have to begin walking to reach the outer planets of our solar system. From the orange to Jupiter, which is represented by a small marble, will be 140 feet. Saturn, the size of a pea, is 120 feet beyond Jupiter. Uranus, no larger than a small pill, lies 510 feet from the orange-a good long city block! Neptune is another small pill 500 feet from the orange; while Pluto, the latest-discovered planet of the solar system, must be represented by another pinhead 1,100 feet from the orange.

But we are only on the threshold of the universe when we have traveled to the farthest corner of our solar system. The nearest star, on the same scale of distances, would be over 1,400 miles from the orange!

The Immensity of Space

Truly the mind is staggered when it attempts to grasp the immensity of the heavens! Our universe is a giant beehive of motion, for the Earth revolves about the Sun, as do also the other planets, asteroids, and comets of the solar system. Our Sun, whizzing through space at approximately 12 miles a second, is one of a mighty group of perhaps a hundred billion stars which compose the Galaxy, or Milky Way. "This system is a great swarm of stars isolated in space," says Dr. Edwin P. Hubble, of the Mount Wilson Observatory. "It drifts through the universe as a swarm of bees drifts through the summer air. From our position near the Sun we look out through the swarm of stars past the borders, into the universe beyond."

The entire Galaxy, or Milky Way, of which our solar system is a particle, is rotating at a high

speed around a center in the heavens. It requires some 200,000,000 years for this galactic system to rotate once; and in it move giant suns-some gathered in groups called globular clusters, some traveling in twos or threes, and some speeding alone on their appointed course. In this system are bright and dark nebulae, believed to be mammoth clouds of tiny particles of cosmic dust.

But we have not yet formed the complete picture. There are millions of other galactic systems, or "island universes," similar to our Milky Way. Each of these separate galaxies comprises a universe in itself with millions of suns and perhaps billions of planets as large as, or larger than, those that revolve around our Sun.

The mind of man has pushed back the frontiers of space to such an extent that he observes a region of the physical universe about a billion light years in diameter, throughout which arc scattered more than a billion individual universes, each comparable to our own Milky Way system, which is composed of 100,000,000,000 individual stars and suns dwarfing our own. Great as the conquest of space has been, it is not possible at the present time to determine whether the billion observed universes represent a sizable part of the physical cosmos or if they merely constitute a figurative "drop" in the infinitude of space.

The Hebrew View of the Heavens

The human mind is stunned by the immensity of the universe. We say with the learned Job: "Lo, these are but the outskirts of His ways: And how small a whisper do we hear of Him! But the thunder of His power who can understand?" Job 26: 14, A.R.V.

Of all the ancient nations, the Hebrew writers alone grasped the truth concerning the universe. The Greeks looked upon the sky as a picture book of mythical figures, the Babylonians and the Egyptians attempted to foretell future events by stargazing; but the prophets of Israel saw the wonders of the heavens as the handiwork of God. The poet of the Psalms was filled with awe as he gazed into the night sky, for he sang: "When 1 consider Thy heavens, the work of Thy fingers, The moon and the stars, which Thou has ordained; What is man, that Thou art mindful of him? And the son of man, that Thou visits him?" Psalm 8:14, A.R.V.

The immensity of the universe challenges the human mind. Here is the perfect handiwork of a Master Designer. With Mazzini, the Italian patriot of the nineteenth century, we can say, "A man learns nothing if he hasn't learned to wonder; and astronomy better than any other science teaches him something of the mystery and grandeur of the universe."

How magnificent is the statement in the opening chapter of Genesis: "And God made two great lights; the greater light to rule the day, and the lesser light to rule the night: He made the stars also." Genesis 1: 16. What a thrilling conception of t lie heavens is revealed in the five simple words, "He made the stars also"! The author of those words writes as if he expects everyone to know without his need of repeating it that the Almighty created the stars. He seems to add this clause as an afterthought-a fact so universally known that it scarcely needed to be stated. What a pity that there are many in this century of enlightenment who refuse to see in the splendor of the heavens the power and order of God who created the universe, and who upholds it with His power.

Why can they not believe, as did John Dryden when he wrote: "This is a piece too fair To be the child of Chance, and not of Care. No Atoms casually together hurled Could ever produce so beautiful a world."

What vistas of thought have been opened to us by the study of the stars! Our world is not what Dr. Harlow Shapley once called it-merely a "little gob of earth, with its splash of ocean, wisp of atmosphere, and smear of biology." No, it is a planet in the solar system, and our Sun and its attending planets are a part of the giant Galaxy, and the Galaxy is a part of the infinite universe, created and upheld by the Eternal One.

"The Heavens Declare"

IF THE STARS SHOULD APPEAR one night in a thousand years," said Ralph Waldo Emerson, "how would men believe and adore; and preserve for many generations the remembrance of the city of God which had been shown! But every night come out these envoys of beauty, and light the universe with their admonishing smile."

Thus, the miraculous lamps of the sky, because we see them often, become commonplace to us. We rush headlong in the rut of everyday existence, failing to lift our eyes to the pageant of the stars, the

eternal jewels of night. The suns of the universe blaze with varicolored lights that vie with the rainbow for beauty. Look through a small telescope and you will see bright red stars and shimmering blue ones in the constellation of Orion, brilliant white stars such as Sirius, yellow stars like our Sun and the great star Capella, and vivid orange spheres, of which Arcturus is one. Look up into the dome of night on an autumn evening and you will see stretching diagonally from northeast to southwest across the sky the jeweled belt of the Milky Way. What seems to be a cloud of light resolves itself into unnumbered individual stars when viewed through a large telescope.

The Glory of the Starry Sky

"No sight that the human eyes can look upon is more provocative of awe than is the night sky scattered thick with stars," says Llewelyn Powys. We have marred nature by exploiting her resources, and we have destroyed the beauty of the starry night with flashing neon signs and glaring headlights. Thousands of people have stood, as 1 have, on a mountaintop in the stillness of a dark night and watched as "the heavens declare the glory of God." If we observed the stars more frequently the experience might shrink our egos and put the sense of wonder in our hearts. As Hermann Hagedorn says in his poem:

We are such little men when the stars come out,
So small under the open maw of the night,
That we must shout and pound the table and drive wild,
And gather dollars and madly dance and drink deep,
And send the great birds flying, and drop death.
When the stars come out we are such little men
That we must arm ourselves in glare and thunder,
Or cave in on our own dry littleness.

We are such little men when the stars come out!
Ah, God behind the stars, touch with Your finger
This mite of meaningless dust and give it substance.
1 am so little, under the frown of the night!
Be You my body, You my eyes, my lips,
My hands, my feet, my heartbeat and my hunger,
That 1 may face the infinite spaces, and live;
And stand in quietness, when the stars come out.

In silent grandeur our Sun shines in the heavens-a giant sphere, 864,000 miles in diameter, composed of incandescent gases. Its surface temperature is believed to be about 10,000 degrees Fahrenheit, but its terrific heat at the center of the ball must be at least 35,000,000 Fahrenheit. According to some estimates, more than 4,000,000 tons of the Sun's materials are poured off into space every second, yet its heat and light are apparently not diminished. What is the secret? If we could fathom this mystery, we might also understand the miracle of the light that blazes from a billion stars in our Galaxy, many of them so large that they dwarf our Sun.

Then consider the immensity of space in which planets, suns, and systems have been set. Our yardstick of measurement for the universe cannot be the mile, for if we attempt such reckoning we will be hopelessly bewildered. Instead of miles we must adopt the light-year as the measure of distances in the universe, and the maze of figures and the myriads of zeros this produces is beyond our comprehension. A light-year is the distance that light, moving at a speed of 186,000 miles per second, travels in one year. Although this is equivalent to some 6,000,000,000,000 miles, yet our immense universe has made even this giant yardstick inadequate to measure the actual vastness of space.

Staggering Speed in the Heavens

Rays from the Sun reach our Earth in 8.5 minutes; but light from the nearest star must travel through space for more than four years to strike our eye! Sirius, the brightest star in the sky, is 8.6 light-years from us, while Arcturus is 33 light years away. Stretch your imagination to its utmost in the attempt

to comprehend the eternity of the universe. Light which reaches us from the fiery cluster of suns in Hercules left there some 34,000 years ago. That light was ceaselessly traveling through space for centuries and millenniums at 11,000,000 miles a minute! Light from the Andromeda Nebula, one of the nearest extra galactic galaxies, travels some 750,000 years before it reaches us.

Look beyond our Milky Way system to the spiral nebulae island universes moving through space on a trackless course and try to comprehend the fact that each may contain a billion suns. Realize, too, that an entire spiral nebula can be seen with the naked eye merely as a blob of light. Who can ponder these facts without saying, "The heavens declare the glory of God?

Today, the largest telescopes are able to reach more than 500,000,000 light years into the universe. If these figures stagger our minds, they also open the infinite vistas of the universe to us and proclaim the immensity of the heavens. In the words of the Scriptures we can say, "Behold the height of the stars, how high they are!" Job 22: 12.

The Weight of the Earth

If the Earth could be put on huge scales, we would find that it weighs 6,600,000,000,000,000,000,000 tons. This seems stupendous, indeed; but when we find that the Sun is 332,000 times as massive as the Earth, and that there are other stars many times as heavy as the Sun, our planet becomes a mere particle of dust. These heavenly bodies have been accurately weighed; they are parts of the harmonious whole, held by a divine force which guides them in their proper courses. No mightier demonstration of the Creator's handiwork could be found in all nature! How fitting it is for the Bible to depict the Eternal One as "upholding all things by the word of His power." Hebrews 1:3.

Amos, in his task of herding sheep in the days of ancient Israel, watched the silent stars above the hills of Palestine. Some of the wonder of God's creation filled his soul, and when he called his people to a revival of justice and true religion he said, "Seek Him that makes the seven stars and Orion." Amos 5:8. His message has much more significance today than it did when it was uttered some twenty-five hundred years ago, since telescopes have revealed many secrets of the Pleiades and Orion which were then unknown.

The Pleiades are an open cluster of stars bound closely together and moving through space on parallel paths with a common motion. Long before science discovered the wonderful laws of the universe which rule the suns as they swing on their appointed courses, men observed this group of stars. Viewed through a small telescope, this cluster looks like "a brilliant array of diamonds on a black background."

When telescopes are turned on the constellation of Orion, a pageant of glory is revealed. We can understand why it is one of the sublime spots in the heavens as we read the astronomers' description of the Great Nebula in Orion. They write in these words: "The soft greenish hue of the nebulous mass, gradually dimming toward the edge of the field, its erratic though immobile shadings, smooth and mellow in spots, hard and sharp elsewhere, together with the diamond like scintillation of the four closely packed stars of the trapezium, present a picture of unsurpassed beauty." The immensity of the star clusters and nebulae, the harmony of their motion, and their perfection and beauty, are an eternal message from the Creator emblazoned in the night sky.

"No man can be a lover of astronomy and an atheist at the same time," are the wise words of Denison Olmsted, nineteenth-century astronomer of Yale University. Before a gathering of five thousand scientists Dr. Robert A. Millikan testified: I have, in effect, fingerprinted God in the heavens. 1 found a Creator continually on the Job. 1 bear witness that the teachings of science are extraordinarily like the preaching of Jesus in that nature is at bottom benevolent and good."

The Exactness of Astronomy

When we look at an accurate clock we are reminded of the exactness of movement in the universe, for the motion of the stars is the basis of our timekeeping. We set our watches by the movement of the Earth, and on every clear night astronomers at the United States Naval Observatory make photographic observations of the stars and record them on three official clocks buried in underground vaults. Latest improvements, according to A. Frederick Collins, "have given the United States the most accurate time in the world, and it is now possible to determine it with an accuracy of 0.00l or 0.002 of a second."

There is no loss of time in the clock of the universe, although all of its parts are moving at terrific velocities. The suns and planets keep their appointed course on the skyways with a schedule that reveals

infinite exactness. The Moon travels around the Earth at a speed of some 2,300 miles an hour. Our Earth hurtles forward at about 18.50 miles per second on its annual 600,000,000-mile journey around the Sun. The Sun is likewise rushing forward at some 12 miles per second, carrying the moving planets, asteroids, comets, and meteors with it. In like manner all the stars are speeding through space in their appointed courses; and, in turn, the entire galactic system is revolving at a tremendous speed around a central axis in the heavens.

Concerning the law and order of the universe, Forest R. Moulton, well-known astronomer, has declared: "It is to the glory of astronomy that in it man started on the pathway to science. How interesting it is that the supreme discovery of science-the orderliness of the universe should have been discovered in the inaccessibly remote heavens before it was found in things near at hand. The very distances of the celestial bodies naturally made them objects of wonder. Such phenomena as the annual migrations of the sun, resulting in the seasons, and the progressions of the phases of the moon [occurred] frequently enough to be remembered and not so frequently as to become commonplace."

Modern science proves that this immense universe is a perfect unit, moving according to the laws of the Creator. Though we live on one of the minute particles we call Earth, we are a part of the universe. Our bodies are made of the same chemical elements found on the Sun and on the distant stars. Dr. Henry Norris Russell, head of the department of astronomy and director of the observatory of Princeton University, declares: "We find ourselves faced with the conception of a universe wholly orderly in every part. The contemplation of this glorious order produces, as the mind begins to realize it, a feeling which can only be called reverence."

That this vast cosmos is the handiwork of God, the Master Designer, is clearly stated by Paul the apostle when he affirms that "all things were created by Him, and for Him: and He is before all things, and by Him all things consist." Colossians 1:16-17. The meaning of these words is amplified in Weymouth's translation, which reads: "Through Him the universe is one harmonious whole."

We live in a universe of miracles which we cannot deny miracles couched in the language of God. As we explore the immensities of the starry sky and stand in awe of the illimitable power displayed, we can sum up the wonder of it all in seven simple words: "The heavens declare the glory of God."

"The Seeing Eye"

FROM TIME IMMEMORIAL the outposts of the starry sky have beckoned to the mind of the adventurous in much the same way that tales of precious treasure enthralled the imagination of knights in the court of Queen Elizabeth. For thousands of years man's only instrument for studying the stars was the unaided eye, and with it he could see some three thousand stars. The first practical telescope, invented in the seventeenth century, opened new vistas to the astronomer; but it was not until modern giant telescopes were built that sufficient seeing power was obtained for actual exploration of the heavens.

In 1609 Galileo Galilei, an Italian scientist, made a visit to Venice, where he learned of a new invention by a Dutchman, Hans Lippershey, that would make objects look closer and larger. Of this important discovery Galileo wrote as follows in his book, The Sidereal Messenger:

"About ten months ago a rumor came to our cars that an optical instrument had been elaborated by a Dutchman, by the aid of which visible objects, even though far distant from the eye of the observer, were distinctly seen as if near at hand; and some stories of this marvelous effect were bandied about, to which some gave credence and which others denied. The same was confirmed to me a few days after by a letter sent from Paris by the noble Frenchman Jacob Badovere, which at length was the reason that 1 applied myself entirely to seeking out the theory and discovering the means by which 1 might arrive at the invention of a similar instrument, an end which 1 attained a little later, from considerations of the theory of refraction. And 1 first prepared a tube of lead, in the ends of which 1 fitted two glass lenses, both plane on one side, one being spherically convex, the other concave, on the other side."

The Discoveries of Galileo

Galileo immediately began his experiments with the "optic glass," as he called it. (The invention was soon given the name telescope, taken from the two Greek roots: tele, meaning far off, and skopos, from a word meaning "to see.") He studied the Moon with his first telescope, a small tube twenty inches long with a magnifying power of only three diameters. He came to the conclusion "that the surface of the Moon

is not perfectly smooth, free from inequalities and exactly spherical, as a large school of philosophers considers with regard to the Moon and the other heavenly bodies, but on the contrary, it is full of inequalities, uneven, full of hollows and protuberances, just like the surface of the Earth itself, which is varied everywhere by lofty mountains and deep valleys."

Desiring to see more wonders, Galileo went back to his workshop to construct a larger instrument. At last he was able to grind and polish the lenses for a telescope forty-nine inches long, having a magnifying power of thirty-two diameters. With this glass he made startling discoveries about the planets, the Sun, and the Moon. For the first time man was able to see four of the moons of Jupiter. Saturn had been visible to the naked eye; but now, with the telescope, the strange rings of the planet could be seen. The phases of Venus, which Copernicus had said would someday be seen, were observed by the astronomer. Galileo's students saw the mountains and craters of the Moon, and sunspots on the solar disk. At last the Copernican system, which had been scorned by many, could be proved true by "the seeing eye"-the telescope.

The work of Galileo was acknowledged so widely that the Catholic Church soon took it into account, and the scientist was brought into conflict with the Roman Inquisition. Although a good church member, Galileo held that the expressions of the Bible which described the Sun as moving around the Earth were figures of speech in everyday language, even as we speak of the Sun rising and setting today. He did not believe that the Scriptures taught that the Earth was the center of the universe.

The church accused the scientist of heresy, and at the age of sixty-nine Galileo was tried and imprisoned because he taught that the Earth and planets moved around the Sun. Crushed by the action of Romanists, the scientist "confessed" his "error."

Dr. I. Bernard Cohen makes this observation: "One can only wonder at the indomitable spirit that enabled Galileo shamed, confined, ill, his major work placed on the Index of Prohibited Books-to complete his last major work, The New Sciences, the publication of which bad to be arranged surreptitiously." It may be of interest to know that Galileo's books were not removed from the Catholic Index until 1822, although the accuracy of his findings had long been proved.

Johannes Kepler soon seized upon the fundamental principles of the telescope, and the instrument he made had definite advantages over Galileo's model, since it used a convex lens with short focus for the eyepiece. Although it inverted the image, this was no serious difficulty for astronomical observations. In the preface to his Dioptrics, Kepler wrote concerning the wonders of the telescope in these words: "O telescope, instrument of much knowledge, more precious than any scepter! Is not he who holds thee in his hand made king and lord of the works of God? Truly All that is overhead, the mighty orbs With all their motions, thou does subjugate To man's intelligence."

Soon larger telescopes were built, and some were so long and unwieldy that the lens was mounted on poles 300 feet from the eyepiece. However, the invention of the achromatic lens which refracts light without decomposing it into its constituent colors brought the telescope back to practical proportions which permitted it to be mounted and equipped with a driving clock to keep the celestial object in the field of the astronomer's vision. Christian Huygens, a Dutch scientist of the seventeenth century, saw the surface of Mars so clearly with one of the large instruments that he was able to make drawings of the markings and from these came the first study of the rotation of that planet.

All of the early telescopes were of the refracting type-that is, the light passed through lenses to produce the magnification. Then James Gregory, a Scotsman, invented the reflecting telescope, which was constructed so that by means of a parabolic mirror incoming rays of light were reflected to a smaller eyepiece, which focused them to form a magnified image.

The reflecting telescope possesses several distinct advantages over the refracting type. It is cheaper to construct and may be made on an immense scale, since it requires a comparatively short tube to mount a set of large mirrors. It has the power to concentrate light of all colors at the same focus, thus preventing chromatic aberration. Then, too, optical glass perfect enough for giant lenses has not been made, and. if it were possible to make them, the amount of light lost by absorption as it passed through thicker lenses would prevent observations from being of great value. The reflector does not allow the light to enter the glass, and, therefore, a cheaper quality of glass may be used in its construction.

In the first half of the nineteenth century the refracting and reflecting types of telescopes were about equal in the estimation of American astronomers. Harvard College installed a 15-inch refracting telescope in 1847, and in the following decades larger instruments of the same type were provided for the University of Chicago Observatory, the U.S. Naval Observatory, Lick Observatory, and Yerkes Observatory. The great 40-inch refractor at Yerkes Observatory is the largest of this type ever constructed.

Giant Reflecting Telescopes of Today

At the turn of the twentieth century, however, the advantages of the reflecting telescope were recognized, and. several giant instruments of this type have been built during the last fifty years. Reflectors in American observatories include the 40-inch Ritchey-Chretien Telescope at the U.S. Naval Observatory, the 60-inch Common-Rockefeller Telescope and the 61 inch Fecker Telescope at Flarvard College Observatory. The 42 inch telescope at Lowell Observatory, the 36.25 inch Crossley Telescope at Lick Observatory, the 82-inch McDonald Telescope at Yerkes Observatory station in Texas, the 100 inch Hooker Telescope at Mount Wilson Observatory, and the 200 inch Hale Telescope at Palomar Observatory.

Pioneering the way for a giant instrument on Mount Wilson, near Pasadena, California, George Ellery Hale was able to interest wealthy John D. Hooker in the 60 inch reflector that was completed in 1908. Not satisfied with this instrument, Hooker proposed that a 100 inch reflecting telescope be built. Steps were immediately taken toward the construction of this instrument, and a glass company in France cast the huge five-ton disk. When it had cooled, the disk seemed to be a failure, for there were bubbles in the glass. Months passed and the glass lay in the shop untouched; but finally it was decided that the seeming flaws would be no hindrance to the finished mirror, and George W. Ritchey went to work supervising the grinding of the disk. The giant dome was built on Mount Wilson, and in the autumn of 1917 the Hooker Telescope was complete. The night of November 1, when the mighty instrument was tested, is described by Collins in graphic words:

"Came then the crucial time on a November night when it was turned on the sky and given its first practical test. Hale had invited Alfred Noyes, the English poet, who was then in California, to be his guest on this momentous occasion, and with Adams they went into the silent dome. Ritchey was also on the mountain but he would not join the others for, as he said, he did not care to be present when it was finally proved his last endeavor was a failure."

The excited astronomers trained the gigantic telescope on the planet Jupiter, and, as Ritchey had dismally predicted, the men saw six or seven overlapping images filling the eyepiece. Walter S. Adams described the view in these words: It appeared as if the surface of the mirror had been distorted into a number of facets, each of which was contributing its own image." Hale would not admit defeat, and his suggestion was that the distortion might be due to the heat of the Sun which the mirror had absorbed during the day as the shutter of the dome had been open while the final adjustments of the telescope were being made.

The disappointed scientists waited for the mirror to cool to normal temperature, and at three o'clock in the morning they returned to the dome. Since Jupiter was too low in the west to be viewed, they focused the reflector on Vega. Through the eyepiece they saw a sharp, dazzling point of light. The great instrument was ready for its great work!

The greatest "seeing eye" man had yet constructed had proved a success, and was ready for new explorations into the heavens. The Mount Wilson Observatory has demonstrated that Ralph W. Emerson was right when he said, "Of all tools, an observatory is the most sublime." Galileo's "optic glass" increased the light collecting some eighty times over the power of the pupil of the eye, and made visible almost a half million stars. In contrast with that pioneer attempt, the 100 inch Hooker Telescope gathers about 160,00 times as much light as the eye. With it one could detect the light of a candle 5,000 miles away! Thousands of millions of stars have been recorded photographically by this accurate instrument, and the majesty of God's handiwork has been revealed in its breath-taking splendor.

The Hale Telescope on Palomar Mountain

But astronomers are always thinking of greater telescopes, and the 200 inch reflecting Hale Telescope at the Palomar Observatory is the culmination of many dreams. Years of planning, which included heartbreaking disappointments, seem to be part of the story of the mammoth mirrors and the colossal domes of modern telescopes. The Palomar Observatory, located on Palomar Mountain, 5,600 feet above sea level, in Southern California, has a metal dome 137 feet in diameter and almost the same height. The marvelous 14.50 ton mirror, with an over-all diameter of 201 inches, cast out of special Pyrex glass, is polished to within two millionths of an inch of a true paraboloid. But as Dr. Frank Preston explains: "The 200 inch mirror for Mount Palomar is made of glass, not for any optical property, not ' for transparency,

not for electrical resistivity, but for its mechanical properties. For in that mirror, the silver or aluminum is on the front face, not the back one, and the light never passes through the glass. The glass is a purely mechanical support for the almost infinitesimally thin mirror."

The skeleton tube of steel, 60 feet long and 22 feet in diameter, and its auxiliary equipment, has a total weight of almost a million pounds. There are 60 small motors in the installation; yet so perfectly is the telescope mounted on its bearing (which, by the way, is 45 feet in diameter) that it requires only a one-twelfth horsepower motor to swing it about.

Seven long years of careful study and computation were necessary to prepare the plans and specifications for this colossus. Engineering skill was severely tested and a myriad theories were considered and rejected before the blueprints and models were ready. Truly this telescope "is a precision instrument gone Gargantuan."

Theoretically at least, the Hale Telescope gathers four times as much light as is received in the 100 inch reflector on Mount Wilson. The 200 inch telescope reaches out into space some three times farther than the 100 inch reflector, thus giving the larger instrument a volume about 30 times as great as is observable with the Hooker Telescope on Mount Wilson.

Tools of the Modern Astronomer

Someone may say, "I'd like to see the Moon through the Hale Telescope, for 1 understand it brings it to within 25 miles of the Earth." To use it for such observation would be like using a 10 ton bulldozer to fill a small hole in the garden. The giant glass is reserved for more important study; for, as Dr. John A.Anderson, of California Institute of Technology, explains, it is dedicated to work which cannot be done by other instruments. It is 1or those observations which require its greater light-gathering power: first, for large-scale spectroscopic work on the brighter stars, and, second, for a study of the very faintest extra galactic nebulae."

A new 120 inch reflector telescope is being erected at the Lick Observatory, Mount Hamilton, California. Within the dome of the new building, perched on the mountain that overlooks the Santa Clara Valley, is the glass blank that will be ground and polished until it is ready to be mounted. The observatory is 97 feet in diameter and 94 feet high. When the telescope is completed, three of the largest reflecting telescopes in the world will be located in California.

Telescopes are but one of the precision instruments used today in the study of the stars. Much equipment that is less spectacular must be employed in connection with telescopes for scientific measurements and special research. The micrometer is one such instrument used to measure minute angles and distances. It is particularly valuable in the study of double stars, for with the micrometer the angular distance separating the two stars can be accurately detected.

The spectroscope is another valuable instrument used in conjunction with the telescope. It is based upon the spectrum of color which Sir Isaac Newton discovered with his triangular glass prism. The light from any heavenly body, such as the Sun, stars, or nebulae, is first focused on a narrow slit, in the spectroscope, and then it is collimated (made parallel), and finally directed through a prism which produces the spectrum of the light. No two elements in the universe have identical spectra. Therefore it is possible to tabulate each element; and when the light from a star is studied, the elements of which it is composed can be easily recognized.

Not only is the composition of stars revealed by the spectroscope, but also the speeds at which they are moving toward or away from the observer. Light moves in waves somewhat similar to sound waves, and the principle by which they move can be illustrated by the whistle of a train. As the engine approaches, the whistle apparently has a different wave length from what it has when the train is speeding away from us. In a somewhat similar manner the wave length of the light as observed by means of the spectroscope reveals the radial velocity of a star.

The camera is a most valuable part of the equipment of the telescope, since the modern astronomer spends far more time studying photographic plates made by the camera attached to the telescope than in actually looking through the eyepiece. The first successful astronomical photograph was taken by Dr. John William Draper in 1840, when he made a daguerreotype of the Moon. With modern cameras especially adapted for star photography, plates of the entire heavens have been made systematically, and they are being studied constantly. George P. Bond, the first to photograph a star, once wrote: "The plates, once secured, can be laid by for future study by daylight and at leisure. The record is there, with no room for

doubt or mistakes as to its fidelity."

The 48 inch Schmidt photographic telescope at Palomar Observatory is a companion of the 200 inch giant in its exploration of space. To this huge sky camera has been assigned the task of photographing the entire visible hemisphere of the heavens. The photographing is being done on 1,000 pairs of plates 14 inches square, one red-sensitive, one blue-sensitive, for each shot. In this way the camera is searching out the spots in the heavens that seem to hold special significance for the 200 inch telescope to examine. This Palomar Observatory photographic telescope, like the Hale Telescope, is pushbutton in its operation. By the push of a button it is set on a desired area of the sky, by the push of other buttons photographic plates are inserted or removed. Plate handling and developing rooms are adjacent to the camera to expedite the photographic processes.

What Secrets Have Been Discovered?

What have astronomers discovered with telescopes during the past century? The list of achievements is long and in many respects too technical for the uninitiated. Marvelous new knowledge of our Sun, its sunspots, atmosphere, and energy, has been gathered and evaluated. Eclipses of the Sun and the Moon have been observed at every opportunity and records of such phenomena accumulated. The search for comets is a fascinating adventure in which both professional and amateur astronomers are constantly indulging. Meteors receive attention, and much information concerning the number and kind that fall upon our planet has been obtained.

The planets of our solar system have not been neglected. Mars has been carefully scrutinized for strange markings and for signs of life; Jupiter and Saturn have been objects of special study because of their numerous moons or satellites. The diligent search for and discovery of the planet Pluto is one of the astronomical achievements of the twentieth century.

The doors of the universe have been opened wider by such astronomers as Dr. Harlow Shapley and Dr. Edwin Hubble, who have used the giant telescopes to probe into celestial secrets. Modern instruments prove that there are many other systems in the universe comparable to our Galaxy, which we call the Milky Way. Tens of thousands of nebulae have been discovered and catalogued. As Collins writes: "Out in the depths of space are hazy patches of light which are just visible on photographic plates after long exposure with the best of astronomy graphic cameras, and these are Island Universes that are just as large as, and, very likely, much larger than, our own, while other and greater systems may be revealed by telescopes of greater light-gathering power." - The Greatest Eye in the World, page 138.

The spiral and spheroid systems of stars are far beyond our Galaxy. Only the excellent photography of the observatories has brought accurate knowledge of these glories in the depths of the universe. The Andromeda Nebula is more than 750,000 light-years from the Earth, yet there are many nebula less than a thousandth as large as Andromeda, which appear on photographic plates. If astronomers had greater telescopes, they might ascertain that these nebulae are as large as, or larger than, those that have been studied; but because they are so far away-perhaps a billion light-years-their size is unknown.

Telescopes such as the one on Palomar Mountain may enlarge the visible universe beyond our most daring dreams. Of these possibilities Professor Edwin B. Frost writes: "New conceptions of a tremendous universe may come to thoughtful persons of today, as the discoveries of the hardy voyagers of the fifteenth century came to the European people of that time. These conceptions are the rightful intellectual possessions of the men and women of today. We are a part of this splendid universe."

Modern astronomy confirms the omnipotence of God who created all things. "His greatness is unsearchable," declares the psalmist; and the glory of His universe is magnified more fully by the telescope and the research of astronomy than by any other branch of science. The telescope, one J the most accurate instruments ever designed, is a key that opens the door so that men may glimpse the glorious realms of the King of the universe.

"Strong Foundations of the Earth"

THIS EARTH, so important and massive to us because it is our home, is only a pin point when compared with the giant suns whirling through space. Perhaps we are puzzled as to why our world should be considered in a study of astronomy; but, after all, it is one of the planets of the solar system, and the more we know about it the more it may help us to understand distant planets and stars.

The planet on which we live weighs 6,600,000,000,000,000,000,000 tons, yet is so delicately balanced that it seems as if the Creator "hanged the Earth upon nothing." Job 26:7. Our world, 7,913 miles in diameter, is not a perfect sphere, for like many middle-aged persons it has a slight bulge at the waist. The diameter at the equator is 27 miles greater than the diameter at the poles. If we ask an astronomer what causes this, he will answer, "Centrifugal force." A complete rotation of the Earth in 24 hours of mean solar time makes it necessary for its equator to move at a speed of almost 1,000 miles an hour. This swift revolution creates enough centrifugal force to produce the bulge at the equator.

Actually, then, what we call terra firma is not as solid as we might imagine. It is a blessing that the Earth is not rigid, for if it were, a bulge could not be formed. The oceans contribute to the equatorial bulge of our spinning globe, and their level is the basis for the measurements of the Earth's diameter. The Designer of our world balanced it perfectly to make it habitable for man. As we consider these things, we remember Job's counsel, "Speak to the Earth, and it shall teach thee." Job 12:8.

The Earth-A Well-Designed Home

A planet on which human beings can live must have certain definite specifications. It must have a temperature that is neither too cold nor too hot. Indeed, as Doctor Frederick L. Whipple points out, it is a miracle how the Sun maintains "a suitable temperature range, only 180 degrees out of millions, and does not raise the temperature too high." A planet on which man can live must have an atmosphere which protects him from sudden temperature changes and from dangerous missiles flying through space.

In addition to a suitable temperature, the Earth fulfills our needs in many ways. We have changes in the seasons of spring, summer, autumn, and winter. What causes the seasons? Why do we have longer and shorter days? Our warm weather does not come because our planet is nearer the Sun at that time of the year, though some people think so. Actually the Sun is some 3,000,000 miles nearer the Earth when we have winter in the Northern Hemisphere than it is during summer.

Our Earth is tipped, or inclined, on its axis 23.50 degrees away from the perpendicular plane in which it moves around the Sun. If the axis always stood at right angles to the plane of orbit, we would have no variation in the seasons in any one locality. But with the axis always tipped at the same angle, and always pointing in the same direction, first the North Pole is nearest the Sun and receives more of its direct rays, and then, in turn, the South Pole receives its share. This produces longer days for the season we call "summer," in the Northern Hemisphere, while at the same time it causes shorter days in the southern half of the world. When the Earth moves around to the opposite side of the Sun, the seasons are reversed in the two hemispheres.

The inspired writer of the book of Genesis recognized the fact that the seasons are caused by planetary motion, for of the heavenly bodies it is recorded that God said: "Let them be for signs, and for seasons, and for days, and years." Genesis 1: 14.

The Earth's atmosphere is not so simple a matter as many people suppose. It is an ocean of air reaching upward from the Earth for more than 2,000 miles and is very complex in its composition. The troposphere is the layer of air reaching from the Earth's surface to a height of 5 to 10 miles. While this shell constitutes less than one third of 1 per cent of the total volume of the atmosphere, its densely packed molecules make up almost 80 per cent of the total air mass. The stratosphere, the second layer of our atmosphere, reaches about 50 miles above the troposphere. Radar and V-2. rockets have aided man in his study of this region.

Above the stratosphere is a huge, rarefied layer known as the ionosphere. It reaches at least 2,ooo miles out from the Earth's surface. Although it comprises 97 per cent of atmospheric space, yet the air is so rare that it contains less than half of 1 per cent of the air mass. Gas particles are only one ten millionth as plentiful there as at sea level.

Our life depends on the layer of gases known as the troposphere, because it contains the air we breathe. It was anciently Called the firmament, and is essential in maintaining an even temperature. It acts as an insulator to keep the temperature from rising too high at noon and from falling too low at night.

Saved From a Rain of Death

Our atmosphere renders a special protection to man by shielding him from the millions of meteoric particles flying through space. These could be more destructive than any atom bomb yet invented if they

came hurtling to the ground. Dr. Whipple explains how the meteor dust particles would render untold harm if they were not burned up by the air surrounding the Earth. He says: "Such a particle would, be no larger than a fair-sized speck of dust, much smaller than an average grain of sand, yet as dangerous to a person as the pistol bullet. Thousands of millions of such particles strike the Earth's atmosphere daily, as faint meteors that can be seen only with a telescope. The meteors visible to the naked eye are several times greater. In the atmosphere these bodies are immediately vaporized by friction with the air."-Earth, Moon, and Planets, page 79. Then, too, the atmosphere shelters us from the impact of falling raindrops. Thus the canopy of the lower atmosphere, reaching up some 6o miles into space, actually protects us from certain death.

In addition to the moving objects, such as meteors and planetary fragments, which are encountered, our Earth is also being pelted by ultra-high-frequency radio impulses and cosmic rays. Our 2,000 mile layer of atmosphere shields us from the majority of these, since it has an absorbing power equivalent to a jacket of lead forty inches thick. However, after many scientific tests, including a series of balloon flights into the stratosphere, rays coming to the Earth have been found to possess two billion electron volts. Dr. Robert A. Millikan and others proved that these powerful rays were penetrating the atmosphere, and in 1925 he named them "cosmic rays." The intensity of the ray's radiation changes with the seasons, with 2 or 3 per cent more mesons being produced in winter than in summer in the Northern Hemisphere.

We seldom think of the menace of deadly rays from which we are shielded, yet Dr. Whipple declares: "The oxygen, nitrogen, and other elements in the atmosphere cut out all of the far ultraviolet rays below the limit of ozone. These rays are used medically to kill bacteria in the air. Could they all reach the Earth it is doubtful that life in any form could exist." Earth, Moon, and Planets, page 81.

Man and the animals carry on their life activities in this thin layer of air that is so shallow compared with the other dimensions of our globe that it might well be represented by the skin of a large apple. Aviators who fly at high altitudes must carry supplies of oxygen with them or use airplanes designed with pressurized cabins. The reason for this is that the air rapidly thins out as we leave the surface of the Earth. Above an altitude of five miles the atmosphere is too rare to support life.

As we walk about in this sea of air we are actually under a heavy burden, for at sea level the atmosphere presses down upon us at about 14.7 pounds per square inch. This means that an average-sized person is weighted down with some seventeen tons of air! It does not bother us, however, because the air pressure from outside is equalized by that which permeates our bodies.

To the student of the Bible it is interesting to know that thousands, of years ago the writer of the book of Job declared that God "sees under the whole heaven; to make the weight for the winds." Job 28:24, 25. Men could not fathom this inspired statement, and they said the Bible must be wrong. They tried to weigh air by filling a bladder and putting it on the scales and then emptying it of air and weighing it again. But the bladder showed no change of weight since it was surrounded by air, and full or empty it displaced nearly the same pressure of air. The empty bladder displaces less air than the full one, because of its collapsed condition. The larger displacement, and hence greater buoyancy, of the inflated balloon is compensated by the greater weight of air contained therein. It was not until Torricelli, a student of Galileo, made his famous experiments with a glass tube (which maintained practically a constant displacement) and a bowl of mercury that the weight of air was proved.

Imagine the thrill that came to Torricelli as he put his theory to the test. "What were the emotions with which he saw the column of mercury fall," writes Charles Talbot Porter, and after completing the oscillations produced by its momentum, stand at a height of between 29 and 30 inches, in equilibrium with the pressure of the atmosphere on the same area of the mercury in the vessel; or with which he realized the fact that the glass tube above the column of mercury enclosed the absolute void, then first obtained by man and which was ever after to be known as the Torricellian vacuum!"

Yes, the Earth carries a heavy load of air upon its surface. Multiplying the pressure of the atmosphere by the total area of the world's surface, gives us the total weight of the air about 5,633,000,000,000,000 tons!

The Air Is in Constant Motion

During World War II many new facts concerning the circulation of air on a global scale were gathered, partly as the result of the high-altitude balloons sent up with meteorological equipment. It is

known that the air does not remain still and become stagnant; it moves over the Earth's surface in definite patterns. Cold air masses come down from the polar regions, while warm air masses spread out from the equatorial region. When the warm air and cold air meet, they do not mix readily. Each mass of air tries to remain intact, with the cold air sliding beneath the warm layer of air. Thus the sky becomes a field of battle as clouds form which often produce rain or snow, cyclones, and even tornadoes.

There are regular circuits in which the winds travel. A great stream of air flowing from west to east is found at the northern edge of the trade-wind regions, and wind speeds up to 250 miles an hour have been recorded. In the Northern Hemisphere the trade winds come from the northeast, and in the Southern Hemisphere they travel in a regular course from the southeast. Some distance above the trade winds are other winds blowing in the opposite direction. These are known as counter trades. Solomon, who never knew of modern science and who never traveled far from his kingdom in Palestine, wrote these inspired words which have been proved correct as the wonders of nature unfold: "The wind goes toward the south, and turned about unto the north. It whirled about continually, and the wind returned again according to his circuits." Ecclesiastes 1:6.

Full confirmation of the Bible statement that the air "whirls about continually" is given by Sir Napier Shaw, who writes: "Of the millions of tons of air which form the atmosphere nearly the whole is moving. The regions of calm at the surface at any one time, taken altogether, do not form a large part of the Earth's surface, and above the surface calm regions are still rarer. Let us remember that the motion of the air is always 'circulation.' Air cannot move forward or backward or upward or downward without displacing other air in front of it and being replaced by other air behind it, though the circulation may be quite local and limited in extent, as is frequently the case when warm air rises or cold air sinks. In the course of investigations into the life history of surface air currents in the Meteorological Office we have traced air over long stretches of the surface of the Atlantic. We have found, on one occasion, the shores of Greenland to be fed with air that left the middle of the Atlantic four days previously, while in the course of six days air traveled from Spitsbergen to join the northeast trade wind off the west coast of Africa. On another occasion the air that formed the wind off the south of Ireland was traced back to the north of Africa, but that which blew at the opening of the Channel two days later came from Hudson Bay, via the Azores." - Popular Science Library, volume 1, pages 139,140.

A Mammoth Water System

The atmosphere contains a part of the Earth's vast water system. In fact, water surrounds the Earth in profusion, since the atmosphere weighs over 5,000,000,000,000,000 tons, and the water on the Earth weighs at least 250 times as much. The wonderful hydrologic cycle begins when the moisture in the atmosphere condenses and falls to the earth as rain, snow, or hail. The writer of the book of Job asks: "Has thou entered into the treasures of the snow? Or has thou seen the treasures of the hail?" Job 38:22. In the mountain regions the snow is stored in winter, and in the summer it melts and flows down to the parched valleys. The writer of Ecclesiastes describes this process in poetic language: "All the rivers run into the sea; yet the sea is not full; unto the place from whence the rivers come, thither they return again." Ecclesiastes 1:7.

The rain or snow is distributed in several ways. Some of it returns to the atmosphere by evaporation. Another part finds its way to streams and eventually flows into the sea. The remainder soaks into the ground as subsurface water, which may be evaporated directly from the soil, assimilated by plants, or by devious underground streams find its way to the ocean.

Evaporation is the process by which water is changed from a liquid to a vapor. This requires energy, which is supplied by the Sun's beat. Fundamentally, then, the hydrologic cycle is dependent on solar radiation in order to change water from its liquid form on the Earth's surface to water in the vapor state in the atmosphere. Thus the Sun is linked closely with the Earth in creating nature's system of supplying water to the thirsty land.

Indeed, the Sun, the air, and the water each plays its part in making a world where man, animals, and vegetation can thrive. When the Earth came from the hands of the Creator it was perfect. "He created it not in vain, He formed it to be inhabited." Isaiah 45:18. Although marred by sin, the Earth continues to reveal the love and the wisdom of the Eternal One who created all things by the word of His power.

"The Eternal is the real God, a living God, an everlasting King. Who by His power made the Earth, Who by His wisdom founded the world, And by His knowledge spread heaven out. Jeremiah 10:10-

12, Moffatt.

"Glory of the Moon"

UPON LEAVING OUR EARTH on an imaginary journey through the universe, we first of all visit our nearest neighbor-the Moon. If we could travel in a jet plane shooting through space at 1,00 miles an hour it would take us about 10 days to reach the Moon; but if we could fly at the speed of light we would arrive in only 1.3 seconds! It is well for us to know all we can about this silver orb, since it is the only satellite of our planet, and because it has a constant and important influence upon the Earth.

In making astronomical calculations, the Moon has long been a valuable factor. The earliest scientific study of the heavens concerned the motions of the Moon and their effect on the calendar. As Sir Richard A. Proctor declares: "Altogether the most important circumstance in what may be called the history of the Moon is the part which she has played in assisting the progress of modern exact astronomy. It is not saying too much to assert that if the Earth had had no satellite the law of gravitation would never have been discovered." Clyde Fisher, The Story of the Moon, page 14.

The Moon is so large and so near the Earth that it benefits the inhabitants in all latitudes by illuminating the night. Its light is especially appreciated in the arctic regions during the long polar night when the Sun does not rise above the horizon for weeks. Shakespeare has well said that the Moon's an arrant thief, And her pale fire she snatches from the Sun.

Shining in all its borrowed splendor, the full Moon is by far the brightest ornament in the sky, since the light it gives is 60,000 times that which we receive from Vega, one of the most brilliant stars in the heavens.

How often have we beheld the Moon in its series of monthly changes? First, we have seen the slender crescent of the new Moon in the western sky soon after sunset. Then night after night we have watched it until it became a glorious full Moon. Later, it diminished and its beauty faded in its last quarter. What we call "phases" of the Moon are actually the various ways in which we see the Sun shining on the Moon's surface during its revolution around the Earth.

There is a great difference in the amount of light reflected by the Moon in its various phases. For example, it is nine times as bright at full Moon as it is at the quarter; but its reflected light fades into insignificance when compared with the Sun. If we could fill the whole visible sky with full Moons we would have only about one fifth the light that comes to us from the Sun. If the Moon were a better reflector, our nights would be much brighter, but its dusky surface returns only 7 per cent of the sunlight that shines upon it. In fact, the Earth receives more light from the Sun in a few seconds than it receives by moonlight in a year.

While the Moon is a small heavenly body, it is large enough to distort the shape of the Earth, and its gravitational pull produces tides in oceans and lakes. Although the Moon's average distance from our planet is 238,857 miles, yet its tide-raising force is one of the mighty demonstrations of natural law. The ebb and flow of the ocean tides is produced by the attraction, or gravitational pull, of the Moon. This force was recognized by Sir Isaac Newton in connection with his discovery of the law of gravitation. The Moon has 7 per cent more pull on that part of the Earth nearest it than on the part farthest away. No invention of man, no harness of human devising, can hold back the seas as they roar toward the shore; yet the silent, inexorable force of the Moon controls the rise and fall of the ocean tides twice every day. Truly, this satellite, one of the smallest bodies in our solar system, is "a faithful witness in heaven." Psalm 89:37.

The Moon and the Tides

Another powerful influence upon the tides is the pull of the Sun. Since this giant body is so much farther away than the Moon it exerts only about 30 per cent as much force upon the Earth; but when the Sun and the Moon are in line-as they are twice every month-their combined forces produce what are known as spring tides.

If there were no tides the shipping of the world would quickly be affected, for there are many harbors that depend upon the ebb and flow of the tides for navigation. The average rise and fall of the tide upon most of the ocean shores is several feet. In some places it is less, but in others, much higher. The highest tides -in the world are in the Bay of Fundy, Nova Scotia, where they sometimes reach a peak of seventy feet. The exact time of the tides is so important to navigation that tables are carefully calculated

and published in advance for all important ports and harbors.

The Moon, traveling at about 2,300 miles an hour, makes a complete revolution around the Earth in approximately 29.50 days. During this period it goes through all the phases of the new Moon, quarters, and full Moon. This period, which is almost the same as a calendar month, is known as the synodic month. Actually the Moon makes the revolution in two days less time, but the Earth itself has moved forward some thirty degrees, and therefore the Moon must travel farther to make the revolution seem complete to us.

One of the awe-inspiring phenomena of the heavens is a lunar eclipse, when, without warning, a black shadow begins to creep across the silver disk of the full Moon. Before astronomers were able to explain it scientifically, people saw in this mysterious event a sign of terrible calamity; but today we understand how an eclipse of the Moon takes place. Since the relative positions of the Earth and the Moon are constantly changing, there are times when the Moon passes directly behind the Earth. When this occurs, the sunlight does not reach the Moon, and we say there is a total eclipse. Sometimes the Moon slips through part of the Earth's shadow, in which case we see a partial eclipse.

Eclipses have assisted scientific discovery. The round shadow of our Earth crossing the face of the Moon is one of the proofs that our world is round. Also at the time of eclipses astronomers have been able to find out interesting facts concerning the temperature of the Moon's surface.

Eclipses of the Moon have sometimes had a significant influence on history. On his fourth voyage to the New World, Christopher Columbus and some of his crew were marooned at Santa Gloria, on the island of Jamaica. The Indians brought the mariners provisions for a time, but soon they tired of helping Columbus and his fifty loyal men. When the supplies were exhausted, he asked the natives for more food; but they refused his request. Then Columbus, with some knowledge of astronomy, found a Regiomontanus Ephemerides in the ship's library which gave predictions of eclipses thirty years ahead. From what he learned in this book Columbus told the natives that the Moon would be darkened on the night of February 29, 1504. As he warned them of the coming total eclipse he made them believe it was divine warning of punishment to come because they had refused to bring food to the crew. Some of the Indians scoffed at the idea. Ferdinand Columbus, historian of the voyage, told what happened then: "But, the eclipse beginning at the rising of the Moon, and augmenting as she ascended, the Indians took heed, and were so frightened that with great howling and lamentation they came running from every direction to the ships laden with provisions, praying the Admiral to intercede by all means with God on their behalf. That He might not visit His wrath upon them, promising for the future diligently to furnish all that they stood in need of. To this the Admiral replied that he wished to converse somewhat with God; and retired while the eclipse lasted, they all the while crying out to him to aid them. And when the Admiral observed that the totality of the eclipse was finished, and that the Moon would soon shine forth, he issued from his cabin, saying that he had supplicated his God and made prayers for them, and had promised Him in their names that henceforth they would be good and use the Christians well, fetching them provisions and necessary things, and that therefore God had forgiven them, in token of which pardon they would see the wrath and inflammation of the moon pass away. This taking effect with his words, they rendered many thanks to the Admiral and praised his God, so continuing until the eclipse was ended. From that time forward they always took care to provide what they had need of."

Eclipses of the Moon have been an irrefutable proof of many historical events. The timetable of the heavens is always accurate. Therefore, a lunar eclipse of April 6, 648 BC, gives historians an exact date in Greek chronology; and the eclipse of the Moon on March 13, 3 BC, which took place at the time of Herod's death, helps to fix the date of the birth of Christ.

The Moon always shows its same side to us, since it rotates on its axis in the same period of time that it revolves around the Earth. However, we are able to peep over its north and south poles from time to time, as it tips back and forth some 6.50 degrees. In this way, astronomers have actually seen and photographed 59 per cent of the Moon's surface.

If, in our imaginary travels, we could stop on the Moon, we would see a rough and barren landscape-one of the driest spots in the universe! We would soon find, perhaps to our sorrow, that we could not live there, for astronomers tell us it has no air, no water, and no sound. Stars disappear behind and reappear from back of the Moon without any fading or displacement, which is a definite indication that there is no atmosphere. Without air or moisture the temperature variations of the Moon are very great. At noon we would find a fierce heat of over 200 Degrees Fahrenheit, which is near the boiling point of water on our Earth; but by the following midnight the severe cold would make life impossible, for the thermometer would drop to some 240 Fahrenheit below zero. Think of attempting to live in a place where the temperature varied over 400 Degrees in twenty four hours!

Mountains and Craters of the Moon

As early as 1610, Galileo was able to observe mountains and craters on the Moon. John Milton, who may have visited with the Italian scientist, describes this astronomer's nocturnal study of the moon in these lines: "The Moon, whose orb Through optic glass the Tuscan artist views At evening, from the top of Fesok Or in Valdarno, to descry new lands, Rivers or mountains in her spotty globe."

Astronomy has increased man's knowledge of our satellite a thousand fold since that day. On the face of the Moon is a record of its history. Its rugged features tell us that tremendous forces were once active there, and they left craters and rough terrain over much of its surface. Over 32,000 craters have been charted by astronomers, and if there are as many in proportion on the side of the Moon which we never see, the total is well over 60,000. In addition to these there are thousands of tiny craters, each of which seems almost like "a tiny pinprick in the lunar skin." Many of the most prominent craters have been named after famous scientists. Among the largest are crater Clavius, with a maximum diameter of 146 miles and a depth of nearly 17,000 feet; crater Copernicus, 56 miles in diameter and 11,000 feet deep; and crater Tycho, 54 miles in diameter and 12,000 feet deep. Rugged mountain ranges sprawl across the Moon's surface, and some peaks rise to a height of more than 25,000 feet.

Early observations of the silver orb revealed large flat basins or plains which were once thought to be bodies of water. They were given the Latin name maria (seas), and this has been retained although it is now known that they are not bodies of water. However, Ralph B. Baldwin says, "It is beyond question that the seas were once liquid, for they have overflowed thousands of craters and left only occasional high spots to mark their existence." - The Face of the Moon, page 38. If they were ever liquid, they were molten lava instead of water. Among these romantically named "seas" are the Sea of Showers, the Sea of Tranquillity, and the Sea of Serenity. One of the largest, Mare Imbrium (Sea of Showers), is 750 miles across at its widest point.

Bright rays, or white streaks, radiate from the surface of the larger craters such as Tycho. If the craters are great "explosion pits," as some astronomers believe, then the rays could well be pulverized rock dust and sand extending out from the craters. Indeed, there are so many interesting and unusual formations on the Moon that their observation could well occupy the total life study of some astronomers.

Strange as it may seem, the pull of gravitation on the Moon is only about one sixth that of the Earth; and it would, therefore, be a fat man's paradise, for he would weigh only one sixth as much as he did here at home. If we could live there we would have unusual powers, too. When we played baseball we would be able to throw a ball six times as far as we can on a sand-lot diamond here, and if we can jump over a three-foot fence here, we could jump over an 18 foot wall on the Moon.

As the result of radar experiments conducted in 1946, scientists may have discovered a new method of studying the Moon. Radar signals were transmitted toward the satellite by a special antenna, and within 2.20 seconds the echoes returned. Technicians found that the signals could be picked up successfully at moonrise and moonset. These radar contacts will assist in the study of radio waves in the atmosphere and in new types of radar communication. They make it possible to measure the distance to the Moon to the tenth of a mile, and may be of help to the astronomer in solving some of the mysteries surrounding the surface features of our nearest neighbor.

The poetic beauty of the Moon has not been destroyed even though scientific study has revealed strange and interesting data concerning it. Dr. Clyde Fisher summarizes the unusual facts about our satellite in these words: "The Moon must be a desolate world plunged in eternal silence, with no blue sky, no twilight or dawn, no colorful sunrises or sunsets, no meteor flashes, no northern lights or southern lights, no clouds or fog, no mist or rain, no hail or snow, no wind, no sun dogs or moon dogs, no sun halos or moon halos, no rainbows, and no life." -The Story of the Moon, page 203.

Yet this queen of the night remains "a faithful witness in heaven," and its glory is not dimmed. Whirling through space at a speed of almost 40 miles a second, revolving around our Earth, yet never varying from its ordered course, our Moon silently and continually testifies to the power of the Creator. Jeremiah, prophet of old, declared that God has given "the ordinances of the Moon." Jeremiah 31:35. These laws, which are clearly demonstrated throughout the universe, testify that "the hand that made us is divine."

"He Goes Forth in His Might"

WHEN MEN OF ANCIENT TIMES turned from the worship of the true God, it was natural for them to adore the Sun, the brightest heavenly body, because it gave heat and light to animal and vegetable life. In ancient times, the sun-god of Babylon was depicted on clay tablets as coming out of the Door of Sunrise. The Phoenicians called the sun-god Baal, while the Egyptians named it Ra, and pictured the solar deity with a circle or disk on his head from which extended bright rays representing the Sun.

Festivals such as Christmas Day can be traced back to pagan sun worship. The heathen watched anxiously as the shadows lengthened for six months when the Sun moved southward for they wondered if its warmth and light might be leaving never to return. They offered sacrifices to their idols and begged the Sun to return. About December 22 the sun worshipers noticed the shadows beginning to shorten, and they held a feast to honor the birthday, or return, of the Sun. It was in the fifth century AD that the pagan festival the "Feast of the Undying Sun" was transferred into the day honoring the birth of Christ, and thus it came to be called Sunday, actually in honor of the solar body.

The true power of the Sun, its benefits to man, its size and distance-these have been left for modern science to fathom. Indeed, we stand in awe of the Sun when we learn of the tremendous amount of energy it pours forth year after year; and there is no explanation for this unceasing power except that the omnipotent Creator has decreed: "Let there be light." It is a monument of God's sustaining power.

The benefits derived from this heavenly body are so great, that if its light were withdrawn for only a short time all living things would come to a tragic end. In addition to the vital rays that come from the Sun, the winds, water supply, and tidal power on our planet are produced by solar energy. In fact, the Sun furnishes all the available energy we have, with the exception of volcanoes, hot springs, lunar tides, and atomic energy. Our hydroelectric power, as well as the wind that drives boats and windmills, is produced by the Sun's energy that is poured on our world. The coal and oil so essential for modern industry are actually sunlight that has been stored away for millenniums in underground treasure houses. They were once forests or living creatures that depended on solar energy for their existence before these organisms met sudden destruction. In considering the Sun's benefits we should remember Sir John Herschel's words: "Giant size and giant strength are ugly qualities without beneficence. But the Sun is the almoner of the Almighty, the delegated dispenser to us of light and warmth, as well as the center of attraction; and as such the immediate source of all our comforts, and indeed of the very possibility of our existence on Earth."

The Sun, the center of our solar system, has a mass 329,320 times that of the Earth. Because of its immense size and weight, it holds the planets in their orbits by the force of gravity. According to the latest and most exact measurements, the Earth is 93,005,000 miles from the Sun. In a jet-propelled plane an aviator flying at the speed of 1,000 miles an hour could cover an equal distance in a little over ten years of nonstop travel; yet, at the velocity of light, a ray of the Sun's energy reaches us in eight and one-third minutes.

At its equator the Sun makes a complete rotation in twenty five days, whirling at a speed of about 4,500 miles per hour, or some four times that of the Earth. Does the Sun have a flattening at the poles similar to that of our globe? The question has never been answered as it is almost impossible to see the surface of the Sun. It is believed that such a flattening must exist, but no way has been found to measure it.

A Power Plant Supreme

We are indeed dealing with a giant when we start measuring the Sun, for it would require 109 Earth's lined up side by side to stretch across its 864,000 mile diameter. But when we talk of its heat we soon find it is beyond our comprehension. Astronomers declare that the Sun is blazing with a surface temperature of 10,000 Degrees Fahrenheit. and an almost unbelievable 35,000,000 degrees Fahrenheit. at its center. As a power plant, the Sun is without a peer. Every passing second 4,000,000 tons of its mass are believed to change into radiant energy estimated to measure half a septillion (24 Zeros) horsepower! Yet of this radiation only one part in two billions reaches us. Every hour the Earth receives as much energy as there is in twenty-one billion tons of coal, and if all the energy that strikes only 200 square miles of the Earth's surface in a day could be utilized, it would be equivalent to all the fuel used in the world during the same twenty-four-hour period. Sufficient energy strikes the Earth in one year to melt a layer of ice 114 feet thick over its entire surface. If you wonder why you cannot look directly at the Sun, remember that every square inch of its surface shines with 300,000 candle power.

"What Are the Spots?"

One of the most publicized features of the Sun is its sunspots. In the seventeenth century Galileo studied the black spots, and he decided that they must be on the Sun itself, for he watched them travel from cast to west. He stated his opinion in these words: "Repeated observations have finally convinced me that these spots are substances on the surface of the solar body where they are continuously produced and where they are also dissolved, some in shorter and others in longer periods. And by the rotation of the Sun, which completes its period in about a lunar month, they are carried round the Sun; an important occurrence in itself and still more so for its significance."

Two hundred years passed and the mystery of the spots had not been solved. Sir John Herschel, nineteenth-century astronomer, could ask, "But what are the spots?" Today it is generally believed that these dark areas which appear on the luminous surface of the Sun are solar storms or disturbances, and they may be compared to whirlwinds or whirlpools. They are of many sizes, from tiny spots only a few hundred miles in diameter to mammoth double ones over 100,000 miles across. .Furthermore, it has been found that the number of sunspots increases and wanes over an irregular period of about eleven years.

A giant sunspot was observed by astronomers on July 26, 1946, when a flaming eruption seared the face of the Sun. Within ten minutes the spot grew to such size and intensity that it was thirty times as bright as the solar surface. In a little over an hour the flame like emanation had shot out 350,000 miles from the surface of the Sun. It fell back gradually, and by the next day nothing remained of this disturbance. The largest sunspot on record, covering a total area of about 6,300,000,000 square miles, was seen in April, 1947. In fact, it was so large that a hundred of our Earth's could have been dropped into it.

When great magnetic storms occur on the Sun they frequently affect the magnetic field of the Earth. The July, 1946, eruption paralyzed short wave radio transmission on the side of our planet where the Sun was shining. By actual measurement, one radio frequency had an increase in static 10,000 times the normal amount.

Solar Prominences

There is constant motion in the solar "atmosphere" because of the high temperature. Since the density or pressure is not high, the atoms collide less frequently than do the molecules of air on our Earth; however, they are traveling so much faster that when they do hit the collision is about 20 times as violent. The Sun's surface area is called the photosphere, meaning "region of light." It consists of layers of gaseous clouds which are so thick they produce the effect of solidness. As the atmospheric density gradually decreases, the photosphere fades into the chromosphere. This region extends out from the Sun for thousands of miles, and may be seen clearly at times of total eclipse. In fact, until the spectrohelioscope was invented, this glowing envelope of gas surrounding the Sun was visible only when it flashed forth for a few moments during a total eclipse. Now, however, regular studies are made at solar observatories, and any unusual prominences are carefully checked and photographed.

What are the Sun prominences? They are geyser like flames of tremendous size and velocity which emanate from the chromosphere. Astronomers have watched the fiery gases shoot out to a height of 25o,oco miles in 33 minutes. In describing one particular prominence, Dr. Donald H. Menzel says: "The prominence continued to rise rapidly, with a speed of about 400,000 miles per hour, more than 100 miles a second." Only an hour and twenty minutes after it was first photographed in the observatory, the material had "blown far beyond the range of the instrument." - Our Sun, page 167. After blowing off with terrific force, the prominences usually appear to slide back into the Sun without apparent loss of matter; however, there are some solar explosions which seem to blow the gases far into space.

The glorious halo that extends for as much as a million miles in all directions from the Sun is called the corona. Its brilliant streamers are irregular in shape and delicate in structure. Sometimes this pearly, irregular crown of glory appears in various colors, and it gives off half as much light as the full Moon.

Elements on the Sun

The Sun is an interesting study for the chemist because of the many elements found there. To date a total of 66 of more than go elements have been discovered on the giant sphere. Two of the most recently

discovered are thorium and gold. Helium was found in the Sun's spectrum in 1868, long before it was known to exist on the Earth. A British astronomer, who was viewing an eclipse in India, saw a bright yellow line in the spectroscope which did not correspond to am known element. He named it helium, from the Greek word for the sun. It was not until 1895 that this helium was found and identified in natural gas. Next to hydrogen, helium is the lightest of gases, and it has the advantage of not being explosive. It has been discovered in sufficient quantities in the Southwestern part of the United States to be used to lift the nation's dirigibles and other lighter-than-air craft.

Another gas, whose presence on the Sun has been proved, is carbon monoxide. For many years it was believed that the gas was a part of the Sun's atmosphere, but only recently has it been positively identified. Carbon monoxide is concentrated high in the atmosphere, where the temperature is about 5,000, Centigrade. On the Earth, carbon monoxide is rare and irregularly distributed. It has been found, for example, high above the Jungfraujoch in Switzerland, but not over Mount Wilson in California.

Solar Eclipses

Nature's most dramatic and awe-inspiring spectacle is a total eclipse of the Sun. Think of man riding through space on his tiny planet, snatching a few moments' glimpse of the secrets of' this giant, luminous star, secrets that may help us better understand the working of our universe. Solar eclipses are fairly frequent, but they cover only a small area of the Earth at any one time. Scientists, newspapermen, and radio announcers will travel to distant lands to "cover" an eclipse. For days and weeks they prepare every detail of the operation so that all will proceed smoothly during the few minutes never much over seven-that the eclipse lasts.

Solar eclipses occur when the Moon moves directly between the Earth and the Sun. This takes place from two to five times each year; however, a total eclipse strikes the same spot on an average of only once every 360 years.

Ancient eclipses have assisted historians in verifying the dates of events. For example, the eclipse Of 585 BC took place while the Medes and Lydians were in a prolonged war. When the mysterious darkness enveloped the armies, the soldiers were so frightened they threw down their weapons and made peace. Chinese astronomers many centuries ago studied the solar motions and forecast eclipses. In fact, the earliest solar eclipse on record is found in the Chinese book Shu Ching, which relates how the shadow of the moon moving across the Sun caused panic in the nation. It seems that the two court astronomers had failed to predict the time of the eclipse and thus warn the royal court of the event. It came without warning and frightened the people. Therefore, a law was made by the Chinese ruler which said that if an eclipse came "before the time, astronomers are to be killed without respite; and being behind the time they are to be slain without reprieve." Evidently it was dangerous to be a scientist in those days! This eclipse occurred on October 22, 2137 BC.

The noted French astronomer Arago gives a most interesting description of a total eclipse of the Sun and its effect upon the watchers. He writes: "The hour of the commencement of the eclipse drew nigh. More than twenty thousand persons, with smoked glasses in their hands, were examining the radiant globe projected upon an azure sky. Although armed with our powerful telescopes, we had hardly begun to discern the small notch on the western limb of the Sun, when an immense exclamation, formed by the blending together of twenty thousand different voices, announced to us that we had anticipated by only a few seconds, the observation made with the unaided eye by twenty thousand astronomers equipped for the occasion, whose first essay this was. During the interval that elapsed between this moment and the almost total disappearance of the Sun, we remarked nothing worthy of relation, in the countenances of so many spectators. But when the Sun, reduced to a very narrow filament, began to throw upon the horizon only a very feeble light, a sort of uneasiness seized upon all; every person felt a desire to communicate his impressions to those around him. Hence arose a deep murmur, resembling that sent forth by the distant ocean after a tempest. The hum of voices increased in intensity as the solar crescent grew more slender; at length the crescent disappeared, darkness suddenly succeeded light, and an absolute silence marked this phase of the eclipse, with as great precision as did the pendulum of our astronomical clock. The phenomenon in its magnificence, had triumphed over the petulance of youth, over the levity which certain persons assume as a sign of superiority, over the noisy indifference of which soldiers usually make profession. A profound stillness also reigned in the air; the birds bad ceased to sing.

"After an interval of solemn expectation, which lasted about two minutes, transports of joy, shouts

of enthusiastic applause, saluted with the same accord, the same spontaneous feeling, the first reappearance of the rays of the sun. To a condition of melancholy produced by sentiments of an indefinable nature, there succeeded a lively and intelligent feeling of satisfaction which no one sought to escape from, or moderate the impulses of. To the majority of the public, the phenomenon had arrived at its term. The other phases of the eclipse had few attentive spectators beyond the persons devoted especially to astronomical pursuits."

The Value of Eclipse Study

What do astronomers learn from the study of solar eclipses? First of all, they are able to test the speed of the Earth's rotation and to check any variations in it. They are also able to compare the accuracy of their predictions of eclipses with the event, for the split second the body of the Moon appears to touch the Sun is recorded and checked with the forecasted time. In this way astronomers are able to make more accurate predictions for future eclipses. As the result of such checking it has been found that our days are getting longer. However, one does not need to be concerned over this discovery, for the amount is only 1,000 of a second in a hundred years!

Scientists also make use of eclipses to check the validity of the Einstein theory of relativity. When a group of stars have been photographed during an eclipse, it has been found from the pictures made at the time that some stars appear around the edge of the Sun. This is caused by the bending of the light as it passes the Sun on its way toward the Earth. The result is that the stars' images are slightly out of place from where the stars actually are. If the same group of stars are photographed at night several months later, when the Sun has moved out of that portion of the sky, the picture does not reveal any bent light rays, and the stars appear in their true position. By measuring the difference in the stars' positions, astronomers are able to check on the theory of relativity.

During the few tense moments of an eclipse, scientists also study the corona, make photographs of the glowing gases, and find new facts about the upper layers of atmosphere surrounding our Earth.

We must come to realize that the Sun, that distant yellow ball of fiery gases, is not only the source of almost all our energy, but also has an influence upon our weather, our radio communication, and the growth of plant life. In addition to these effects, the Sun also makes possible a great deal of the beauty of our world. The blue of the sky, the glorious colors of the sunset, the refreshing quality of the rain, the snow of winter, the wondrous rainbow-all these and many more exist because of the Sun's activity.

"The Sun is the primary factor governing weather conditions," points out Dr. Menzel. "The mere existence of the seasons is proof enough. We have winter when the Sun's rays strike glancing and summer when they are more nearly vertical and thus concentrate their heat on a smaller area of surface." - Our Sun, page 309.

We may expect that as the knowledge of weather conditions increases, attempts at long-range forecasting of climatic changes become more accurate, and the effects of the Sun on climatic changes may be more fully understood.

Solar Magnetic Storms

The solar "magnetic storms" seem to be linked with brilliant displays of the northern lights, the Aurora Borealis, and other auroral phenomena, as well as "blacking out" radio transmission. Radio waves are able to travel long distances because of several electrified layers in the Earth's atmosphere. These ionized layers, known as the ionosphere, are at heights ranging from 70 to 250 miles. They reflect the longer radio waves so that these waves bounce back and forth between the Earth and these layers, thus traveling long distances. We now know that the ionosphere is produced by solar radiation. Therefore, when there are solar disturbances, including sunspots and solar prominences, the electrified layers above our Earth are affected. Sometimes these disturbances cause "radio fadeout," which may last from a few minutes to several hours. Today various governments are co-operating in the study of the ionosphere by establishing a network of stations to make scientific observations and report their findings. How severe the solar magnetic storms may be is seldom realized by the average person. Dr. Menzel says: "Magnetic storms cause effects on the Earth's surface as well as in the higher atmosphere. Changes in magnetism induce large electric currents in land lines. The stray currents may blow fuses, cause teletypes to emit unintelligible messages without benefit of operator, or interfere with telephone and power operation. At times of severe disturbances, large numbers of men must go out to repair the damage occasioned by solar activity." - Our

Sun, pages 306, 307.

"The Light of Life"

The Creator gave light to this world soon after it was called into existence. "God said, Let there be light: and there was light. And God saw the light, that it was good." Genesis 1:3,4. Science is able to describe many of the characteristics of light, and can tell us how rapidly it travels; but science has not solved the divine mystery of what light is.

The light of the Sun when passed through a prism is resolved into the various colors of which it is composed. Each color has its own particular wave length and produces differing chemical effects in the laboratory. For example, the wave length of violet light from the prism is 1/62,000 of an inch. In like manner it takes 48,000 light waves to the inch to produce green, and 40,000 for yellow. It is an amazing fact that 756,000,000,000,000 waves strike your eye each second to give you the sensation of seeing violet color. How wonderful is the eye of man to be able to receive such waves of light!

The Sun's rays have a powerful effect upon all life. We know that the ultraviolet rays, for example, help to keep down disease by destroying harmful bacteria. Certain colors of the sunlight assist growing plants in using the carbon-dioxide gas in the air, a food-producing process known as "photosynthesis." As man learns more about solar radiation, we may see new varieties of plants as well as more abundant harvests.

What wonderful spiritual lessons may be drawn from the Sun and its light! The Bible has proclaimed Jesus Christ to be the Sun of Righteousness" who comes with healing. He is also "the Light of the world." The psalmist wrote: "The Lord God is a sun and shield: the Lord will give grace and glory." Psalm 84:11. Even as man is dependent upon the Sun for light and physical health, so he is dependent upon Christ for 'I the true Light, which lights every man that comes into the world." His radiant love, shining into the human heart, destroys the virus of sin and produces a new creation.

As we comprehend something of the tremendous power, heat, and light of the Sun, and how it continues to shine on with unabated energy, we are reminded of the poetry of the Psalms, where the Sun is described as "a strong man" who rejoices in running a race. We can better understand what the Master Teacher meant when He used sunlight as an illustration of the inexhaustible power available to the Christian. He said: I am the Light of the world: he that follows Me shall not walk in darkness, but shall have the light of life." John 8:12.

"To the Planets"

AS THE GREEKS looked at the five glowing lights that moved across the heavens they called them "planets," which, in their language, means "wanderers." The planets were distinguished from "fixed stars" because they moved among them, and because they gave a steady light in contrast to the twinkling of the stars.

The Greeks and Romans wove legends around these heavenly bodies, and these myths continue to color our speech and literature today. Venus was designated the goddess of life; Mercury, because it was closest to the Sun and moved so rapidly, was considered the messenger of the gods; while the largest planet was named Jupiter, after the chief of the pagan deities. Mars, the brilliant red planet, was lord of war; and Saturn, god of seed sowing.

Science has fathomed many characteristics of the planets, however, and today we know them to be fellow travelers in our solar system moving around the mighty monarch, the Sun. Furthermore, the family has grown, for instead of only five planets, we now know of eight in addition to the Earth. Within the last two hundred years three of the distant spheres have been located and studied. The motions of each of the planets have been charted, and it is known that all of them move about the Sun in the same direction. The minerals and gases of which they are composed have been analyzed with the aid of the spectroscope, and many of their moons have been seen. The planets in the order of distance from the Sun are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.

While the planets vary in size, they all sink into Insignificance when compared with the Sun, which contains over 99 per cent of all the matter in our solar system. Jupiter has a diameter eleven times as great as that of the Earth and is 317 times as massive. But if all nine of the planets were rolled into one mammoth ball, it would still take 600 such balls, all rolled into one, to equal the Sun!

Meet Little Mercury

Since we desire to become better acquainted with each of our planetary neighbors, let us start with Mercury, the smallest sphere, that snuggles close to the Sun. This planet is only 3,100 miles in diameter-about the size of our Moon; and because its average distance is only 36,000,000 miles from the Sun it frequently receives ten times as much heat and light per unit area as we do on the Earth.

We can easily understand why Mercury has been likened to a swift messenger when we find that it makes a complete revolution around the Sun in 88 days, less than one fourth the time it takes for our Earth to make the journey. Mercury turns on its axis in approximately the same time it revolves around the Sun, therefore it has a perpetual bright side, since one face is always turned in that direction. Astronomers have found that the temperature on the sunny side of the planet rises to about 770 Degrees Fahrenheit. On the dark side, where no rays of the Sun ever penetrate, it must be extremely cold and dismal.

Since Mercury moves in an orbit relatively close to the Sun, the only time it can be seen is just before sunrise and soon after sunset. In the northern hemisphere it is observed best in April and October. Careful study of the planet by skilled astronomers reveals dark spots and other markings on its surface, but these are sometimes obscured by cloud like patches.

Bright and Beautiful Venus

Traveling out from Mercury some 31,000,000 miles, we find Venus, the brightest heavenly body we normally see, except for the Sun and Moon. The light which reaches us from this planet is 15 times as bright as is that from Sirius, the most brilliant star.

Venus has been termed the "twin sister" of our Earth, since it is almost the same size and because the two planets are closer together in space than any others in the solar system. This planet has a diameter of about 7,700 miles, and it receives about twice as much heat and light from the Sun as we do. Mystery continues to shroud Venus because it is surrounded by a heavy atmosphere which makes close study of' surface markings impossible. The clouds may indicate that there is abundant water on the planet, and they may help create a temperate atmosphere that is favorable to life as we know it.

The exact period of the planet's rotation is not known, although it is generally believed that it rotates slowly, probably taking from three to six weeks to turn once on its axis. If this is true, then a "day" on Venus would equal a month or more on the Earth. But a "year" on our sister planet is only about seven and a half months, for it makes a complete circuit around the Sun in 225 days. Venus has the honor of being both our "evening star" and "morning star" at certain times in the year. One may frequently see this brilliant planet in the daytime if he knows in what part of the sky to look.

Because Mercury and Venus have orbits that are inside the orbit of the Earth, it is sometimes possible to observe these planets moving across the face of the Sun. Such a phenomenon is known as a "transit." The next transit of Venus visible in North America will not occur until June 6, 2004.

After considering the two planets that are nearer the Sun than we are, we turn our eyes toward a bright, reddish-colored "wanderer" that moves in an orbit beyond that of the Earth's. Mars, a sphere only 4,216 miles in diameter and one ninth as massive as the Earth, swings about the Sun at a mean distance of 141,500,000 miles. Since it is farther from the Sun than we are, it is never possible for us to observe it in a crescent phase as we can often see in Venus and Mercury.

Mars, the Nearest of Neighbors

Mars offers to the astronomer the best surface view of any of the planets, and as early as 1636 a Neopolitan astronomer saw some of its distinct markings. Sir William Herschel made a careful study of the white markings on the poles of the planet, and in 1783 he wrote: "The analogy between Mars and the Earth is perhaps by far the greatest in the whole solar system." The atmosphere of this planet makes it possible to study its surface, especially during periods when its orbit brings it to within 34,000,000 miles of our telescopes. The geographical features most frequently observed on Mars are the white polar caps, which may be snow, and the many straight lines, which were once called "canals." The coloring of the planet's surface is of great beauty. Antoniadi, of France, as he viewed Mars, described it in these words: "Not only

green areas, but also grayish or blue surfaces, turned to brown, to brown-lilac or to carmine, while other green or bluish regions remained unchanged. The colors were almost exactly those of leaves that fall from trees in summer and autumn in our latitudes." - Translation from La Planete Mars, quoted by Whipple, Earth, Moon and Planets, page 221.

If we lived on this neighboring planet we would find that a day there is approximately the same length as ours; in fact, it is only about 38 minutes longer. But its year is almost twice as long as ours, since it requires 687 days for Mars to make a revolution around the Sun.

Mars is the first planet we have considered, other than our Earth, that has a moon. indeed, it is blessed with two tiny satellites which have been named Deimos (Fear) and Phobos (Flight). Deimos is 7.50 miles in diameter, while Phobos is about 15. If we lived on Mars we would have the unusual pleasure of seeing one moon race through the heavens from west to east while the other moved from cast to west, the same way that ours travels. Phobos produces this phenomenon by revolving faster than its mother planet.

The Giant of the Solar System

Almost 400,000,000 miles from our Earth is the next planet, Jupiter. This giant of the solar system is 1,312 times the size and 317 times the mass of the Earth, and its average distance from the Sun is 483,200,000 miles. A "year" on Jupiter equals 11.86 of our years. But though it takes much longer for it to revolve around the Sun, it turns on its axis in only 9 hours and 55 minutes. So a busy person, who finds the days short here, would be in a dither on Jupiter, since a day there is less than half as long as ours. The planet turns so rapidly that the centrifugal force of rotation causes a bulge, thus making the diameter through the equator almost 4,000 miles more than from pole to pole.

The surface markings of this king of planets have not been clearly charted because of the cloud mass that always encircles it. Astronomers studying the composition of these great clouds with the spectrograph have analyzed the elements they contain. They have found two of the principal gases in the clouds to be ammonia and methane. The Sun shining on the giant sphere makes it resemble a golden disk with irregular red or brown splotches of clouds across it.

Jupiter has a large family of moons, for twelve have been discovered. With his first small telescope, Galileo saw four of the satellites on January 7, 1610. Later that month he described what he had seen in a letter to a friend. He said the moons of Jupiter moved around the planet "Just as Venus and Mercury, and perhaps the other planets, move round the Sun." Ganymede, the largest moon, exceeds Mercury in size. It was by studying the moons of Jupiter that astronomers discovered the velocity of light. Until a Danish scientist, Olaus Roemer, worked on the problem it was believed that the movement of light was instantaneous. However, in 1675 this astronomer found that eclipses of the moons of Jupiter occurred 16 minutes earlier when the Earth was moving toward that planet than when it was moving away from it, which made a difference in the distance between them at conjunction and opposition. He deduced that this must be caused by the time it took for light to travel the extra distance, and his calculations revealed that light traveled at the velocity of about 186,000 miles a second. The twelfth satellite of Jupiter was found by accident on September 2-9, 1951, on a photograph taken on the Hooker telescope on Mount Wilson. Dr. Seth Nicholson, discoverer, followed the satellite carefully for some days to be certain it was not an asteroid or an already known moon. When he felt sure of his discovery he notified Harvard College Observatory, and the news was flashed to the world. Other astronomers quickly verified the accuracy of Dr. Nicholson's work. The latest member of Jupiter's family is one of the outer satellites, which means it is some 14,000,000 miles from the giant planet.

The Jewel of the Night

The gem of the planets is Saturn-a golden yellow ball with encircling rings that shimmer with the light of the Sun. Although the planet is about nine and a half times as far from the Sun as the earth (a mean distance of 886,000,000 miles.), it is one of the brilliant lights of the heavens because it is 734 times as large as our planet. Saturn is also accompanied by nine moons, and Titan, the largest, like one of the satellites of Jupiter, exceeds Mercury in diameter.

Saturn revolves on its axis in 10 hours, 14 minutes. It has a giant orbit around the Sun, and, although it travels at the speed of six miles a second, it requires 29.46 years to complete a revolution, or "year." Saturn is the lightest of all the planets in proportion to its size (only 0.72 the density of water), and

it has a bulge of 7,900 miles at its equator.

But our attention is focused on the unique and glorious rings, for Saturn is the only member of the solar system with such adornments. Half the light that this planet sends us is reflected by these rings, which have been described as "the most purely beautiful object in nature." Galileo had a glimpse of them through his telescope; but he could not explain them since the planet soon passed through the phase where the rings were on edge, and they seemed to disappear. It was a Dutch astronomer, Huygens, who made the first study of them in 1655, and announced their size and composition. These rings -for they are in three parts-are 37,500 miles wide from edge to edge; but they are less than ten miles thick. The outer ring is a golden hue, and is separated from a brighter inner ring by a dark line known as Cassini's division. Inside the bright ring is a shadowy circle called the "crepe I ring. What are these strange rings? They are small fragments of rock or meteor like substance moving in their own orbit about Saturn in complete harmony with the law of momentum and gravitation.

We now turn to the planets that had never been seen by man until the telescope was invented. In 1781, when Sir William Herschel was systematically studying the stars, he found one that moved among the others. He gives his experience in these words: "On Tuesday the 13th of March, between 10 and 11 in the evening, while I was examining the small stars in the neighborhood of H Geminorum, I perceived one that appeared visibly larger than the rest. Being struck with its uncommon magnitude, I compared it to H Geminorum and the small star in the quartile between Auriga and Gemini, and finding it to be much larger than either of them, suspected it to be a comet." - Whipple, Earth, Moon and Planets, pages 35, 36.

It was a planet, however, and received the name Uranus, to conform with the other planets named after mythical gods. Uranus is 31,000 miles in diameter and has an average distance of 1,783,000,000 miles from the Sun. This huge pale green sphere turns rapidly, and a day on this faraway planet lasts only 10 hours and 7 minutes. Because of its distance from us and the hazy atmosphere surrounding it, no distinct permanent markings have ever been seen. However, four moons have been discovered, though they are so very faint only giant telescopes can observe them.

How Neptune Was Found

By watching the seeming irregularities in the movement of Uranus, astronomers discovered a still more distant wanderer, Neptune, in 1846. As early as 1841 John C. Adams, a student in St. John's College, Cambridge, worked on the mathematical problem of explaining, the discrepancy in the path of Uranus. The young man found the solution and went to see Sir George Airy, astronomer royal at Greenwich; but the men did not meet and the astronomer forgot the note that Adams left on his desk. About the same time jean J. Leverrier in France was working on the same problem. He also solved it, and he wrote to the German astronomer, Dr. Johann G. Galle, who immediately turned the telescope of the Berlin Observatory to the place in the sky Leverrier directed and the new planet was discovered within a degree of where it was predicted! This was perhaps the most outstanding achievement of mathematics as related to astronomy, and it further verified the theory of universal gravitation.

William J. Showalter has imagined the planet telling the story of its discovery: "Two astronomers, Adams of England and Leverrier of France, each working without knowing that the other was engaged on the same problem, undertook to diagnose my brother's [Uranus's] case of nerves and to explain his perturbations. Each finally reached the conclusion that the trouble was caused by me, as yet an undiscovered planet.

"They figured that it, though undiscovered, must be nearly a billion miles farther out in space than Uranus; that 1 must be eighty-five times as big and sixteen times as heavy as the earth. They also calculated that it must have a year twice as long as that of Uranus and 165 times as long as the earth's.

"They said that the perturbations of Uranus were due to the fact that every now and then he got between the sun and this hypothetical me, and that the rival pulls of the sun and myself upon him were responsible for his nervousness. And then they, in effect, made a most audacious prophecy. They said that if they were right about it would put in my appearance at a certain hour, on a certain day, in a certain spot of the heavens, to answer whether their conclusions were right or not.

"And, sure enough, it was right there, Johnny-on-the-spot, exactly on schedule time and in my assigned position." - The National Geographic Magazine, August, 1919, Page 157.

With a diameter of about 27,700 miles, according to the latest findings, Neptune is one of the largest planets; but its distance from the Sun is so great (2,796,600,000 miles) it does not look like a disk

until seen through the eyepiece of at least a 12 inch telescope. It requires almost 165 years for Neptune to make one revolution around the Sun. Two moons have been found circling this planet, and they have been named Triton and Nereid.

Pluto, the Far Off Wanderer

If we seem bewildered in this immensity of space, we shall certainly become lost when we journey on to the latest-discovered planet in our solar system, Pluto. After years of research at the observatory at Flagstaff, Arizona, Percival Lowell, in 1914, announced that a Planet X must exist beyond Neptune. He began the task of locating it by mathematical calculations. His research proved to him that the unknown planet was located in a section of the heavens that was thick with stars. This made the work difficult, for the planet was so far away the pin point of light could not be seen readily on photographs, and it moved so slowly it would not move to a darker part of the heavens for a hundred years.

Before Lowell died in 1916, he set a team of young scientists to work photographing this spot in the heavens night after night. A young Kansas farm boy, Clyde Tombaugh by name, had come to the observatory at Flagstaff to learn to be an astronomer. The many photographs that had been made of this part of the heavens were set up in a sequence in a blink machine, which made them flip much as a pad of miniature pictures move when we flip them. Clyde Tombaugh began the work of checking the tiny dots as they flashed past. If he could find one that moved its position it might be the planet. He studied thousands of star dots, and finally in January, 1930, he found one that moved. It was the planet that was later named Pluto!

When the news was released in March of that year, Tornbaugh told this story to an Associated Press reporter: “How would you feel if you saw a new world giving you the high sign from beyond the rim of the solar system? That is what happened to me in the darkroom when 1 was running another bunch of photo-plates through the machine. Just a strange flicker of starlight in a routine day’s work. Excited? I should say so. I just didn’t know what to do or think. Sure, 1 was the first to see it, but the whole Lowell staff has been working on it for a quarter of a century. I was just lucky.”

This far-off “wanderer” is, at its average distance, some 3,670,000,000 miles from the sun. A “year” on Pluto would equal about 248 of ours, for this is the length of time required for it to trek around the sun.

The size of Pluto was determined by Dr. Gerard P. Kuiper, of the Yerkes Observatory, in 1950, while he was a guest observer at the 200-inch Hale Telescope on Palomar Mountain. Though the planet had been discovered twenty years before by Clyde Tombaugh’s study of photographs, the disk of this faraway planet was seen directly by the eye of man for the first time when Dr. Kuiper made his observations visually. He concludes that Pluto has a diameter of only some 3,600 miles, or 46 per cent of that of the Earth, and its mass must be about one tenth of that of our world.

Because the laws of the universe are perfect, it has been possible for astronomers to “find” Neptune and Pluto. When the planet Uranus deviated from the course that mathematical rules based on the behavior of the then-known planets declared it should follow, astronomers realized that another heavenly body must be disturbing its course. Indeed, when Uranus was charted and observed, it was found that it had moved an “intolerable quantity” of two minutes of are, an angle that is barely perceptible to the human eye. Because of such deviations from the laws of the heavens, astronomers set to work to find the cause, and the two distant planets were eventually discovered.

This is the family of planets that moves in an orderly procession about the central Sun. Whether there are other planets out beyond Pluto is a question that cannot be definitely answered. As Dr. Whipple has said: 1f other planets exist they must be considerable fainter than Pluto, which means that they must be either farther away, or smaller.”-Earth, Moon and Planets, pages 43, 44.

These massive spheres accompanied by their moons-31 of which have been seen by astronomers-and a thousand or more asteroids, whirling about in their orbits, declare by their motions that order is heaven’s first law. They demonstrate the omnipotence of the Creator who upholds “all things by the word of His power.”

Wide are the meadows of night
And daisies are shining there,
Tossing their lovely dews,

Glory of The Stars

Lustrous and fair;
And through these sweet fields go,
Wanderers amid the stars,
Venus, Mercury, Uranus, Neptune,
Saturn, Jupiter, Mars.

Attired in their silver, they move,
And circling, whisper and say,
Fair are the blossoming meads of delight Through which we stray.
-Walter de la Mare.

The planets testify to the Creator's love of the beautiful. Venus shimmers with soft radiance and Saturn's rings are a crowning glory. Mars glows with light as from celestial fires, while Jupiter moves majestically with his retinue of satellites. To the sensitive, receptive mind, the Sun and the planets seem to say, "The hand that made us is divine."

"He Made the Worlds"

ONE CLEAR NIGHT a visitor at an observatory in western America was given the privilege of looking through the giant telescope. The astronomer in charge turned the instrument to the constellation of Hercules and focused it so that the mighty cluster of a hundred thousand blazing suns might be seen. The man gazed in silence for some time, and then asked: Is it true, doctor, that 1 am looking at a system of suns like ours, and that there are a hundred thousand of them in that cluster?"

"That's correct," replied the astronomer. "But, of course, those stars are many times brighter than our Sun."

"Could it be possible that there are planets going about those suns like the planets that move around our Sun?"

It would seem very probable that some of those suns have planetary systems; but, of course, we could never hope to see them with our telescopes."

The man thought a moment, and then continued: "Well, if there are planets, do you suppose some of them have climatic conditions similar to that of our earth?"

"It would seem very possible," affirmed the astronomer. "And on those planets there may be intelligent beings like man on this Earth?"

"Why should it not be possible?" returned the man of science.

"Well, sir," said the visitor with a sigh, I am not nearly as worried about who is elected in the political campaign next week as I thought I was."

As the mind grasps the significance of our solar system, expanded today by the discoveries of astronomy, it is natural for us to ask: Is there life on other planets? Are these neighboring worlds inhabited by creatures similar to man and the animals on the Earth? Do other suns, which we call "stars," have planets revolving about them, and do they move in harmony with the laws of the universe?

Astronomy can give no conclusive answer to the questions; but there have been numerous discoveries in recent years which lead to interesting speculations. Atmospheric conditions, as accurately as they are known, would seem to eliminate the possibility of living beings existing on some of the planets, if the requirements for life are similar in other parts of the universe to those on our Earth. Mercury, for example, seems to have no atmosphere. And if the measurement of a maximum temperature of 770 Degrees Fahrenheit is correct, it is difficult to imagine how this terrifically hot sphere could possibly be the abode of life. Conditions on some of the other planets are much more favorable, and we may well believe that they are inhabited.

Alfred Noyes, the English poet, puts these words into the mouth of Sir William Herschel in The Torch-bearers: "I grow aware of an appalling mystery. We, this throng Of midgets, playing, listening, tense and still, Are sailing on a midget ball of dust We call our planet. What does it mean? Oh, God, what can it mean?"

Life on Other Worlds

It is almost impossible for one who has faith in a Creator who "made the worlds" to think that our little planet is the only one that was made to be inhabited. "Can it be," asks H. Spencer Jones, English astronomer, "that throughout the vast deeps of space nowhere but on our own little Earth is life to be found?" The very perfection of the universe testifies to a design in the organization of the heavenly bodies. Dr. R. T. Crawford has well expressed his philosophy of life on other planets when he says: "Not only do I believe that the other planets of our solar system are inhabited, but I believe firmly that the worlds of other solar systems are likewise inhabited. To me it is the smallest thought imaginable to think that this speck of cosmic dust is the only place in the universe that is inhabited by intelligent beings."

This conception of the universe is in harmony with the inspired testimony of the prophet Isaiah. Concerning the purpose of the creation of the Earth, he wrote: "For thus said Jehovah that created the heavens, the God that formed the Earth and made it, that established it and created it not a waste [or, "in vain," margin], that formed it to be inhabited." Isaiah 45:18 A.R.V. Accepting the major premise that God created the Earth for a specific purpose, namely, to be the dwelling place of His creatures, it is logical to believe that His great design calls for some of the other planets to be inhabited.

We must not of necessity conclude, however, that a planet or other heavenly body is purposeless in the eyes of the all-wise Architect if it is not inhabited. There may be other reasons for its existence which man has not fathomed. It has been proved that our Moon is not the abode of life, but we realize that it has other definite purposes for being, and we know that it contributes directly to our Earth.

In considering the possibility of life on other planets, Mars has been most frequently discussed since it offers an excellent opportunity for astronomers to study its peculiar surface markings. Its coloration and distinct lines suggest that vegetation may exist there. Professor William H. Pickering, who devoted over thirty years to special research of Mars, points out that there are three kinds of evidence to justify the belief that it is the abode of life. The first, he declares is "the presence on Mars of conditions which support life. The second kind of evidence is the existence of changeable dark markings of vast extent on the planet's surface. These markings cannot reasonably be accounted for by any other explanation than that they are fields of vegetation. The third kind of evidence is the appearance of surface markings which cannot be accounted for as accidental occurrences of nature. Some are so straight and regular that we can explain them only as the result of intelligent design. Some of them appear to be permanent features of the Martian landscape, and the belief that they are caused by the flow of canals constructed to aid the distribution of water over the planet is the most reasonable explanation that we have."

Do Planets Circle About Other Suns?

The astronomer concludes by saying, I think we are justified in saying that, with the evidence so strong for conditions similar to those found on the Earth, and with vegetable life fairly assured, animal life is almost certain. I am now inclined to consider it possible that even human life, if transported to Mars, might exist and perhaps flourish there." If the same intensive study could be made of some of our other planetary neighbors, similar conclusions might be reached.

After we have considered the planets of our solar system, we immediately ask: Are there other "worlds" than those revolving about our sun? Out in the depths of the universe are there heavenly bodies, comparable to our Earth, that circle about giant stars? Yes, according to the latest findings of astronomers, there are satellites worthy of the name "planet that attend other stars. No human eye will ever see them as we view Venus or Mars, for they are too distant, and only the effect of these non luminous bodies upon the stars to which they owe their allegiance is known.

Dr. K. A. Strand, astronomer of Sproul Observatory, has discovered a number of these unseen companions of stars. Making a special study of a double star in Cygnus, the Swan, he obtained proof of a third body associated with this pair. Although the body cannot be seen, the mathematical calculations are so exact and the laws of the universe are so perfect, that lie has been able to show the irregularity of this pair of stars along their set course. The only logical reason for this variance, the astronomer reasoned, must be in the presence of a third heavenly body near enough to affect the double star, 61 Cygni. This unseen third member proved to be a "planet" about 216,000 miles in diameter, or sixteen times the mass of Jupiter, and it swings around its giant sun once in 4.9 years.

A similar dark companion has been found for a double star in Ophluchus, the Serpent Bearer. Studying measurements made on photographs of these stars, two astronomers, one from the University of

Virginia, and the other from Lurid University, of Sweden, tracked down the invisible partner. Smaller than the "planet" found in Cygnus, it requires 17 years to complete its course around its sun.

Although the search for these dark companions is in its initial stage, other stars with "planets" are being discovered. Perhaps the recent findings will lead to the knowledge of many "worlds" circling around blazing suns in the universe.

Are these newly discovered "planets" the habitation of life? This fascinating thought opens new vistas into God's wonderland of the heavens. Our minds are staggered at the possibilities! Suppose the majority of the millions of suns have planets whirling about them, and suppose they are inhabited with created beings.

We are naturally interested in the opinions of noted astronomers on this subject. That it is a scientific possibility that these "worlds" are inhabited is attested by Dr. Flenry Norris Russell, head of the department of astronomy and director of the observatory of Prineeton University. He declares: "On the basis of the new evidence, it, therefore, appears probable that, among the stars at large, there may be a very large number which are attended by bodies as small as the planets of our own system. With this as a guide, it appears now to be probable that the whole number of inhabited worlds within the Galaxy is considerable. To think of thousands, or even more, now appears far more reasonable than to suppose that our planet alone is the abode of life and reason."

Dr. Russell has also said: "Recent precise photographic observations, however, show that several of the nearest stars have invisible companions, revolving about them, which can be detected because their attraction causes the bright stars to move in slightly wavy curves. The smallest of these companions are certainly dark bodies, and may fairly be called planets. We can find small companions of this sort only if they belong to some one of the few hundred stars which lie nearest to the sun. Among the many millions of remoter stars, there are very likely great numbers of them."

Worlds Without End

Another noted astronomer who believes there are other worlds beyond our solar system is Dr. Gerard P. Kuiper. He declares that there are about a billion suns in the Milky Way, and each may well have a family of planets revolving around it. "One can only speculate on the possible forms of life which may have developed on these many unknown worlds."

Concerning the kinds of life on other planets, Dr. Russell has this to say: "There is no reason, however, against supposing that, under favorable conditions" there may be creatures on these planets "which equal or surpass men in reason and knowledge of nature-and, let us hope [live] in harmony among themselves!" He adds as a final blow at human egotism: "There is no longer a basis for supposing that either this world or its inhabitants are unique, or in any way the 'first, last, and best of things.' The realization of this should be good for us."

Even before scientists made their startling new discoveries, Dr. Edwin B. Frost, of Yerkes Observatory, declared: "There is no logical reason to suppose that our Sun is any better fitted to have planets about it than thousands of others, or that the planet Earth should be highly exceptional. It is difficult to believe that a similar development has not occurred for vast numbers of other suns."

Since this Earth-one of the smallest planets in our solar system-was designed for the glory of God and "He formed it to be inhabited," can we logically believe that the immense systems of heavenly bodies hurtling through space according to divine law were placed there without purpose or design? Furthermore, the Bible recognizes a plurality of worlds, for the writer of the book of Hebrews states plainly that the Creator "made the worlds."

Another noted astronomer agrees with this conception of the universe, for Dr. David Todd, director of Amherst College Observatory, has said: "The chances must be overwhelmingly in favor of vast numbers of the planets of the other stellar systems being favorably circumstances as to heat and moisture for the maintenance of life at the present time. That is, they are habitable, and if habitable, then no doubt thousands of them are inhabited now."

An argument from the realm of physical science may be of value in considering whether life exists throughout the universe. In studying the stars it has been found that most of them, as far as is known, are made of the same elements as our Sun. Professor Harlan True Stetson considers this fact one of the strongest grounds for believing life exists on other worlds. He writes: "On the grounds of the similarity and unity of matter there is, perhaps, the strongest argument for the universality of life." H. Spencer Jones says:

"The same atoms that occur on the Earth are to be found in the remotest parts of the universe. The same chemical laws necessarily prevail throughout the universe."

One mighty power is manifesting itself throughout the stars, the nebulae, and the galaxies. The glory of the Creator is revealed in the molecules that make up our world, and in the atoms, ions, and electrons of which the blazing suns are composed.

As the immensity of the universe unfolds, we can better understand why the Old Testament writer should be inspired to say of the Creator: "It is He that sits upon the circle of the earth, and the inhabitants thereof are as grasshoppers." Isaiah 40:22. When the astronomer becomes meditative, he will say as did Garrett P. Serviss: "Let any thoughtful person who is acquainted with the general facts of astronomy look up at the heavens some night when they appear in their greatest splendor, and ask himself what is the strongest impression that they make upon his mind. He may not find it easy to frame an answer; but when he has succeeded, it will probably be to the effect that the stars give him an impression of the universality of intelligence; they make him feel, as the sun and moon cannot do, that his world is not alone; that all this was not made simply to form a gorgeous canopy over the tents of men. If he is of a devout turn of mind, he thinks, as he gazes into those fathomless depths and among those bewildering hosts, of the multitude of created beings that the Almighty has taken under His care. Thus the natural tendency, in the light of modern progress, is to regard the universe as everywhere filled with life."

Yet we are not insignificant in the eyes of God, although our world may only be one of the millions in the starry sky. Every human being, made in the image of the Creator, is precious, for God so loved this little planet "that He gave His only-begotten Son, that whosoever believes in Him should not perish, but have everlasting life." John 3:16.

"I Saw a Star Fall"

THE SKYWAYS OF OUR SOLAR SYSTEM are busy with traffic. The Sun and its attending planets and their moons are not the only objects whirling through the heavens. In the space between the planets there are thousands of swiftly moving bodies: tiny planets or asteroids, comets, and particles of matter, some of which become meteors and meteorites. These sky wanderers make exciting scientific study, for they contribute to man's understanding of the laws of the universe.

As astronomers of the past studied the orbits of the planets revolving around the Sun, they found what seemed to be a gap of space between the orbits of Mars and Jupiter which, according to certain mathematical formulas, should contain another planet. Giuseppi Piazzi, an Italian astronomer of the nineteenth century, began to solve the mystery while he was cataloguing the positions of certain stars. One night he made his usual observations, and the next evening, when he went to check his work, he found that one of the "stars" had moved from its position. The third night he discovered the object had strayed still farther away. For six weeks Piazzi watched the object move westward for a time, then stop, and finally return eastward. He discontinued his observations for a time because of illness, and when he returned to his telescope the object had vanished. Although Piazzi sent records to other astronomers, the Italian received no assistance from them, for the mails were so slow that before the scientists could turn their telescopes on the wandering object it was lost from view.

Karl Gauss, a young German mathematician, picked up the Italian -astronomer's records and attempted to harmonize them with Newton's laws of motion. He believed there must be some objects in the space between Mars and Jupiter. On December 31, 1801, a year after Piazzi's discovery, a telescope was turned to the spot where Gauss predicted a new heavenly body would be found. Sure enough, there was a small planet! It was named Ceres Ferdinandea, or Ceres for short. This tiny planet-less than 500 miles in diameter-happens to be the largest asteroid ever discovered, although it is only a grain of sand compared with the largest planets and giant suns.

The Secrets of the Asteroids

Here was the beginning of a new field of discovery for astronomers. Soon another asteroid was found, and this one was named Pallas. In 1804 Juno and in 1807 Vesta were added to the group. Before the end of the nineteenth century more than 450 of these small bodies had been discovered and charted, and the total now numbers some 4,000. At first, as you may have guessed, the tiny planets were named after goddesses of mythology; but as more were discovered this plan was put aside. Today they receive the

names of individuals, observatories, and cities, and most of them are given a feminine ending form, as Pittsburghia.

In what kind of pathways do these asteroids move? Gauss was the first scientist to compute the path of an asteroid. He was so accurate in his calculations that when the telescope was turned on the spot, astronomers found it to be only a moon s width from the place predicted! Asteroids move in an orbit which may be likened to the shape of an egg, with one end of the path swinging around the Sun, and the other end circling near a planet, such as Jupiter.

The brightness of these small planets depends upon their size and their distance from the Sun and the Earth. An asteroid that travels close to the Earth may look as bright as one of the major planets, and, of course, will be observed by astronomers. Most of the asteroids are not large enough to make such a dramatic appearance, and they seem to be mere pin points of light.

Among the goo asteroids that have been discovered by Dr. K. Reininuth, an astronomer of Heidelberg, Germany, is Apollo. This dwarf planet, as well as two others - Adonis and Hermes which were found a few years later, swish by the Earth. Hermes comes the closest, flashing past at a distance of less than 750,000 miles, or a little more than three times the distance to the Moon. Hermes, estimated to be less than two or three miles in diameter, was photographed by Reirimuth when at a point nearest the Earth. This was an amazing feat, for as Dr. Fletcher G. Watson points out, the complex problems which arise in attempting to observe these wanderers of the sky make them almost impossible to photograph. He says:

"The difficulties of discovery and observation are shown by the fact that when the discovery of Hermes was telegraphed around the world many people attempted to photograph it, but not one succeeded for it moved at such a rate that it was many degrees ahead of them. On October 30, 1937, when it shot past the Earth, Herines was of the eighth magnitude [in brightness] and moving five degrees an hour. In spite of its brightness no image could be found on several photographs known to cover its position. In nine days it moved completely across the sky. The effect was much like that obtained by standing near the railroad tracks when the evening express roars past. The only observations available for the determinations of its orbit were from photographs taken for other purposes before the asteroid was discovered." - Between the Planets, pages 28, 29.

Discovery of Eros

Eros, another interesting asteroid, shaped like a dumbbell, is about 16 miles in diameter. It has been helpful in making astronomical measurements. It was the first asteroid to be found whose orbit passes inside the path of Mars. In 1931, when Eros came within 16,000,000 miles of the Earth, measurements were taken of it at various observatories, and from these findings new information was obtained on the distance of the planets from the Sun.

Another minor planet was found in 1950 by Dr. C. A. Wirtanen. This baby planet is less than a half mile in diameter, and at its nearest point is only a third as far from the Sun as is Eros. There are hundreds and perhaps thousands of tiny planets, a mile or less in diameter, speeding along their designated paths. They have no light except the reflected light of the Sun, and they can be seen only when they are near our Earth. Since there is so little chance of observing them, their orbits can be charted only with the greatest difficulty, and we do not know when they will suddenly appear and then quickly slip off again into space.

Comets are another group of sky wanderers that have held a fascination for astronomers. Down through the centuries men have trembled when great comets, with tails stretching across the sky, appeared in the night. 1 began to understand better what some of the superstitious fears of past generations were when I read Chambers's Book of Days, published in 1864. He says: "Halley's comet, so called, has been the means of dispelling many popular illusions concerning the influence of those mysterious bodies on worldly affairs. Before it had been ascertained that comets are periodical in their appearance, there was unbounded scope for speculation on the nature of this influence. The excellence of the celebrated vintage of 1811 was attributed to the great comet which appeared in that year; as was also the abundance of the crops. Nay, the number of twins born in the same year, and the fact that a shoemaker's wife in Whitechapel had four children at a birth, were in like manner laid to the charge of the comet; as likewise were the facts that wasps were few, and that flies became blind that year. A church clock, destroyed by a meteoric stone; an unusually large flock of wild pigeons in America. The disasters which were experienced by the Christians at the hands of the Turks in 1456. A fit of sneezing that became very prevalent in some parts of Germany;

the deaths of eminent persons in various countries-all were believed to have been either produced or presaged by comets which appeared in certain years."

The word "comet" is derived from the Latin root meaning "hair," a reference to the long tails which many of them have. Because of their strange appearance, comets were once thought to be glowing clouds in the atmosphere. It was Tycho Brahe who first proved that these celestial objects belonged to the Sun's family. In 1577 he observed a comet far beyond the Moon and therefore outside our atmosphere. Later he was able to give added proof to his theory by observing six other
comets.

Most Comets Have Tails

If you have the idea that comets swish across the heavens like a Fourth of July skyrocket, then you will be disappointed when you actually see one. Comets move majestically in the night sky, and they are visible for nights, weeks, and even months. The average comet has a bright nebulous head, called a "coma." In the center of the coma is a nucleus-the most brilliant spot of all. The comet's tail streams out from the coma, perhaps millions of miles in length. The tail always points away from the Sun. Therefore, when a comet moves toward the Sun the tail follows behind; but when it swings away from the Sun the tail goes first, like the headlight on a speeding locomotive.

The extremely thin tail of the comet is composed of minute dust particles, and possibly gases. Sometimes a comet's tail looks like a long wisp of luminous smoke drifting in the sky. When a comet is far out from the Sun it has only the coma, or head; it seems to develop a tail as it speeds closer toward the great central body. The powerful light or electrical repulsion from the Sun is believed to exert pressure on the comet, actually blowing the tiny dust particles and the molecules of gas away from its head. It is this action which may produce the comet's tail. The light of comets is reflected from the Sun, and, naturally, as the speeding comet approaches its source of light it grows brighter and brighter.

Along with the mystery of what comets actually are, is the problem of the weird course they seemed to take across the heavens. Tycho Brahe thought that the comet he saw in 1577 had a circular path outside the orbit of Venus; while his student, Kepler, believed that comets traveled in straight lines. It was Edmund Halley who solved the mystery and published his findings in 1705. The young scientist of England began his study by attempting to discover the law of force that caused the planets to move in elliptical orbits around the Sun. When Sir Isaac Newton announced to the world his discovery of the law of gravitation, Halley accepted it and made it the basis of his calculations. He found how the pull of one planet would speed up or retard the motion of another, depending upon their positions. In 1680 and 1682 two bright comets had appeared, and some astronomers were bold enough to say that it was the same comet first swinging in toward the Sun and then speeding out again on the other side. Since no one knew the path of this comet, Halley undertook the long, tedious task of computing it. Records showed that the appearance of bright comets in 1531, 1607, and 1682 were strikingly similar. "Could this be the same comet?" Halley asked himself. Finally he wrote to Newton, saying: 1 am more and more confirmed that we have seen that comet now three times since the year 1531.

The Path of the Comet

In the report presented to the Royal Society of London, Halley gave an arithmetical calculus he had worked out for computing the orbits of heavenly bodies. He recognized that these bodies might be disturbed from the regular motion and path by other planets. After taking into account the retarding influence of planets on comets, he was willing to set down the orbit of the comet of 1682. He said further, I would venture to predict with confidence a return of the same in 1758."

As to what happened to Halley's prediction, let us call the comet to the witness stand and imagine it speaking, as William J. Showalter has done in these words: "Yes, I'm a comet. For countless generations I had been swinging through space. When I approached the Earth men believed me a messenger of evil. They knew precious little about me or my kind. In 1682 I appeared on one of my excursions into realms bounded by the Earth's orbit. A little before that Sir Isaac Newton had worked out the fundamental principle of celestial mechanics, namely, the law of gravitation.

"He had a friend by the name of Halley. This man undertook to see whether or not 1 was subject to that law, and whether, indeed, Newton's interpretation of it was correct. Applying Isaac Newton's law to

me, he said that 1 was traveling thirty-four miles a second when 1 was nearest the Sun, and that 1 had turned round and was headed for the regions whence 1 had come. He said 1 would travel out into space some three billion miles, my gait slowing down as 1 journeyed, and that when 1 got ready to make the turn to come back 1 would be loafing along at the celestial snail's pace of a mile a second.

"Furthermore, he figured out my mass and many other details about me. Then he said that if he was right I would come back in about seventy-six years, the exact month of my coming depending on how much influence Jupiter and other planets would have upon me, which he had not had time to calculate.

I knew that he had fathomed my mystery and solved my secret. But the people of the Earth did not. Halley 'stood pat' and called on an impartial posterity to witness that it was an Englishman who had first predicted the return of a comet. Sure enough, in the language of the street, 'he had my number.' With less proportionate departure from his schedule than the Congressional Limited makes in its Washington-New York run, 1 reappeared, having traveled some seven billion miles in the interim. So 1 have to admit that Halley must have known what he was talking about." - The National Geographic Magazine, August, 1919, Pages 153, 154.

No wonder this famous comet was named after the man who first discovered so much about it-Edmund Halley!

The Search for New Comets

New comets are constantly being discovered by both amateur and professional astronomers. The amateur sweeps the sky with his small telescope, searching for fuzzy-looking objects that move from night to night among the stars. Professional astronomers find many comets as the result of their study of photographs made in the observatories. In 1892 the first comet on a star photograph was discovered by Barnard, and today more than half of the new comets added to the records are located by this method.

Originally comets were named for the men who first discovered them; but when these sky wanderers returned again and again and were seen by other astronomers, this system was found to be impractical. At the present time comets are designated according to the year they are found, and to this is added a letter of the alphabet to indicate the order of discovery, such as 1952d. Later the annual list is revised according to the order in which the new comets come to perihelion, that is, the point in their orbit when they are nearest the Sun. Out of courtesy to the finders, some comets are still designated by the names of the discoverers. However, the names of not more than three independent discoverers can be attached to one comet. Sometimes as many as a dozen persons see a new comet in a single night, and this makes it almost impossible to name the new sky object after an individual.

While Halley's Comet takes a period of seventy-six years to complete a trip along its orbit, some comets take centuries, and a few, like 1947n, have periods of almost incredible length. Halley's Comet made its last visit to the Sun in 1910, and it should return again about the year 1986. Encke's Comet has the shortest period known, for it travels around the Sun every 3.3 years.

It is a thrilling moment when a comet is discovered. Is it a new comet or a familiar friend coming back after years of absence? Will it have a long tail? How close to the Earth will it come? The position of the comet must be charted and its relative motion to the Earth and Sun. Astronomers must make observations for several days before the news can be flashed around the world announcing the new arrival. After all the observations are collected, the findings are put together and the definite orbit of the comet is ascertained.

Since comets seem to have such a small quantity of matter in their make-up, being largely dust particles and gas, they have too little mass to exert any noticeable pull on the planets they pass near. In fact, Percival Lowell, the noted astronomer, describes a beautiful comet with sweeping tail as "a bag full of nothing."

When Meteors Fall

While many persons go through life without ever seeing a comet, there are very few who have not seen a flaming meteor burning a trail through the night sky. Every day a billion or more tiny particles fly into the Earth's atmosphere, the majority of which are no larger than a grain of sand. Most of them flare for a moment and are gone; but a few are large enough to survive, and when they do they strike the Earth.

Ancient historians recorded the fall of meteors. The Chinese annals for 687 BC tell of a night

when the "stars fell like rain." And Pliny, in his Natural History, described a meteorite that fell in Thrace in 467 BC. He said it was as large as a cart, dark in color, and that the people of the land venerated it because it fell from heaven. As late as the eighteenth century, however, the men of science scoffed at the idea that stones could fall from the sky. It had been generally believed that meteors were formed in our atmosphere as a result of certain weather conditions. In fact, meteor is derived from the Greek word meaning "something in the air."

Members of the French Academy of Science made visits to three sections of their country where meteorites had fallen. They saw the stones and heard the testimony of witnesses who had seen them fall; yet it was not until the third investigation, almost fifteen years after the first, that the scholars would admit that the meteorites had dropped from the sky.

Serious scientific research about meteors was begun by two German young men in 1798. They watched shooting stars from different positions several miles apart, and, by the process of triangulation, charted their course. They were the first to find that meteors were objects high in the sky, for of those they charted, the average height at the time of disappearance was 61 miles. But their work might have been forgotten and the entire subject neglected if the famous star shower of 1833 had not occurred. A noted astronomer makes this statement: "On November 12, 1833, however, a great meteor shower, so rich that the meteors were as thick as snowflakes, once again attracted attention to these celestial rockets. Several persons independently noticed that the meteors of the shower spread out from a point in the constellation Leo much as the ribs of an umbrella spread out from the point." - Fletcher G. Watson, Between the Planets, page 89. From that date to the present the study of meteors has received increasing attention, and today the new instrument of radar is used to study them.

These falling bodies are usually classified in three groups: fireballs or bolides, meteors or shooting stars, and meteorites. The brightest meteors are called "fireballs," and as they flash across the sky they are sometimes brighter than the planets Jupiter or Venus. Only a few thousand fireballs appear in the sky in a single day. Occasionally one plunges through the atmosphere to within ten miles of the Earth and explodes with a roar like thunder. Those that explode are usually called "bolides." The majority of meteors are smaller fragments which appear faintly for an instant or two, and then are gone. The average speed of these particles is about 30 miles a second! Thousands of shooting stars are so faint they can be seen only with a wide-angle telescope or a pair of binoculars. Meteorites are fireballs or shooting stars that are not consumed in the air, but reach the Earth as solid bodies. There are also occasional "meteoric showers," marvelous displays in the sky, when the Earth's path goes through the path of meteor swarms, and hundreds or thousands of shooting stars are seen in a single night.

When the Stars Fell

The greatest display of shooting stars ever witnessed was the meteoric shower which began on the night of November 11, 1833, and continued on the two following nights. The shower, according to the records, had its greatest brilliancy in North America. Astronomers observed that the shooting stars seemed to radiate from the region of the constellation Leo, so they were named Leonids. The records from astronomers of the past showed that star showers had appeared from this region of the sky many times before. The Earth passes through the path of the Leonids every year and at that time more than an ordinary number of meteors are seen. Subsequent study revealed that a huge swarm of meteors moves in an orbit which requires thirty-three years to complete. In other words, an unusual shower of stars should be seen in November every thirty-three years. In the sky spectacle of 1833, however, men witnessed the most wonderful display ever recorded in history.

Professor Denison Olmsted, of Yale College, wrote this description: "About daybreak this morning our sky presented a remarkable exhibition of fireballs, commonly called Shooting Stars. The attention of the writer was first called to this phenomenon -about five o'clock, from which time until nearly sunrise, the appearance of these was striking and splendid, beyond anything of the kind he has ever witnessed.

"To form some idea of the phenomenon, the reader may imagine a constant succession of fireballs, resembling rockets, radiating in all directions from a point in the heavens. They commenced their progress at different distances from the radiating point but the lines they described, if produced upwards would all have met in the same part of the heavens. The balls just before they disappeared exploded. The flashes of light were so bright as to awaken people in their beds." - Silliman's journal, volume 25, pages 354-411,

quoted by Charles P. Olivier, Meteors, pages 24 - 25.

This was a glorious sign in the heavens, an omen which the Bible centuries before had foretold would come. To His disciples, Jesus Christ had said: "The stars of heaven shall fall, and the powers that are in heaven shall be shaken." Mark 13:2-5. The apostle John was given a picture of this sky display, for he wrote: "And the stars of heaven fell unto the Earth, even as a fig tree casts her untimely figs, when she is shaken of a mighty wind." Revelation 6:13.

Many Bible students saw in the falling of the stars in 1833 the fulfillment of God's word. Others scoffed and said a similar display occurred every thirty-three years. It is true that there was a spectacular display of meteors in 1866, but thirty-three years later when astronomers and laymen anticipated the greatest display of celestial fireworks of their lives, what happened? Dr. Watson writes: "Alas! They were disappointed. Between 1866 and 1899 the meteors passed near both Saturn and Jupiter; these planets pulled the particles aside so that the Earth passed through only the fringes of the swarm. As 1932 approached and the possibility of another shower was apparent many people hoped that some perturbation had swung the particles into their previous orbit. As in 1899 the meteors came at the rate of one a minute, but compared to the earlier displays this was disappointing. It is not likely that we shall again witness great ' displays from this stream." - Between the Planets, page 121.

How significant are the words of this scientist! The Creator and Upholder of the universe allowed this tremendous display of meteors to come in 1833 at the exact time that would synchronize with Bible prophecy. The signs in the heavens turned men to God's message, and faith in divine predictions was confirmed by evidence in the starry sky. Certainly, the heavens declared the glory of God, and astronomers have been unable to explain why no other shower before or since has been as glorious or spectacular.

There are other meteor showers caused by the Earth's passing through streams of cosmic particles. Among the meteor swarms are the Perseids, which appear in August; the Geminids, in December; and the Orionids, in October. Many of the star showers which recur year after year are associated with comets. It seems that when the Earth passes near the path of a comet, the particles from the tail form a stream which produces shooting stars in our atmosphere.

A comet-produced meteor shower took place on October 9 and 10, 1946, when the Earth passed within 135,000 miles of the path of Comet Giacobini-Zinner. All sections of the United States, as well as Europe and Asia, were alert and waiting for the sky display, and the shooting stars did not disappoint the watchers. From Florida to Oregon and from Maine to California the meteors were seen, and European observers gave accounts of their observations as well. Single watchers counted from 60-100 shooting stars per minute, and most tabulations for five-minute intervals gave from 300-500 meteors. The Mount Wilson Observatory reported its watchers saw meteors falling at the rate of one per second during the height of the display.

It was an exciting evening for the author of this book. With his family he drove up into the hills of Northern California away from the lights of the valley. For almost two hours we watched the cosmic fireworks flashing from every part of the heavens. A brilliant moon made only the larger fireballs visible, but even then we could count 40-50 per minute. If it had been a moonless night the star shower would have been much more dramatic. It seemed as if the comet had said to the earth dwellers, "Watch my dust," for we were seeing cosmic particles that had traveled far through space!

When a large shooting star dashes through the air it may not be burned up completely. If fragments remain, naturally they strike the Earth. These are meteorites, composed of stone or iron, or both. Dr. H. H. Nininger, best-known authority on meteorites, estimates that over 5,000 bodies weighing ten pounds or more strike the Earth in a year. More than 100 meteorite craters, ranging in size from 30 feet in diameter to more than 2 miles across, have been definitely identified on the Earth's surface.

When Meteorites Fall

It is difficult to learn much about these falling bodies, since most of them are seen only by untrained observers. A few fireballs have struck buildings, but no damage on a large scale has ever been recorded. In 1847 a meteor weighing about 45 pounds fell through the bedroom of a house and buried itself in the ground without harming three children sleeping in their beds. In 1951 a rain of meteorites is said to have killed 12 persons, injured 19, and taken a heavy toll of livestock in southwest Iran. Sixty-two houses were believed destroyed by the meteoric shower.

Meteorites usually have a black crust or varnish covering, the result of intense heat. The coating is

thin, however, which indicates that the heat caused by the atmosphere had only a short time to work as the body fell.

On June 30, 1908, a Russian peasant saw a huge meteor flash across the sky in Siberia. The light was so bright and the heat was so intense that a farmer named Semenow, living 50 miles from where the body struck, thought his clothes would catch fire. The explosion broke windows miles away, and an engineer on the Trans-Siberian Railway stopped his train for fear the blast would derail it. Years later, in 1923, the meteorite was found in a depression about two miles wide. There were some two hundred crater holes where fragments had struck. So intense had been the heat and the blast the meteor caused that forests 15-20 miles around the depression were laid flat. It has been estimated that the swarm of meteorites that struck this spot must have weighed at least 40,000 tons!

A "Sky Bomb" Fell

The most famous meteor crater in the United States is the gigantic bowl found near Canyon Diablo, Arizona. The crater is an almost round, saucer like depression with walls rising 125-160 feet about the desert plateau. The bowl is 500 feet deep and more than three quarters of a mile wide. Drilling has been done on the floor of the crater, and some meteoric material has been found. From the evidence available it would seem that a giant fireball came from the north. It must have been some 500 feet thick and probably weighed a million tons. When it struck the ground it bored its way through solid rock for hundreds of feet, grinding the rock into dust. Certainly this is the largest "bomb" that is known to have dropped from the sky onto our Earth.

The largest crater yet discovered, which is believed to be of meteoric origin, is the Chubb crater in the northern part of Quebec, Canada. The crater, which is 11,000 feet wide, has been studied by scientific expeditions; and while meteorite fragments have not been found, other evidences seem to prove that a massive missile from the heavens once struck this spot.

Millions of meteors are so small they are never heated enough to blaze across the sky as faint "shooting stars." Dr. Fred L. Whipple, of Harvard College Observatory, declares that at least 1,000 tons of meteor dust from outside our atmosphere rain down upon the Earth each day. How do we know this? When rockets are shot high into the upper air, their polished surfaces are always pitted by contacts with these micro-meteors. These tiny particles also add to the mineral content of the Earth and even make a sediment in the oceans which has been detected by scientists in their study of the floor of the seas.

This, then, is the story of meteors and meteorites that come within the range of the Earth. As the Sun and its family of planets travel on their course through space they pass through regions, apparently without beginning and without end, where these particles are found. These small bodies are a continuous stream of messengers from outer space. They are bombarding our atmosphere; but through the kindness of a loving and merciful Creator, we are protected from disaster which might be caused by these falling bodies.

"Lift Up Your Eyes on High"

BEYOND OUR SOLAR SYSTEM with its central Sun, nine major planets and their satellites, thousands of asteroids and comets, and billions of meteors, lies the starry universe. Now we must take the celestial highway and travel at the speed of light to the Milky Way to learn more of the power and majesty of the Creator.

We have found that our nearest neighbor, the Moon, is about 238,857 miles away, while the Sun is more than 93,000,000 miles from the Earth. Pluto, the most distant planet known in the solar family, is 39.50 times as far from the Sun as is the Earth; yet its light takes only a little over five hours to reach us. Thus, the outer edge of our planetary system, as measured by the orbit of Pluto, is a little over ten hours across at light's speed. As we stand at this point, however, ready to take our next step into the universe, we are breathless with wonder.

Our solar system is in the Milky Way, the common term for the Galaxy, which in the Greek means "milky." Almost all the stars we see with the naked eye, as well as millions of others too far away or too faint to be observed except through a telescope, are a part of the Galaxy. Our Sun sinks into insignificance when we find that there are from one to two hundred billion suns in the Milky Way system. How large is the Galaxy? According to Dr. Harlow Shapley, it is so wide that light requires about 100,000 light-years to

cross it. As we look at the Galaxy on a dark night it seems to be a belt, or band, of stars across the sky. We might think of it as a wheel about 10,000 light-years thick and 100,000 light years in diameter. Where is our Earth and our little solar system, some 10 hours in diameter as light travels, in this stupendous galaxy system? First of all, in spite of our wish to think so, we are not in the center of things. Our solar system, from all that we can learn, is about one half to two thirds of the way out from the center, or about 30,000 light-years from the hub of the Galaxy.

Since there are billions of giant suns in this space we might imagine that they are crowded together in a traffic jam. This is not true, however, for the nearest star to the Earth is Proxima Centauri, over twenty-five trillion miles away. It takes light 4.28 years to reach our eyes from the star that is our "next door neighbor."

Measuring the Distance of the Stars

Within the Galaxy there are many kinds of stars: single stars, double stars, multiple stars, dwarf stars, giant stars, cool stars, hot stars, globular clusters, and nebulae. There is no monotony in the task of the astronomer, for new and fascinating discoveries are always being made as telescopes ferret out the sky wonders and record them on photographic plates for the scrutiny of scientists.

As we look at a star we naturally ask: "How far away is it? How bright is it? Is it larger and heavier than our Sun?" For centuries astronomers have observed the stars and charted their positions. They have also recorded the apparent brightness,, and described the brilliant colors of the blazing suns. One of the problems of astronomy has been to measure accurately the star distances. The method used on the nearer stars is similar to that employed by a surveyor who wishes to measure the width of a river or the distance across a gorge. The surveyor finds his unknown distance by first establishing a base line, perhaps several miles in length, along the riverbank or gorge. Then he makes his observations and measurements from the two ends 6f the base line. When he has the length of the base and the two angles at the ends of the base he can work out the length of the other two sides and the other angle. In this way the unknown distance is determined.

James Pickering uses an illustration to help us understand the measurement of star distances. Hold the right hand at arm's length with fist clenched and thumb pointing up. Then, with your right eye closed, sight over your thumb at some object beyond it. Now open your right eye and close your left. Your thumb will appear to have moved an inch or more to the left of the object you originally sighted. This seeming motion caused by viewing an object from two points (the distance between your right and left eye) is similar to the apparent motion, called the parallax, of stars when they are seen from two widely separated points.

Astronomers have taken the orbit of the Earth as one of the base lines of measurement. Photographs of stars are taken and compared with other pictures made exactly six months later when the Earth has moved 186,000,000 miles to the opposite side of the Sun. A bright star photographed from these two points shows a shift of position against a background of fainter stars much farther away. It is thus that the nearer stars can be measured. However, the distant stars are a greater problem, for the angle at the base lines becomes infinitesimal as the distance increases. It is as though a surveyor were asked to measure the shift of direction of a point several hundred miles away and was given a base line no more than a yard in length.

In figuring the parallax of a star, we know that the greater the distance to the star the smaller the parallax, or apparent motion. Alpha Centauri, one of the nearest stars, has been found to have a parallax, or angular shift, of about one second of arc. This has little meaning to us until we realize that one second of arc is the 6oth part of a minute, which is in turn 1/360th part of the circumference of a circle. This unit of measurement is called a parsec, taken from the two words: parallax and second. A parsec represents a distance Of 3.26 light-years in space. Knowing the parallax of Alpha Centauri, astronomers tell us its distance is 4.28 light years from the Earth. In other words, the star is 2,721,000 times as far away as our Sun. No wonder the most delicate instruments and the most exact measurements and calculations are necessary!

It was near the middle of the nineteenth century that the distance to a star was first measured with accuracy. A German astronomer named Friedrich Bessel made a two-year study of 61 Cygni, a star of the fifth magnitude in the constellation of the Swan. Using the methods of measuring we have described, he charted 61 Cygni with reference to one or more faint stars in the background as the Earth moved round in

its orbit. In December of 1838 Bessel was able to announce that the distance of the star 61 Cygni was almost sixty trillion miles, or nearly 11 light-years.

Within two months after Bessel made his announcement, another astronomer named Henderson, who had made numerous observations of Alpha Centauri, announced its distance from the Earth. Thus a new phase of astronomical knowledge was made possible, and Sir John Herschel, son of the astronomer who discovered Uranus, paid tribute to Bessel at a celebration in his honor. I congratulate you and myself that we have lived to see the great and hitherto impossible barrier to our excursions into the sidereal universe-that barrier against which we have chafed so long and so vainly-almost simultaneously overleaped at three different points. It is the greatest and most glorious triumph which practical astronomy has ever witnessed. Perhaps I ought not to speak so strongly-perhaps I should hold some reserve in favor of the bare possibility that it may all be an illusion and that further researches, as they have repeatedly before, so may now fail to substantiate this noble result. But I confess myself unequal to such prudence under such excitement. Let us rather accept the joyful omens of the time and trust that, as the barrier has begun to yield, it will speedily be prostrated."

The nineteenth century did not see the barrier broken down, however, for the distances of only a few stars were obtained. Not until more accurate photographic methods could be used, as they were at the beginning of the present century, could rapid progress be made in stellar measurements. Today the distances of some 4,000 of the brighter stars in our Galaxy are known. It has been a long and arduous task, however, for photographs must be taken at long intervals, and sometimes years are required to check and recheck the findings. Even the above-described methods of measurement are not trustworthy for measuring the distance of stars over 600 light-years away, and astronomers have had to devise other elaborate and more complicated techniques to find the magnificent distances of the universe. Truly we can say with Job, who had only a faint idea of the glory of the stars as compared with our knowledge, "Behold the height of the stars, how high they are!" Job 22:12.

How Bright Is a Star?

After the distance and the apparent brightness of a star are known it is possible to establish its true brightness. It has been proved that the brightness of a point source of light diminishes as the square of its distance. if, for example, the Sun were twice as far from the Earth as it is, it would appear only one-fourth as bright to us as it does now. The ancient Egyptians attempted to classify the stars they could see according to their brightness. Hipparchus, in the second century, BC, was the first to make six classes, or magnitudes, of stars seen with the naked eve. In modern times the brightness of the stars has been fixed scientifically, and the relationship of magnitudes has been set so that a first magnitude star has the light of a hundred sixth-magnitude stars. Each magnitude 2.50 times brighter than the next below it. The brighter stars seen in the heavens, such as Altair and Aldebaran, are of first magnitude. With the aid of the giant telescopes on Mount Wilson and Palomar Mountain, scientists now photograph stars as faint as the twenty-first magnitude and beyond.

How bright are the stars compared with our Sun? Astronomers realize that if they could place all the stars at an equal distance from the Earth they would then be able to compare their relative brightness. This has been done in principle by setting up a standard distance of ten parsecs, or 32.6 light years, and theoretically putting all stars at that point to measure their comparative brightness. It is believed that the absolute magnitude of most stars comes within the range -5 to +15, with the Sun's absolute magnitude of +4.73 being approximately in the center. Rigel, in the constellation of Orion, has an absolute magnitude of --5.8, and is 21,000 times as bright as our Sun. The twenty brightest stars in the heavens, which include Sirius, Vega, Capella, Arcturus, Antares, and S Doradus, are all more brilliant than our Sun. As C. A. Young declares, "The Sun is a private in the host of heaven." The distances of these bright stars vary greatly, with Sirius being only 8.6 light-years away; while S Doradus, in the southern hemisphere, is over 75,000 light-years distant. Recent discoveries show that S Doradus is perhaps the brightest star known, with an absolute magnitude of -7 or more. This giant of the skyways is therefore between 300,000 and 500,000 times as bright as our Sun. It has also been found to be a double star, and astronomers believe that the diameter of each of this pair of stars must be about 1,800,000,000 miles. In other words, here are two giant suns revolving about each other, each with a diameter approximately that of the orbit of Saturn!

How true are the words of the apostle Paul concerning the brightness, or glory, of heavenly bodies. He said: "There is one glory of the Sun, and another glory of the Moon, and another glory of the stars: for

one star differs from another star in glory." 1 Corinthians 15:41.

Multiple Star Systems

Multiple star systems are common in the heavens. In recent years as many as four, five, and even six suns have been found to revolve about one another. More than 17,000 double stars are listed in Aitken's star catalogue; but few of the exact orbits of these suns are known.

What would our solar system be like if we had two suns instead of one? This is a reasonable question, since it is believed that some forty per cent of the stars are binaries, or multiple systems. Here is a description of what we might see with two suns of different colors in the sky: 1magine our Sun replaced by an immense globe of a distinct greenish color; also picture with it in the heavens another immense ball of rich blue, both forming together a double sun. At times both would be visible simultaneously in the sky; at other times one alone would be discernible for a few hours, following which the other one would likewise rise and illuminate the heavens and the landscape, so that there would actually be no real night at all!"- Bernhard, Bennett, and Rice, New Handbook of the Heavens, pages 155, 156.

One of the best-known double stars is Alpha Centauri, which consists of two suns that move in orbits about one another, making a complete revolution once in eighty years. The brighter of the two is comparable to our Sun in size, although it is probably a little heavier and more brilliant. The fainter star of the pair is similar and less massive. A third star, of the eleventh magnitude, has recently been discovered moving with the pair, so Alpha Centauri must now be known as a triple system.

Castor, in the constellation Gemini, is a multiple system, two of the stars having been discovered in 1719. Herschel called this visual binary the finest double star in our hemisphere. The members of this pair move about one another in a period of about 340 years. In 1896, as the result of spectroscopic studies, the fainter star of the two was found to consist of two stars; and in 1904 the brighter of the pair was found to be a double star. Since that time other astronomers have found a faint star moving with Castor, and this has also proved to be a double star. So, what is seen with the naked eye as one star, has, with telescopes and spectroscopes, proved to be a system of six suns whose components appear in pairs.

Twin stars of unusual speed in the constellation of Cygnus, the Swan, have been discovered and charted recently by astronomers at the observatory in Victoria, B. C. It is found that they race around each other at the rate of over 1,500,000 miles an hour, and although the two suns are over 11,500,000 miles apart they completely circle each other in less than two days. They are giants of the sky, too, for one takes up 691 times as much space as our Sun, and the other is 630 times as great in volume.

Another interesting study with the telescope is Epsilon Lyrae. It is a complex system which appears to the eye as a double star. Through the telescope the twin stars each become double, and the brightest of the four is also a binary. The tremendous length of time probably required for one pair to revolve around the others is beyond our comprehension.

The study of double stars is rewarding, for when their orbital speed and the time of revolution is known, the size and weight of these stars can be determined. When double stars are so close together that they cannot be separated by even the most powerful telescopes, they are called spectroscopic binaries. The spectroscope reveals the compound nature of such stars because the characteristic lines of the spectrum will be doubled. As a pair of stars revolve about each other the widening and narrowing of the spectral lines can be observed. If one of the pair is dark, the spectral lines from the bright body will shift from side to side as it revolves around its dark twin. Then, too, a change of velocity either toward or away from us is shown by this delicate instrument. 1f, however, the plane of the orbit is so tilted as to appear edgewise in the sky, the passage of one star in front of the other will produce a periodic eclipse, not unlike an eclipse of the Sun by the Moon. Such double stars are known as eclipsing stars. In general, each star masks the other once during a revolution, thus producing two eclipses per cycle." - Leo Goldberg and Lawrence N. Aller, Atoms, Stars, and Nebulae, page 13.

Algol is one of the most fascinating of eclipsing systems. This Gargantuan star received its name from the corrupted form of two Arabian words, E1 Ghoul, which mean "changing spirit," and from this comes the term "The Demon Star." The Arabs probably called it "changing spirit" because they could see that it varied in brightness. Modern astronomers in the eighteenth century watched Algol grow fainter and then return to its full brightness. They found that at intervals of a little more than 2 days and 20 hours the star suddenly diminished to about one third its usual brightness. Careful study brought the discovery that Algol is a double star. The diameter of the brighter star is 2,700,000 miles, while the larger but fainter body

is 3,200,000 miles across. The two stars are about 6,500,000 miles apart-close proximity, indeed, for such giants! The fainter star swings in front of its brighter twin and eclipses it. This causes the light of the binary to diminish almost one third during that interval.

A Universe of Color

God's heaven is full of beautiful colors. Since the stars differ in chemical composition they produce light of various hues. Rigel is a rich blue color, Sirius is a brilliant white Capella is yellowish like our Sun, Arcturus is reddish in hue, while Betelgeuse and Antares are red. Astronomers are able to "fingerprint" the stars by studying the band of light each one gives off through a spectroscope. When light passes through any substance its spectrum shows certain characteristic dark lines. Since no two chemical elements display the same spectrum, it is possible to analyze the light of a star 500 light-years away and find its temperature and its chemical elements. The color of a star is also an index of its surface temperature, even as a red-hot poker is more brilliant than one that is a dull gray-red. Blue stars, such as Rigel, are hotter than red ones. "One of the achievements of modern astronomy is the assignment of a specific value of surface temperature to the stars. For Betelgeuse, for example, it is about 3,500 Degrees Centigrade, for Capella it is about 5,500 Degrees Centigrade, for the Sun it is about 6,000 Degrees Centigrade, and for Rigel about 12,000 Degrees Centigrade."-W. M. Smart, Some Famous Stars, page 9.

Some of the double stars are the most beautiful jewels of the sky. There are the two suns of Albireo-one a brilliant yellow orange, the other a deep blue. The yellow one is magnitude 3.0, while the blue star is 5.3. Again, there is Gamma Leporis with one pale yellow and one garnet sun. Castor is a creamy white star, while Pollux, a near neighbor, is orange in color. These, then, are only a sampling of the glories of the stars. The Milky Way is a treasure house of beauty with gems of richest colors.

Milky Way with stars unnumbered,
Merged in clouds of light;
Beauty, mystery, that arches
Round the summer night,
Yours are times that none can fathom,
Spaces none can span;
Light of ages, see in darkness
Your wee watcher, man.
Selected

The Speed of the Stars

The speed of the heavenly bodies, when compared with earthly travel, is almost unbelievable. We know that our Sun is traveling at the rate of 12 miles per second, but this is relatively slow motion on the celestial highways.

If the distance of a star is known the next thing to find is its "proper motion"-that is, its motion at right angles to our line of sight. The movement toward us or away from us is called "radial velocity." If a star is moving on a diagonal course in relation to us, the proper and radial motions must both be measured. Proper motion is usually obtained by comparing the distance stars have traveled as shown on photographs taken years apart.

The proper motion of some of the stars may help us better understand the power of the Creator and the wonder of His works. Sirius has a proper motion of 11 miles a second, Pollux 28 miles, Altair 12 miles, and Spica 17 miles. We find that 61 Cygni is speeding at about 49 miles per second, while Areturus is traveling 85 miles a second, or about 4,000 times the speed of a streamlined train. The twenty stars nearest the Earth have an average transverse motion of 31 miles per second.

"When one reflects on the immense speeds of the stars," says Dr. W. M. Smart, Regius Professor of Astronomy, University of Glasgow, "the suggestion of the possibility of collisions between the stars immediately occurs. But the distance between any two stars is so enormous and the target which any single star presents is so small compared with these vast distances that the probability of a stellar catastrophe in the shape of a collision is, according to calculations, infinitesimal." - W. M. Smart, Some Famous Stars, pages 65, 66. He suggests that a collision is as improbable as for a man with a rifle to hit a penny at the

distance of a mile on a dark night when even the direction of the coin is unknown!

There are some one million suns in our Galaxy brighter than the twelfth magnitude, which is the practical limit for photographing stars and classifying their spectrum and color. There are over 14,ooo,ooo stars between the twelfth and fifteenth magnitudes. As to the total mass of the Milky Way, the estimate of the best authorities is that there are from one hundred to two hundred billion suns!

One night while 1 was taking courses in astronomy, our college class was studying the stars with the aid of the telescopes at Lick Observatory. The wintry sky made the stars seem numberless and they looked so near that a person could almost reach out and touch them. After spending some time at the eyepiece, a friend and 1 left the giant dome and walked out into the cold night air of Mount Hamilton. 1 never felt so near the Creator before," said my friend. "Look at those stars."

"Yes," 1 agreed, 1 know how you feel. The greatness of the universe and the love of the Eternal One are written in every blazing sun."

"The Host of Heaven"

WE HAVE FOUND that the millions of suns in our Galaxy vary greatly in size, density, and brightness. In order to have a system for grouping these stars, astronomers have agreed on the following classification. Super giants, with high luminosity, which have a diameter of at least one hundred times that of the Sun. Giants, which run from sixteen to one hundred times the Sun's diameter. Main sequence stars, the most numerous of all, which are about the size of our Sun; and the dwarfs, which may be as small as one fifth the Sun's dimensions. In recent years still another group known as the white dwarfs has received much attention. Some of these stars, though no larger than the Earth, have amazing characteristics that are almost unbelievable.

Let us become acquainted with some of the super giants that shrink our Sun in size and dim its brightness by comparison. In the constellation of Hercules, for example, there is a double star named Ras Algethi. Although not especially brilliant, this star is the largest of all the super giants yet measured, with a diameter of almost 700,000,000 miles-about 800 times the diameter of the Sun. This blazing star, 800 light years from us, is 1,900 times as luminous as our Sun.

Next in rank is Betelgeuse in the northeast section of the constellation of Orion. Although only about one-half the size of Ras Algethi, this star has 3,600 times the luminosity of the Sun. Professor A. A. Michelson measured the angular diameter of "The Giant's Shoulder," as this sun is sometimes called, and he could scarcely believe his figures. Betelgeuse, 300 light-years from us, has a diameter of 400,000,000 miles, or about 46o times the Sun's diameter. This red star gives off tremendous heat, and if it were our Sun we would have to be twice as far away as Neptune is to exist in comfort!

Mira, in the constellation of Cetus, the Whale, is the same size as Betelgeuse, with a diameter 460 times that of the Sun. It is a red variable star some 250 light-years from the Earth. The volume of this super giant is 30,000,000 times that of the Sun. It is so large that if it were dropped into our solar system with the Sun as its center, the surface of Mira would extend out beyond the entire orbit of Mars!

Another super giant is Antares, 250 light-years distant, in the constellation of the Scorpion. This star's name means "The Rival of Mars," referring to its reddish color similar to that planet. Though 330 times as large as the Sun in diameter, and with a luminosity 1,900 times as great, "Antares weighs only 1/100,000 as much as an equal amount of water," according to James S. Pickering.

We next survey some of the giant stars of our Galaxythose less than one hundred times the diameter of the Sun. Rigel, a blue-white star, 35 times the Sun's diameter, yet 21,000 times as luminous, is 540 light-years from us. It looks brighter to the unaided eye than Betelgeuse, and its absolute magnitude is -5.8. The surface temperature of Rigel is estimated to be about three times that of the Sun, or approximately 30,000 Degrees Fahrenheit.

We can put Aldebaran, in the constellation of the Bull, with the red giants. This star is the same size as Rigel, or about 35 times the diameter of the Sun. In other words, the distance across this star from edge to edge is 30,000,000 miles.

Capella, in the constellation of Auriga, is a comparatively small giant, merely 16 times the Sun's diameter. This yellow orb is the third brightest star to be seen in the northern hemisphere, since it is 150 times as bright as the Sun, but only 42 light-years away.

Two main sequence stars, well known to all star lovers, are Vega and Sirius. Vega, in the constellation of Lyra, is one of the brightest bodies seen with the unaided eye. This blue star, 2.2 times the

Sun's diameter, is 27 light-years away. Our solar system is speeding toward the constellation Hercules at some 12 miles a second, or about 540,000,000 miles a year. We do not need to worry about a collision, however, for it would take 325,000 years for our Sun to reach the spot, and by that time the constellation would also have shifted its position and would be out of danger.

Sirius, in Canis Major, is a "near neighbor" to us, since it is only 8.6 light-years away. Blue in color, this star is three times as hot as the Sun, but only twice its diameter. Sirius caused some perplexity among astronomers in the nineteenth century. When Friedrich Bessel studied the weight and position of Sirius in 1834, he found that its proper motion was not uniform. The star seemed to make a wavy path across the sky. After ten years of observation, Bessel concluded that Sirius must be a double star and that a companion star was causing its strangely erratic course. Some thirty years later, as Alvan Clark, renowned telescope maker, was testing a newly completed 2o-inch lens of his ground by focusing the telescope on Sirius, he saw a faint point of light in almost the exact spot Bessel had predicted the companion star would be found. This newly discovered Sirius B is a white dwarf. It has a surface temperature of about 8,000 Degrees Fahrenheit and radiates almost four times as much light and heat energy per square foot as does our Sun.

Strange White Dwarfs

Sirius B, though only 26,000 miles in diameter (a little more than three times the diameter of the Earth), has a mass 250,000 times that of our planet. In other words, a tablespoon of the material of this star weighs a ton, and a piece no larger than a grain of sand weighs over a pound. "The force of gravity exerted by this star," says Pickering, "would cause the average man to weigh 2,600 pounds if he were upon its surface, and would flatten him out so thoroughly that he would have to be picked up with a razor blade-if you could lift the razor blade!"-The Stars Are Yours, page 127.

Another white dwarf is Omicron 2 Eridani B. Though less than one fifth the diameter of the Sun, it is composed of material with a density 700,000 times that of the Sun. A person weighing 200 pounds on the Earth would weigh 7,400,000 pounds on this white dwarf. No place for a fat man!

The discovery of a star only about one third the size of the Earth has been made recently by American astronomers. This star, the smallest known to date, is only 2,500 miles in diameter; yet it is estimated to be 40 per cent heavier than our Sun. It is, in fact, not much larger than the Moon. It would take 300 stars the size of this white dwarf to make a body as large as the Sun. "The average material of which the star is made is about 55,000,000 times as dense as water," declare Dr. W. J. Luyten and Dr. E. F. Carpenter, co discoverers of the star. "As much of the star as you could put in a matchbox would weigh 1,000 tons here on the Earth." If a 150 pound man should stand on its surface, his body would weigh 300,000 tons!

In this same group is "van Maarien's star," about the size of the Earth and magnitude 14.4. The density of this little stellar body may be as high as 7 tons per cubic inch. Then there is Krueger 6oB, the faintest star whose mass is known. With absolute magnitude 18.5 it gives out only 1/50,000 as much light as the Sun. More white dwarfs are being discovered, and it would seem that they make up a considerable proportion of the star population of our Galaxy.

We have frequently used the stars as an illustration of the changeless nature of the universe. The poet John Keats began one of his beautiful sonnets with these words: Bright star! would 1 were steadfast as thou art.

But the modern astronomer, the true explorer of the twentieth century, has some surprises for us. He finds that not all the stars give off a steady, constant light. There are variable stars that fluctuate in brightness, color, spectrum, yes-and even in size. Some of these stars flare up and fade in brightness from hour to hour, while others take months to go through their period of variation. For example, Polaris, "the Pole Star," has a cycle of varying brightness of a little less than four days. It is actually a system of three stars revolving about one another, and their period of revolution produces a i o per cent variation in the light Polaris sends us.

The Variable Stars

Betelgeuse is a semi-irregular variable which changes by one-half magnitude of brightness from time to time. This red super giant does not vary because it is a double star; it seems to flare up as the result

of a sudden burst of energy. After its bright period it gradually subsides to normal luminosity. Strangely enough, Betelgeuse varies as much as 110,000,000 miles in diameter between its maximum and minimum brilliance.

We can readily understand how two stars that eclipse each other will cause a variation in brightness. This produces what is known as an eclipsing binary. Since more than twenty thousand double and multiple stars have been charted, we would expect a goodly number to be eclipsing. We found that Algol was a star of this type. See page 148. As early as the seventeenth century modern astronomy recorded the variability of Algol; but it was not until 1784 that John G. Goodricke, a young deaf and dumb Englishman who spent much time studying the stars, found that the variation of light was caused by Algol's being a huge binary. He found that the fainter star came in front of its brighter companion, thus shutting off the light. This cycle occurs every 2 days, 20 hours, and 49 minutes, with the star fading for 41.50 hours until it reaches its minimum brightness. For twenty minutes it remains dim and then it begins its return to 2.2 magnitude. This dimming of Algol can be seen with the unaided eye, since it loses five sixths of its brightness during these periods of eclipse.

The Cepheid Variables

In 1784 young John Goodricke, who had previously found Algol's secret, announced that he and his friend, Pigott, had discovered three new variable stars. We are particularly interested in two of these, Delta Cephei and Eta Aquilae, since they are members of a large family of stars that have been named Cepheid variables, after Delta Cephei. This interesting star has a regular brightness rhythm, for its light changes from magnitude 3.6 to magnitude 4.3 during a cycle of 5 days, 9 hours. From the weakest point the rise in brightness is rapid, taking only about one and a half days to reach the maximum. Then its light begins to wane, and it continues to dim slowly but constantly for about four days. At this point the cycle starts over once more. Because of this cycle of light change, the Cepheid variables have been called "pulsating stars."

The discovery of the first Cepheid started a search for other stars with the same characteristics. In 1895 Professor Solon L. Bailey, of Harvard College Observatory, discovered a number of variable stars in certain globular clusters. These variables were found to have pulsation periods of less than a day. This discovery led to the division of the Cepheids into two groups: the classical Cepheids, some of which can be seen with the unaided eye and which have periods longer than one day; and the cluster type, none of which can be seen without telescopic aid and which have a period of less than a day. The cluster type travel at speeds up to 200 miles per second, and at least 1,500 have been located. The cluster type Cepheids number almost 3,000 of which about 2,500 are located outside our Galaxy.

How the Cepheids became one of the most accurate yardsticks for measuring the heavens is an interesting story. The Clouds of Magellan hold amazing wonders, for they have a wonderful richness in stars which can be numbered only by the tens of thousands. Prior to 1906 Miss Henrietta S. Leavitt, of Harvard Observatory, studied some 1,700 variable stars in the Magellanic Clouds on photographic plates. In 1912 she found that 25 of these stars had periods ranging from 2 to 120 days. As she arranged them according to their increasing periods of pulsation (that is the time interval separating periods of maximum brightness), she found that they automatically fitted themselves into a pattern of increasing brightness. A star that takes 100 days to complete its period of brightness to dimness and back to brightness is about 22,000 times as bright as the sun, while a Cepheid that has a cycle of only 5 days is about 700 times as bright. Stars with periods of about 2 days have photographic magnitude 15.5, and as the periods increase the brightness grows until those with the longest periods have magnitude 12.5.

Since the stars in the Magellanic Clouds were so far away, they could, for practical purposes, be considered at the same distance. It was therefore concluded that difference in distance was not the cause of the variation in brightness. There must he a difference in the intrinsic brightness of the variables, which depended directly on the period of pulsation. If this period-magnitude relation held for the Cepheids of the Magellanic Clouds, would it not also hold for other Cepheids? If the period of a variable is known, then the true brightness of the star is also known. With these two facts it would be comparatively easy to find the distance of each Cepheid by computing the difference between its true brightness and the brightness at which it appears. Astronomers now realized that the Cepheids were giants-a fact easily discovered from their motions and other peculiarities.

With this empirical law to guide them, Professor Ejnar Hertzsprung, and later Dr. Harlow Shapley,

seized on the Ccpheids as a yardstick for sky measurements. By 1942, Shapley was able to compile data on over 500 variables of the Small Magellanic Cloud, and thus he was able to obtain a correlation between the period and the true brightness from which the luminosity of any Cepheid could be deducted to within half a magnitude. With these variable stars to aid the astronomer, the sky distances have become more and more certain. A single Cepheid found in a globular cluster or spiral nebula is now enough to estimate the distance to the starry system in which it is found. Since there are many Cepheids in the globular clusters, Dr. Shapley gave these his special attention. He has found the globular cluster system to be more than a hundred thousand light-years across. The Small Magellanic Cloud is approximately 84,000 light-years away; the Large Cloud is 75,000 light-years distant, while the Andromeda Nebula is not less than 750,000 light-years from us. It is another great galaxy like our own, proved so because of the Cepheids found in it.

"Once a base line of one or two million light-years was established from the study of Cepheids in the nearest galaxies, there was apparently nothing to stop astronomers in their new race into space. Farther and farther receded the horizon of our visible universe; one, two, three hundred million light years, figures that can mean little to us, made their appearance in astronomical publications. " - Leon Campbell, The Story of Variable Stars, page 75.

The Cepheids may be likened to signs in the sky, flashing on and off with special messages for man. They have been sending out their signals for countless ages, but only today has science found how to read what they are telling of the immensity and wonder of God's universe.

Stars That Explode

History has recorded the sudden appearance of brilliant objects in the sky. These were named novae, the Latin word for "new," because it was first thought that they were new stars. Modem study with the telescope has brought out the fact that they are faint stars that suddenly flare up in brightness, and then, after a period of time, gradually fade back to their former appearance.

Over two thousand years before the birth of Christ the Chinese watched these novae with awe and fear, for they considered them to be omens of disaster. Only one new star was recorded in Europe before the seventeenth century, a brilliant one named "Tycho's Star," since Tycho Brahe was one of the first persons to see it and note its variations in light.

In 1604, thirty-two years later, another unusually bright star was seen in the constellation of Ophiuchus. Since Kepler made a special study of it, this star we named for him. It is believed that our Galaxy has some 2,500 such explosions in a century, but only 8 have been seen without the aid of a telescope since the twentieth century began.

Nova Persei 1901 was discovered in an unusual manner. A Scottish clergyman, Dr. T. D. Anderson, was walking home late on the night of February 21, 1901, when he noticed a strange star in the constellation of Perseus. His study of the stars had made him so familiar with the heavens that he recognized this bright object to be a new addition in that part of the sky. The Greenwich Observatory was notified, and after checking the fact that a star was there, astronomers flashed the news to the world. With the help of photographic plates Dr. E. C. Pickering, of Harvard College Observatory, proved that this nova was not actually new. It had been a faint star of the thirteenth magnitude' when it had been photographed only two days before. Forty-eight hours later it was a third magnitude star-an increase in brightness of 10,000 times! As the star was watched from night to night it increased in brightness, but after six days at its brightest point it began to fade slowly. Eleven years later the star had returned to magnitude 13, its original luminosity. The celestial drama was over for that star in the constellation of Perscus.

There are supernovae-over thirty have been discovered to date-which make the average ones seem like candlelight by comparison. Some of these have a brightness 100,000,000 times that of our Sun. What causes these seeming explosions, or flare-ups, no scientist has been able to determine. There have been a number of theories as to how they are produced, but the real cause of these sky spectacles has not been determined.

The fires of strange suns shine above us, and we can observe the celestial light on any clear night. Why do we not become better acquainted with "the host of heaven"? It is time for us to disprove the statement Ralph Waldo Emerson made a century ago: "The man in the street does not know a star in the sky." We can know many strange and wonderful things about the stars today; and as we learn of variable stars, novae, and the giant suns whose weight is beyond our comprehension, we bow our heads in reverence before the Creator who made them all.

Electronic telescopes of the future may join with great instruments of today in discovering more and more about the glory of the stars; but our knowledge will have little value unless it helps us understand the meaning of life and our relation to the universe. The pattern begins to fit together as we listen to the apostle John's words: "Behold, what manner of love the Father bath bestowed upon us, that we should be called the sons of God.

"The Stars in Their Courses"

MANY OF OUR MEN OF ANTIQUITY were more familiar with the stars than we are, and in the quiet hours of darkness the wonder of the heavens entered their souls. In the drama of Job God speaks from the whirlwind and challenges job and his friends to consider the blazing suns that they frequently gazed upon with awe. The voice of the Eternal asks: "Can thou bind the sweet influences of Pleiades or loose the bands of Orion? Can thou bring forth Mazzaroth in his season? or can thou guide Arcturus with his sons?"

When we consider each of these references in the light of modern astronomy, we find that the inspired words reveal a knowledge of the stars that harmonizes with the most recent scientific research. It was Charles Burckhalter, astronomer at Chabot Observatory, who, after reading these verses in the book of Job, declared: "The study of the book of Job and its comparison with the latest scientific discoveries has brought me to the matured conviction that the Bible is an inspired book and was written by the One who made the stars." and history. It appears as a hazy patch of light in the wintry sky, and five or six stars are plainly visible. The name Pleiades is of ancient origin, probably from the Greek word meaning "full" or "many." Indeed, the Pleiades consist of hundreds of stars which cover an area in the sky about 30 light-years in diameter.

When the scholars of King James' time prepared the Authorized Version of the Bible, they translated this question to read: "Can thou bind the sweet influences of Pleiades?" The word "influences" is better rendered "chains" or "fastenings;" but the sixteenth-century theologians did not realize the wonderful movement of the cluster of stars, and they thought the word merely referred to the "influence" which the stars were supposed to cast upon men. Today science agrees with the original meaning of the Hebrew word as it is rendered in the Revised Version: "Can thou bind the cluster of the Pleiades?" The Creator has bound this wonderful group of over 200 stars together, and, as Sir James Jeans says, "They are journeying perpetually through the sky in one another's society." Their relation to one another seems to be eternal, for they are speeding on their course as a unit.

The Pleiades, some 350 light-years distant, have nine prominent stars. We begin to see this cluster in the evening sky about the first of October. Alcyone, the brightest, is a super giant, and the eight others, all brighter than the sixth magnitude, are at least 8oo times the size of our Sun. Most of the stars in the open cluster are blue in color, and they are traveling at terrific speeds. Man can do nothing to hold, or chain, them together; but the Creator has decreed that they shall move as a unit. Truly this jewel like cluster testifies to the power of the everlasting God and to the truthfulness of His word.

The Orion Nebula

When 1 look into the sky on a winter's night my eyes always turn toward Orion, for this constellation seems to dominate the heavens. Ancient peoples imagined this group of stars had the shape of a giant man who raised a menacing club in his hand. He wore, also, a belt about his waist from which hung a sword. This many-sided figure has four bright stars marking the main corners of the outline, and of these two are Betelgeuse and Rigel. A diagonal row of three bright stars form Orion's Belt, and from top to bottom they are Mintaka, Anilam, and Alnitak. Each is a double star, and Alnitak may be a triple sun.

Those three stars of the airy Giant's zone
That glitter burnished by the frosty night.

Job was asked by the Creator if he could 1oose the bands of Orion." Of course the answer is No. It is of particular interest to find that the three stars of the belt are moving in different directions and eventually the shape of the belt will change. From the third star in the belt hangs Orion's sword, composed of four principal stars. In the midst of these is M 42, the Great Nebula of Orion. It appears to the naked eye as a misty object suspended from the giant's belt.

Although the Orion Nebula is more than 600 light-years from us, its vastness is beyond the power of words to describe. Here is what two astronomers say about it: “The soft greenish hue of the nebulous mass, gradually dimming toward the edge of the field, its erratic though immobile shadings, smooth and mellow in spots, hard and sharp elsewhere, together with the diamond like scintillation of the four closely packed stars of the trapezium, present a picture of unsurpassed beauty. No telescope has ever been able to resolve this glowing mass, and spectroscopic evidence shows that it is a true nebulous cloud of gas, shining in the transmitted glory of its central stars.” Bart J. and Priscilla Bok, The Milky Way, page 1 10.

This cloud of glorious light, with hues of the rainbow, shines with a brilliance that reminds us of what heaven must be like, for in the dwelling place of the omnipotent King the light is so dazzling the angels cover their faces.

Just above the Great Nebula is a dark region known as the Horse Head Nebula. It is so called because the dark area takes the form of a horse’s head as it is outlined by the starlight behind it. This cloud, suggesting a mammoth thunderhead, absorbs the light of countless suns beyond it. It is a celestial curtain stretching over a vast region and probably hiding millions of stars, all perhaps larger than our Sun.

I shall never forget the nights 1 have looked at Orion through the telescopes at Lick Observatory and at Chabot Observatory. Many times 1 have read the words of Alfred Tennyson, the poet who loved stars, where he describes this celestial region.

A single misty star Which is the second in a line of stars That seem a sword beneath a belt of three, 1 never gazed upon it but 1 dreamt Of some vast charm concluded in that star To make fame nothing. The Orion Nebula seems to shine because of the great winds of light pressure which blow through interstellar space.

From the center of the nebula the glory reaches out some trillion miles in all directions, for the diameter is about four light years. Years ago Edgar L. Larkin, in an article which was quoted by the Signs of the Times Magazine, gave his impressions of Orion’s glory spot in these words: “What, then, should be said of the mighty cavern in the depths of Orion’s Nebula? Torn, twisted, and riveted masses of shining. gas, irregular pillars, columns, and stalactites in glittering splendor, and stalagmites rising from the mighty floor! The appearance is that of light shining and glowing behind Herculean walls of ivory or pearl, and these studded with millions of diamond points shining stars.”

How significant become the words of the renowned astronomer, George Ellery Hale: “Like buried treasures, the outposts of the universe have beckoned to the adventurous from immemorial times. Princes and potentates, political or industrial, equally with men of science have felt the lure of uncharted seas of space. As yet we can barely discern a few of the countless suns in the nearest of these spiral systems and begin to trace their resemblance with the stars in the coils of the Milky Way.”

The Glory of Arcturus

“Can thou guide Arcturus with his sons?” is another question propounded to Job. This blazing sun, the fourth brightest star we see in the Northern Hemisphere, is some 22 times as large as the Sun. It moves through space like a rocket, for it glides forward at over 5,000 miles a minute. How would you like to steer such a missile in space? We need not worry about its keeping on course, however, for it is guided by its Creator.

Men of ancient times were not able to measure the speed of the stars, for Arcturus moves only about one eighth of the apparent diameter of the Moon in a century; but God referred to the speed of this sun and how it moves in perfect accord with divine law.

Arcturus is about 33 light-years from the Earth. Some 25 years ago it was believed that the speeding star was 40 light years away, and when the Century of Progress Fair was opened in 1933 the rays of light of that star were used to set off the switch that illuminated the exhibits. It was said the light left the star at the time of the World’s Fair of 1893. However, the distance had not been reckoned correctly, and today we know Arcturus is 326 light-years distant.

We have lost much of the thrill of living if we have not learned to wonder. Certainly in the science of astronomy we feel the mystery and grandeur of God’s creation. As we ponder the unity of the Pleiades, the glory of Orion, and the speed of Arcturus, we agree with President John Quincy Adams, who said that a study of the starry sky seems to lead man “blindfold up to the council chamber of Omnipotence, and there, stripping the bandage from his eyes, bid him look undazzled at the throne of God.”

A beautiful appeal to seek the Creator of the universe is made by the prophet Amos, who had been

a herdsman of the Palestinian hills. He says: "Seek Him that makes the seven stars [the Pleiades] and Orion, and turned the shadow of death into the morning, and makes the day dark with night: The Lord is His name."

'To the Uttermost"

MEGA GALAXY! What does that word mean? It is the term used by astronomers to describe the entire universe-galaxies, clusters, nebulae, stars, planets, interstellar gas, and dust and radiation. Our Galaxy, though over a hundred thousand light years in diameter, is only one of perhaps billions of galaxies in the universe. It may well be that each of these galaxies has more than a billion stars like our Sun, and that around these suns move unnumbered planets. No wonder our minds become bewildered at the immensity of God's creation and "the number of the stars."

We have found that the Milky Way is the shape of a flat pancake some 100,000 light-years in diameter and 10,000 light-years thick, and composed of stars and gaseous clouds. We learned, too, that our Sun and its attending planets are located about two thirds of the way out from the center of our galactic system. But after we have made these discoveries, we ask, "What lies beyond our Milky Way?"

For many years scientists saw nebulous clouds of light in the heavens which they believed to be luminous gas. As stronger telescopes probed these regions and cameras could take long exposure photographs, it was found that these were not hazy clouds at all but gigantic collections of stars. Therefore, what were in many instances thought to be nebulae, and were so named, have since been found to be galaxies. They are one of the most recent discoveries of the science of astronomy. By studying their form and spectra, and by establishing their distance, nebulae can be put in two classes: the galactic nebulae and the extra galactic nebulae. The first group are those inside the limits of our Milky Way. They are usually irregular in shape and possess low-density gases. The extra galactic nebulae, as the name implies, are beyond our Milky Way system. Circular, elliptical, or spiral in shape, they are usually much larger than those found within our Galaxy.

During a period of eighteen years astronomers of Harvard College Observatory have discovered a million galaxies on their photographs. Varying in size and brightness, they seem to be moving away from one another at fabulous speeds. Only a dozen or fifteen of these galaxies are "near" us, according to Dr. Harlow Shapley, and by this he means they are less than a million light-years away! Astronomers now believe that almost a billion galaxies lie within a billion light-years of us, only waiting to be photographed. If the distribution is at all uniform, perhaps another billion galaxies lie hidden by the star clouds of our Milky Way.

The Andromeda Nebula

The most familiar external galaxy is the Andromeda Nebula, which the Great Architect placed in the heavens so that man can see it on a clear autumn or winter night with the unaided eye. You will find it to be a faint spindle-shaped speck of light if you search the upper part of the constellation of Andromeda. Take a deep breath as you look, for you are watching an object without the help of telescopic lenses that is more than four quintillion miles away. The light you see left the galaxy more than 750,000 years ago. In awe we whisper, "From everlasting to everlasting, Thou art God."

This nebula appeared as a hazy spot of light in the sky to a German, Simon Marius by name, as he observed it through his telescope in 1612. He said the cloud effects reminded him of a candle shining through a plate made of horn. With the advent of powerful telescopes the nebula became distinct and dark rifts could be seen. Then globular clusters, open clusters, and clouds of gas were distinguished as photographs were taken of this wonder spot of the heavens.

The size of the Andromeda Nebula has been computed from angular measures, and it is found to be 35,000 light-years long and about 8,700 light-years thick. The Andromeda system can be considered a fair example of what our Milky Way looks like, only on a smaller scale. Photographs show the nebula to be oblong in shape and the brightest in the center where the largest number of suns are found. They seem to thin out rapidly toward the outer edges of the system, as if disliking to be alone in the far reaches of space. According to Dr. Hubble, the Andromeda Nebula may have 100,000,000,000 times as much mass as the Sun and it may be 2,500,000,000 times as luminous. If this is the case, then it should have about 200,,000,000,000 stars in its titanic system.

"Neighboring Systems"

There are three "neighboring galaxies" in the region of Andromeda - Messier 32, Messier 33, and NGC 205. (These refer to star catalogue numbers.) Much of the study of the stellar content of galaxies has centered on these four neighbors. The nebulae seem to be of varying sizes and they differ in brightness. It is amazing to find great clusters of suns all moving in the same general direction and at about the same speed. They seem to prove anew that the universe is a perfectly planned and integrated system of heavenly bodies moving according to divine law.

Messier 32 is a typical spheroid galaxy, brighter than its companion NGC 205, although no individual stars of any kind have been located with certainty in them. In fact, NGC 205 has a luminosity much less than the giant Andromeda Nebula, and may be considered a pygmy among the galaxies. The third neighbor, Messier 33, is a little brighter than the average spiral nebula, and it possesses Cepheid variables, novae, open clusters, and super giant stars.

The Magellanic Clouds

When we turn to the Southern Hemisphere we find two star clouds associated with the name of the circumnavigator Magellan. The clouds were described by Pigafetta, the historian of the round-the-world voyage, who wrote of his sky observations as well as about the exciting adventures the crew had on sea and land.

The Small Magellanic Cloud is in the constellation of Toucan, while the Large Cloud is in Dorado. When the clouds are viewed with the unaided eye or a small telescope they give evidence of rich treasure. Astronomers of the Harvard College Observatory began to make discoveries about these galaxies over sixty years ago, and they reported that these clouds had an "appalling richness in stars, which could be counted not by the hundreds but by the tens of thousands." This was the beginning of a great astronomical "find."

In a study made by Miss Henrietta S. Leavitt, she found over 1,700 variable stars in the Clouds of Magellan. Other stars similar to those found in the Milky Way were charted. The most unusual object photographed was the Loop Nebula (known as 30 Doradus). So gigantic is it in size, that, says Dr. Shapley, "there is nothing like it in our galactic system, as far as we can discover; but far away in some other galaxies we have found comparable super giant gaseous nebula." When red-sensitive photographs were taken of the Loop Nebula, they revealed a cluster of over a hundred super giant blue stars. This cluster is about one hundred times as bright intrinsically as the globular cluster in Hercules.

Variable stars have helped to ascertain that the Magellanic Clouds are much nearer to us than the Andromeda Nebula. The Small Cloud is 84,000 light-years distant, while the Large Cloud is 75,000 light-years away. The Large Cloud is moving away from us at about 170 miles a second, while the Small Cloud is jogging along at only 100 miles a second.

A small but interesting galaxy, NGC 6822, was discovered in the constellation of Sagittarius by Dr. Edward E. Barnard in 1884, while he was still an amateur astronomer. Eleven Cepheid variables have been found in this galaxy and they tell us that its distance is approximately 500,000 light-years from the Earth.

Altogether there seem to be about a dozen galaxies within a million light-years of us. As we leave our "near neighbors" and push farther out into space, we find fewer galaxies in proportion to the distance. At three million light-years, an increase of 27 times the volume surveyed, only another dozen galaxies have been located. But at this point we are only at the frontier of the universe, for photographs are now being made of galaxies 500,000,000 light-years away. Our minds stagger at the immensity of space and the infinitude of time, for these pictures show the position of these galaxies as the light left them half a billion years ago!

As astronomers probe at infinity and seek the depths of space, we ask again: How did they all begin? There is only one answer-an omnipotent Creator called them into existence. Although the universe is beyond our comprehension, we can see everywhere the handiwork of the Creator.

Is there a general trend that would suggest a form or structure of the mega galaxy similar to that of a star cluster, with dense nucleus and peripheral thinness, or analogous to the structure of our flattened spiral Galaxy?

"To save time, we go to the answer immediately without bothering to present facts or arguments.

The answer is, 'No Bottom.' There is no indication of a boundary; nor is there good evidence that there might not be one if we went out far enough." - Harlow Shapley, Galaxies, page 190.

Think of the distant points of the universe 500,000,000 light-years away that have been reached with the telescope! Look at only one galaxy with a billion stars moving around in it in perfect order, turning like a mammoth wheel in space at speeds from 150 to 200 miles a second. Here shine the super giants in all their glory. No wonder Isaiah would say that the inhabitants of the Earth "are as grasshoppers," and "nations are as a drop of a bucket."

In his recent volume Dr. W. M. Smart, Regius Professor of Astronomy, University of Glasgow, makes this confession of faith in God. "When we study the universe and appreciate its grandeur and orderliness, it seems to me we are led to the recognition of a creative power and cosmic purpose that transcends all that our limited minds can comprehend. In one of his essays Lord Bawn expressed this belief picturesquely as follows: 'I had rather believe all the Fables in the Legend and the Talmud and-the Alcoran than that this Universal Frame is without a Mind.' Today we have learned very much more about the 'Universal Frame' than was known in Bacon's time; nevertheless, to many of us, scientific and nonscientific alike, the belief in a divine Creator is as necessary now as ever it was. To one astronomer at least 'the heavens are telling the glory of God and the wonder of His works.' "-The Origin of the Earth, page 235.

"The Ordinances of Heaven"

THE STARRY HEAVENS humble us and at the same time, exalt us. Flow amazing is the mind of man to be able to discover the speed of light, to take the delicate instruments he has made and analyze the elements that compose a far-off star. Nor does he stop here, for with the talents God has given him man probes the universe and discovers the laws by which all things move in perfect harmony.

Orderliness is the first law of the starry heavens. There could be no science of astronomy if the motions of the planets, suns, and galaxies were not in harmony with the laws of nature. The' planets in our solar system move in the same direction very nearly along a common plane. (Pluto's orbit is highly inclined to the average plane of the other planets.) In addition, about a thousand asteroids follow the same path around the Sun. Most of the moons, except those of Uranus and Neptune and the outer moons of Jupiter and Saturn, move in the same common direction. Our world speeds along a highly convoluted path through space without collision. It turns at about 1,000 miles an hour, moves in its orbit around the Sun at some 68,000 miles an hour, and speeds with the Sun and its system toward the constellation Hercules at some 44,000 miles an hour.

Then consider that every other sun and its planets are also moving at comparable speeds, and our bewilderment becomes more intense. Are there collisions? No, a head-on collision between two stars, says one astronomer, could not occur oftener than once in a trillion years-which, as far as man is concerned, is never!

The prophet Jeremiah wrote poetically of the laws of the universe in these words: "Thus said the Lord, which gives the Sun for a light by day, and the ordinances of the Moon and of the stars for a light by night, which divides the sea when the waves thereof roar; the Lord of hosts is His name."

In all these motions there is harmony and obedience to law. It was Immanuel Kant, a German philosopher, who testified: "Two things there are that inspire wonder and constantly increasing reverence the oftener and more they are considered. The starry heavens above me, and the moral law within me."
The poet Percy B. Shelley sees the glory of the stars as-

Countless and unending orbs In mazy motion intermingled, Yet still fulfilled immutably
Eternal nature's law. Above, below, around
The circling systems formed A wilderness of harmony;
Each with undeviating aim,
In eloquent silence, through the depths of space Pursued its wondrous way.

For hundreds of years scientists attempted to solve the mystery of how the planets moved. Johannes Kepler, following up the research of Tycho Brahe, showed that heavenly bodies do not travel in circles, but in ellipses; he also gave the world three laws of planetary motion. However, it was not until Sir Isaac Newton came that the laws of the universe were fully known and understood. It was Lagrange who

said Newton was the greatest of geniuses, "and most fortunate, for nobody ever again could be the first to set the world in order."

Newton's Discoveries

In 1678 Newton's Principia Mathematica was published. It is sometimes described as "the greatest work on exact science that the human mind has ever conceived." How he came to discover the general principles is told in a recently discovered life of Newton written by the Rev. William Stukeley. Many scholars scoffed at the story of the apple that fell from the tree in the garden and the inspiration it gave the man. But Stukeley confirms the anecdote in these interesting paragraphs concerning his own experience with Newton:

"After dinner, the weather being warm we went into the garden and drank tea under the shade of some apple trees, only he and myself. Amidst other discourse, he told me, he was just in the same situation, as when formerly, the notion of gravitation came into his mind. It was occasioned by the fall of an apple as he sat in a contemplative mood. Why should that apple always descend perpendicularly to the ground, thought he to himself. Why should it not go sideways or upwards, but constantly to the Earth's center? Assuredly, the reason is, that the Earth draws it. There must be a drawing power in matter: and the sum of the drawing power in the matter of the Earth must be in the Earth's center, not in any side of the Earth. Therefore does this apple fall perpendicularly, or towards the center. If matter thus draws matter, it must be in proportion of its quantity. Therefore the apple draws the Earth, as well as the Earth draws the apple. That there is a power, like that we here call gravity, which extends itself through the universe.

"And thus by degrees he began to apply this property of gravitation to the motion of the Earth and of the heavenly bodies, to consider their distances; their magnitudes and their periodical revolutions. To find out, that this property conjointly with a progressive motion impressed on them at the beginning, perfectly solved their circular courses; kept the planets from falling upon one another, or dropping all together into one center; and thus he unfolded the universe. This was the birth of those amazing discoveries, whereby he built philosophy on a solid foundation, to the astonishment of all Europe."

As the result of his cogitations, Newton went on to write his Prinicipia, in which he stated laws of the universe that have since become a part of every textbook on physics. He presented the law of universal gravitation, according to which bodies attract each other in direct proportion to #heir masses and in inverse proportion to the square of the distance between them. Newton said that every body, if not impelled by a force, continues in its state of rest or of uniform motion; that the change of motion, the acceleration, is proportional to the motive force; and that the mutual actions of two bodies upon each other are equal and contrarily directed.

By the law of gravitation we are able to predict and compute the motions of all bodies, not only on the Earth but in the universe. Newton's discoveries proved what Galileo had believed concerning the law of falling bodies and the law of the composition of velocities. He showed that the force that keeps the Moon revolving in its circuit is the same force that causes a stone in flight to curve toward the ground. He reasoned that since the Earth attracts an apple or a stone that is thrown it should also attract the Moon. The Moon would fly off in a straight line unless it was acted upon by a force. Since the Moon moves in a curved line it must be continually falling toward the Earth, and the rate of fall is measured by its deviation from motion in a straight line. The pull of the Earth must be of the exact magnitude to cause the Moon to fall as it does.

The discovery of the law of gravitation brought to light the omnipotent force by which the Sun holds the planets in their course, and in turn shows how the planets hold their satellites in their orbits. If the law of gravitation is true, then the different bodies must disturb one another, for Newton had pointed out that every particle of matter attracts every other particle by a force that varies in direct proportion to their masses and in inverse proportion to the square of the distance between them. Planets attract each other and also the Sun. Since the Sun is so much larger and heavier its pull is much greater than that of the planets. Nevertheless, the gravitational pull made corrections in the motions necessary, and these corrections are called perturbations, because one planet perturbs or disturbs the motions of another one.

Newton tracked the Moon through all her devious motions, carefully measuring the action of the Sun on her movements. He found where the Moon would speed up and where she would slow down because of the Sun's gravitational pull. He solved most of the strange actions of the Moon by showing how the laws were at work inner motions.

Speaking of the far reaching effect of Newton's law of gravitation, Dr. Whipple says that "the whole foundation of astronomy rests on application of the law. Outside the solar system, in the far reaches of the universe, the law is still the key to the solution of many of the most important problems." One of the greatest proofs that the law of gravitation is universal is the motion of double stars. The rate of motion of two stars in a double-star system about one another depends on the gravitational force between them. After astronomers have observed the time required for two stars to circle each other and by measuring the distance between them, they find the restraining force and, as the result, the mass.

A Reign of Law

The stars declare that the universe is under a reign of law. Indeed, "the heavens declare the glory of God," and "the law of the Lord is perfect." The scientist Charles C. Froude has said: "All nature is under the reign of law-everything, from the tiny, single-celled protozoa to the mightiest planet. We have liws of gravitation, laws of attraction and repulsion, laws of tides and seasons; the simplest elements of nature, gas, liquids, solids, heat, cold, electricity-all are governed by law. Is it reasonable to suppose that the Creator should have started this world on its course, placed man in a world of law, but left him without law? It is unthinkable."

As Sir Isaac Newton beheld the perfection of the universe and the wonder of the heavens and the Earth, he said: "This universe exists, and by that one impossible fact declares itself a miracle. Postulates an infinite Power within itself, a whole greater than any part: a unity sustaining all, binding all worlds into one. This is the mystery, the unquestioned miracle that we know, implying every attribute of God."

Can anyone who knows the glories of stars believe that the suns, galaxies, and the universe as a whole is moving by blind chance? Long ago Copernicus said: "To know the mighty works of God, to comprehend His wisdom and majesty and power, to appreciate, in degree, the wonderful working of His laws, surely all this must be a pleasing and acceptable mode of worship to the Most High, to whom ignorance cannot be more gratifying than knowledge." The majestic procession of the starry sky, the motion of a billion fiery suns, the laws of the heavenly bodies-all proclaim an omnipotent God who rules over all. They prove to us that all creation has unity and harmony. As Samuel Rogers has well said:

The very law which molds a tear And bids it trickle from its source, That law preserves the Earth a sphere And guides the planets in their course.

"When I Consider Thy Heavens"

THE SUN HAS SET behind the hills west of the little village of Bethlehem, and a young shepherd, David by name, looks at the afterglow which is fading from crimson to blue. Twilight deepens as the son of Jesse brings the last lagging sheep into the sheepfold. His work done, the youth leans on the stone wall and gazes into the sky where the first stars of night are beginning to glimmer as pin points of light. Soon, in the clear air of Palestine, the heavens are filled with stars. A wisp of breeze from the Great Sea touches the grass, and a night bird calls to his mate. David watches the stars, and poetic inspiration wells up within his soul. He whispers the words of a psalm: "The heavens proclaim God's splendor, The sky speaks of His handiwork; Day after day takes up the tale, Night after night makes Him known."

The quietness is almost overwhelming; a solitary man feels close to God as he looks with awe at the stars. Their speech has never a word, not a sound for the car And yet their message spreads the wide world over, Their meaning carries to Earth's end. How were all the wonders of the universe made? The shepherd reflects. The answer comes to David as faith possesses him. The heavens were made at the Eternal God's order And all their host by His mere word.

We, like David, feel the awe and majesty of the Creator when we meditate upon the design and orderliness of the universe. When we consider the mighty ocean, the miracle of life, the starry sky, our mind is possessed by a sense of the sacred. We say with the poet of Israel:

Bless the Eternal, 0 my soul! Eternal One, my God, Thou art most great, Arrayed in glorious majesty.

There is no branch of science that confirms faith in God more than does astronomy. By searching the heavens we do not find God, but we are able to see the glory of His creation and fathom some of the bewildering complexity of the structure and motion of the starry systems which obey divine law.

Dr. Robert G. Aitken, once director of Lick Observatory, recounted how the eruption of the great

Andean volcanoes in April, 1932, threw clouds of ashes into the sky and blotted out the sun, moon, and stars for days. The people were panic-stricken, for the end of the world seemed imminent. Then came a night, as a journalist phrased it, when "the stars reappeared and confidence was restored."

How beautifully this expresses our reaction to the experiences that we face in these dark and chaotic times. We have little confidence in man's ability to bring peace or security to this generation; we are at out wit's end. But when we go out under the open sky and look up at the stars our confidence in God returns and we can face the future with hope.

The Master Architect reveals His planning in the electron, molecule, living cell, plant, and animal. The same wonderful laws rule on this Earth as in the farthest recesses of the universe; the same chemical elements are found on our planet, in our bodies, as in a glowing far-off nebula.

We cannot delve into the science of the stars without feeling humbled and insignificant. Again we are reminded of the words of David, for he declared:

Let me sing of this, Thy heavenly strength,
Like tiny children lisping out Thy praise.
For, as 1 look up to the heavens Thy fingers made,
The moon and stars that Thou has shaped,
1 ask, "And what is man, that Thou should think of him?
What is a mortal man, that Thou should heed him?"

If David, who did not have the privilege of observing a thousand suns through a powerful telescope, could recognize the grandeur and beauty of God's symphony of the stars, it is no wonder we ask, "Why should the Eternal One care for such creatures as man on one of the tiniest planets in a solar system that is dwarfed by star clusters and galaxies?"

This is the mystery of divine love. We have a Creator who not only made millions of suns, but He loves the human race so much that although we turned our backs upon Him and disobeyed His commands He sent His only Son to live with us and die for us so that we might be brought back into the family of God. "Think what a love the Father has for us, in letting us be called 'children of God!"

While the stars testify of the Creator's wisdom and power, yet it is in the gift of Jesus Christ that we see the clearest revelation of the Father's love and mercy. Taking the weakness of humanity upon Himself, Jesus was made like one of us. He knew what it meant to be hungry and weary; he felt discouragement and wore the garment of loneliness. He was tempted to do wrong even as you and 1 know the pull of sin; yet in all His weakness He was strong and undefeated. He gained the victory over sin and death in order that we might be redeemed from the penalty that doomed us.

It was on the cross on Golgotha that God's love focused in its greatest intensity. As we see Jesus dying there-a kind, sympathetic Savior who had done no wrong, we can but say: "God so loved the world, that He gave His only-begotten Son, that whosoever believes in Him should not perish, but have everlasting life." This is the divine answer to the question, "What is man?" Here is final and irrefutable proof that God loves and values every human being beyond the most priceless treasure. It is through Jesus, the divine Son, that we receive every blessing. Nothing is insignificant that Christ has blessed. He made the Sun and Moon; He called the stars into existence; and He died on the cross that we might have life eternal.

Does God reject us when we come to Him? No, listen to His words after you have traveled millions of light-years into space through the eye of a telescope. "This is the word of the Eternal, who sets the Sun to light the day and the Moon and stars to light the night. This is the Eternal God's word: only when heaven above can be measured and the foundations of the Earth below laid bare, will 1 ever cast off the race of Israel for all that they have done, says the Eternal."

Have you worried that God will not forgive the evil you have done or the wrongs you have committed? Think again of the expansive universe and the comparison the psalmist makes between it and the greatness of the Fathers forgiving love:

But, high as heaven is over Earth, So vast His love is to His worshipers; As far as cast from the west So far He puts our sins away from us.

Though we ".See through a glass, darkly" with our finite knowledge, yet we catch a glimpse of God's glory and feel the presence of His Spirit in our hearts. What will it be when we shall see Him face to face! Then we shall travel from one part of the universe to another and perhaps visit a thousand planets. Imagine, if you can, the "sons and daughters of God" who live on other worlds. No doubt the heavenly Ruler and His Son have visited them. This is an awe-inspiring thought, and Alice Meynell captures some of

it in her poem, "Christ in the Universe:

Nor, in our little day, May His devices with the heavens be guessed, His pilgrimage to thread the Milky Way Or His bestowal there be manifest.

But in the eternities, Doubtless we shall compare together, hear A million alien gospels, in what guise He trod the Pleiades, the Lyre, the Bear.

If we are faithful to God there will be a million frontiers for us to explore in His universe. Talk of a trip to the Moon on a rocket ship! It sinks into nothingness when we consider God's plan for us. To the Milky Way and beyond, we shall travel, for we shall "follow the Lamb whither so ever He goes." For our lesson book the mysteries of the universe will be opened to us and we shall have eternity to learn of the wisdom of God.

"Signs in The Stars"

LONG AGO men of the out-of-doors who loved the stars saw many patterns in the heavens, and they imagined the shapes of animals, birds, crosses, crowns, warriors, and heroes in the pageant of the sky. From one generation to another the stories of these star figures were passed along by camel drivers, shepherds, sailors, and soldiers. There are almost ninety constellations, the majority of which date back more than two thousand years before Christ's birth.

The Greeks and Romans took these figures from their predecessors, wove many legends about the objects, and thus made the stars a part of Greek and Latin mythology. Aratus of Soli, who wrote a few years after the death of Alexander the Great, has told us much about the constellations and their names. He said: "Someone no longer living, mapped out the forms. The stars were so multitudinous, so varied in shape and size, and they all went winding about in such a way that he could not possibly enumerate them all; so he grouped them into forms and figures-thus did the constellations get their names.

The medieval concept of the universe is depicted in this woodcut, which shows a scientist looking beyond our solar system.

This may not be the full history of how constellations were named, but it seems to be true in part. We cannot actually see many of the legendary figures in the sky, and some people saw one object in a group of stars, while others imagined an entirely different picture. For example, Lyra, the Harp, has also been called a ram, a turtle, a bird, and even a mule.

Stretching around the sky like a belt is the zodiac, a word from the Greeks signifying "a circle of animals." The twelve groups of figures in the zodiac represent living creatures. The first of these signs was Aries, the Ram. Some of the others include Taurus, the Bull; Gemini, the Twins; Leo, the Lion; and Scorpio, the Scorpion. These celestial markers were linked with astrology, and people in ancient times were careful to order their life to fit the supposedly favorable seasons of the zodiac.

Among the Constellations

Let us look at some of the constellations that fill the sky, for when we recognize the more prominent ones we are able to locate many of the best known and brightest stars. Ursa Major, the Big Bear, of which the Big Dipper is a part, is recognized by almost everyone. The two outer stars of the Dipper's bowl point toward Polaris the North Star. Indeed, the Big Dipper is a beacon that points the way about the sky. James Russell Lowell refers to this constellation in his poem Prometheus: "One after one the stars have risen and set, Sparkling upon the hoarfrost of my chain; The Bear, that prowled all night about the fold Of the North Star, hath shrunk into his den, Scared by the blithesome footsteps of the dawn."

Above the second star from the end of the handle of the Dipper is a faint extra star. Long ago the stargazers of Arabia thought that a person had unusually good eyes if he could see this dim star. However, when it is called to the attention of most people they are able to see Alcor, the extra star near Mizar.

The Big Dipper might be considered a mammoth clock, for it revolves around Polaris every day in about 23 hours and 56 minutes. Indeed, some people are so well versed in star study they can tell the hour of night from the position of the Dipper, if they reckon the time of year.

Aratus speaks about the Big and Little Bears and also of Bobtes, the Herdsman (sometimes called the Bear Driver), which is near Ursa Major. The glorious orange-colored star in Bootes is Arcturus. Below Ursa Major and in a line diagonally through the Dipper is Gemini, the Twins. This constellation, seen best in winter months, features the two bright stars, Castor and Pollux, which, according to the Greeks, were the

twin sons of Leda. In the legend, Helen of Troy was said to be a sister of Castor and Pollux. The twins accompanied their sister on a sea voyage, and in the storm on the return trip the boat was almost wrecked. According to the legend the two stars suddenly appeared in the sky and this was the promise that they would weather the storm. Because of this ancient legend, we have sometimes heard Castor and Pollux referred to as the stars of mariners. In the book of the Acts of the Apostles we find that the boat that took Paul on part of his journey to Rome was under the sign of Castor and Pollux. See Acts 28:11.

If we continue on southward from the Pole Star in the same straight line we find Orion, the giant with the upraised club, who wears a three-star sword hanging from a belt of three stars of the second magnitude. Four bright stars mark the corners of this glorious constellation that is so conspicuous on winter nights. In the northeast corner, or shoulder of the Giant, is Alpha Orionis, known more generally as Betelgeuse. In the south west corner is Beta Orionis, or Rigel. Because this is a huge constellation and appears during the winter season Orion has been linked with storms and tempestuous times.

The Lion and the Whale

Halfway between the handle of the Big Dipper and the horizon is Leo, the Lion. This constellation is easily found in this position on a spring evening, because of the sickle which is attached to its west side-a sort of reversed question mark among the stars. At the end of the sickle's handle is Regulus, often known as the "star royal." Near the lion's tail is Denebola, a bright star that helps to form the Virgin's Diamond. Then between Ursa Minor, the Little Bear, which stays far north, and the Big Dipper, is Draco, the Dragon. It is a large constellation and its tail circles halfway around the Little Dipper.

Below the Dragon is Hercules, best seen in the summertime. Between Hercules and Bootes is the Corona Borcalis, the Northern Crown. Aratus said it was placed in the sky by Dionysus to honor Ariadne. It is a small gem of beauty formed in the heavens by a semicircle of bright stars. The huge figure of Hercules lies next to Bo6tes on the cast. Aratus describes this constellation as a toiling man in the sky. It is the cluster of Hercules that has received special attention by modern astronomers.

Below Hercules toward the horizon is the great constellation of Ophiuchus, the Snake Bearer. This figure is supposed to represent Aesculapius, the son of Apollo, who has been linked with the medical profession and its symbol of the caduceus, the two serpents intertwined. The Snake Bearer is pictured in the sky as a man having a snake around his waist, and he walks on the huge Scorpion. Because Scorpius is so far south not all of it can be seen in northern latitudes. It is in the Scorpion that the red star of the first magnitude, Antares, is found. According to the legends, Scorpius frightened the horses that pulled the Sun's chariot and caused it to run away. The chariot almost collided with the Earth, the myth declared. The best time to view these last-named constellations is during July and August.

To the cast of the Scorpion is Sagittarius, the Archer. A large portion of this constellation is shaped like a dipper lying upside down, with its handle pointing west. Sagittarius is in one of the prominent parts of the Milky Way. It is in this region that the great star cloud becomes so densely populated that the astronomer Barnard says, "The stars pile up in great cumulus masses, like summer clouds." This sky figure is linked with hunting and the chase.

A small constellation to the east of Hercules is Lyra. This word may originally have meant "tortoise" instead of "harp," and when we look at the group of stars we agree that it has more resemblance to a turtle than a musical instrument. In this constellation is Vega, one of the most brilliant stars in the heavens. To the east of Lyra is Cygnus, the Swan. The principal stars of this group form the Northern Cross, a celestial sight familiar to star lovers. Lowell depicts this constellation as presiding over the New Year in these lines: "Orion kneeling in his starry niche, The Lyre whose strings give music audible To holy cars, and countless splendors more, Crowned by the blazing Cross high-hung over all."

Above Cygnus is Cetus, the Whale, which makes a dramatic appearance in the autumn evenings about nine o'clock. One may find this constellation by sighting through the outer stars of the Big Dipper to the Pole Star and then beyond. Below the Whale is Pegasus, the Winged Horse. The Greeks said that Bellerophon tried to ride this horse into the sky, but Jupiter sent a gadfly to sting Pegasus and he threw his rider. This constellation is famous for its great square, the boundaries of which are marked by four magnificent stars. To the east and merging with Pegasus is Andromeda, the Chained Lady, a wide-stretching constellation formed by a double curve of stars. In fact, Alpha Andromedae is the corner star in the Square of Pegasus as well as the end star of Andromeda. The Great Nebula of Andromeda is centered above this double curve of stars, and it can be seen with the naked eyes as a faint haziness or misty patch of

light.

Cassiopeia, a constellation shaped like a widespread W, is north of Andromeda. It has sometimes been called Cassiopeia's Chair, because of the rude resemblance to an armed chair that the stars seem to make. Below Andromeda is Triangulum, a constellation named to fit its shape. This is a long isosceles triangle of stars, a beautiful sight in the night sky. To the east of Andromeda is Perseus, the Greek legendary hero who freed Andromeda from chains and married her. The pagans thought that their hero's memory was kept bright, for they saw his figure in the stars. This constellation possesses one of the most interesting variable stars-Algol.

Directly east of Perseus is Auriga, the Charioteer, shaped somewhat like a kite. This constellation, seen overhead during the winter, has a brilliant star in the center of the Charioteer-Capella, a star 150 times as bright as our Sun. This chariot driver was supposed to have been the hero who drove the Sun's chariot in its daily course across the sky-a part of the Greek myth as to how the earth was lighted by the Sun.

Between Triangulum and Orion is Taurus, the Bull, which is noted for the open clusters of the Pleiades and the Hyades. Taurus is one of the most notable constellations in the sky, not only as the result of its star clusters but also because of the red giant Aldebaran, a star that follows the Pleiades.

The constellations discussed in this chapter and others found on the Star Charts on the end leaves help us to locate the stars and become familiar with them. If you will take the Star Chart in your hands, face south, and hold it above your head you will be able to compare the figures with the stars in the heavens. If you are looking), between 7 and 9 p.m., in the south should appear the constellations that are listed on the chart for the month in which you are making your observations.

As we become familiar with the constellations they are like old friends to us. They are constant, always appearing at the appointed time in their procession across the sky. Harlan T. Stetson, in Man and Stars, has said: "To acquire some appreciation of the meaning of the skies one must make the friendship of the stars; watch their majestic march through the night, and the slow seasonal advance of constellation after constellation from east to west throughout the year. To know Orion, Sirius, Taurus, and the Pleiades as leading roles of the winter skies. Or Lyra, with its Vega, Cygnus, with its Northern Cross, Scorpio, and Antares as the quieter leaders of the softer skies of summer, gives one a sense of kinship with nature which makes a knowledge of their movements more significant, and even life a bit more worth while."

We do not need expensive telescopes or special equipment to enjoy these star groups. Furthermore, as we look at them we can feel a kindred spirit with past generations, for we are looking at the same constellations that Abraham, Moses, David, Socrates, Ptolemy, and thousands of other men have watched.

"See Through a Glass"

IT IS NOT NECESSARY for a person to wait for the day when he can buy an expensive telescope in order to enjoy studying the stars. An amateur may make a simple instrument that will help satisfy his ambition to see the heavenly bodies more clearly, and at the same time increase his interest in a fascinating hobby. If he does not wish to construct an instrument, he may purchase a pair of good field glasses or put a little more money into a portable telescope.

Some amateur telescope makers have developed their ability until they made it their vocation, as an example by famous telescope builders such as Warner, the Clarks, Brashear, Porter, and Swasey, who were first interested in the field as a hobby. R. A. Porter, noted astronomer, once said: 1 have often seen with pleasure the surprise with which the performance even of an opera glass, well steadied, and directed towards certain parts of the heavens, has been witnessed by those who have supposed that nothing but an expensive and colossal telescope could afford any views of interest. But a well-constructed achromatic telescope of two or three inches in aperture will not only supply amusement and instruction; it may be made to do useful work."

Modern prism binoculars are well adapted to star study. A good pair of field glasses with a magnifying Power of 7-10 diameters (meaning the times of magnifying the object) will show four of the moons of Jupiter, the crescent phase of Venus, some of the more prominent features of the Moon, and bring to view the beauty of such stars as those in the Pleiades. If the glasses are too high-powered the view will be unsteady, however. It is well, therefore, to mount the binoculars on a tripod to make the seeing more nearly perfect.

A portable refracting telescope with an opening, or aperture, through which light passes, of from one to six inches may be purchased at reasonable prices. This instrument has a lens, or objective, at one end of the tube. The image formed by this lens is focused at the other end of the tube where the eyepiece-actually a magnifying glass-makes it possible to study the image focused there. A three-inch telescope collects about 2-2.5 times as much light as the eye, while a four-inch lens gathers 400 times as much.

Making an Inexpensive Telescope

A teen-age boy can construct a simple telescope with cardboard wrapping tubes and two lenses. It is best to obtain achromatic lenses for the best results. They may be purchased from companies that supply such kits for amateurs. The object glass should be fitted at one end of the larger cardboard tube, and the eyepiece fastened at the end of the smaller tube so that this tube will fit snugly into the large one with the lenses at opposite ends from each other. (See diagram.) To help prevent reflection of light it is best to blacken the inside of the tubes with black lacquer, water color, or ink. Be certain that the lenses are at right angles to the tube so that the image will be clear. The object glass should also be in exact alignment with the eyepiece to prevent distortion. This is nothing to worry about, for they usually require adjustment after the instrument is finished. A bright star, such as Vega, should appear as a point of light if the night is calm and clear. If there is extra light at one side, it means that on that side the object glass should be moved slightly nearer the eyepiece.

A small reflecting telescope is easily made with three optical Parts: (1) a six-inch-diameter concave mirror, (2) a small, oval, flat mirror, and (3) an eyepiece such as is used in an old microscope. The six-inch mirror must be silvered on the surface. The light is gathered by it and directed to the flat mirror which is supported by crossbars that will not obstruct the light. The tube can be a light open frame type, square, with plywood to cover the ends and the middle. Complete details and specifications of the construction for telescopes may be obtained from amateur telescope handbooks.

How to Observe the Stars

One must become accustomed to looking through the eyepiece of a telescope in order to get good results. The eye must be placed close to the edge of the metal, and if one wears glasses it is best to take them off and adjust the eyepiece to your vision. One should go about the study of the stars in a systematic way. Get a good star chart, or buy a copy of A Beginner's Star-Book. Then, too, a flashlight is essential so that you may check the stars on your chart while you are in the darkness. To make the light reddish and less disturbing to the eyes, one may cover the flashlight glass with nail polish.

Sometimes the air will be unsteady and when you look through the eyepiece the star will seem to waver. On a night when there is such a disturbance one may look at the Moon or other close object, but it is not a good time to observe the stars. A homemade telescope will not have an electric driving apparatus to keep the object in the line of vision. Therefore, it will be necessary to move the telescope slightly and readjust it after looking at the stars for only a few moments in order to bring the instrument into proper focus again.

The Moon is one of the most interesting objects to study, and an amateur may soon become familiar with the best-known features of its surface. The darker areas on the Moon's surface are depressions where the sunlight does not strike so readily. These regions are called "seas," because the early astronomers thought they must be water. Some of the mountain ranges and craters stand forth boldly with the aid of good field glasses or a small telescope. Many of the best-known regions, such as the Sea of Serenity or the Sea of Showers, the crater of Copernicus, and the Carpathian Mountains, may first be located on a map of the Moon and then found with your instrument. Such an adventure on a summer evening will be a never-to-be-forgotten experience!

In order not to confuse the planets with the stars, one should realize that planets will show a disk and even surface markings, while a star will only reveal a bright pin point of light. Then, too, the light of a planet is usually steadier than that of the stars, although there are times when the planets seem to wink and waver. Do not miss watching Venus when it is in its crescent phase like our Moon. This beautiful sight may be enjoyed even with a good pair of field glasses.

The Moons of Jupiter

With a telescope or a strong pair of binoculars one can see four of Jupiter's moons. If you find them they will be Io, Europa, Ganymede, and Callisto. They arc all larger than our Moon, with Ganymede being 3,600 miles in diameter.

Of his experiences in stargazing with a two-inch telescope, Lester Sussman has this to say: "Exploring the vast wilderness of the universe with a small telescope is a pioneer adventure all its own. The sunspots, the Moon, and the planets are the outstanding scenery of the sky, while the stellar universe, too, has its gems for the small instrument.

"The Pleiades in Taurus and the Beehive in Cancer are open clusters showing swarms of individual stars. The Hercules globular cluster shows a round mist. Visible nebulae are found in Orion's sword, in Andromeda, and in Sagittarius. The Andromeda galaxy looks like an oval fog. There are many colored multiple stars (mostly gold and blue pairs as Albireo in Cygnus) which add beauty to the glittering worlds of the universe."

Is it possible to see the sunspots? Yes, an amateur can observe them with a small telescope. Simply set up the telescope so that the image of the Sun can be projected on a piece of white paper a foot or eighteen inches from the eyepiece. The size of the image will depend on the focus of the eyepiece and the distance of the paper from the telescope. The full round Sun will show on the paper, and if there are any sunspots on the surface of the Sun they will be distinct. Usually they are small gray areas with black spots in the center of them. If you find a nest of sunspots during your time of telescope study it will be of interest to observe them at intervals for several days, for you will find that they move across the Sun's disk, since it is rotating. Some sunspots return through several rotations of the Sun.

Here then is an enriching hobby that will stretch your thinking and expand your view of the universe. As you adventure forth among the planets and stars and find what exists beyond this little world of ours, your interest in the subject will increase. You may wish to become acquainted with other amateur astronomers. If you do a great deal of observing you may wish to join the Amateur Astronomer's Association. After all, you may make this hobby as fascinating as you wish. Truly, the sky's the limit!

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