



ARTLINE

Globes

The finest contemporary globes.

USER'S GUIDE TO ARTLINE GLOBES' STARSHIP EARTH® II GLOBE

A STARSHIP EARTH CREW MEMBER OPERATIONS MANUAL

by

George Lovi

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INTRODUCTION

The ancient Greeks (most notable among them Plato and Aristotle) developed the concept that the Earth is a sphere and the heavens are a rotating dome that carry the stars with it. Aristotle's *On the Heavens* proposed that the stars and planets are supported by "ether" - the transparent invisible material of the heavens.

Many centuries later, the Polish astronomer Nicolaus Copernicus (1473-1543) wrote his startling *De Revolutionibus Orbium Caelestium*, in which he placed the Sun at the center of the solar system. Shortly thereafter, the Danish astronomer Tycho Brahe (1546-1601) unstintingly recorded thousands of celestial observations - all without the aid of a telescope. The foundation laid by these two giants was built upon by the German astronomer Johannes Kepler (1571-1630). His announcement of the laws of planetary motion (or "Kepler's Laws") is commonly regarded as the beginning of the modern era of astronomy.

In the nearly 400 years that have passed since Kepler's momentous discovery, astronomy has continued to fascinate humankind and has provided the arena for some of its greatest intellectual triumphs. The heavens are full of wonders that excite the imagination and offer the romance of the unknown. Yet, understanding the basic concepts of astronomy which allow us to fully appreciate this vast and important field of knowledge is confusing to many and, to some, even intimidating.

The primary reason Spherical Concepts was founded, was to make it easier for you to visualize, understand and appreciate astronomy and geography and their importance in your daily activities. Our purpose is to create products that are educationally valid, stimulating to the imagination and aesthetically appealing. We hope that we have succeeded in these efforts for you. Should you have any comments, questions or inquiries about this or any of our other products, we would be pleased to hear from you. Our dedicated craftspeople - now proudly pass this instrument from our hands to yours!

Futurum Est ad Astra

John M. Szal
Founder & C.E.O.

THE UNIVERSE IN YOUR HANDS

What is a Celestial Globe?

We all know what an Earth globe is - a model of the huge ball we live on, the third planet orbiting our star, the Sun. But while an Earth globe represents the real shape of a planet, a celestial or sky globe is a model of the illusionary celestial sphere over our heads.

When we look up into a clear night sky, we look out into the vastness of space. During the day, the dazzling brilliance of our "daytime star" - the Sun - overwhelms everything else in the sky. It's blinding light brightens the atmosphere so that very little else in space is visible to our eyes. Only the Moon, and occasionally a brilliant planet like Venus (if you know where to look), are visible without optical aid. But when our spinning Earth carries us into its own shadow at night, we can then see other suns far out in the depths of space - the stars!

The universe we live in is gigantic - far larger than anything we can possibly imagine. How can we map it? How can astronomers construct charts and tables that tell where to find a particular celestial object and where to point a pair of binoculars or telescope to see it? For this purpose, they use the concept of a celestial sphere. This is an imaginary ball larger than the entire visible universe. Imaginary lines are drawn from the Earth through heavenly bodies, extending beyond them until the lines touch the "surface" of this celestial sphere. These points mark the apparent positions of those objects - the ones given in star catalogs, almanacs and charts. These are also the points where celestial bodies are plotted on celestial globes.

The Starship Earth II Globe

We are all traveling together through space on a giant starship - our home planet Earth! From aboard this "spacecraft" we can look out in various directions at the universe that surrounds us - at our nearby neighbors like the Sun, Moon and planets, and beyond to the more remote denizens of space. These include those faraway suns that we call stars, glittering star clusters, glowing interstellar gas clouds or nebulae, and far beyond all these those incredibly remote "star cities" known as galaxies. The galaxy we live in is the Milky Way, believed to contain more than 200 billion stars! All of these cosmic wonders form a majestic backdrop to the velvet canvas of night - the period each day when our spinning planet carries us into the shadow of night and hides our dazzling daytime star so we can gaze at the universe.

Yet, what in particular are we seeing on various dates, times and locations as we look out into the night? Aside from being a beautiful work of art in itself, your **Starship Earth II** greatly facilitates answering such questions and helps visualize Earth-sky interrelationships as well. It will enable you to find and identify celestial objects from anywhere on Earth, at any hour of the day or night, on any date of the year!

This "Starship Earth crew member" operations manual provides all the information needed to use this scientific tool effectively, and includes much information about the starry sky as well. We have attempted to make this a clear and readable guidebook for the lay person rather than a heavy scientific text. Teachers and advanced students of astronomy, navigation, geography and associated fields will find virtually limitless applications with **Starship Earth II** for instruction, experimentation, lab exercises and much more.

While reading through this manual, we ask that you have your globe placed directly in front of you. In doing so, you will not only see what is being described but also be able to carry out the procedures as they are outlined. Happy stargazing!

BECOMING FAMILIAR WITH YOUR STARSHIP EARTH II

Components

* 16" Diameter Outer Celestial Globe (See Figure I): Information shown on the celestial globe consists of stars symbols in white with star names and (in many cases) distances in lightyears directly underneath plus Greek-letter designations all in black. Constellation names and patterns are in blue, as are the constellation boundaries (indicated by . _ . _ lines). The ecliptic pathway of the Sun is outlined by golden Sun disks at 5-day date intervals, together with the names of the twelve months. The precessional paths of the North and South Celestial Poles, and deep-sky objects with their Messier or NGC number, are again shown in black. Circles of Right Ascension (or celestial longitude) and Declination (or celestial latitude) are also shown in black every 15 degrees (or 1 hour) and 10 degrees, respectively. And finally, the Milky Way is displayed as a pale blue hazy band circling the globe. All of these features will be explained and discussed further in this guide.

* Interior Components (See Figure I): The Sun ball is movable along its ecliptic path around the sky as seen from the Earth globe by turning its control knob located at the top of the outer sphere. The horizon ring has a compass rose printed on its upper surface indicating degrees of azimuth, and can be adjusted by reaching through the access port in the outer sphere. The central Earth globe shows major cities or geographic locations in each time zone as well as longitude lines every 15 degrees and latitude lines every 10 degrees. It can be turned by using the Earth rotator control knob at the bottom of the outer sphere.

* Tabletop Support Base (See Figure I): The base is designed to hold the **Starship Earth II** globe and allow easy access to all its parts. You will note that one support leg is longer than the other two - this corresponds to North as shown on the compass rose in the center of the base. By keeping the North pole on the Earth globe pointed in the same direction as North on the compass rose and the long base leg, the entire unit will be properly oriented for use. If you have selected a floor stand base, you'll note that it too was designed with attractiveness and ease of use in mind.

* Accessories: Along with the above components, you will find an envelope containing the guide you are now reading, a wax pencil for charting on your globe (which can be removed by carefully wiping with a soft flannel or cotton cloth), and a certificate signed and dated by the proud craftsman who created your authentic **Starship Earth II** globe by hand.

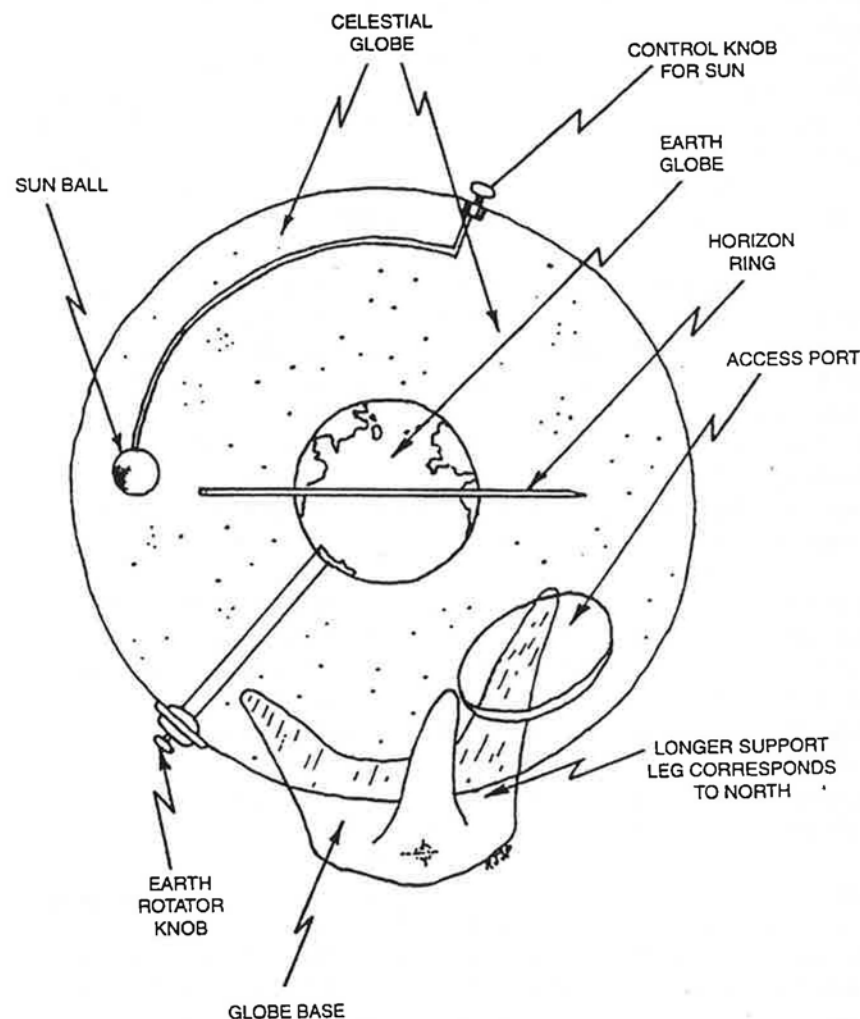


FIG. I

STARSHIP EARTH® II

SETTING UP & ADJUSTING THE GLOBES

A Cosmic Perspective

Our Earth is but a tiny speck in this vast universe, whose remote members are located in every direction from us. Their distances vary enormously - from a mere quarter of a million miles for the Moon to millions and even billions of lightyears for the remote galaxies and quasars. (A lightyear is the distance that light travels in a year -nearly 6,000,000,000,000, or six trillion, miles!) In order to locate and plot the positions of these various heavenly bodies, astronomers make use of the imaginary celestial sphere mentioned in the previous section of this guide.

Your **Starship Earth II** is an actual physical model of this celestial sphere (the outer transparent globe) with the Earth globe at its center. However, the real relative sizes of these two spheres is vastly different than what can be shown in such a representation. Since we cannot make the outer celestial globe infinitely large as in nature, it might help to picture the Earth globe in the center reduced to an infinitely small speck. But in doing so, we then could not see it at all! So for our model to exist, we must greatly exaggerate the size of the Earth globe in a far too small celestial sphere - something that should always be kept in mind when using this device.

A significant advantage that the **Starship Earth II** has over traditional opaque celestial globes that have been in use for centuries is its transparent "see through" feature. This enables the user to look through its surface across to the far side, in effect placing the viewer inside the sphere in the same way we are placed inside the actual universe. This allows us to see the stars and constellations positioned correctly in relation to each other, arching over the Earth globe just as they do when looking at the real sky outdoors on a clear night. (See Figure II.)

It is for the above reason that the lettering and labeling for the celestial objects are placed on the outer globe so that they read correctly only when viewed through the transparent sphere. Additionally, all the printing has been done on the inside surface of the sphere, both to protect it from abrasion and other damage and to permit the use of the wax pencil that is supplied for charting.

As we stand on the surface of the Earth, its huge bulk hides one half of the celestial sphere at any given time and place. The half not covered by the Earth - the visible hemisphere - forms the sky we see. The point at which Earth and sky meet is the horizon - a circle that completely surrounds the observer and which (as long as the observer is on the Earth's surface)

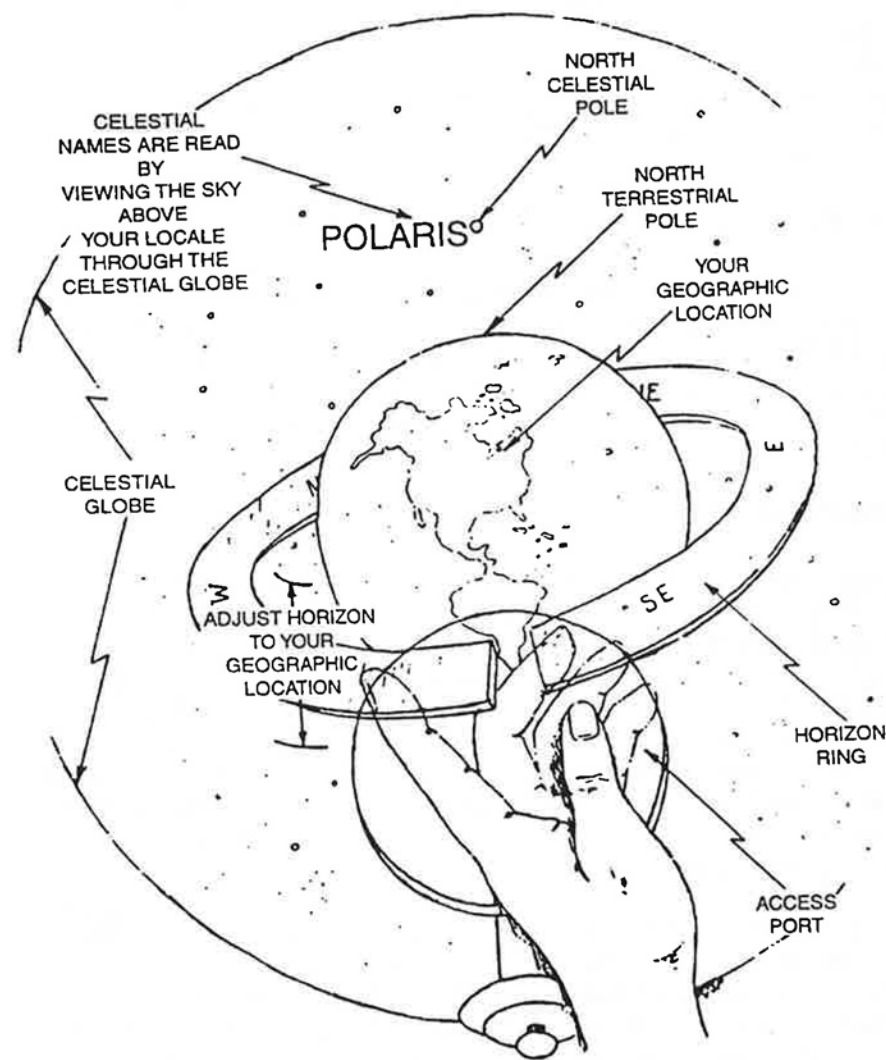


FIG. II

divides the celestial sphere into its visible and invisible hemispheres. As we rise higher and higher above the Earth's surface, the horizon drops lower and lower (what aircraft navigators call the "dip of the horizon"), uncovering progressively more than half the celestial sphere to our view. If we were to head out into space, what was formerly considered to be the horizon now begins to form the edge or limb of the round Earth. (The term "limb" refers to the visible edge of the Sun, Moon or a planet.) As we continue outward into space, our home planet becomes but another heavenly body against the backdrop of the celestial sphere, which from our spaceship is now visible in its entirety.

The Earth Globe

The inner Earth globe of your **Starship Earth II** clearly shows the continents, oceans, important islands and a number of major cities around the world. Also shown is a complete gridwork of longitude and latitude lines to help you plot the position of any other desired city or location whose coordinates can be obtained from an atlas, almanac, encyclopedia or other source.

The Horizon Ring

Suppose you could be shrunk down small enough to stand on the inner Earth globe at your location. You would see approximately half of the celestial sphere (the outer globe) - that part of the sky not hidden by the Earth. To indicate the visible half of the sky from the half you cannot see, a movable horizon ring has been provided that encircles the Earth globe. Before you can use the celestial globe to show the visible sky, you must adjust the horizon ring for your particular location on the Earth. Again, you must visualize the Earth globe as a tiny object at the center of the horizon ring opening. This ring indicates both the orientation of your horizon and the various compass directions.

Notice that the horizon ring has a "V" shaped pointer at its North point and an opening (to clear the support post) at its opposite or South side. Direction labels (abbreviated) are provided for North, Northeast, East, Southeast, Southwest, West and Northwest. South itself falls right in the center of the support post opening. An azimuth (distance around the horizon) scale is also provided with tick marks every degree and a numerical label for each 10 degrees. (This scale is of fundamental importance in navigation and surveying. For example, you've probably noticed the huge numbers painted on the ends of airport runways. They represent the azimuth heading of the runway to the nearest 10 degrees, with the final zero omitted. The number "27" means that the runway is pointed at 270 degrees azimuth, or due West.)

Before the horizon ring can be used, it must be adjusted for your latitude and longitude. The Earth globe has these lines clearly marked on it. Longitude is your position on the Earth in an East or West (right or left) direction from the "prime meridian" in Greenwich England, measured in angles up to 180 degrees either side of it. Latitude is your position North or South of the Earth's Equator, measured in angles from 0 degrees at the Equator up to 90 degrees (+ or -) at the poles.

To set the longitude of your location on the Earth, turn the outer celestial globe so the access port is in front of you. Next, make sure the horizon ring has the azimuth scale on its top side so you can read it and that the opening in the ring is also facing you. Now reach through the access port, and holding the horizon ring stationary, turn the Earth rotator knob at the button of the outer globe (See Figure I) in a clockwise direction, which will turn the Earth globe from East to West. Continue turning the knob until the desired location (let's say Denver, Colorado) bisects the opening in the horizon ring. You have now set the Earth globe for the longitude of Denver.

To set your latitude on the Earth globe, keep in mind that the North Celestial Pole (or NCP - marked approximately by the Pole Star, POLARIS, on the outer celestial sphere) is always the same number of degrees above your northern horizon (i.e. above the horizon ring) as you are above the Earth's Equator. For example, if you live in Denver at 40 degrees North latitude, count down from POLARIS 40 degrees (remembering that each DEC circle indicates 10 degrees). Now move the horizon ring so that the V-shaped pointer is aimed at the DEC circle 40 degrees below POLARIS. You will notice that this circle is the 50-degree DEC one. That's because the DEC circle the horizon ring V-pointer must be aimed at is the complement (90 degrees minus your latitude) of your actual position on the Earth.

To illustrate this further, if you lived on the Equator in Ecuador your latitude would be 0 degrees. Counting down from POLARIS 0 degrees, the horizon ring V-pointer would be aimed right at this star. This means that the Pole Star has an altitude at the Equator of 0 degrees and thus lies right on the northern horizon. Its DEC is 90 degrees (the complement of your latitude: $90 - 0 = 90$). If instead of being at the Equator you were at the North Pole (or latitude 90 degrees North), you would count down from POLARIS 90 degrees. The horizon ring's V-pointer is now aimed at the Celestial Equator at a DEC of 0 degrees ($90 - 90 = 0$) and POLARIS lies directly overhead at an altitude of 90 degrees above the horizon ring.

Following the procedure used in our first example where the horizon ring was set for the latitude of Denver, you can set the longitude and latitude for

any place on the Earth globe. Once the ring has been set for a given location, there is no further need to reach inside the outer globe's access port unless you wish to change your latitude and longitude. Once this has been done, position the entire **Starship Earth II** globe so that the horizon ring on the inside is horizontal - parallel to the table top or floor just as the real horizon is in nature. This should place the location you have selected uppermost on the Earth globe, so that wherever you are on Earth will always be "on top" of the globe.

For an added touch of realism, place the entire unit on its base so that the North pointer on the horizon ring is over the North pointer of the base's compass rose. If you now point both of them to real North, the **Starship Earth II** will reproduce the actual outdoor sky and position of the Earth itself. Remember that the outer celestial globe's hemisphere that lies above the horizon ring's surface represents the visible sky.

The Outer Celestial Globe: Setting The Sky

The sky is first set for the date and then for the time. Notice again the row of dots labeled with the months of the year and calendar dates for every five days on the surface of the celestial globe. These dots represent the Sun's apparent position against the sky over the course of a year. As the moving Earth on which we live revolves around the Sun, our motion makes the Sun appear to move along its ecliptic pathway around the heavens. This means that the Ecliptic is actually the plane of the Earth's orbit projected against the sky. Keep in mind that your **Starship Earth II** is showing you the relationships between the Earth, Sun and stars as they appear to us on our home planet.

The golden "Sun ball" is positioned using the Sun ball control knob located near the top of the outer celestial globe (See Figure I). As you turn this knob 360 degrees in a counter-clockwise direction, you will see that the Sun follows the path of the calendar dates throughout the course of the year. This line of date dots tracing out the Ecliptic - one of the most important of all celestial coordinate circles - it will be discussed in more detail below.

Suppose you now wish to look at the sky as seen from Denver on, say, August 5th at 9:00PM local standard time (which would be 10:00PM local daylight savings time). First, place the Sun ball in front of the August 5th dot. The outer celestial globe is now set for that date. (Any date you decide to use is set in exactly the same way.) The next step is to set the desired time of day.

Holding the Earth rotator knob (See Figure I) so that the Earth globe and

horizon ring remain fixed with the latter parallel to the table top or floor, rotate the entire celestial globe so that it turns from right to left (which means that the stars will be moving from East to West). Continue this procedure until the Sun ball is directly over the opening in the horizon ring. In this position with the Sun directly over Denver's longitude meridian on the Earth globe, your **Starship Earth II** is set for noon local standard time in Denver on August 5th.

There are actually two methods of now setting the outer globe to the desired time of observation. In our example of noon in Denver on August 5th, the Sun ball is directly over the opening in the horizon ring and the longitude line for the Mile High City. Since the longitude meridians on the Earth globe are 15 degrees apart, each one represents 1 hour of time, because 15 degrees divided into 360 degrees (or a complete circle) equals 24, the number of hours in a day). So each time the Sun ball passes over a meridian line as the outer celestial sphere is turned from East to West, it is 1 hour later. For example, if you turn the globe until the Sun ball just drops below the horizon ring to the West, this represents sunset in Denver. How many meridians did the Sun ball pass over? You should have counted seven. This means that sunset in Denver on August 5th occurs at 7:00PM local standard time (or 8:00PM local daylight savings time). If you now rotate the outer celestial globe across five more meridians - or a total of 12 from the noon position - you will arrive at the midnight sky setting desired.

The other method of adjusting time is to use the RA lines (or hour circles) on the celestial sphere itself. Rotate this outer globe around to the noon position again by placing the Sun ball directly over the opening in the horizon ring. You will note that the hour circle directly down from the August 5th date dot is the 9-hour RA line (which will appear backwards to you in this position) and that it bisects the opening in the horizon ring. Next, turn the outer globe from East to West (again holding the Earth globe fixed) another 9 hours (the difference between noon and 9:00PM) until the horizon ring opening is bisected by the 18-hour ($9 + 9 = 18$) RA line. Everything you now see above the horizon ring is the way it will appear from Denver at 9:00PM on August 5th. Should you wish to see the sky three hours later (at midnight), the horizon ring opening must be bisected by the 21-hour ($9 + 12 = 21$) RA line on the celestial globe. To set the sky for 4:00AM the following morning, the 1-hour ($21 + 4 = 25$, or 24 hours plus 1 hour) RA line should bisect the horizon ring opening.

So far, these hour labels have been used simply to step off time intervals, their actual numerical values being irrelevant except as "measuring rods." However, these numbers running continuously from 0 hours to 23 hours around the sky represent what is known as "sidereal (or star) time." As described further on, they are invaluable in locating the precise positions of

celestial objects on the celestial sphere. Also note that underneath each of the RA hour labels are degree markers. These, in turn, are used for navigational purposes.

Review of Procedures for Setup & Adjusting The Starship Earth II Globe

1. Rotate the Earth globe to bring your selected location to the middle of the horizon ring opening.
2. Aim the horizon ring's V-shaped pointer to the DEC circle location below POLARIS that corresponds to the same number of degrees as the latitude you've selected. (For locations South of the Equator, the V-pointer will be above POLARIS.) Position the entire Starship Earth II globe so that the horizon ring is parallel to the table top or floor.
3. Rotate the Sun ball to your selected date using the Ecliptic date dots.
4. Holding the Earth globe and horizon fixed, rotate the outer celestial globe until the Sun ball reaches the middle of the horizon ring opening. This represents noon at your selected date and location. To set a time later than noon, simply turn the outer celestial globe from East to West (again keeping the Earth globe and horizon ring fixed), counting one hour of time for each line of RA (or hour circle) that passes through the opening in the horizon ring. The reverse procedure is used for times earlier than noon.

A TOUR OF THE SKY

North & South

Suppose we go back to August 5th at 9:00PM in Denver. To see what is above the horizon, place your eye just level with the horizon ring (See Figure 11). To view any direction in the sky, position yourself at the opposite direction on the horizon ring and look through the outer celestial globe to the other side. For example, to view - as we're doing here - the southern sky over Denver at 9:00PM on August 5th, place yourself closest to the northern portion of the horizon ring and view the southern heavens by looking through the outer celestial globe.

Let's now look at some of the highlights of the heavenly scene visible from this location. Low in the South, just above the horizon, are the two prominent constellations SCORPIUS (the Scorpion) and SAGITTARIUS (the Archer- also known as the "Teapot " asterism). The brightest star in SCORPIUS is ANTARES. Directly to the west and resting on the horizon is VIRGO (the Maiden), whose brightest member is the star SPICA. About halfway up the western sky is the prominent star ARCTURUS in the constellation BOOTES (the Herdsman, or Bear Driver). The bear he's driving is URSA MAJOR, a large figure to the right of BOOTES, which is known for its prominent seven-star group called the "Big Dipper" - now about a third of the way up the northwestern part of the sky. If we turn our attention to the northeast, (which again should be viewed from the opposite or southwestern part of the horizon ring), we see the constellation ANDROMEDA a short distance above the horizon; this group is noted for the prominent galaxy it contains. ANDROMEDA is a Princess whose mother, CASSIOPEIA, will be recognized as a W-shaped pattern higher up in the north-northeast at this time. (We discuss a famous legend about these constellations in the section "Stories in the Sky"). In this fashion you can pick out other stars and constellations with the aid of the horizon ring, which, after being set for a particular place and time, will show you where to find them in the sky.

By rotating the outer celestial globe as described, you can see how the stars rise and set, and it is particularly interesting to try it for various latitudes. For example, notice that while we're still at 40 degrees latitude there's a large area of stars in the northern part of the sky that remains above the horizon continuously - these stars never set. In the center of this group, directly North, is the star POLARIS, popularly known as the "North Star." It lies less than a degree from the North Celestial Pole (or NCP). See how it remains virtually fixed in one location while the other stars move around it. Those stars that never set are called "circumpolar" and the further you go North, or South from the Equator, the larger is the circum-

polar area of the sky. If you set the globe to view the sky from the North Pole (the horizon ring is then parallel with the Equator - or seams - on the inner Earth and outer celestial globes, and move the entire unit so the horizon ring is again horizontal) all stars are circumpolar. They move parallel to the horizon and none of them ever set! See this for yourself.

On the other hand, let's travel to the Equator, with the horizon ring's North pointer aimed directly at POLARIS and the entire unit re-oriented so the horizon ring is again horizontal to the table or floor - now all stars rise and set as you turn the celestial globe, none of them being circumpolar. If you continue to latitudes south of the equator, POLARIS drops permanently below the northern horizon and a new circumpolar area appears around the South Celestial Pole (SCP), which is located above the southern horizon. However, there is no prominent star like POLARIS - or "South Star" - close to the SCP. This point is indicated where the Earth globe support rod passes through the sky globe.

Let's now take a plane trip to Buenos Aires and look at those beautiful southern stars visible "down under." When we go South of the Equator, the interior support rod will always rise above the level of the horizon ring and POLARIS will remain below it at all times.

To set the horizon ring for Southern Hemisphere locations, we still follow the same general procedures as for northern locales. We use the horizon ring's North pointer, which is aimed the same number of degrees from POLARIS as your latitude except that now you point above it rather than below it, as in the case for Northern Hemisphere locations.

Let's say that we've arrived at Buenos Aires on April 15th. We've had a leisurely dinner and wish to see the sky at 9:00PM. Remembering our rules from before, we set the Earth globe in relation to the horizon ring so that Buenos Aires (which is marked on the Earth globe at 35 degrees South along the eastern coast of South America) passes centrally through the horizon ring's opening. Now adjust the ring so its North pointer is aimed midway between the 50 degree and 60 degree DEC circles on the outer celestial globe - or 35 degrees up from POLARIS. Then adjust the entire unit so the horizon ring is horizontal.

The next step is to place the Sun ball in front of the April 15th dot and by holding the Earth rotator knob (now in an elevated position), rotate the outer celestial globe until the Sun is directly North over the horizon ring's North pointer. Yes, North! Down here, the Sun crosses the northern sky during the day rather than the southern one as at home.

For setting the sky as it appears at 9:00PM, rotate the outer celestial globe

so that the horizon ring's North pointer passes 9-hours worth of increasingly numbered RA hour circles. In this instance, the pointer is at just about 1.5 hours at noon, so adding 9 hours to it gives us 10.5 hours for the pointer's 9:00PM position on April 15th in Buenos Aires.

Now let's look at the sky. What a sight! The southern part of the heavens is ablaze with a celestial necklace of brilliant stars extending nearly from the eastern to the western horizon. This is the most splendid area in all the sky, but is largely invisible from the United States (although it can be seen close to the southern horizon from the Caribbean - check this out on your globe later if you wish!).

Back to the sky above Buenos Aires. About midway up, and a little to the East of South is the famous "Southern Cross," which is labeled with its official name CRUX. This constellation is found on the flags of Southern Hemisphere countries such as Australia and New Zealand. To the left (East) of CRUX are two very bright stars called HADAR and RIGIL KENTAU-RUS, which are sometimes referred to as the "Guardians of the Cross" because of the way they closely follow the Cross itself around the sky. RIGIL KENTAURUS is better known by its Greek-letter designation, AL-PHA CENTAURI, and is the closest star to us (except for the Sun) at 4.3 lightyears away - some 25,000,000,000,000 (25 trillion) miles from us!

By the way - where is the Big Dipper? Just beneath the northern horizon! In fact, people in Buenos Aires don't get to see it at all except for the star ALKAID at the end of its handle, since it doesn't rise at all down here. ALKAID just manages to peek briefly over the northern horizon (turn the outer celestial globe and see for yourself).

Day & Night at Various Times & Places

Even those of us who seldom look at the sky are aware of a very fundamental celestial phenomenon - the drastic differences in the amount of daylight we receive during the year - greatest at the beginning of summer and least at the onset of winter.

Your **Starship Earth II** globe can reproduce these daylight variations for both your home latitude and other places on Earth. It's very easy to determine how many hours the Sun is above the horizon - i.e., the length of the day - by positioning the Sun ball in front of the desired date, then bringing it to the eastern horizon. This is done, of course, by rotating the outer celestial globe while holding the Earth rotator knob. Now take note of what hour circle - or interval between - bisects the horizon ring's opening.

Continue turning the outer celestial globe until the Sun reaches the opposite, or western horizon. Now take another hour circle reading. The length of daylight is simply the number of hour circles that pass the horizon ring's opening between sunrise and sunset.

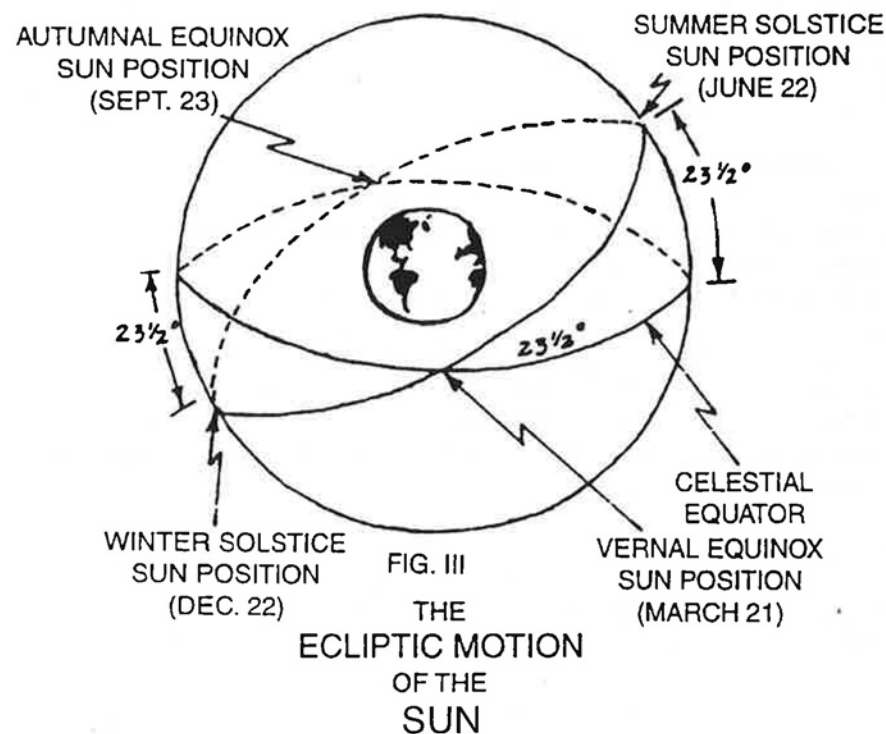
But that's not all your globe can tell you. Not only does the amount of time the Sun spends in the sky vary during the year but correspondingly so does its altitude above the horizon. (The two are connected - the higher the Sun, the longer it remains above the horizon.) By setting the **Starship Earth II** globe as we've described for June 22nd (the beginning of Northern Hemisphere summer) and then for December 22nd (the beginning of Northern Hemisphere winter), we can observe the Sun's altitude range at noon throughout the year. You can measure its noontime elevation with the aid of the DEC circles, 10 degrees apart, by counting how many of them are between the Sun ball and southern horizon at noon with the Sun directly over the ring's opening. (See Figure, III.)

And there's still more! You can observe the azimuth (compass direction) of sunrise and sunset with the aid of the horizon ring markings. That, too, changes drastically during the year - about 60 degrees at latitude 40 degrees North!

Moreover, why is summer warmer than winter? There are two main reasons, the first of which is the Sun's altitude. In winter it is considerably lower in the sky than during summer, so its rays strike the Earth at a much less direct, or slanting angle. This is readily noticeable by looking at the Sun ball's relation to your location on Earth (or any other desired location). During the summer, the Sun is much higher in the sky its rays are more direct and concentrated. Secondly, the number of hours the Sun is in the sky each day and available to warm the Earth is much longer in summer than in winter.

A rather interesting curiosity is that the Earth is actually closer to the Sun during January than in July (the difference is approximately 91 versus 94 million miles). So, even though the Earth receives slightly greater heat from the Sun in the Northern Hemisphere winter, the factors we just discussed more than cancel this effect and make the winters colder than summer. You might think, however, that because the Earth is closer to the Sun in January than in July, the Southern Hemisphere has hotter summers and colder winters than does the Northern Hemisphere. Not so! The substantially greater amount of ocean area down there (see the Earth globe) serves to moderate potential temperature extremes.

Returning to seasonal daylight differences, they become more and more pronounced as we travel progressively further North or South of the



Equator. When we get to the Arctic or Antarctic Circles (those latitude lines 66 1/2 degrees North and South of the Equator, respectively), we have reached the beginnings of the polar zones, which encompass the "Lands of the Midnight Sun." This means that between these polar circles and the poles themselves there is a period each year centered on the beginning of summer (which, remember, occurs six months apart between the Northern and Southern Hemispheres) during which the Sun does not set at all. It remains above the horizon continuously for 24 hours, being visible at midnight above the North point in Arctic areas and above the South point in Antarctic regions. Also, for a similar period centered on the beginning of winter, the Sun never rises at these same locations that experience the Midnight Sun in summer. The time during which the Sun does not rise or set varies from a day or so along the Arctic and Antarctic circles to six full months at the poles.

Your **Starship Earth II** globe can indicate the range of dates when these phenomena occur in polar locations. Using the procedures thus far outlined, set the horizon ring for the desired polar location and rotate the outer celestial globe while noticing the range of dates that remain above the horizon ring. For example, when the famous Alaska Pipeline was being installed, workers at its starting point at Point Barrow, Alaska (latitude 70 degrees North), had approximately two months of continuous daylight from late May to late July. Similarly, from late November to late January, the Sun never rose for them, although for a few hours before and after noon, the sky brightened into a twilight resembling what we see just before sunrise and after sunset.

Yet, even if you don't go as far as the polar regions, you can experience very long summer days from places such as Great Britain, Scandinavia, and other northern European locations. You can enjoy outdoor daylight activities well into mid-evening and even later (up to 10:00PM). On the other hand, if you have ever traveled to the Caribbean or other places close to the Equator during the summer, and anticipated participating in some outdoor activities after dinner, you found to your surprise that it is dark outside at the same time that there would normally be plenty of daylight back home! How can this be explained?

Let's set the Starship Earth II for a place and time of your choice in the Caribbean (with the Sun ball in front of that date). Turning the Sun ball knob, bring the Sun directly South over the horizon ring opening. Then rotate the outer celestial globe until the Sun sets. Again, count the hours between noon and sunset. You will see that the Sun sets significantly earlier than in more northern locales like the United States. However, the Caribbean has a compensation for its early summer sunsets. Those who travel there for a winter vacation enjoy a later sunset than at home (which

however, always occurs before 6:00PM in the winter).

More Curiosities

If you live at the Equator, there is no change at all in the length of the day during the year. The Sun is always in the sky for 12 hours. Also, where on Earth does the Sun pass directly overhead - through the Zenith* - at least once a year? (In other words, you could see it from the bottom of a well or chimney.) This can only occur at places between those two other special latitude circles called the "Tropic of Cancer" and the "Tropic of Capricorn," which are 23 1/2 degrees North and South of the Equator, respectively, and mark the boundaries of the torrid (tropical) zone. Again, verify this for yourself using your globe.

Finally, we mentioned how early the Sun sets during the summer in the Caribbean. That's not all! Once it sets, the period of twilight - the time it takes for the sky to get dark - is considerably shorter than at places further North. This is due to the steeper angle (as well as the faster rate) at which the Sun drops below the horizon at places close to the Equator compared with those at higher or lower latitudes.

* The ZENITH is the point directly overhead in the sky. Another important celestial marker involving the ZENITH is the MERIDIAN. This is the line passing directly North-South through the ZENITH from horizon to horizon. Its significance lies in the fact that celestial objects rise in the East and set in the West (as seen from the Northern Hemisphere). They are at their highest in the sky (therefore best observed), when crossing or "transiting" the MERIDIAN.

LOCATING OBJECTS ON THE OUTER CELESTIAL GLOBE

Right Ascension & Declination

You will notice that your **Starship Earth II** celestial globe has a grid-work of lines similar to the latitude and longitude ones on the Earth globe. Latitude is measured North and South of the Equator, while longitude is measured East and West of an arbitrary zero line - which by international agreement passes through Greenwich, England, site of the old Royal Observatory. (See Figure IV.)

The celestial coordinate system reflects this Earthly one translated into the sky. The sky has a Celestial Equator, which is an extension of the one on Earth projected onto the celestial sphere. On your globe, it's where the two hemispheres are joined together. The points 90 degrees North and South of the Celestial Equator mark the North and South Celestial Pole (NCP and SCP, respectively) - the points about which the sky appears to turn as the Earth rotates on its axis. If you were standing at the Earth's North pole, the NCP would be directly overhead at the Zenith and the Celestial Equator would circle the sky around the horizon. If you were at the Equator, the Celestial Equator would pass directly overhead through your Zenith and extend East-West across the sky.

By a fortunate coincidence the Earth's northern axis of rotation is aimed at a point in space very close to the 2nd-magnitude star POLARIS (less than a degree away at present). Popularly known as the "Pole Star" or "North Star," it's conveniently located at the end of the Little Dipper's handle and provides a fairly good naked-eye marker for the NCP.

However, POLARIS was not always - and will not always be - close to the NCP. Due to a wobbling of the Earth's axis called *precession*, the direction its axis points in the sky changes (like that of a spinning toy top) over a period of 26,000 years. On your celestial globe you'll notice a circle labeled "Precessional Path of Pole" near the NCP. It indicates the path traced out by the Earth's northern axis over this 26-century span. As a matter of historical interest, the star THUBAN in the constellation DRACO was the Pole Star around 3,000 B.C. when ancient Egypt was in its glory. (It's sometimes referred to as the "Pyramid Star" due to this circumstance.) And the brilliant summer star VEGA in LYRA will occupy this position in the remote future - as it has done in the dim past.

On the celestial globe, horizontal lines parallel to the Equator are called parallels of *Declination*. The celestial counterparts of parallels of latitude

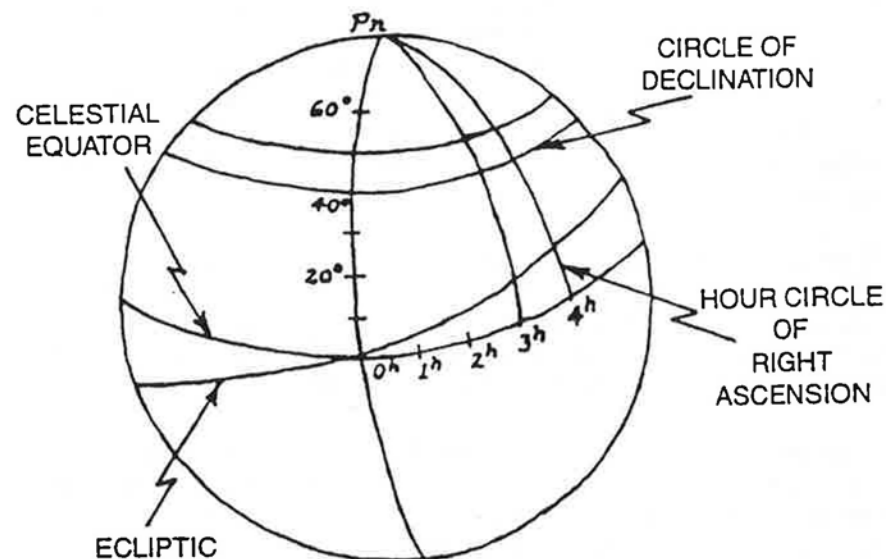


FIG. IV
TIME
AND
COORDINATES

on Earth, the numbering system is the same for both. *Declination* (or DEC) is measured in degrees (and fractions thereof) North and South of the Celestial Equator (0 degrees), with the poles being at +90 and -90 degrees, respectively. And as with the Earth's Equator, if you are standing at, say, 40 degrees North latitude, the 40-degree DEC circle will pass through your Zenith. Thus, any star or other celestial object with that DEC will reach the Zenith at the top of its nightly arc across the sky. (At DEC +39 degrees, the bright star VEGA mentioned earlier lies just South of it.)

The celestial counterpart of longitude on Earth is different in both name and numbering system. It's called Right Ascension (or RA) and is measured eastward around the sky in hours (and fractions thereof) from the Vernal Equinox which marks the 0-hour of RA. This point lies on the Celestial Equator and is the Sun's position against the starry background at the beginning of spring in March. RA lines are called hour circles. They extend vertically between the NCP and SCP, intersecting the Celestial Equator at right angles.

RA is measured in hours (h), minutes (m) and seconds (s) of time, while DEC is specified in degrees (°), minutes (') and seconds (") of arc (angular measure). One hour of RA is equal to 15 degrees of angular measure in the sky, just as the defining longitudes of our civil time zones here on Earth are separated by 15 degrees ($360/24 = 15$ degrees).

As can be seen by looking at your celestial globe, the approximate RA and DEC of the star VEGA are 18.5 hours and +39 degrees, respectively. RA is labeled in whole hours, the numbers being superimposed on the hour circles just above the globe's Celestial Equator. DEC is labeled every 10 degrees at the 0-hour, 6-hour, 12-hour, and 18-hour RA circles, extending North (positive values) and South (negative values) of the Celestial Equator to each pole.

Special for Navigators

You will notice that each RA hour circle has two labels - the hour value already mentioned, and a degree value in italics. This second number is known as the sidereal hour angle - or SRA - and is the navigator's version of Right Ascension. It's a degree system that increases westward from the Vernal Equinox - in the opposite direction than for RA. In the navigator's nautical and air almanacs, the SHA and DEC (the same DEC as used by astronomers) are listed for important stars, planets, the Sun and the Moon. This data enables these objects to be used in obtaining a "fix" for finding positions on the Earth in accordance with standard navigational procedures. Note that the Earth globe's horizon ring has both the letters for the compass points as mentioned earlier in this guide and a 360 degree

azimuth scale which is used for expressing direction or "heading."

The Ecliptic & Zodiac

As already pointed out in this guide, the Sun's yearly path traced out around the sky is the Ecliptic, which also represents the projection of the Earth's orbital plane onto the celestial sphere. (If an observer could watch the Earth racing around its orbit while standing on the Sun, our planet would be seen moving along the Ecliptic just as the Sun does to us.) Again, this ecliptic pathway is represented on your celestial globe by the row of date dots indicating the Sun's position throughout the calendar year. As the Earth circles the Sun, the latter's apparent position against the stellar background (or celestial sphere) continually changes in an eastward direction.

The Ecliptic is also important because of its being the pathway of the planets, the planes of their orbits (with the exception of Pluto) being tilted only slightly to that of the Earth. From ancient times, 12 of the major constellations were formed along the route of the Ecliptic. This group constitutes the well-known zodiac (from the Greek for "circle of animals"), made up of the familiar constellations ARIES, TAURUS, GEMINI, CANCER, LEO, VIRGO, LIBRA, SCORPIUS, SAGITTARIUS, CAPRICORNUS, AQUARIUS and PISCES. The Ecliptic also passes through the bottom part of a 13th major constellation - OPHIUCHUS, the Serpent Bearer. It has never been accepted as an official zodiacal group by astronomers (and has been completely ignored by astrologers!).

PATTERNS IN THE SKY

Constellations & Asterisms

Anyone who looks at the sky regularly will notice that the stars form fixed patterns in relation to each other. As the Earth spins on its axis, the stars appear in the East (for Northern Hemisphere observers), rise, cross the sky, and then set in the West. However, their positions relative to each other do not change as they do so. (Actually, over thousands and millions of years they do, since all of the stars including our own Sun are swiftly moving through space. But over the course of a human lifetime, they appear as constant as the Rock of Gibraltar!)

Since antiquity, practically every culture has created pictures and patterns out of the so-called "fixed stars" - these form the familiar constellations. On old star maps and globes, the constellations are shown with the images of animals, human beings and other objects in the sky. The heavens were the picture and story book of the ancients!

Present-day astronomers view the constellations as simply conveniently divided sections of the sky, in much the same way as the states divide up our country. In 1930, the International Astronomical Union adopted a set of official constellation boundaries which show the exact extent of each figure. On your **Starship Earth II** celestial globe these boundaries are marked with dashed blue lines running up and down, and left and right (parallel to lines of RA and DEC) across the sky. Astronomers today recognized 88 "official" constellations - 44 dating from ancient times and 44 from more recent periods of history. The constellation table below gives the names, three-letter abbreviations and meanings for all 88 of these. An excellent project is to identify each one of them on your globe, and then as many as possible that are visible from your latitude in the real sky over the course of the year.

On many star maps the constellation figures are portrayed as "stick figures" with solid lines connecting the principal stars. These are shown in blue on your celestial globe. Unlike constellations boundaries, these representations are in no way "official" and they often differ from one map to another.

Another type of star pattern is an asterism. Unlike most constellations, this is an easily traceable picture or pattern that may be part of an existing constellation, such as the Big Dipper in URSA MAJOR. Or it may involve the stars in two or more different constellations, one example being the well-known "Summer Triangle" formed by the stars VEGA, DENEK and ALTAIR in LYRA, CYGNUS and AQUILA, respectively. Asterisms don't

enjoy official status, but they often help in finding your way around the sky and are certainly fun to identify. Constellation names (listed in the table below and labeled in upper case blue letters on your globe) are commonly given in Latin. URSA MAJOR and URSA MINOR, for example, mean "great bear" and "small bear." Some constellations, however, are the names of mythological characters such as ORION, the mighty hunter of the skies. "ORION" does not mean "hunter" in Latin as is sometimes supposed, but rather is the name of a mythological hero. CEPHEUS, CASSIOPEIA, PERSEUS and ANDROMEDA are other examples of constellations named from mythology - in this case all involved in the same story of rescue from danger and romance, as told below.

THE 88 CONSTELLATIONS (Arranged alphabetically)

<u>Name</u>	<u>Abbreviation</u>	<u>Meaning</u>
Andromeda	AND	Princess
Antlia	ANT	Air Pump
Apus	APS	Bird of Paradise
Aquarius	AQR	Water Bearer
Aquila	AQL	Eagle
Ara	ARA	Altar
Aries	ARI	Ram
Auriga	AUR	Charioteer
Bootes	BOO	Herdsmen
Caelum	CAE	Chisel
Camelopardalis	CAM	Giraffe
Cancer	CNC	Crab
Canes Venatici	CVN	Hunting Dogs
Canis Major	CMA	Big Dog
Canis Minor	CMI	Small Dog (or Puppy)
Capricornus	CAP	Sea Goat
Carina	CAR	Ship's Keel
Cassiopeia	CAS	Queen
Centaurus	CEN	Centaur
Cepheus	CEP	King
Cetus	CET	Whale
Chamaeleon	CHA	Chameleon
Circinus	CIR	Compass
Columba	COL	Dove
Coma Berenices	COM	Berenice's Hair
Corona Australis	CRA	Southern Crown
Corona Borealis	CRB	Northern Crown
Corvus	CRV	Crow
Crater	CRT	Cup

Crux	CRU
Delphinus	DEL
Dorado	DOR
Draco	DRA
Equuleus	EQU
Eridanus	ERI
Fornax	FOR
Gemini	GEM
Grus	GRU
Hercules	HER
Horologium	HOR
Hydra	HYA
Hydrus	HYI
Indus	IND
Lacerta	LAC
Leo	LEO
Leo Minor	LMI
Lepus	LEP
Libra	LIB
Lupus	LUP
Lynx	LYN
Lyra	LYR
Mensa	MEN
Microscopium	MIC
Monoceros	MON
Musca	M U S
Norma	NOR
Octans	OCT
Ophiuchus	OPH
Orion	ORI
Pavo	PAV
Pegasus	PEG
Perseus	PER
Phoenix	PHE
Pictor	PIC
Pisces	PSC
Piscis Austrinus	PSA
Puppis	PUP
Pyxis	PYX
Reticulum	RET
Sagitta	SGE
Sagittarius	SGR
Scorpius	SCO
Sculptor	SCL
Scutum	SCT

Southern Cross
Dolphin
Swordfish
Dragon
Little Horse
River
Furnace
Twins
Crane
The Kneeler/Son of Zeus
Clock
Sea Serpent
Water Snake
American Indian
Lizard
Lion
Lion Cub
Hare (or Rabbit)
Balance Scales
Wolf
Wildcat
Lyre or Harp
Table Mountain (or Mesa)
Microscope
Unicorn
Fly
Carpenter's Square
Octant
Serpent Bearer
Hunter
Peacock
Winged Horse
Rescuer of Andromeda
Resurrected Firebird
Easel
Fishes
Southern Fish
Ship's Stern
Ship's Compass
Fisherman's Net
Arrow
Archer
Scorpion
Sculptor's Tools
Shield

Serpens (Caput)	SER
Serpens (Cauda)	SER
Sextans	SEX
Taurus	TAU
Telescopium	TEL
Triangulum	TRI
Triangulum Australe	TRA
Tucana	TUC
Ursa Major	UMA
Ursa Minor	UMI
Vela	VEL
Virgo	VIR
Volans	VOL
Vulpecula	VUL

Serpent (Head)
Serpent (Tail)
Sextant
Bull
Telescope
Triangle
Southern Triangle
Toucan
Big Bear
Little Bear (or Bear Cub)
Ship's Sails
Virgin
Flying Fish
Little Fox

Star Names & Designations

The names, designations and labels for stars often baffle newcomers to astronomy. There are a number of ways that stars can be labeled; common or proper names, Greek or Roman letter-designations, the star's number in some catalog, and even special names (sometimes that of an astronomer if the star is noteworthy for some special reason).

Proper names such as SIRIUS, VEGA, ARCTURUS and CAPELLA are for the most part used today only for the brightest stars like those in the table of 1st-magnitude ones given above. On your celestial globe, these are labeled in black in smaller size upper-case Roman letters. The proper names we recognize today are mainly of Arabic origin. One clue to this is the prefix "Al" or "El" - as in ALDEBARAN, ALTAIR, ALPHECCA, ELNATH, ELTANIN all of which appear on the globe. Other names are derived from the Greek (SIRIUS and ARCTURUS) and Latin (REGULUS), and a few from other languages including English (the star PEACOCK, which is the English translation of the constellation it's in - PAVO).

The second most common method of labeling stars is with a lower-case Greek letter, which originated with the German astronomer Johann Bayer in his epochal star atlas *Uranometria* published in 1603. These are usually assigned in order of brightness, with "alpha" being the brightest star in a constellation, "beta" second brightest, etc., but there are some exceptions to this rule. A great many of these Greek letters will be seen on your celestial globe, all in black. The star VEGA, for example has a Greek "alpha" next to it (in addition to its proper name), so its designation is Alpha LYRAE (the genitive or possessive case of the constellation's Latin name always being used for this purpose). An interesting twist to the usual name verses Greek-letter designation scheme exist with the bright South-

ern Hemisphere star named RIGIL KENTAURUS. It's Greek letter label is Alpha CENTAURI. Even though it does have a proper name, it's always been known by its Greek letter designation as the famed "Alpha CENTAURI" - closest star to us after the Sun (at 4.3 lightyears).

Stellar Distances

The distances to many of the named stars shown on your **Starship Earth II** celestial globe are given in lightyears under their labels. Again, a light-year is the distance that light (and all electromagnetic waves) travels in one year - about 6 trillion miles. Knowing the distances to the stars and other objects on your globe expands your cosmic perspective by providing a 3-dimensional feel for their locations in space.

Special Note for Navigators

All 57 standard "navigation stars" are indicated on the celestial globe. They are set off by upper-case black italic lettering of their names, adding to this device's usefulness and overall versatility.

Stories in the Sky

The major constellations recognized today date largely from ancient times and are based on well-known stories and legends from the early Middle East civilizations. Who hasn't heard of mighty HERCULES and his famous feats? He's immortalized as a major constellation in the northern sky of summer.

One of the classic early Greek myths involves the constellations of CEPHEUS, CASSIOPEIA, ANDROMEDA, PERSEUS, CETUS and PEGASUS. CEPHEUS was the mythological King of Ethiopia and had a beautiful wife, Queen CASSIOPEIA. Their daughter ANDROMEDA was a rival to her mother in beauty, CASSIOPEIA even boasting that she was more attractive than the sea nymphs. When the sea god Neptune heard of this, he became so angry that he demanded ANDROMEDA be sacrificed to the ferocious sea monster CETUS by being chained to a rock by the ocean. If this were not done, CETUS threatened to ravage the coast and kill many people. So ANDROMEDA was sorrowfully chained to the rock. But just as CETUS approached her, the hero PERSEUS was flying overhead perched on his winged horse PEGASUS. In his pouch he carried the head of the gorgon Medusa - a hideous creature who had snakes for hair and was so ugly that anyone looking at her was immediately turned to stone. So PERSEUS held Medusa's head directly in front of CETUS, who was turned into a huge beach bolder upon gazing at it. PERSEUS released ANDROMEDA and the couple became husband and wife!

Numerous other legends have been handed down over the ages from other cultures about the constellations. Yet, the main emphasis has been on the stories of the Middle East civilizations, which have been responsible for the major sky figures we in the West recognize today. It should be mentioned that a number of the constellations now recognized do not date from ancient times but rather were formed after the Renaissance. These mainly involve fainter, unclaimed stars that were used to fill in gaps in the sky that the ancients left blank. Among these are MONOCEROS the Unicorn, CAMELOPARDALIS the Giraffe, VULPECULA the Fox, and a whole group largely in southern skies representing inanimate objects such as PICTOR the Easel and FORNAX the Furnace. The meanings of many other star patterns - both modern and ancient - can be found in the constellation table given above.

A rich body of star lore is coming to light about the sky figures visualized in the heavens by cultures elsewhere in the world. Native Americans, Eskimos, South Sea Islanders, Africans and Australians among others all have their own stories about the stars. To certain North American Indians, the four stars that comprise the Big Dipper's bowl (which is just part of the Great Bear to most of us) constitutes a bear itself, while the stars in the Big Dipper's handle represent hunters following the creature. Another New World picture of these stars - this time from the Skidi Pawnee Indians - portrays the bowl as a stretcher for carrying the wounded and dead with the handle being medicine men and mourners. The Skidi also conceived what is surely the ultimate "constellation" - one involving all of the visible stars, which they associated with the North American bobcat!

This same culture regarded POLARIS, the Pole Star, as the "Chief Star" who watched over the comings and goings of his celestial tribe. To the Scandinavians - particularly the seafaring Vikings, POLARIS was of special importance as a stellar guidepost for navigating their relatively frail ships on the high seas. To these people, this star was the jeweled tip of the "World Spike" or the celestial nail holding all of creation - the Earth and sky - together.

Those having access to dark, non-light-polluted skies can enjoy the wispy band of light arching across the sky known as the Milky Way. This stunning sight is the combined radiance of the hundreds of billions of stars making up our home galaxy. As mentioned earlier, it's represented on your **Starship Earth II** celestial sphere as a pale-blue river of light encircling the globe. Native cultures in both South America and Australia actually created separate constellations out of its intricate maze of dark rifts, which are the result of vast interstellar dust clouds lying between us and the more distant stars. The Sumerians, Vikings and certain New World Indians regarded the Milky Way itself as the pathway of the deceased en route to

heaven. Others saw the bright stars along its way as campfires where the travelers stopped to rest and refresh themselves. In the Orient, the Milky Way was regarded as the "Heavenly River."

The lore behind the constellations is quite extensive and we've been able to do no more here than offer a sampling of it. Those wishing to pursue this fascinating subject further should consult the references in the recommended reading list at the end of this guide.

THE STARRY UNIVERSE

The Stars

How many stars can be seen on a really dark, clear moonless night away from city lights? Although they seem countless, most people do well to discern but a few thousand of them. The "countlessness" is simply an illusion resulting from the overwhelming vastness of the stellar canopy.

Aside from the fixed patterns in the sky formed by the stars, it's readily apparent that they vary greatly in brightness. A star's apparent brightness is determined by a combination of its real or intrinsic luminosity and how far away it is from us. The early Greeks created six categories or magnitudes as a brightness scale for the stars visible to the naked eye. Originally, the brightest stars were all labeled "1st-magnitude" and the faintest "6th-magnitude." During the last century a more precise mathematical scale was established in which it was found that the most luminous stars in the sky are even brighter than 1st-magnitude. As a result, we now have stars of both 0-magnitude and even -1-magnitude. The brightest star in the sky - SIRIUS - has an apparent visual magnitude of -1.46. It was also found that two stars a whole magnitude apart differ in brightness by nearly a factor of 2.5 times. (For the mathematically inclined, this is the 5th root of 100, or 2.512. Therefore, two stars five magnitudes apart have a difference in brightness of 100 times.)

On the **Starship Earth II**'s celestial globe, we have followed the popular convention of grouping the stars into whole-magnitude categories - sometimes called magnitude "bins." With this system, any star that has an apparent magnitude anywhere from 1.50 to 2.49 is called 2nd-magnitude, a 3rd-magnitude star is one lying between 2.50 and 3.49, and so on. The stars shown on the globe range from the brightest down to 4th-magnitude (although not all of the 4th-mags are shown), and a few important 5th-magnitude ones are included here and there. Every star of 3rd magnitude and brighter is displayed. On the globe, the larger the star dot the brighter it is. Note the magnitude scale in the box below the Celestial Equator at 20-hours of RA.

For your convenience, we give the following table of the standard "1st magnitude" stars. Notice that the star CASTOR (Alpha GEM) actually falls below the 1.49 cutoff for this magnitude class. Since it has traditionally been regarded as a member of the elite "First-Magnitude Club" and is very important astronomically from a number of standpoints, it has been included in our tabulation.

STANDARD "1ST-MAGNITUDE" STARS

<u>Name/Designation</u>	<u>Visual Magnitude</u>	<u>Distance</u>	<u>Spectral Type</u>
ACHERNAR (Alpha ERI)	0.46	90LY	B3V
ALDEBARAN (Alpha TAU)	0.85	68LY	K5 III
CAPELLA (Alpha AUR)	0.08	45LY	G6 III + G2 III
BETELGEUSE (Alpha ORI)	0.5v	520LY	M2 I
RIGEL (Beta ORI)	0.12	900LY	B8 I
CANOPUS (Alpha CAR)	-0.72	98LY	A9II
SIRIUS (Alpha CMA)	-1.46	8.7LY	A1 V
ADHARA (Epsilon CMA)	1.50	490LY	B2 II
PROCYON (Alpha CMI)	0.38	11LY	F5 IV
CASTOR (Alpha GEM)	1.94	49LY	A2 V + A5 V
POLLUX (Beta GEM)	1.14	35LY	K0 III
REGULUS (Alpha LEO)	1.35	84LY	B7 V
ACRUX (Alpha CRU)	1.33	510LY	B1 IV
MIMOSA/BECRUX (Beta CRU)	1.2v	490LY	B1 III
SPICA (Alpha VIR)	1.0v	280LY	B1 V
ARCTURUS (Alpha BOO)	-0.04	36LY	K2 III
RIGIL KENTAURUS (Alpha CEN)	-0.01	4.3LY	G2 V + K1 V
HADAR (Beta CEN)	0.6v	360LY	B1 III
ANTARES (Alpha SCO)	0.9v	520LY	M2 I
VEGA (Alpha LYR)	0.03	26LY	A0 V
ALTAIR (Alpha AQL)	0.77	17LY	A7 V
DENEK (Alpha CYG)	1.25	1600LY	A2 I
FOMALHAUT (Alpha PSA)	1.16	22LY	A3 V

Star Colors

Just as the magnitudes of stars differ, so do their colors - from blue-white to reddish-orange. This is the result of different surface temperatures, ranging from more than 60,000 degrees F for the O stars to less than 5,000 degrees F for those of type M. This in turn depends on a number of factors including a star's mass, size and age. The nature of this relationship is part of the field called *astrophysics* and is described in detail in a number of the references given in our reading list.

Late in the 19th century, Harvard astronomers systematically classified star colors, arranging them in various categories known as *spectral classes*. They discovered that there exists a definite relationship between a star's color and the appearance of its spectrum. The major spectral classes recognized today are designated by the letters O, B, A, F, G, K and M,

running from blue-white to reddish orange. These in turn are subdivided with numbers running from 0 to 9. Contrary to what many books say, M-type stars are not really red and there's relatively few truly red stars visible to the unaided eye. The brightest of these is the supergiant Mu CEP - better known as "Herschel's Garnet Star" - whose vivid tint is best seen in binoculars or a small telescope.

A further refinement in spectral classification has been the addition of Roman numerals to the letter designations to indicate the intrinsic luminosity and size of a star. These typically run from type-I (the most luminous supergiants) to type-V (dwarfs or "main sequence" stars like our Sun, which is classified as "G2V"). Note that the table of 1st-magnitude stars above gives not only the visual magnitude for each entry, but also its spectral type and distance.

Variable Stars

Not all stars are constant in brightness - some have magnitudes that change continuously, sometimes even drastically. These are the variable stars, of which there are two major types: *extrinsic* and *intrinsic*. The first of these is actually an orbiting double star (see the following section) in which one member periodically eclipses the other as seen from our line of sight, causing the brightness to change. The best known naked-eye example is ALGOL (Beta PER), which drops from magnitude 2.1 to 3.4 every 2 days, 20 hours and 49 minutes. The "eclipse" itself takes about 10 hours, the star remaining at minimum light for nearly two of those hours.

The other type is a star that varies in brightness because of internal instabilities, causing it to pulsate like some giant beating heart. One of the best-known examples visible to the unaided eye is MIRA (Omicron CET), prototype of the long-period variables. It varies from as bright as 2nd-magnitude at maximum to as faint as 10th at minimum (well below naked-eye visibility) over an average period of 331 days. Another is Delta CEPHEI, prototype of the so-called "Cepheid variables," named for the constellation in which it is located. Also an attractive visual double star (see the table below), it varies from magnitude 3.1 to 4.3 over a period of 5.4 days. The brightest example of an intrinsic variable is the reddish-orange supergiant BETELGEUSE (Alpha ORI). It changes in brightness irregularly from its normal magnitude of 0.5 to as faint as 1.2, in multiple periods roughly ranging from a fraction of a year to nearly six years. All of these variables are shown on the celestial globe of your **Starship Earth II** for your study and enjoyment.

Double & Multiple Stars

More than half the stars in the night sky are double or multiple as viewed through a telescope, and many examples are easily seen with binoculars and even the unaided eye itself. Most such pairs are true physical doubles - bound together by their mutual gravity and orbiting each other far out in the depths of space. Some, however, are merely optical doubles - chance alignments of two stars at different distances along the same line of sight. Double stars display a seemingly infinite array of component brightnesses, angular separations, configurations and colors. Referred to by some observers as "jewels of the sky" and "flowers in the meadows of heaven," many of these objects are exquisitely tinted. Certainly one of the most beautiful telescopic pairs in the sky is ALBIREO (Beta CYG) - a stunning combination of topaz and sapphire suns in close proximity shining against the backdrop of the summer Milky Way!

Some bright examples of these objects spaced around the sky are given in the table below. Ranging from ones easily resolved with the unaided eye to those requiring a small telescope, all appear on the **Starship Earth II** celestial globe. The column marked "Sep (arc sec)" gives the apparent angular separation of the components in seconds of arc, which is 1/3600th of a degree. Both the Sun and Moon subtend an angle of 1/2 degree in the sky, which is 30' (minutes of arc) or 1/1800" (seconds of arc). Those having excellent eyesight can resolve pairs of nearly equal brightness down to several minutes of arc in separation without optical aid.

SOME BRIGHT DOUBLE & MULTIPLE STARS

* * * * *

<u>Name/Designation</u>	<u>Mags</u>	<u>Sep (arc sec)</u>	<u>Remarks</u>
Beta TUC	4.2, 4.5	26"	Bluish & white
Eta CAS	3.7, 7.4	9"	Yellow & lilac
MESARTHIM/Gamma ARI	4.2, 4.4	8"	Matched white duo
ALMACH/Gamma AND	2.3, 5.4	10"	Orange & aquamarine
ACAMAR/Theta ERI	3.4, 4.4	8"	Brilliant white pair
32 ERI	4.0, 6.0	7"	Yellow & greenish blue
Theta 1-2 TAU	3.4, 3.8	337"	Naked-eye orange pair in Hyades Star Cluster
RIGEL / Beta ORI	0.1, 8.0	9"	Tight blue-white pair
MINTAKA / Delta ORI	2.0, 6.8	53"	Binocular duo
Lambda ORI	4.0, 6.0	4"	White & purplish
Theta-1 ORI	4.7, 6.3, 7.0, 8.0	7", 13", 22"	"Trapezium" in Orion Neb
Gamma LEP	3.6, 6.2	95"	Yellow & garnet binoc duo
Beta MON	5.0, 5.5, 6.0	7", 10"	Herschel's Wonder Star
CASTOR/Alpha GEM	2.7, 3.7	4"	Radiant blue-white binary
SUHAIL / Gamma VEL	2.7, 4.5	42"	Bright binocular pair
Iota CNC	4.4, 6.5	30"	Orange & blue
ALGIEBA / Gamma LEO	2.6, 3.6	4"	Golden yellow pair
ACRUX/Alpha CRU	1.4, 1.9	5"	Brilliant close duo
ALGORAB/Delta CRV	3.0, 7.5	24"	Yellow & lilac
24 COM	4.7, 6.2	20"	Orange & blue beauty
PORRIMA/Gamma VIR	3.6, 3.7	3"	Tight binary - closing up
COR CAROLI/Alpha CVN	3.2, 5.7	20"	Easy blue-white pair
MIZAR / Zeta UMA	2.1, 4.2	14"	Famous pair - ALCOR in field forms naked-eye duo
RIGIL KENTAURUS/Alpha CEN	3.0, 1.7	4"	White & red - closest star
IZAR/Epsilon BOO	3.0, 6.3	3"	Close yellow & green pair
ALYA/Theta SER	4.6, 4.9	23"	Easy matched white duo
Zeta CRB	4.1, 5.0	6"	Both greenish-white
ZUBENELGENUBI/Alpha LIB	2.8, 5.2	231"	Wide binocular pair
GRAFFIAS/Beta SCO	2.6, 4.9	14"	Blue-white pair like MIZAR
Nu SCO	4.2, 6.7	41"	Both stars close doubles
RAS ALGETHI/Alpha HER	3.1-3.9, 5.4	5"	Primary variable - orange & blue-green

95 HER	4.9, 4.9	6"	Apple-green & cherry-red!
Nu DRA	4.6, 4.6	62"	Matched white binoc pair
Psi DRA	4.0, 5.2	31 "	Yellow & purple
70 OPH	4.1, 6.1	7"	Yellow & red binary
Epsilon 1-2 LYR	4.6, 4.9	208"	"Double-Double" - both stars close pairs
Zeta LYR	4.2, 5.5	44"	Greenish-yellow & white
Delta 1-2 LYR	4.5, 5.5	630"	Wide orange & blue pair
ALBIREO/Beta CYG	3.0, 5.3	35"	Topaz & blue - superb!
Omicron-1 CYG	3.7, 6.5, 5.0	107", 337"	Orange, white & blue trio
ALGEDI/Alpha 1-2 CAP	3.6, 4.2	376"	Naked-eye orange pair
DABIH/Beta CAP	2.5, 6.0	205"	Yellow & blue binoc duo
Gamma DEL	4.3, 5.1	10"	Yellow & blue-green
Delta CEP	3.1-4.3, 6.2	41"	Gold & blue - primary
		"	Cepheid variable
Delta 1-2 GRU	4.0, 4.1	900"	Wide naked-eye pair
Zeta AQR	4.3, 4.5	3"	Close white binary

Denizens of the Deep-Sky: Clusters Nebulae & Galaxies

There are five major types of deep-sky objects in space - open clusters, globular clusters, diffuse nebulae, planetary nebulae, and galaxies and quasars. (Technically, any object lying beyond the confines of our solar system is a "deep-sky object" or DSO, including single, variable, and double and multiple stars. But the term is commonly reserved for these objects alone.) The brighter DSO's - in addition to often having names like the "ORION NEBULA" or "SOMBRERO GALAXY" - are generally designated by either their "M" number (if they have one) or their "NGC" number. The first derives from the famous Messier catalog of some 110 showpieces compiled by the 18th-century French astronomer Charles Messier. The second comes from The New General Catalogue of Nebulae and Clusters of Stars published by John Dryer in 1888, which contains over 7,000 deep-sky objects. The table of prominent DSO's given below contains samples of each major class (many visible to the unaided eye and in binoculars). All of them can be found on your **Starship Earth II** celestial globe, adding a whole new dimension to its usefulness for sky exploration and educational purposes.

Open Star Clusters (also known as galactic clusters) are relatively loose groupings of young stars located in the spiral arms of galaxies like our Milky Way and containing dozens to hundreds of stars. Wider, generally looser gatherings of such stars are referred to as *stellar associations*. In both cases, the stars in such clusters form a physical system bound to-

gether by the mutual gravity of the individual members. One of the best-known and most striking open star clusters is the famed PLEIADES (M45) in TAURUS - a glittering commune of blue-white diamonds in the winter sky above ORION, obvious to the naked eye and a truly incredible sight in binoculars! Except for the PLEIADES and HYADES where the individual naked-eye members are actually shown on the globe, open clusters are indicated by a dotted open circle.

Globular Star Clusters are much richer and denser families of stars than are open clusters. These colossal stellar beehives contain tens of thousands up to millions of stars, all mutually bound together by gravity as they orbit the center of the cluster. They lie largely outside the main bodies of galaxies like the Milky Way, forming a spherical halo around their central nucleus, and contain some of the oldest stars known. Probably the best example for Northern Hemisphere observers is the HERCULES CLUSTER located in that constellation's central "keystone" area. Visible in binoculars, it's an incredible sight in medium to large amateur telescopes. The famed Southern Hemisphere OMEGA CENTAURI CLUSTER is visible to the unaided eye as a fuzzy star and is the brightest such object in the sky. Globular clusters are shown on the globe as a circle of dots surrounding a dot in the center.

Diffuse Nebulae are either glowing clouds of gas in which new stars are being born, or ghostly dark patches silhouetted against the star background. The rifts and gaps seen along the path of the Milky Way on your **Starship Earth II** celestial globe are caused by the latter, the best known dark nebula being the COAL SACK in CRUX. The most famous example of the former is the magnificent ORION NEBULA (M42-M43) located in that constellation's "sword." It appears as an emerald-green patch of light in binoculars and small telescopes enveloping the stunning "Trapezium" multiple star (see the double star list above).

Planetary Nebulae are so called because the pale gray or blue-green disks displayed by many of them reminded early telescopic observers of planets. These bubbles of gas are the cast-off outer layers ejected by dying stars, or "novae." Two of the brightest and most famous planetaries are the RING NEBULA (M57) in LYRA and the DUMBBELL NEBULA (M27) in VULPECULA. Related to planetary nebulae are the *Supernova Remnants* - the remains of a massive star that has blown most of its material into space in a spectacular cosmic explosion. The best-known example (and the only one bright enough to be shown on your **Starship Earth II** celestial globe) is the CRAB NEBULA (M1) in TAURUS - the result of a brilliant supernova witnessed by Chinese astronomers in the year 1054 A.D. Nebulae are shown on the globe as a disk composed of three dashes.

Galaxies are vast "star cities" or "island universes" containing up to half a trillion stars floating in the infinite ocean of space. Billions of these objects exist in various sizes and types extending to the very limits of the observable universe (and probably beyond). The best-known example is the famed ANDROMEDA GALAXY (M31), easily visible to the unaided eye as an elongated smudge of light on a dark, clear night, and an amazing sight in binoculars and small telescopes. But there's an even more spectacular specimen - the one in which we live - the Milky Way Galaxy! We see this grandest of all "deep-sky objects" from our view inside of it as a sparkling misty glow encircling the entire heavens. Together with its two neighboring satellite galaxies - the Large and Small Magellanic Clouds visible from the Southern Hemisphere - the Milky Way is shown as a pale-blue river of light on your **Starship Earth II** celestial globe. All other galaxies are denoted by an open ellipse. Related to galaxies in a way not yet fully understood by astronomers are the mysterious Quasars - incredibly remote and intensely luminous star-like objects visible only through a telescope. No member of this class is obvious enough to be shown on your celestial globe - the brightest one (3C-273) is a 12th-magnitude glimmer of light in the constellation VIRGO lying some three billion lightyears from us!

SOME PROMINENT DEEP-SKY OBJECTS

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OPEN CLUSTERS

<u>Name/Designation</u>	<u>Constellation</u>	<u>Magnitude</u>	<u>Distance</u>
PLEIADES (M45)	TAU	1.2	410LY
HYADES (MEL 25)	TAU	0.5	150LY
DOUBLE CLUSTER (NGC 869 & 884)	PER	4.3	7,500LY
M35	GEM	5.1	2,800LY
BEEHIVE CLUSTER (M44)	CNC	3.1	590LY
COMA CLUSTER (MEL 111)	COM	1.8	300LY
WILD DUCK CLUSTER (M11)	SCT	5.8	5,600LY
BUTTERFLY CLUSTER (M6)	SCO	4.2	1,500LY
M7	SCO	3.3	800LY

GLOBULAR CLUSTERS

47 TUCANAE (NGC 104)	TUC	4.7	16,000LY
M3	CVN	6.4	35,000LY

OMEGA CENTAURI (NGC 5139)	CEN	3.5	17,000LY
M5	SER	5.8	26,000LY
HERCULES CLUSTER (M13)	HER	5.9	24,000LY
M22	SGR	5.1	10,000LY
M 15	PEG	6.4	34,000LY

DIFFUSE NEBULAE

ORION NEBULA (M42 & M43)	ORI	4.3	1,800LY
LAGOON NEBULA (M8)	SGR	5.8	4,500LY
COAL SACK	CRU	—	—
NORTH AMERICAN NEBULA (NGC 7000) CYG	—	—	3,500LY

PLANETARY NEBULAE

RING NEBULA (M57)	LYR	9.0	5,000LY
DUMBBELL NEBULA (M27)	VUL	8.1	3,500LY

SUPERNOVA REMNANT

CRAB NEBULA (M1)	TAU	8.4	4,000LY
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GALAXIES

ANDROMEDA GALAXY (M31)	AND	3.4	2,200,000LY
PINWHEEL GALAXY (M33)	TRI	5.7	3,400,000LY
SCULPTOR GALAXY (NGC 253)	SCL	7.1	14,000,000LY
SOMBRERO GALAXY (M104)	VIR	8.3	55,000,000LY
WHIRLPOOL GALAXY (M51)	CVN	8.1	36,000,000LY
LARGE MAGELLANIC CLOUD (LMC)	DOR	0.1	163,000LY
SMALL MAGELLANIC CLOUD (SMC)	TUC	2.3	196,000LY
MILKY WAY GALAXY (HOME!)	—	—	—

BINOCULAR & TELESCOPIC OBSERVATION

Stargazing With Binoculars

While much can be seen and enjoyed in the heavens with the unaided eye alone, a whole new dimension of exploration is made possible with the application of optical aid. Before jumping into a costly telescope, however, you should spend time studying the sky with a pair of binoculars. Any size and type you already happen to have on hand for other purposes like birding or sports events - even a lowly theater or "opera glass" - can be turned skyward.

Binoculars make the ideal "first telescope" with their wide fields of view, ease of use, total portability, low cost (only a fraction of that of a good telescope) and surprising performance. Yet most people never realize that ordinary binoculars can be used for stargazing. The mountains and craters on the Moon, the satellites of Jupiter, asteroids, comets, pulsating variable stars, colorful double and multiple stars, glittering stellar associations and star clusters, and even the brighter nebulae and galaxies all lie within reach of such glasses!

Conjunctions of the Moon, planets and brighter stars with each other are actually better seen in binoculars than through most telescopes, with their limited fields of view. So too are eclipses of the Moon and the sweeping tails of bright comets. And for one of the greatest thrills in astronomy, sweep over the massed starclouds along the path of the Milky Way (shown on your *Starship Earth* globe) with a good pair of binoculars on a dark, clear moonless night!

Those planning to buy binoculars for stargazing use will find the 7X35 and 7X50 or 10X50 models ideal for the purpose. The first number followed by the "X" is the magnification or "power," while the second number is the size or aperture of the main lenses in millimeters - there being about 25 millimeters to the inch. Thus, a 7X50 binocular magnifies seven times (7X) and has objectives two inches (50mm) in diameter. Higher magnification and/or larger apertures generally require mounting the binocular on a tripod or other type of support for steadiness. A lawnchair is also quite useful for scanning the skies with hand-held glasses.

All of the deep-sky objects, as well as many of the wider double and multiple stars, listed in the tables in this manual can be seen with 7X50mm binoculars under good dark-sky conditions. This includes even the galaxies shown, all of which lie at distances of millions of lightyears from us! With a pair of binocular around your neck and your *Starship Earth II* globe as your guide, you're ready to embark on nightly voyages of celestial exploration into realms vast and beautiful.

Telescopic Observation

In most cases, views of celestial objects are greatly enhanced over that given by binoculars. But selecting a good instrument can be a confusing, frustrating and disappointing (if the wrong choice is made!) experience. Astronomical-quality telescopes (as opposed to spotting scope-grade ones) start at several hundred dollars and run up into the thousands. And there's a plethora of scopes to choose from on today's market - of both good and bad optical/mechanical workmanship.

There are three basic forms of optical telescopes used for stargazing - the *refractor* (or lens type), the *reflector* (or mirror type) and the *catadioptric* (or mixed lens-mirror type). Volumes have been written on the relative merits of each form; suffice it to say that all three types perform equally well for visual sky observing if properly made. Generally speaking, reflectors are the least expensive of the three for a given size and catadioptrics the most compact for their aperture. Refractors require less maintenance and adjustment, but top-rate ones are often more costly than either of the other two types, aperture-for-aperture.

It's important to point out here that magnification (or power) is secondary in importance to the size and quality of a telescope's main objective lens or mirror - the larger it is, the brighter and more detailed will be the image. Apertures from 2.4 inches (or 60mm) to 8 inches are those in most common use by casual stargazers today. In any size, beware of telescopes that are marketed on the basis of power alone. A magnification of 30X to 100X will literally show anything you might ever want to see in the sky and can provide a lifetime of viewing pleasure. Perhaps the best advice we can offer those considering buying a telescope (as opposed to assembling one from commercially-available components or of making one from scratch including the optics) is to check the numerous ads by reputable manufacturers and dealers that appear monthly in the magazines *Sky & Telescope* and *Astronomy* (see reading list).

Even the smallest of telescopes will provide views of the heavens undreamed of by early astronomers. Several thousand deep-sky wonders lie within reach of even a 3-inch telescope! Those shown on your *Starship Earth II* globe will serve as a jumping off point for your nightly explorations. To probe deeper, one of the star atlases given in the reading list can serve as your celestial roadmap. Through the porthole of your telescopic "spaceship" you can gaze out upon the universe in what is surely the next best thing to actually being "out there." Clear skies and happy hunting!

STARSHIP EARTH CREW MEMBER TRAINING EXERCISES

The ways in which your **Starship Earth II** globe can help you understand and enjoy the sky are virtually limitless! To "get a feel" for some of its uses, following are a few examples of questions that can be solved with this highly versatile device. Based on what you know and have learned about the globe already, try working them out yourself first. Then check your results against the answers and explanations given in the next section of this guide.

Q#1. How many hours is the Sun in the sky on June 22nd (the first day of summer for the Northern Hemisphere) as seen from a latitude of 40 degrees North? **Your Answer:**

Q#2. How many hours is the Sun in the sky on that same date as seen from 70 degrees North latitude? **Your Answer:**

Q#3. How high is the Sun in the sky at noon on December 22nd (the first day of winter for the Northern Hemisphere) at 40 degrees North latitude? **Your Answer:**

Q#4. At about what time in the evening does the bright star VEGA in the constellation LYRA rise on March 30th as seen from a latitude of 20 degrees North? **Your Answer:**

Q#5. What is the northernmost latitude from which we can see the Southern Cross (the constellation CRUX)? **Your Answer:**

Q#6. Around what time of the year is the constellation PEGASUS on the Meridian at midnight? **Your Answer:**

ANSWERS TO EXERCISES

A#1. About 15 hours. After setting the Earth globe's horizon ring for 40 degrees North latitude, locate the June 22nd position on the celestial globe's row of dated Ecliptic dots. It falls 2/5ths of the way between the June 20th and June 25th dots and happens to be just where the 6-hour Right Ascension (RA) circle intersects the Ecliptic. This point marks the summer solstice (which is better called the June solstice since this also marks the winter solstice for the Southern Hemisphere where the seasons are reversed). Now turn the globe so that the June 22nd point appears just above the eastern horizon. Notice what part of the RA grid appears in the South at that time (about 22.5-hours). Next rotate the globe until the June 22nd point reaches the opposite or western horizon, and while turning it count the number of hours of RA that pass through the horizon ring opening. You'll find this to be 15 hours, which is how long the Sun remains above the horizon at 40 degrees North latitude on this date.

A#2. The Sun is above the horizon continuously. By adjusting the latitude ring so that the North pole is 70 degrees above the horizon (and the 20 degree Declination (DEC) circle is even with the northern horizon), you'll see that the June 22nd location on the globe does not drop below the horizon. This marks the famed "Midnight Sun" at which time our daytime star appears on the Meridian below the North pole at local midnight.

A#3. About 26.5 degrees. Making sure that the horizon ring on the Earth globe is again set for 40 degrees North latitude, locate the December 22nd spot on the Ecliptic. This is the winter solstice point through which the 18-hour RA circle passes. Bring this point to the South and measure (or estimate) its altitude above the horizon ring.

A#4. About 11PM local time. Set the globe for 20 degrees North latitude and rotate it so that VEGA is above the horizon ring in the Northeast. Notice the RA hour circle in the ring opening at this time - it will be about 11.5-hours. Now rotate the globe backwards - i.e. eastward, or counter-clockwise - until the March 30th dot is in the South, counting as the globe turns how many hours of RA passes through the horizon ring opening. You'll find this to be about 11 hours; when the March 30th dot is at the horizon ring, 0.5-hours of RA falls on the Meridian. Since we had to run through 11 hours to get back to noon, this means that Vega rises 11 hours after noon, or at 11 PM.

A#5. About 25 degrees North latitude. First locate this bright compact constellation figure on the celestial globe's southern hemisphere

by looking near 12.5hours RA and -60-degrees DEC. Adjust the latitude so that CRUX just rises in its entirety above the southern part of the horizon ring. Now read the altitude of the North pole above the horizon ring's North pointer - this equals a latitude of 25 degrees. Thus to see the Southern Cross, you must go at least as far South as the southern portion of Florida. But for a really good view, you should go even further South since Crux may be hidden by trees, buildings or other obstructions lying along the horizon line.

A#6. About early September. Bring PEGASUS (located at about 23-hours RA and +20-degrees DEC) to the Meridian, midway through the opening in the horizon ring. If this is its midnight location, rotate the celestial globe halfway around to find the calendar date as given by the Sun's noon position. An RA of about 11-hours should be on the Meridian along with the September 7th dot. Since PEGASUS itself is actually a fairly large constellation, "early September" is an adequate enough time frame to give for its midnight Meridian transit date.

FOR FURTHER READING

For the convenience of those who wish to explore the subject further, we offer the following carefully selected list of books - arranged alphabetically by author - with a brief description of each work and its main area of focus:

Allen, Richard Hinckley - *Star Names: Their Lore and Meaning*
Dover Publications, New York, 1963

Reprint of a classic which originally appeared in 1899. Filled with fascinating lore on the stars and constellations, its emphasis is on the origins of a great many star names.

Audouze, Jean and Israel, Guy; editors - *The Cambridge Atlas of Astronomy*
Cambridge University Press, Cambridge, England, 1985
Perhaps the ultimate introduction to the cosmos currently available. More an encyclopedia than an atlas of astronomy, the publisher pulled out all the stops with this volume! An extensive text written by nearly four dozen leading authorities, numerous lavish photographs, and high-quality artwork and diagrams are its hallmarks.

Beyer, Steven L. - *The Star Guide*
Little, Brown & Co., 1986

A highly readable layperson's introduction to the stars. A celestial "travel guide" in which the author not only introduces the leading stars, but also makes these remote suns come alive as real astronomical bodies in space.

Burnham, Robert, Jr. - *Burnham's Celestial Handbook*
Dover Publications, New York, 1978

An indispensable reference for the serious sky observer. Arranged by constellation, this three-volume set provides information on more than 7,000 celestial wonders with fascinating descriptions and illustrations for many of the more famous objects.

Cleminshaw, C.H. - *The Beginner's Guide to the Skies*
Thomas Y. Crowell Co., New York, 1977

A noted astronomy popularizer with extensive planetarium experience created this very readable introduction to the heavens. Contains many lucid charts, diagrams and material on constellation lore.

Lum, Peter - *The Stars in Our Heavens: Myths and Fables*
Pantheon Books, Inc., New York, 1948

Although out of print, this classic volume is well worth seeking out in libraries and used book shops. A topnotch guide to the star lore of many cultures, it contains many beautiful sky charts.

Mayall, R. Newton, Mayall, Margaret and Wyckoff, Jerome - *The Sky Observer's Guide*

Western Publishing Co., Inc. - Golden Press, New York, 1985

A companion volume to Stars (see below), this pocket guide deals more-in depth with binoculars, telescopes and observing techniques, and contains lists of interesting objects for viewing.

Norton, Arthur P. - *Norton's 2000.0 StarAtlas and Reference Handbook*
Sky Publishing Corp., Cambridge, MA, 1990
The 18th edition of another long-time classic for stargazers containing one of the best sets of star maps available.

Ottewell, Guy - *The Astronomical Companion*
Furman University Physics Dept., Greenville, SC, 1979

This most unique, clever and imaginative softbound, atlas-size book uses highly original graphics to take the reader step by step into the remote reaches of the cosmos with the aid of clear and comprehensive commentary. An excellent companion to any celestial globe.

Pasachoff, Jay M. - *Contemporary Astronomy*
Saunders College Publishing, New York, 1981

A very well-written and illustrated college-level text which presents the essentials of astronomy in a well-organized manner. Can be used equally well for classroom or individual home study.

Rey, H.A. - *The Stars: A New Way to See Them*
Houghton Mifflin Co., Boston, 1976

One of the most popular constellations books - traces out sky pictures with highly original patterns developed by the author. Written in an informal and light-hearted style, the author frequently uses humor to get points across.

Reymo, Chet - *365 Starry Nights*
Prentice Hall, Inc., Englewood Cliffs, NJ, 1982

A great introduction to the starry scene above - night by night - with information, diagrams and charts that not only enable the novice to locate members of the celestial canopy, but also to grasp the fundamental astronomical concepts associated with what we see at night.

Tirion, Wil - *SkyAtlas 2000.0 (Deluxe Color Edition)*
Sky Publishing Corp., Cambridge, MA, 1986

The finest all-purpose star atlas ever produced. Covers the entire sky in 26 large-scale charts, showing some 43,000 stars and more than 2,500 deep-sky objects! (Two companion volumes are also available from Sky Publishing providing data for every object plotted on the atlas itself.)

Tirion, Wil and Lovi, George - *Uranometria 2000.0*
Sky Publishing Corp., Cambridge, MA, 1992

The most comprehensive work of its type ever published, this up-to-date major star atlas contains nearly 500 charts showing 332,000 stars and over 10,000 deep-sky objects. Indispensable to the serious telescopic observer, it (like Tirion's Sky Atlas 2000.0 above) is an excellent companion to *Burnham's Celestial Handbook*.

Zeilik, Michael - *The Evolving Universe*
Harper & Row, New York, 1982

Another leading textbook written in a up-beat manner by an author who relates very well to his readers. Like Pasachoff, Zeilik is an astronomer who is equally at home in both the observatory and the classroom.

Zim, Herbert and Baker, Robert - *Stars*
Western Publishing Co., Inc. - Golden Press, New York, 1985

One of the finest and most wonderfully-illustrated field guides to astronomy ever published, this little pocket book first appeared in 1951 and is still widely used and recommended. Here is the ideal "passport to the stars" - superb for all ages!

Following are some of the leading magazines and celestial almanacs in the field of astronomy that provide up-to-date information on current sky events and latest discoveries:

Astronomy

Kalmbach Publishing Co., 21027 Crossroads Circle, Waukesha, WI 53187
A lavishly-illustrated monthly magazine written in an easily understood style aimed at the casual stargazer and astronomy enthusiast. Contains excellent star and planet finding maps for each current month.

Astronomical Calendar

Furman University Physics Dept., Greenville, SC 29613 Another work by Guy Ottewell, similar in format and flavor to his *Astronomical Companion* (see above). This annual publication describes and discusses "what's up" in the sky during the current year.

Mercury

Astronomical Society of the Pacific, 390 Ashton Ave., San Francisco, CA 94112
A semi-popular bimonthly journal with articles, book reviews, upcoming celestial events and general news from the field of astronomy.

Observer's Handbook

Royal Astronomical Society of Canada, 124 Merton St., Toronto, Ontario, M4S 2Z2

A highly useful guide to the year's celestial events. Issued annually, this volume is indispensable to many stargazers for planning their observing sessions.

Sky & Telescope

Sky Publishing Corp., 49 Bay State Rd., Cambridge, MA 02138
Published monthly since 1941, "S&T" (as it's called) is regarded by many as the world's leading magazine on astronomy for both amateur and professional astronomers. Written on a semi-popular but authoritative level, it contains in-depth articles on all areas of astronomy, telescopes, observing, and recent discoveries, in addition to detailed monthly star and planet charts.

Sky Calendar

Abrams Planetarium, Michigan State University, East Lansing, MI 48823 An excellent monthly guide to the sky for the novice. Issued as a single sheet, one side is a very simple and easy to use star map while the other side is a day-by-day calendar of celestial events.

ABOUT THE AUTHORS

George Lovi was an astronomy and space science writer, lecturer and popularizer who had extensive experience in the creation of both hardware and software in these fields. He was formerly on the staff of the Hayden Planetarium in New York City where he wrote shows, taught classes and created educational materials. He was one of the authors of the landmark star atlas *Uranometria 2000.0*, which is the most comprehensive work of its type ever published. He also wrote a popular-level book entitled *Men, Monsters and the Modern Universe*, and edited a number of other astronomical works. Mr. Lovi for many years wrote a monthly column for *Sky & Telescope* magazine entitled "Rambling Through The Skies" and drew the star charts that appeared in the centerfold of each issue. He also participated in a number of solar eclipse expeditions as a scientific tour leader and instructor. An internationally-recognized specialist in celestial cartography and star names, Mr. Lovi joined forces with **Victor Schrader** to create the cartography and "uranography" for your **Starship Earth II** globe. George Lovi and Victor Schrader were both rare talents. Their work lives on in this globe and manual, touching thousands of minds into the future as their work has done in the past. Both are greatly missed by all of us who had the privilege of knowing and working with them during their time on this planet.

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