Instructions

Horizon Globe

3-D sky simulator

www.horizonglobe.us

Contents

Introduction **5**
About **7**
Parts & Features **9**
- Main Components 9
- Sphere Detail 11
- Accessories 13

Using the Horizon Globe **17**
- Latitude Adjustment 17
- The Observer Man (TOM) 19
- Icons 21

Seasons **23**
- Summer 23
- Autumn 25
- Winter 27
- Spring 29

Effects of Latitude **31**
- Equator 33
- Tropic of Cancer 35
- Arctic Circle 37
- North Pole 39

Moon Phases **41**
- New Moon & Full Moon 43
- Quarter Moon 45

Guideposts **47**
- Orion 49
- Big Dipper 51
- Summer Triangle/Cygnus the Swan 53
- Cassiopeia 55

Zodiac **57**
- Bull & Twins 57
- Lion & Virgin 59
- Scorpion & Archer 61
- Water Carrier & Fishes 63
- Ram & Crab 65
- Scales & Goat 67

Constellations near Guidepost #1 .... **69**
- Charioteer, Dog & Bone 69

Constellations near Guidepost #2 .... **71**
- Herdsman 71

Constellations near Guidepost #4 .... **73**
- Great Square 73
- Southern Fish 75

Little Dipper **77**
Southern Constellations **79**
- Ship 79
- River 81
- Centaur & Southern Cross 83

Planets **85**
- Planet Calendar key 87
- Planet Calendars 89

Horizon Globe

The Ultimate Sky Guide

Observe the sky from your desktop:

- Demonstrate the motion of celestial objects from the viewer's vantage point.
- Show the seasonal path of the Sun: altitude, rise and set azimuths, and length of day.
- Adjust to show motion of the sky at any latitude, from the equator to the poles.
- See how the Moon traces out the ecliptic each month.
- Observe how the 5 visible planets: Mercury, Venus, Mars, Jupiter, and Saturn travel along the ecliptic.
- Use the four guidepost constellations to define the celestial grid and contrast their motion with the Sun, Moon, and planets.

Introduction

The **Horizon Globe** is a modern twist on an ancient idea. For millennia astronomers have used armillary spheres to model the celestial globe in their quest to understand why the Sun, Moon, planets, and stars behave the way they do.

The Horizon Globe reintroduces this powerful device in an essentialized way. We have removed the distractions and difficulties of previous devices, leaving an uncluttered tool that has unprecedented power to explain the sky.

Key to the Horizon Globe is the focus on the observer and his horizon. We call this stargazer The Observer Man (TOM). Once your latitude is set, the Horizon Globe simply and dramatically shows how the sky moves. The mental image you carry with you after manipulating the globe makes understanding and organizing your own observations second-nature.

This manual walks you through the steps of setting up the Horizon Globe with all of its components to illustrate the most fundamental and important concepts of astronomy. First untangle the complexity of the Sun's motion, then move on to the Moon, stars, and planets. Learn your own place on Earth first, then advance to remote regions of the Equator and North Pole.

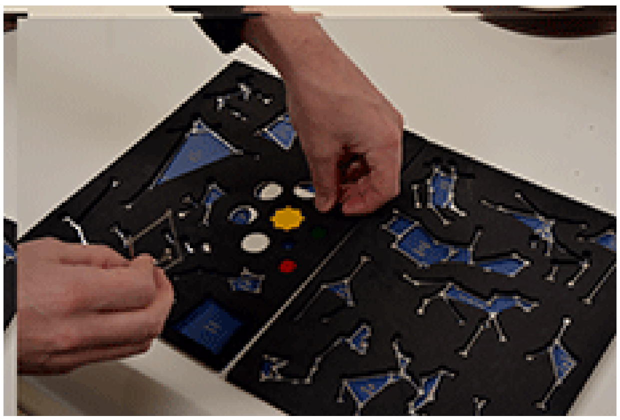
Horizon Globe

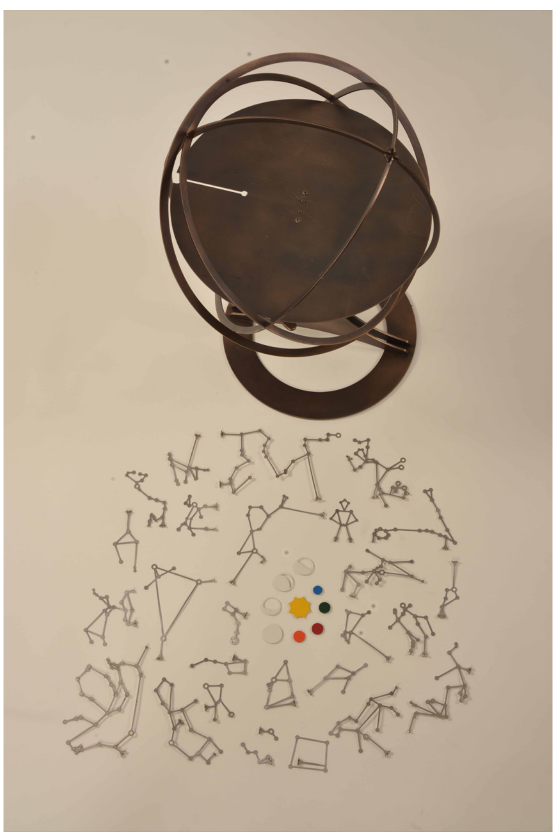
- 360^0 globe rotation
- Fully adjustable for latitude
- Easily adjustable horizon plate
- Precision TIG-welded steel
- 16 inch diameter
- All metal construction
- Made in U.S.A.

Care & Maintenance

The Horizon Globe and accessories are made out of steel with a durable finish that requires no maintenance. Apply some light oil to the pivot points and bronze bearings periodically to maintain smooth operation.

Celestial Objects





- 37 magnetically-attachable celestial objects
- Color-coated Sun, 4 Moon phases and 5 visible planets
- Four guidepost constellations
- Twelve Zodiac constellations
- Other constellations with first-order stars
- 9"x 13" box with convenient labeled cutout trays

Main Components

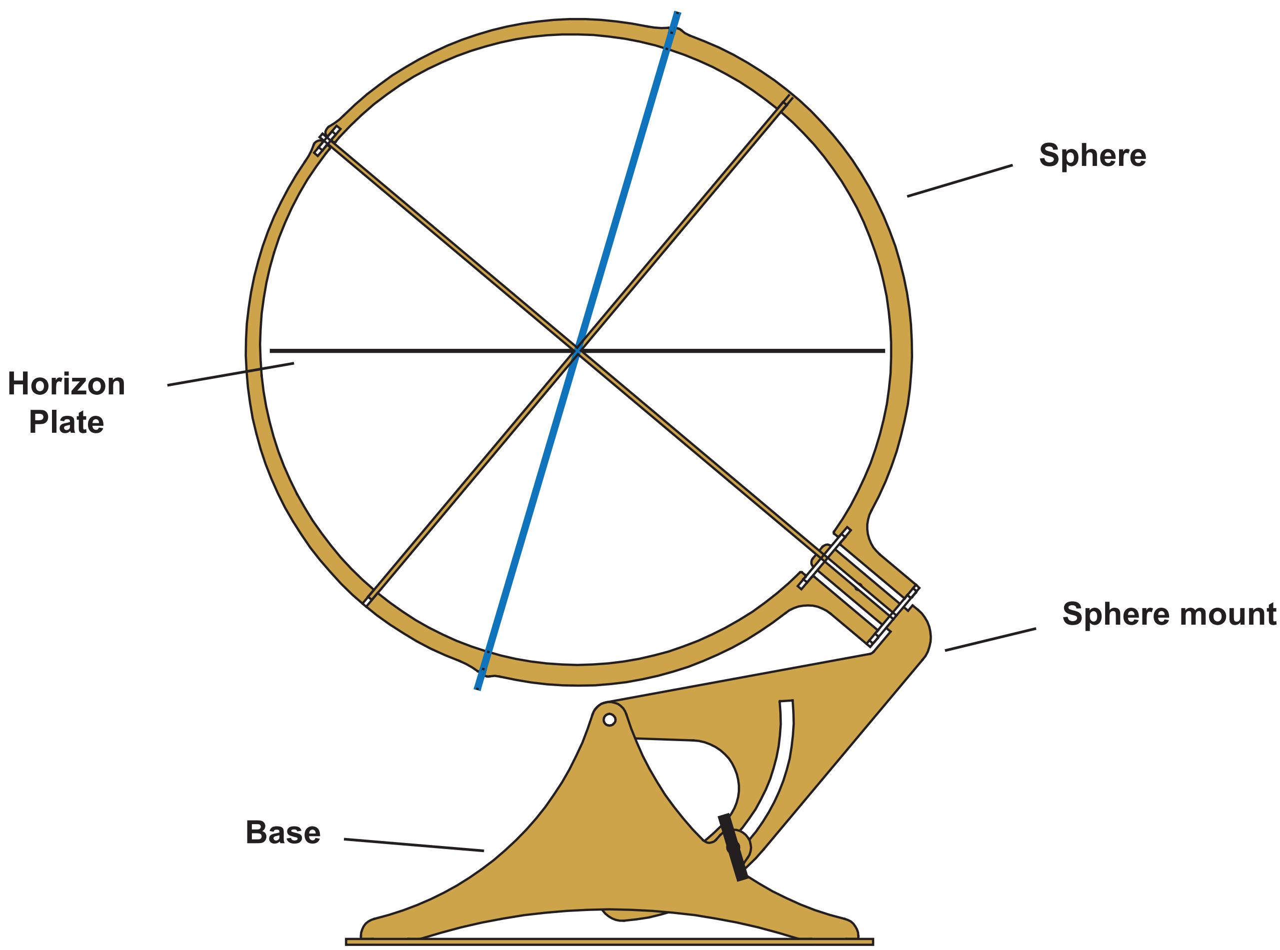
(refer to diagram on facing page)

Base - Metal annulus with a welded-on triangular bracket provides a sturdy foundation.

Sphere - Made of welded metal rings, the sphere defines the space of the sky and provides a place to mount celestial objects. See Page 10 for a more detailed view of the sphere.

Sphere mount - Attaches the **sphere** to the **base,** allows the sphere to tilt. The adjustment mechanism (the slot and wing nut) allows the user to adjust the latitude of the globe, and is specially designed to keep the sphere's center of gravity over the base ring throughout its range of motion. Latitude can easily be adjusted by loosening the wing nut and pivoting the sphere to any position. See Page 16 for more detailed instructions of how to adjust latitude.

Horizon Plate - An adjustable flat metal plate where the The Observer Man (TOM) stands. The Horizon Plate has a specially-designed magnetic clutch that allows the plate to be set by simply pushing on it, yet it will stay in position.


Sphere
Horizon Plate
Sphere mount
Base

Detail of Sphere

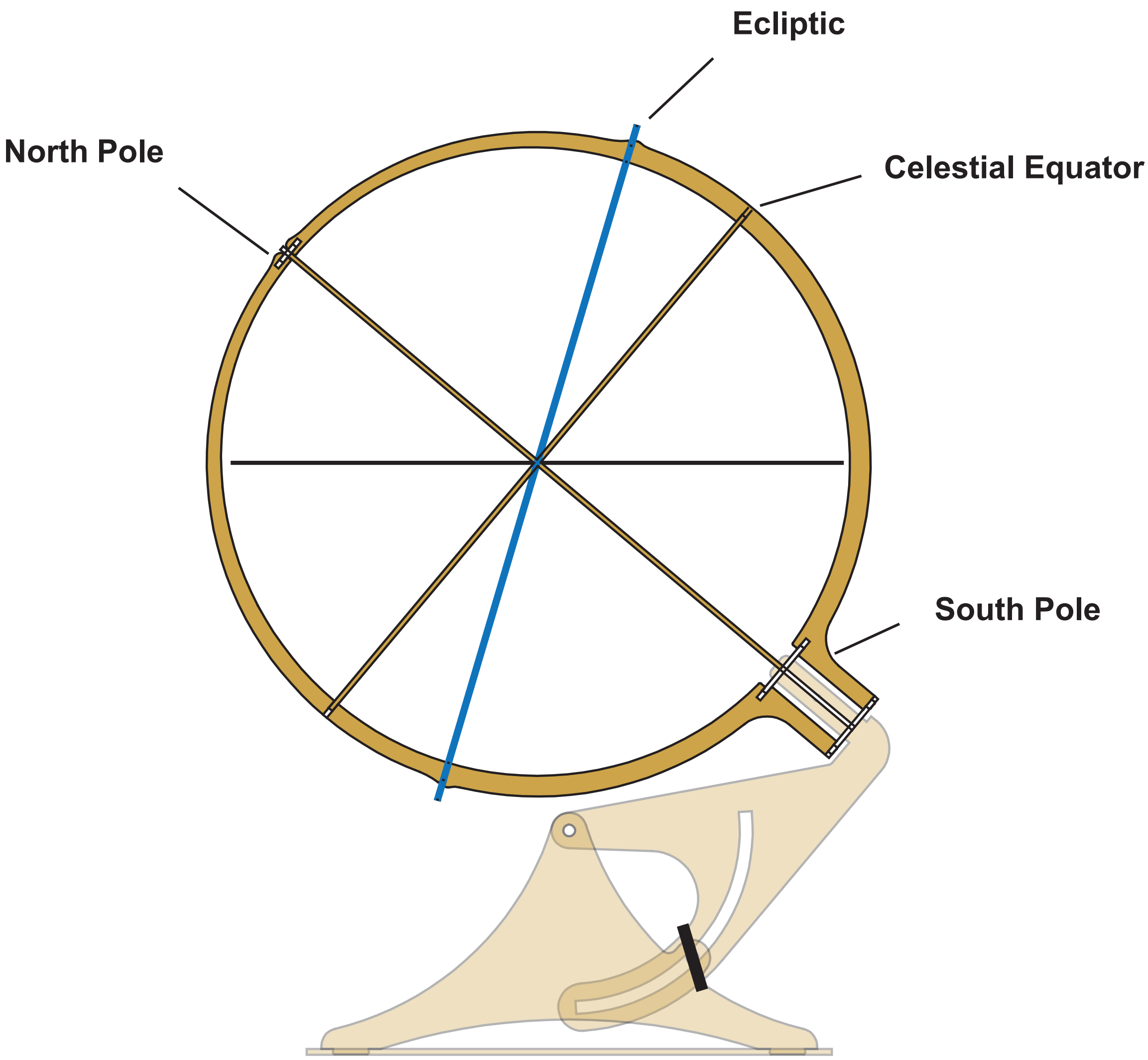
(refer to diagram on facing page)

Celestial Equator - Solid ring that divides sphere into hemispheres. North is positive declination and South is negative declination. The main reference point for all stargazing and navigation.

Ecliptic - A fixed ring at 23.5° from the **celestial equator**. The Sun, Moon, and planets ride on the ecliptic. Colored blue in the diagram.

North Pole - The tip of the sphere opposite the bearings represents the North Pole. The Horizon Globe does not have a physical axis between the North and South Poles, just as the actual Earth does not have a physical axis.

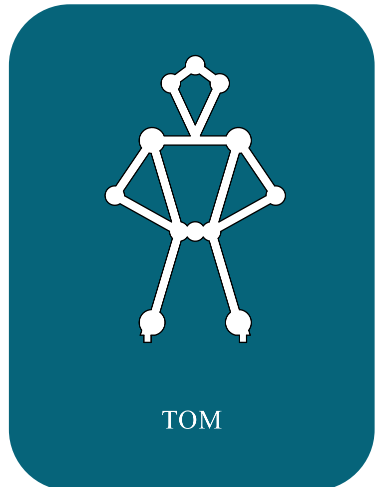
South Pole - The bottom of the sphere which houses the bearings represents the South Pole.



Ecliptic
North Pole
Celestial Equator
South Pole

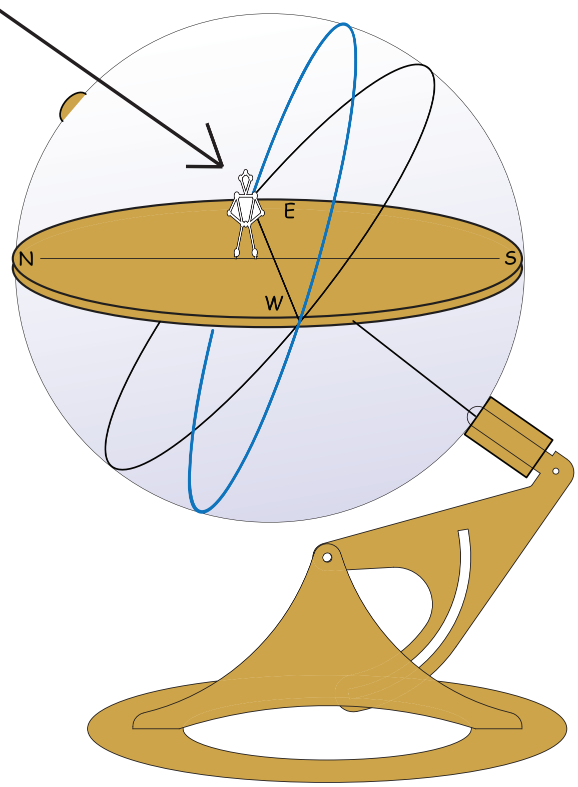
The Observer Man (TOM)

Let The Observer Man (TOM) show you his unique perspective on observational astronomy. His vantage point helps you see what you would see from actual observations. We will investigate the motion of the Sun, Moon, stars, and planets from TOM's vantage point.

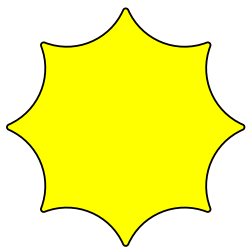


To position TOM

TOM stands inside the sphere on the horizon plate facing south. The sky moves clockwise, or left to right, from his viewpoint. All star views in this manual are from this observer's position, i.e. from inside the globe

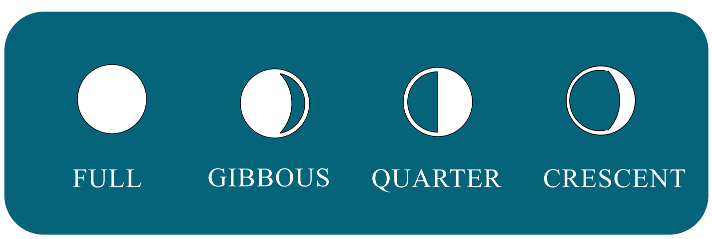


Sun



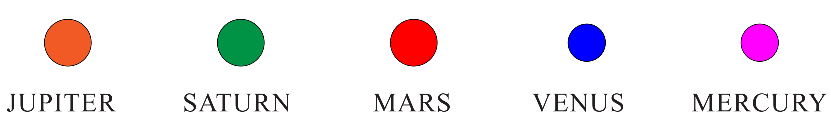
The Sun is the most important object in the sky, and sets the stage for all other observations. Use the Horizon Globe to show how the Sun moves across the sky daily and how it changes for each season. The other celestial bodies move in a similar way, so a firm understanding of the Sun's path will give a good basis for understanding the Moon, planets, and stars.

Moon(s)



The Moon is the only celestial body that can be seen both day and night. Its phases are easy to see and understand, and give us important clues to establishing the position of the ecliptic against the background of stars.

Planets

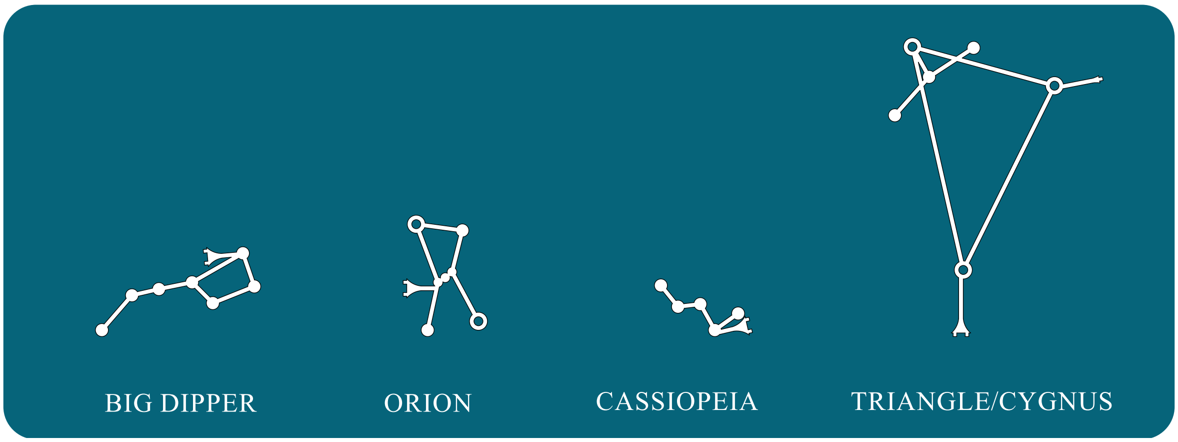


The planets each have their own unique characteristics. Use the Horizon Globe to understand where and when each planet appears.

The Horizon Globe comes equipped with 26 constellations, which include the entire zodiac and all of the first-order magnitude stars.

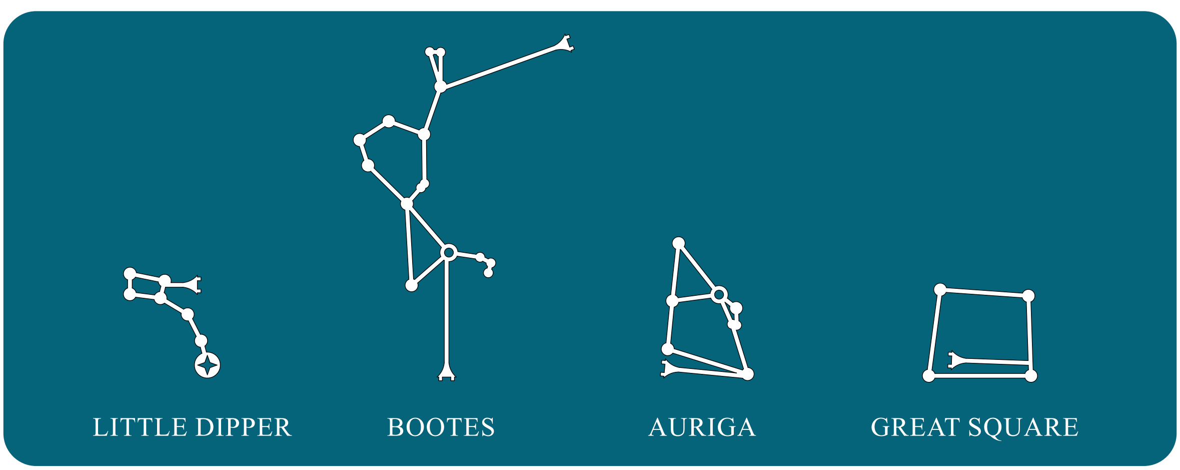
The constellations are shipped flat, and need to be hand-formed to match the radius of the sphere when they are first installed. Pictures are not to scale.

Guidepost Constellations



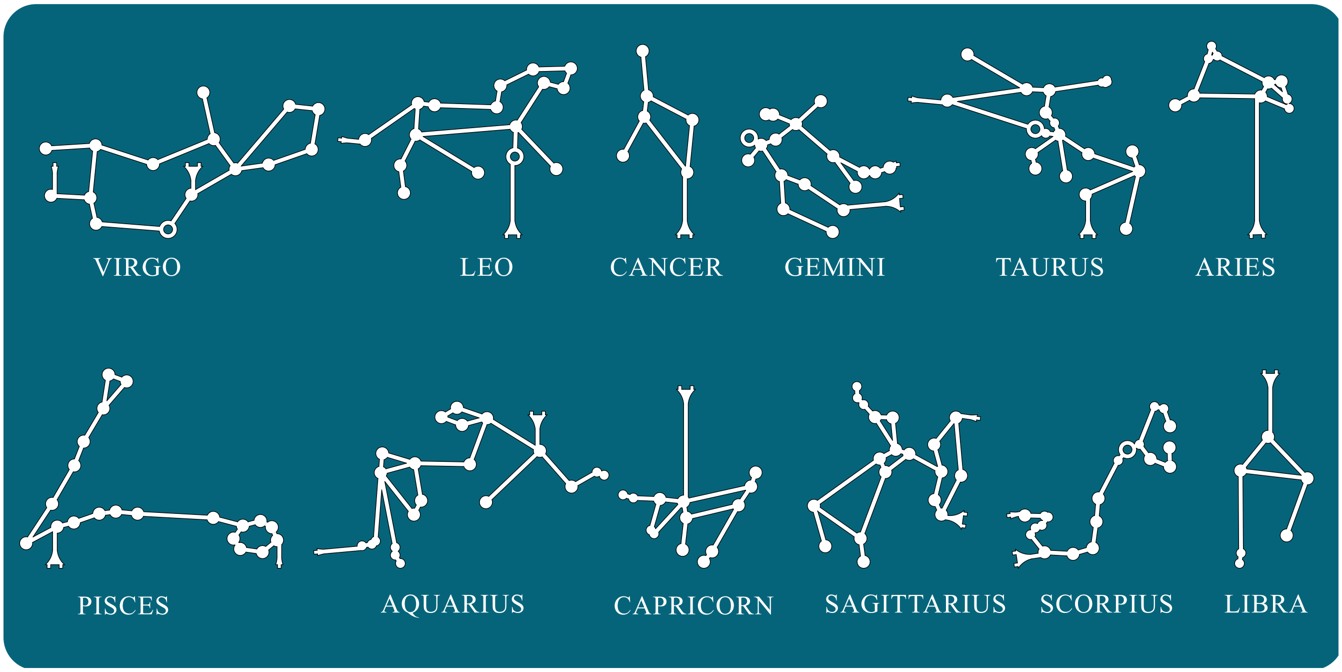
The Guidepost constellations are a special group that are easy to identify and occupy strategic positions in four quadrants of the sky. These four groups of stars can be used to help locate (in the sky) and position (on the globe) the rest of the constellations.

Northern Constellations



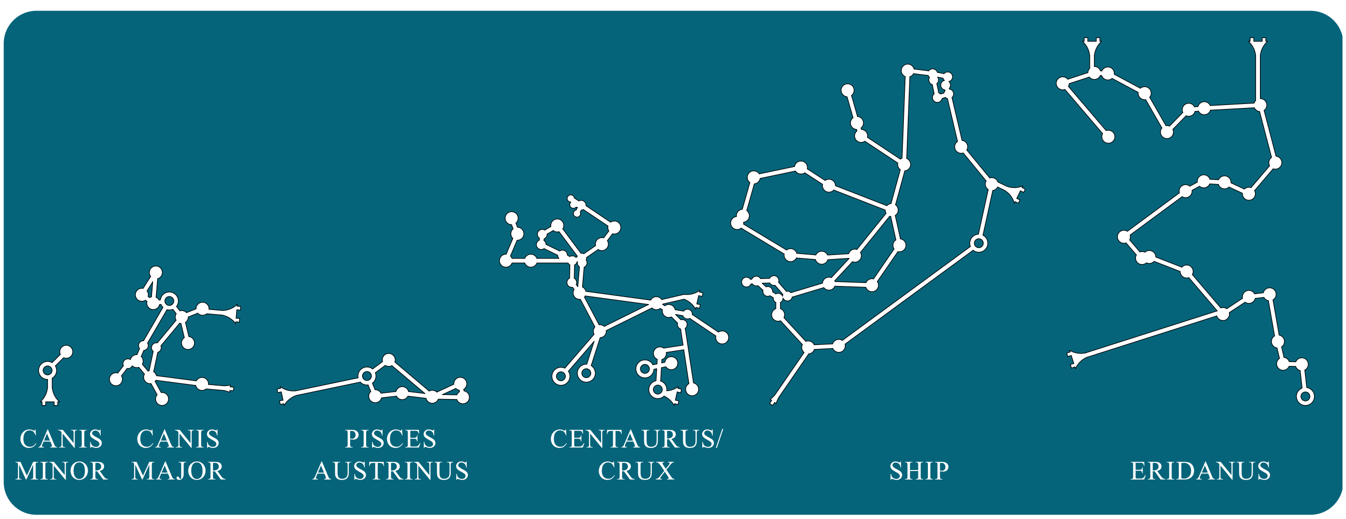
The Northern constellations are visible from our hemisphere. The Little Dipper is included because it contains Polaris. Bootes and Auriga each contain a first-magnitude star, Arcturus and Capella, respectively. The Great Square occupies an otherwise empty part of the sky, so is included for stargazing during that season.

Zodiac Constellations

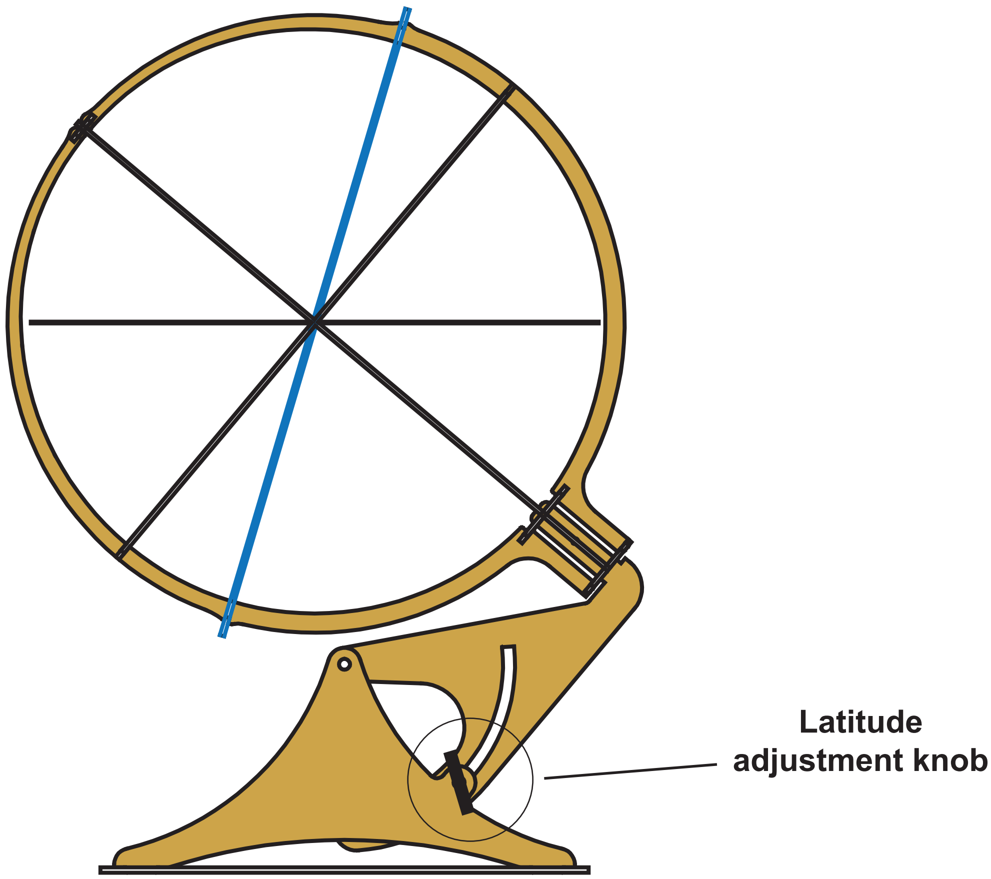


The Zodiac constellations are a special group of stars that lie along the ecliptic and have been used historically for soothsaying and horoscopes.

Southern Constellations



The Southern constellations are included because each of these southern-declination constellations contains at least one first-order magnitude star. From mid-northern latitudes, the Centaur and Cross, and the larger portions of the ship and river Eridanus are always below the horizon. They are included to complete the 21 first-magnitude stars, and to illustrate the phenomena of new stars appearing when you travel south.



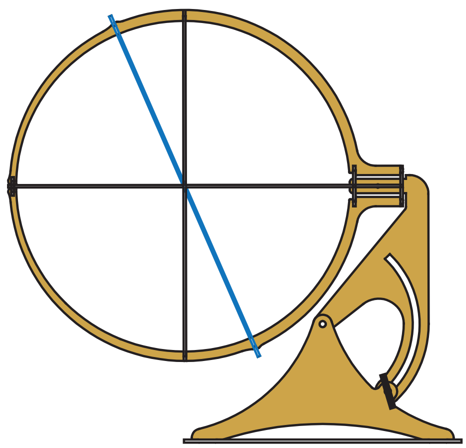
Latitude can easily be adjusted on the Horizon Globe by using the latitude adjustment knob (as shown above) on the sphere mount and pivoting the sphere to any position.

The Horizon Globe can be set to any latitude, from zero at the equator to +/- 90 degrees at the poles. See the diagrams at the top of the following page for illustration.

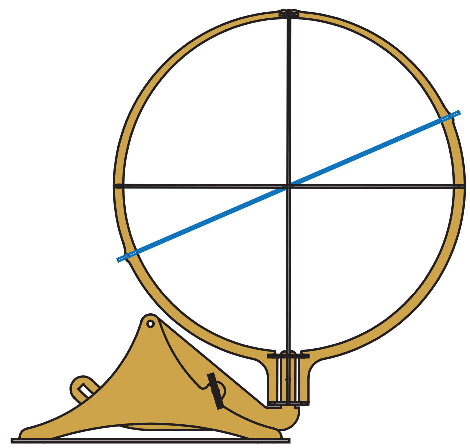
To adjust the latitude, begin by loosening the adjustment knob on the base. Then tilt the sphere to the desired position and retighten the knob.

Latitude is equal to the angle of the North Pole above the horizon, or equivalently, the zenith angle of the celestial equator. See the diagram at the bottom of the following page to see an example of the Horizon Globe set for 45^{0} latitude, about the location of Minneapolis, MN.

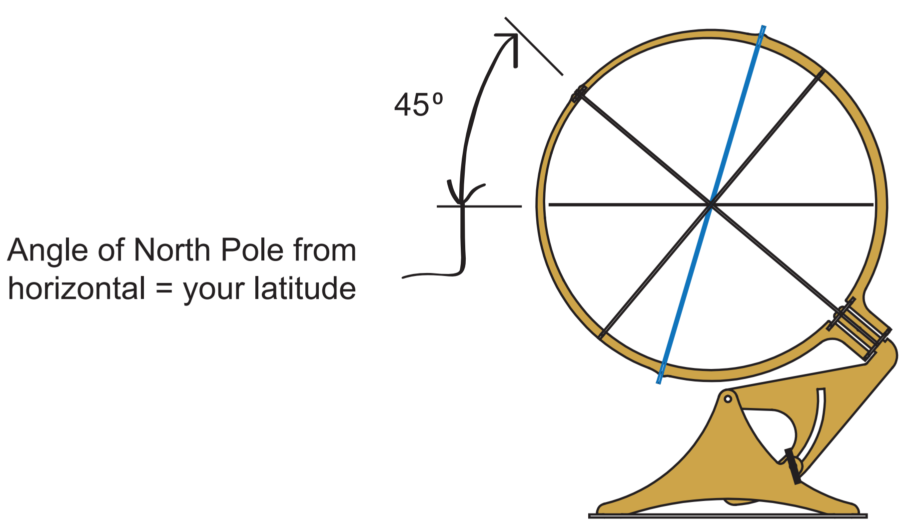
For qualitative studies the latitude can simply be estimated. For quantitative study, use a protractor to set latitude.



Equator
Latitude = 0 degrees



North Pole
Latitude = 90 degrees



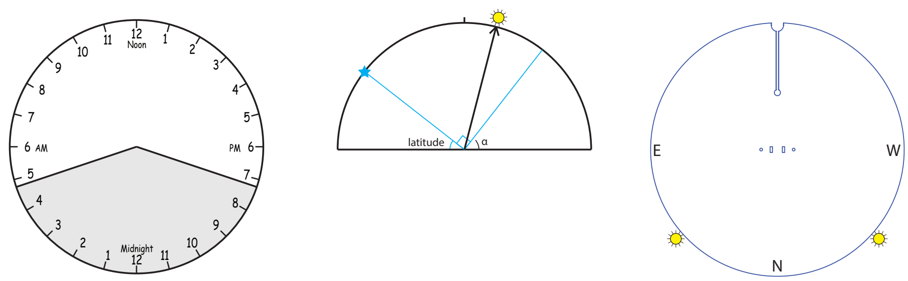
Minneapolis, MN
Latitude = 45 degrees

The celestial sphere makes one complete turn each day. As it turns, it carries all of the celestial objects along. Thus, the Sun, Moon, planets and stars all make about one revolution per day.

Turn the sphere clockwise from the perspective of The Observer Man (TOM) in the center of the Horizon plate facing south, as shown on the facing page. One complete revolution of the sphere simulates one day.

But it's not exact. The Sun slips back (counterclockwise) about 1^0 per day. Since we keep time by the Sun and not by the stars, the celestial sphere actually turns about 361 degrees each day.

As the Sun slips back each day, it defines a path around the celestial sphere called the ecliptic. The Horizon Globe has a fixed ring to represent the ecliptic. As the Sun slides back along this ring, which represents the changing location of the Sun through the seasons, notice three changes that occur:



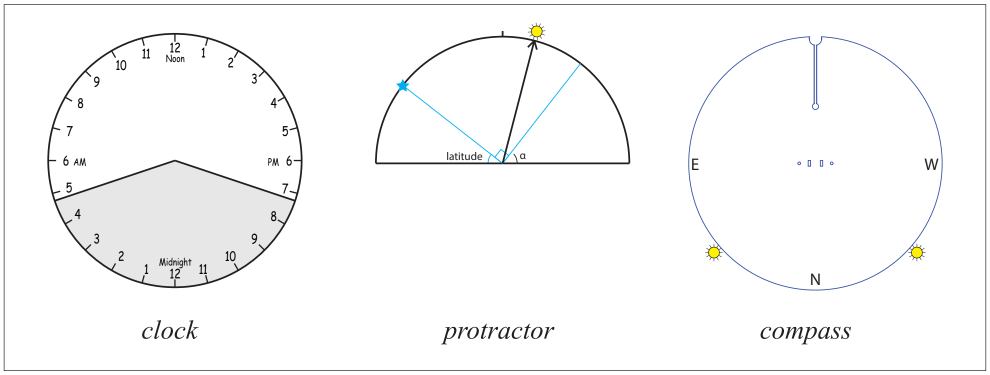
clock *protractor* *compass*

1. Length of day - as the Sun moves from high to low on the ecliptic (summer to winter), the days get shorter and the nights get longer. This is shown visually by the clock in the row of icons above.

2. Height of the noon Sun - as the Sun moves from high to low on the ecliptic (summer to winter), the noon Sun has less altitude. This is shown by the protractor.

3. Direction of sunrise and sunset - as the Sun moves from high to low on the ecliptic (summer to winter), the direction of sunrise and sunset move from northeast to southeast. This is shown on the compass above. The *azimuth* is the north-south direction.

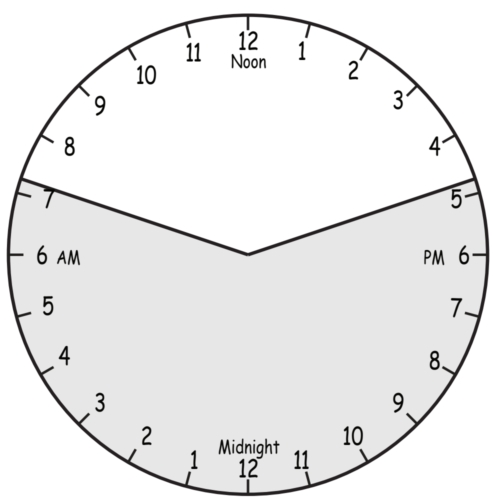
These icons are explained in further detail on Page 20.



Icons used to simplify setup

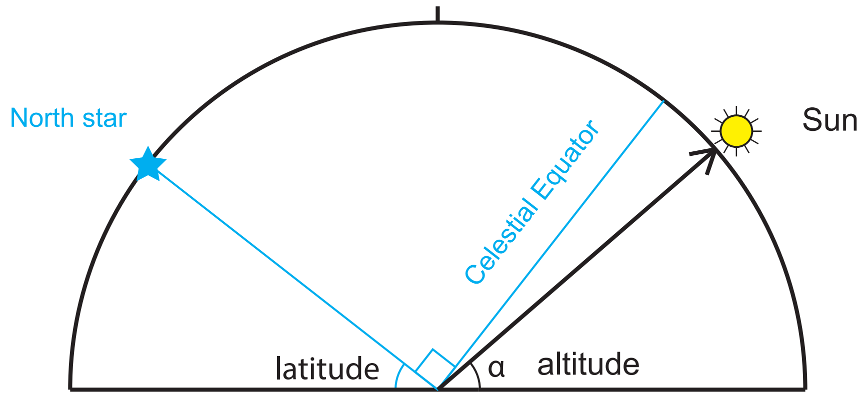
The Horizon Globe can be used to demonstrate a variety of phenomena. To simplify setting up the globe, there are three icons used throughout this manual: a **clock**, **protractor**, and **compass**, as shown above.

These three icons will help you model the celestial motion. Let’s take a closer look at each one individually.



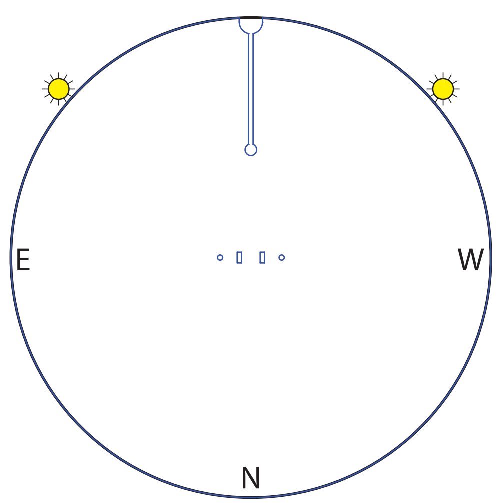
clock

Clock icon, shown above, indicates number of hours spent above and below the horizon. The white portion represents hours of daylight and the gray portion represents hours of night. For example, the clock above shows that the Sun rises at 7:15 am and sets at 4:45 pm, 9½ hours of daylight, 14½ hours of night.



protractor

Protractor icon, shown above, is used to show the maximum altitude reached by the Sun during the day. The north star and celestial equator correspond to the latitude being illustrated. The diagram above shows a latitude of 40^0 North, and indicates that the Sun's noon altitude is also about 40^0.



compass

Compass icon, shown above, indicates direction of sunrise and sunset. Notice that on our compass South is at the top. This is because TOM usually faces south, so the rising and setting positions are given relative to him. North is normally at his back.

It’s not always obvious how seasons are related to the position of the Sun. The Horizon Globe makes it easy.

Let’s look at the motion of the Sun, starting with summer.

With latitude adjusted to a middle northern latitude, e.g. 40^{0}, place the Sun on the highest, most northern part of the ecliptic ring. This represents the *summer solstice*, June 21.

Slowly turn the sphere clockwise (facing south) to simulate the apparent motion of the celestial sphere. Notice the path traced out by the Sun over the course of a day.

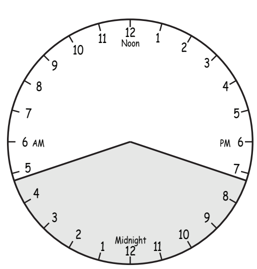
Important: please note that the daily path of the Sun is not along the ecliptic, but rather it is parallel to the celestial equator.

Summer Sun

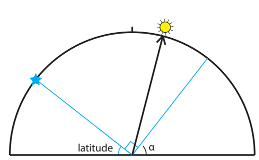
1. Length of day - the Sun is above the horizon for more than half of the rotation and below for less than half. This illustrates the longer days and shorter nights of summer.

2. Height of the noon Sun - the altitude of the noon Sun is high, but still a little to the south and never directly overhead.

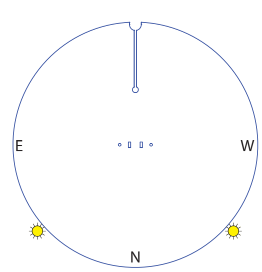
3. Direction of sunrise and sunset - the Sun rises in the northeast and sets in the northwest. The rising and setting points are symmetrical about the north-south axis.



long days



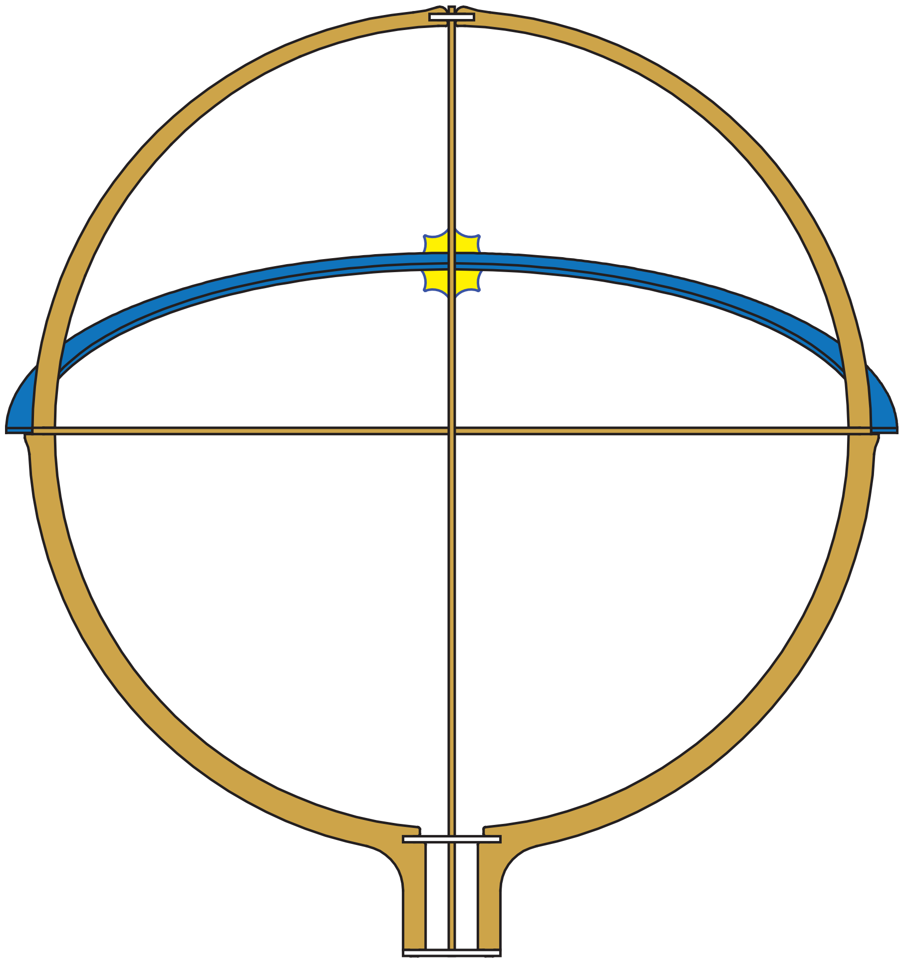
high altitude

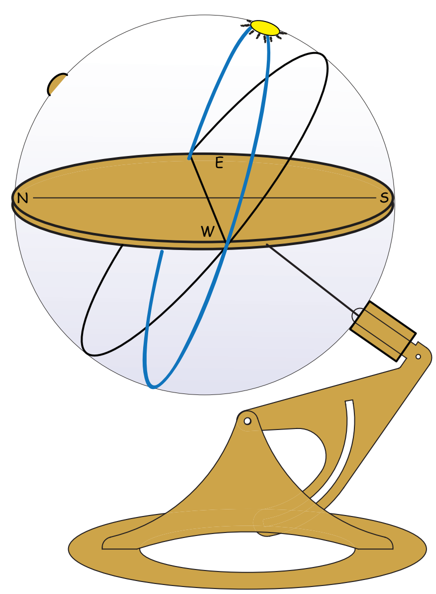


northerly azimuth

Seasons

Summer





Now change the season and see what happens in autumn.

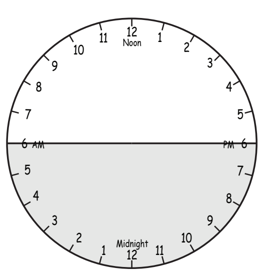
Slip the Sun back along the ecliptic (it moves east to west more slowly than the stars) until it reaches the point where the ecliptic crosses the equator from high to low. This is the *autumn equinox*, September 23.

Autumn Sun

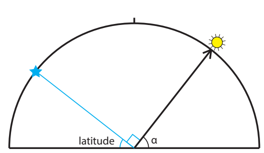
1. Length of day - the Sun is above the horizon for exactly half of the rotation and below for exactly half. This illustrates the equal days and nights of the equinox.

2. Height of the noon Sun - the altitude of the noon Sun is lower and more to the south than in summer.

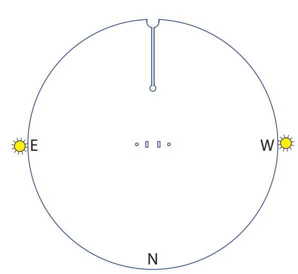
3. Direction of sunrise and sunset - the azimuth of the sunrise and sunset are exactly due east and west. Notice how the Sun rises due east and sets due west, but never travels directly overhead.



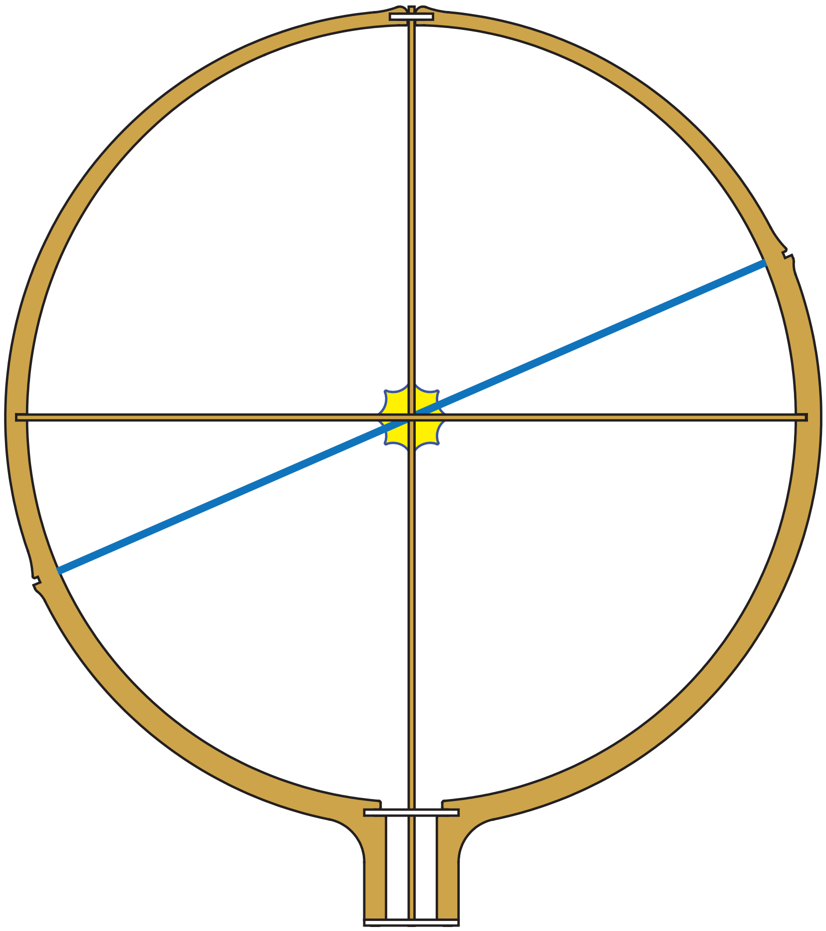
equal days & night

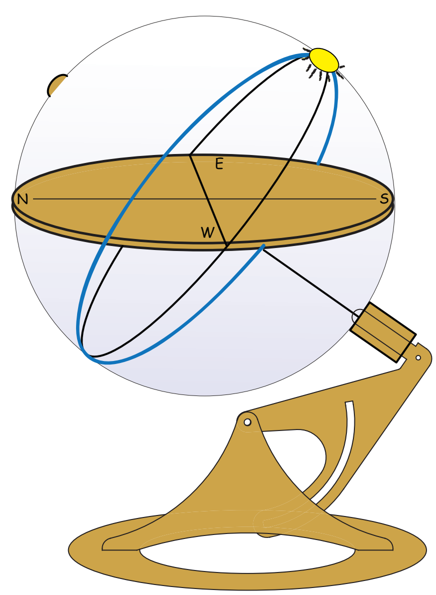


average altitude



east-west azimuth




E
N
S
W

Now let’s see what happens to the Sun in winter.

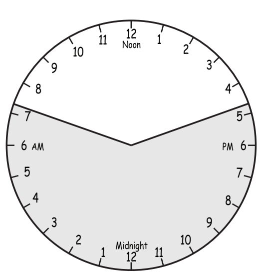
Slip the Sun back along the ecliptic again until it reaches its lowest point on the ecliptic. This is the *winter solstice*, December 21.

Winter Sun

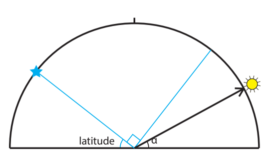
1. Length of day - the Sun spends more time below the horizon than above it. This illustrates the shorter days and longer nights of winter.

2. Height of the noon Sun - even at noon, the Sun never reaches a very high altitude.

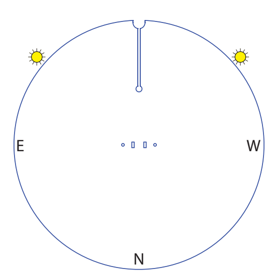
3. Direction of sunrise and sunset - during winter, the Sun always stays toward the south, rising southeast and setting southwest.



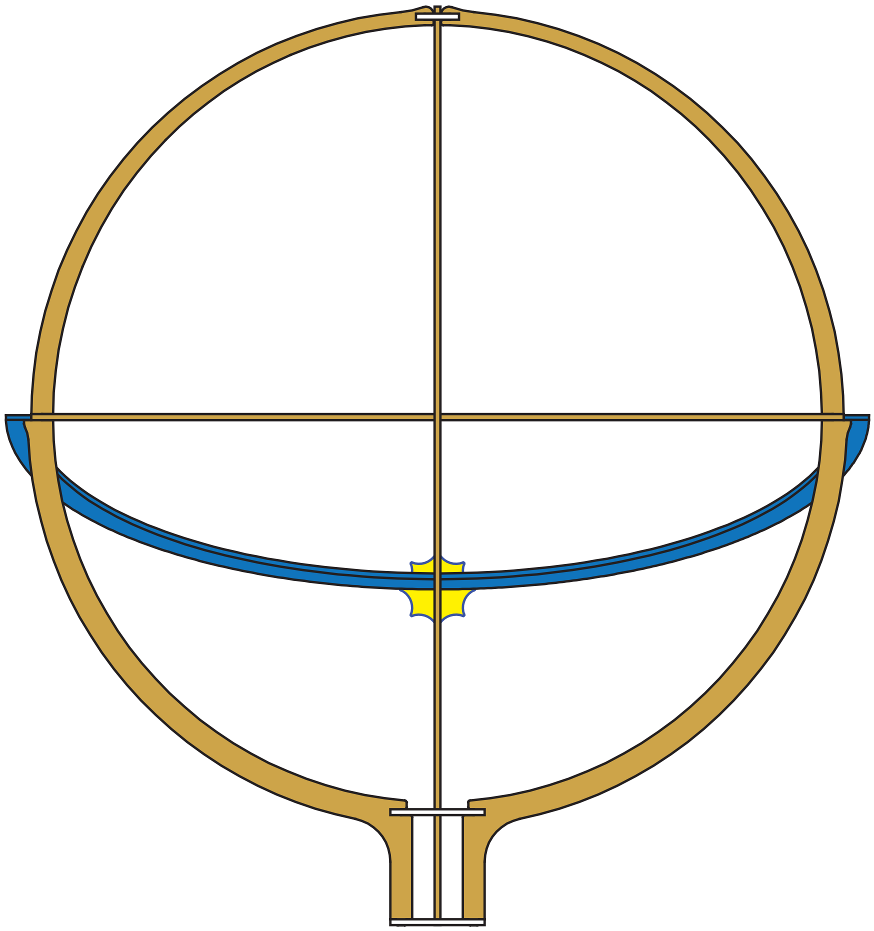
short days

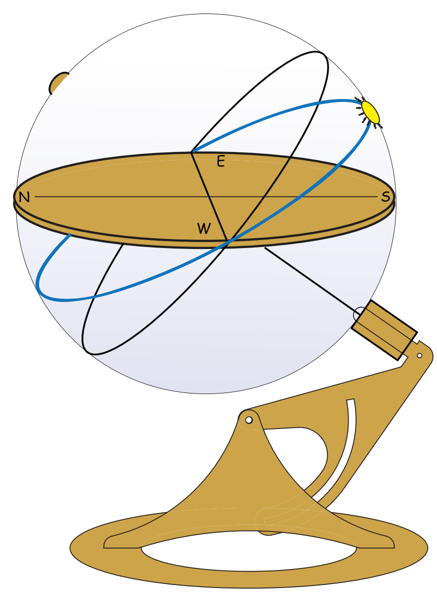


low altitude



southerly azimuth




E
N
S
W

Let's take a look at the Sun in the spring.

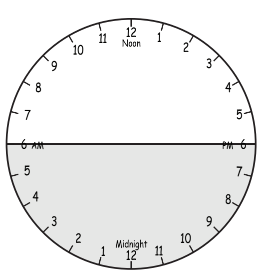
To model spring, slip the Sun back once more to the point where it crosses the celestial equator from low to high. This is the *vernal equinox*, around March 21.

Spring Sun

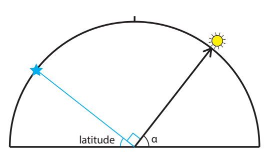
1. Length of day - the Sun takes the same path as it did on the autumnal equinox. Days and nights are again equal length.

2. Height of the noon Sun - the Sun's noon altitude is equal to the height of the celestial equator, its yearly average height.

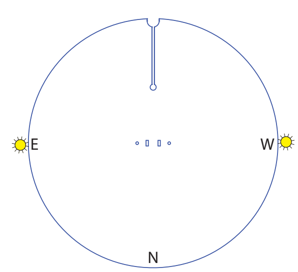
3. Direction of sunrise and sunset - the azimuth of the sunrise and sunset are exactly due east and west.



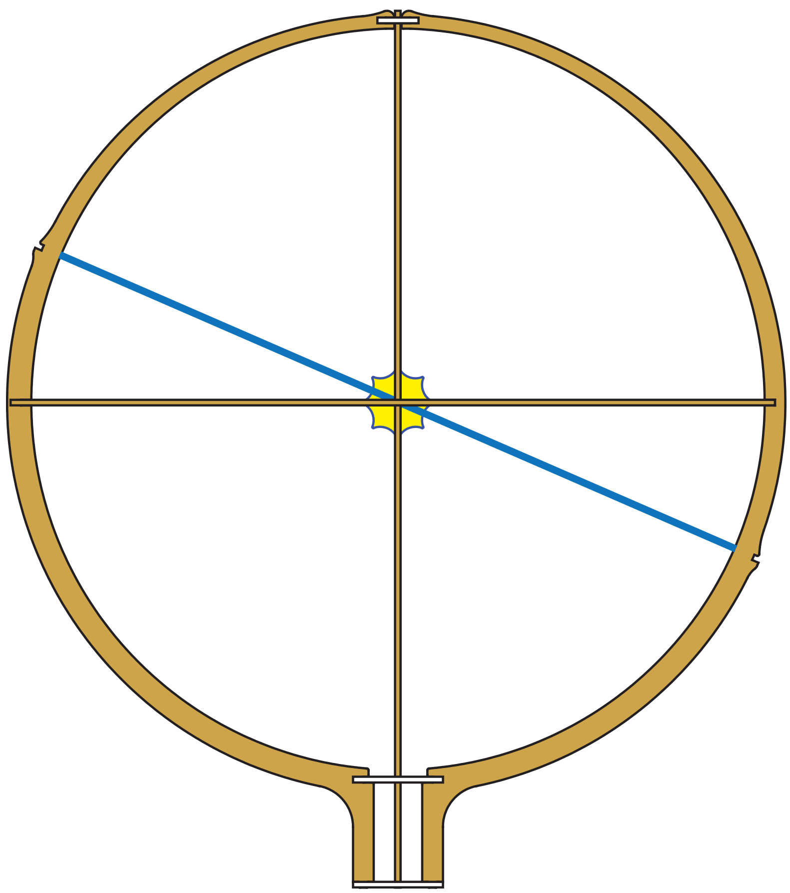
equal days & nights

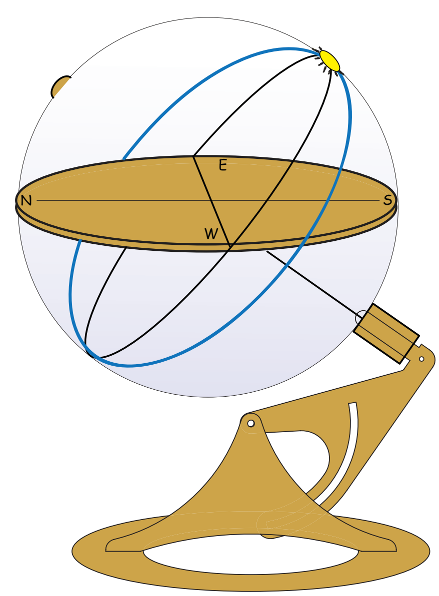


average altitude



east-west azimuth




E
N
S
W

The Horizon Globe can be adjusted to simulate the sky anywhere on Earth, including: the North and South Poles, the Equator, the Tropics, and the Arctic and Antarctic circles.

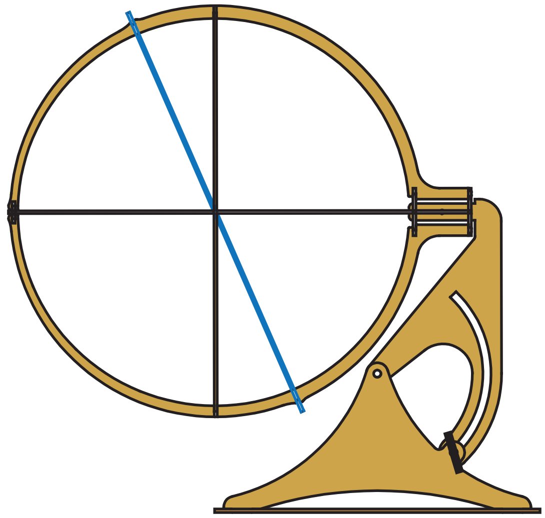
In the previous section about the seasons, we saw how the Sun looks from a middle northern latitude. In this section we will investigate other significant and more extreme latitudes.

Adjust the globe for different latitudes to see how our latitude affects how we see celestial objects. Refer to the illustrations on the following page. The ecliptic is colored blue. Also note:

> At the **equator**, latitude 0^{o}, the horizon plate is in line with the poles.
>
> For the **Tropic of Cancer**, latitude 23.5^{o}, the Sun is directly overhead at its maximum latitude.
>
> At the **Arctic Circle**, latitude 66.5^{o}, the ecliptic aligns with the horizon plate at one point in its revolution.
>
> At the **North Pole**, latitude 90^{o}, the horizon plate aligns with the celestial equator.

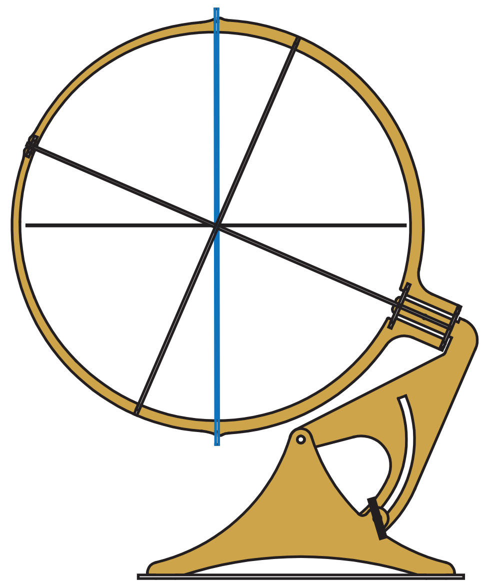
This section provides a way to practice and solidify the user's knowledge of how latitude affects what we see in the sky. These four examples are expanded and explained in the following pages.

Effects of Latitude



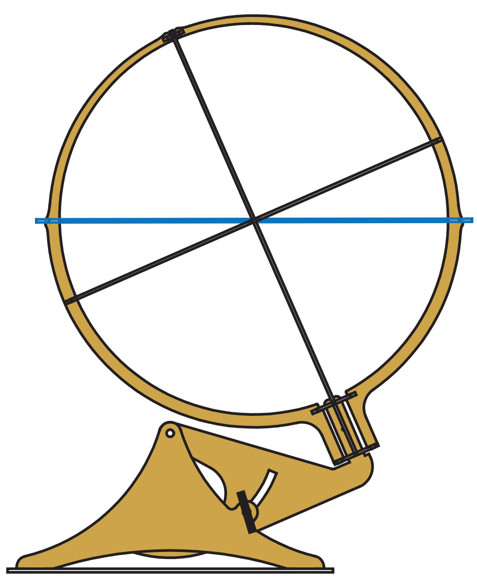
Equator

Latitude = 0 degrees



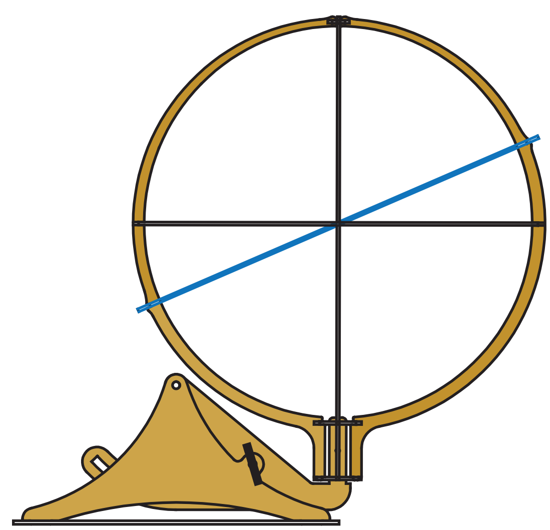
Tropic of Cancer

Latitude = 23.5 degrees



Arctic Circle

Latitude = 66.5 degrees



North Pole

Latitude = 90 degrees

First let's take a look at what happens at the equator, latitude = 0⁰, during the equinoxes and solstices.

Set the Horizon Globe to a latitude of zero, with the horizon plate in line with the poles.

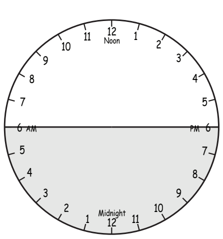
Here we will demonstrate the Sun's behavior from this vantage point during the spring and fall equinox (shown below), summer solstice and winter solstice (shown on the facing page). The three relevant things to notice are: length of day, height of the noon Sun, and direction of sunrise and sunset.

Spring and Fall Equinox

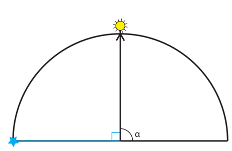
1. Length of day - days and nights are equal length.

2. Height of the noon Sun - the Sun's noon altitude is 90⁰, directly overhead.

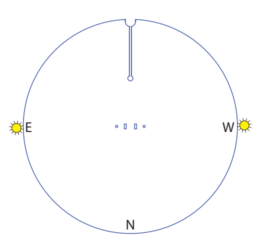
3. Direction of sunrise and sunset - the azimuth of the sunrise and sunset are exactly due east and west.



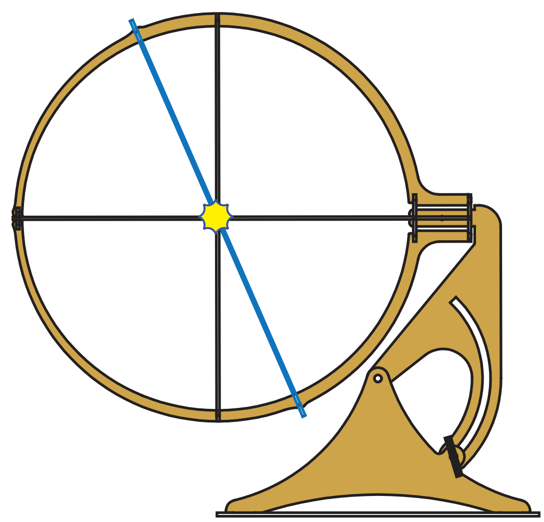
equal days & nights



noon Sun 90⁰



east-west azimuth



Latitude = 0⁰
Equator

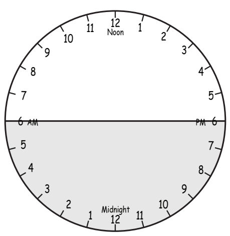
Latitude = 0^{0}
Equator

Summer Solstice

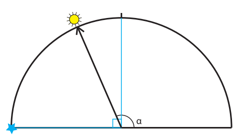
1. Length of day - days and nights are still equal length.

2. Height of the noon Sun - the Sun's noon altitude is 23.5^{0} to the north of the zenith.

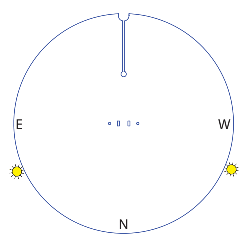
3. Direction of sunrise and sunset - the azimuth of the sunrise and sunset are to the north.



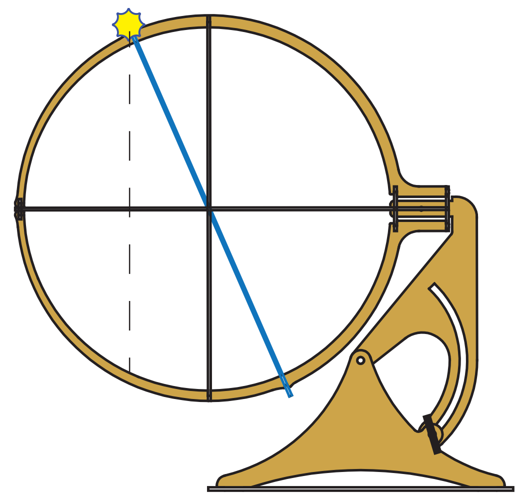
equal days & nights



noon Sun
to the north



northerly azimuth



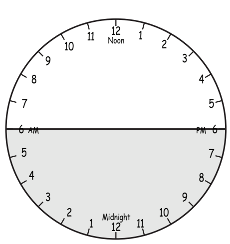
Latitude = 0^{0}
Equator

Winter Solstice

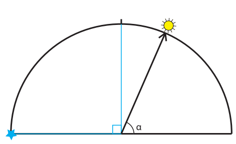
1. Length of day - days and nights remain equal length.

2. Height of the noon Sun - the Sun's noon altitude is 23.5^{0} to the south of the zenith.

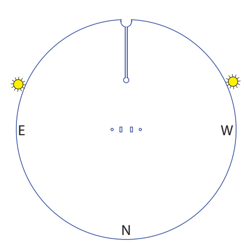
3. Direction of sunrise and sunset - the azimuth of the sunrise and sunset are to the south.



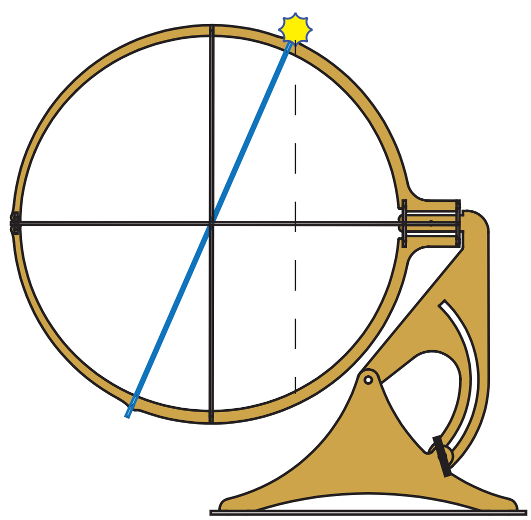
equal days & nights



noon Sun
to the south



southerly azimuth



Latitude = 0^{0}
Equator

Set the Horizon Globe to a latitude of 23.5^0, i.e. the Tropic of Cancer. Demonstrate the Sun's behavior from this vantage point during the spring and fall equinox, and summer and winter solstice.

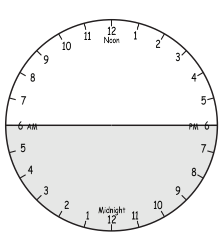
After constellations are placed, notice that the Sun is near the zodiac constellation Cancer at the summer solstice, i.e. when the Sun reaches its most northerly point on the ecliptic. The fact that the Sun is not exactly in Cancer at this time is explained by the amount of precession of the equinoxes that has occurred since ancient times.

Spring and Fall Equinox

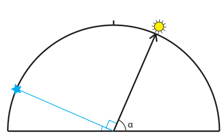
1. Length of day - days and nights are equal length.

2. Height of the noon Sun - the Sun's noon altitude is to the south.

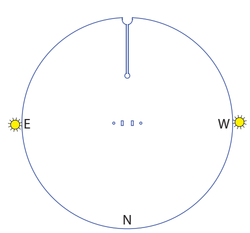
3. Direction of sunrise and sunset - the azimuth of the sunrise and sunset are exactly due east and west.



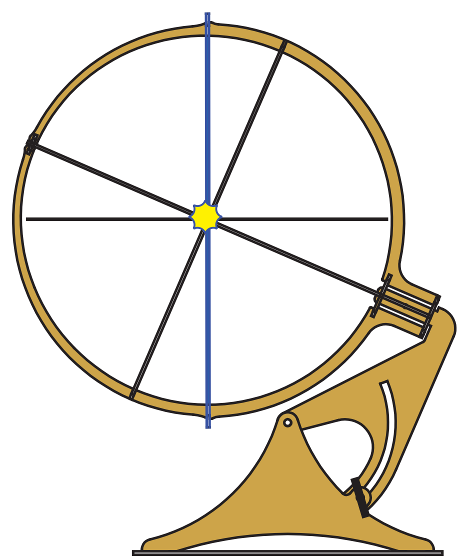
equal days & nights



noon Sun
to the south



southerly azimuth



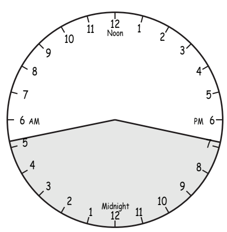
Latitude = 23.5^0
Tropic of Cancer

Summer Solstice

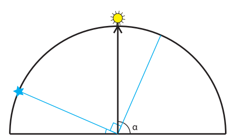
1. Length of day - days are longer than the nights.

2. Height of the noon Sun - the Sun's noon altitude is 90^0, straight up.

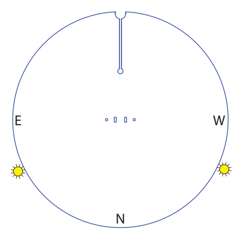
3. Direction of sunrise and sunset - the azimuth of the sunrise and sunset are to the north.



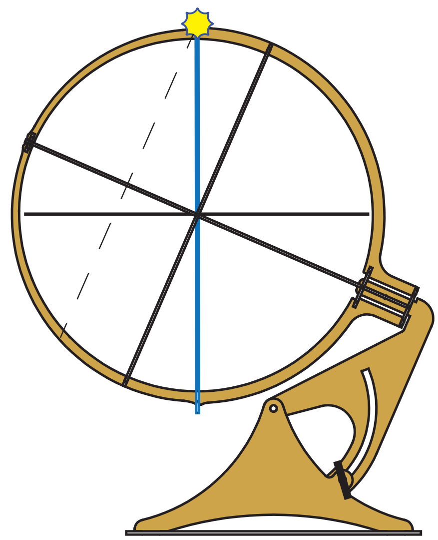
longer days



noon Sun straight up



northerly azimuth

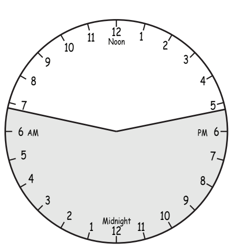

Latitude = 23.5^0
Tropic of Cancer

Winter Solstice

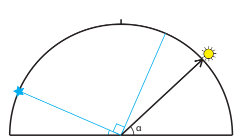
1. Length of day - days are shorter.

2. Height of the noon Sun - the altitude of the noon Sun is noticeably lower.

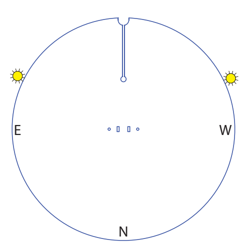
3. Direction of sunrise and sunset - the azimuth of the sunrise and sunset are to the south.



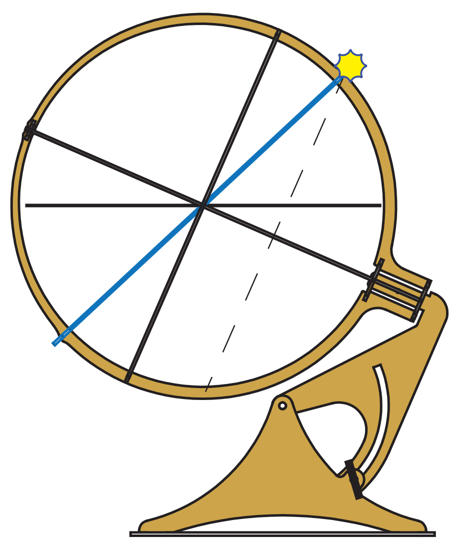
shorter days



noon Sun lower



southerly azimuth


Latitude = 23.5^0
Tropic of Cancer

Set the Horizon Globe to a latitude of 66.5⁰, i.e. the Arctic Circle. Notice that this is the place where the lowest point of the winter Sun is even with the horizon plate.

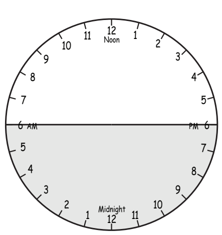
Demonstrate the Sun's behavior from this vantage point during the spring equinox, fall equinox, summer solstice, and winter solstice.

Spring and Fall Equinox

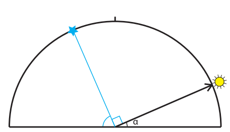
1. Length of day - days and nights are equal length.

2. Height of the noon Sun - the Sun's noon altitude is 23.5⁰, and to the south.

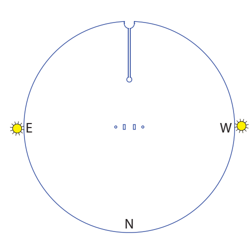
3. Direction of sunrise and sunset - the azimuth of the sunrise and sunset are exactly due east and west.



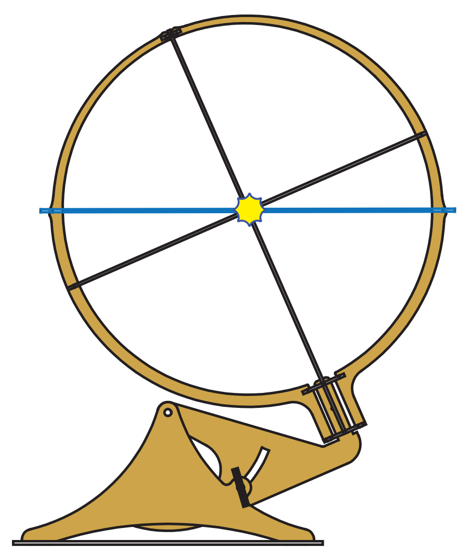
equal days & nights



noon Sun
to the south



east-west azimuth



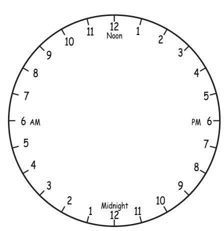
Latitude = 66.5⁰
Arctic Circle

Summer Solstice

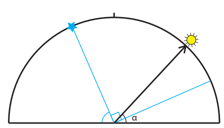
1. Length of day - days are 24 hours long, land of the midnight Sun.

2. Height of the noon Sun - the Sun's noon altitude is 47⁰.

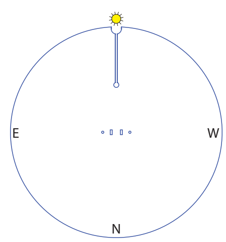
3. Direction of sunrise and sunset - the Sun circles the entire sky and never sets.



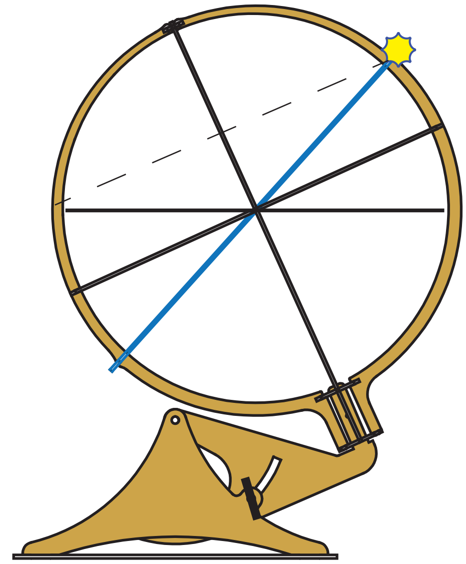
24-hour day



noon Sun 47⁰



no sunset



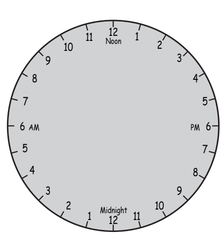
Latitude = 66.5⁰
Arctic Circle

Winter Solstice

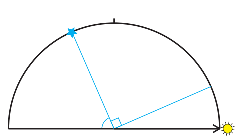
1. Length of day - no daylight, 24 hours of night.

2. Height of the noon Sun - the Sun stays below the horizon.

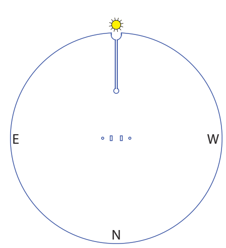
3. Direction of sunrise and sunset - the Sun does not rise.



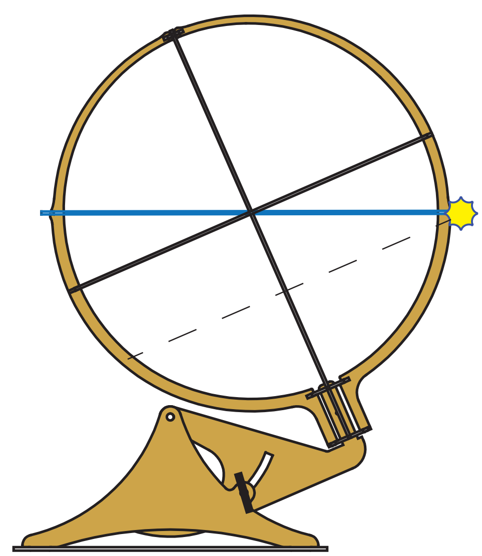
24-hour night



no Sun



no sunrise



Latitude = 66.5⁰
Arctic Circle

Set the Horizon Globe to a latitude of 90^0, i.e. the North Pole.

Sky watching from the North or South pole must be a strange experience indeed. Day and night here are determined not by the apparent rotation of the celestial sphere, but by the seasonal motion of the Sun.

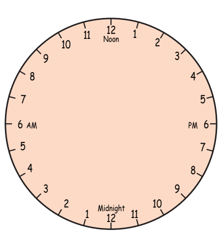
Only half the stars are ever seen. The Moon makes a low arc on the horizon every two weeks, its phase telegraphing the location of the Sun during the long polar nights.

Spring and Fall Equinox

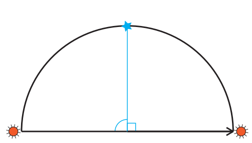
1. Length of day - the Sun is half above and half below the horizon, making 24 hours of twilight.

2. Height of the noon Sun - the Sun's altitude doesn't change with the hours, but rather with the days.

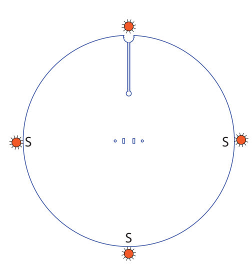
3. Direction of sunrise and sunset - the Sun makes a complete circle around the horizon.



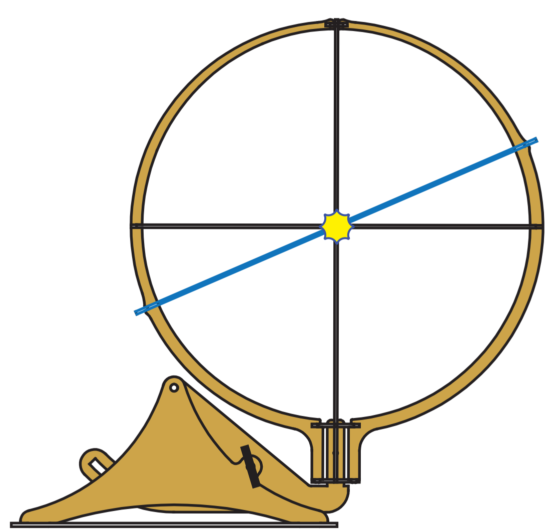
24-hour twilight



Sun half-visible



360^0 azimuth



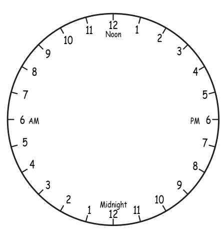
Latitude = 90^0
North Pole

Summer Solstice

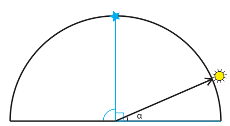
1. Length of day - days are 6 months long.

2. Height of the noon Sun - the Sun's altitude is 23.5^0, 24 hours a day.

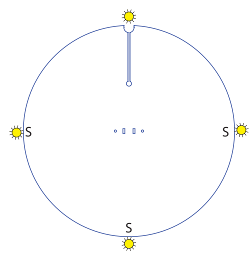
3. Direction of sunrise and sunset - the Sun circles the entire sky and never sets.



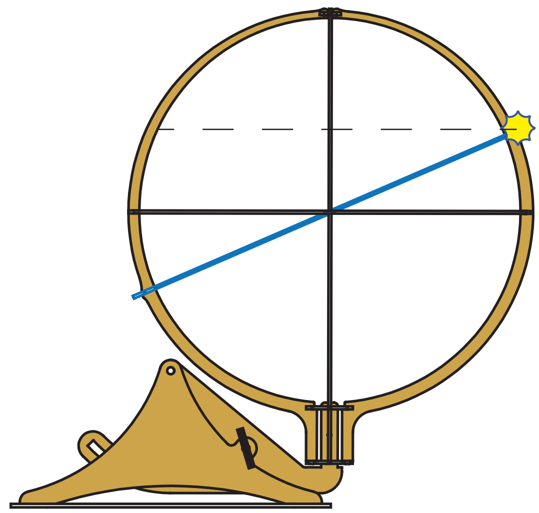
6-month days



noon Sun 47^0



no sunset



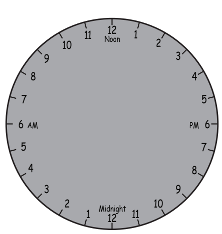
Latitude = 90^0
North Pole

Winter Solstice

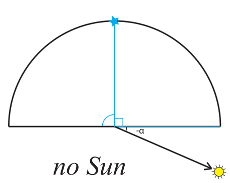
1. Length of day - nights are 6 months long.

2. Height of the noon Sun - the Sun stays below the horizon.

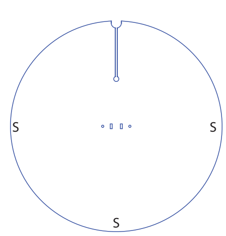
3. Direction of sunrise and sunset - the Sun does not rise.



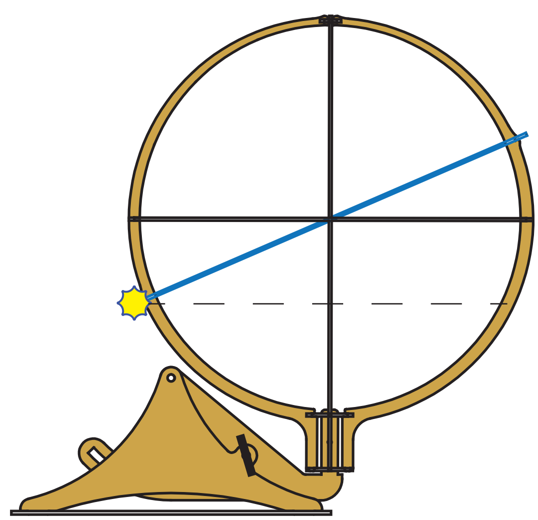
6-month night



no Sun



no sunrise



Latitude = 90^0
North Pole

Overview

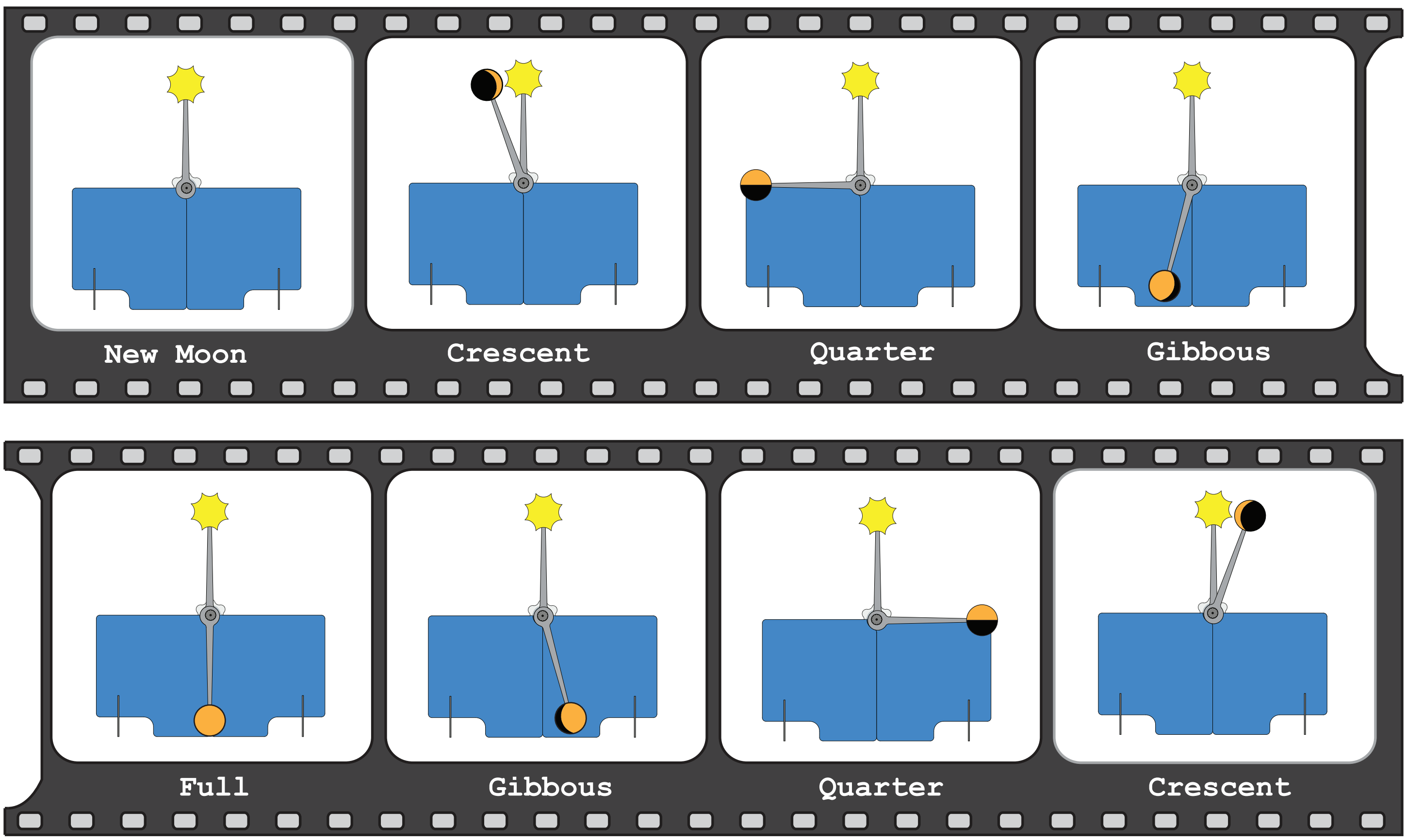
Just as the Sun slips behind the stars by a degree per day, the Moon slips behind the Sun by 12^o per day (50 minutes). In about 30 days the Sun catches back up to the Moon:

$$12^o \times 30 \text{ days} = 360^o$$

As the Moon falls behind the Sun, its angle with the Sun changes. The Moon's phase is determined by its angle with the Sun. A new Moon is in the same direction as the Sun, so its angle with the Sun is zero. A 90^o Sun-Moon angle yields a quarter Moon, and a 180^o angle gives us a full Moon.

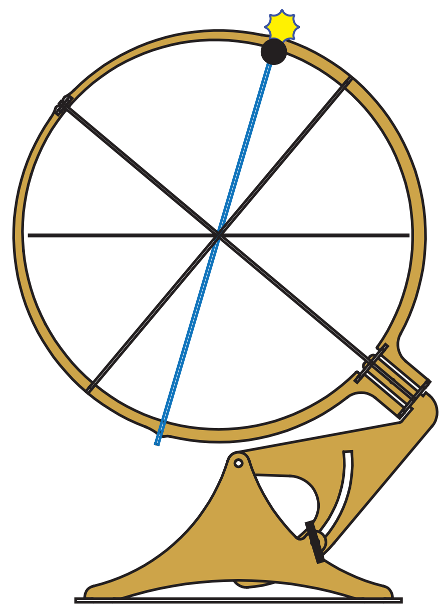
The illustrations on the following page show the Sun Puppet, a demonstration device, depicting the relationship between the Moon and Sun for Moon phases beginning with the new Moon. The phase of the Moon is directly related to the Sun-Moon angle.

As the Moon falls behind the Sun, it follows the ecliptic. An implication of this fact is that the Moon traces out the entire yearly path of the Sun each month. On the following pages we will model the Moon phases on the Horizon Globe to show this phenomenon.


New Moon
Crescent
Quarter
Gibbous
Full
Gibbous
Quarter
Crescent

Moon Phases

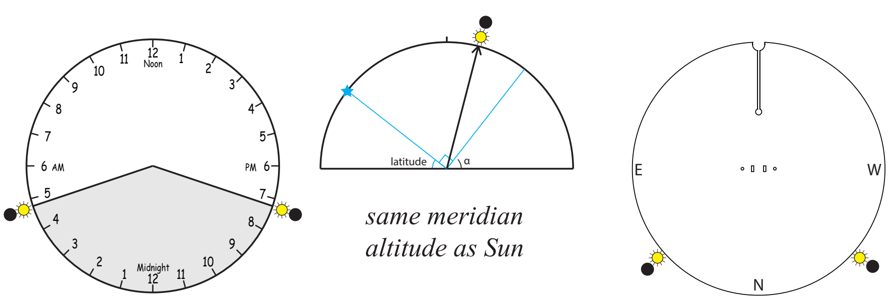
New Moon



To illustrate, begin with the Sun in the summer solstice position and the Moon on top of the Sun, in the new Moon position.

Notice that the Moon is the same as the Sun on all three of our metrics: it is above the horizon the same amount of time, it reaches the same meridian altitude, and it rises and sets at the same azimuth as the Sun.

Summer new Moon follows the Sun



above horizon same as Sun

same meridian altitude as Sun

azimuth same as Sun

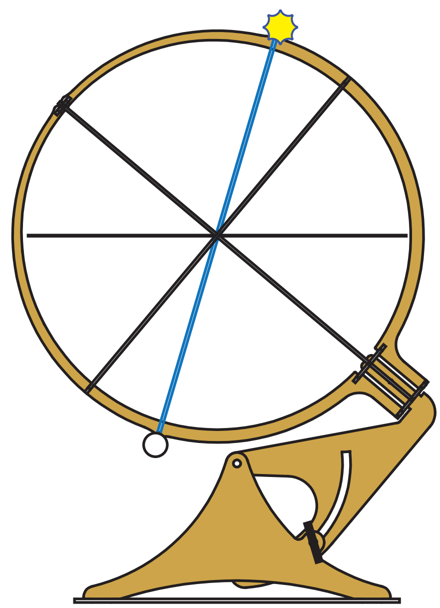
Full Moon

After two weeks, the Moon has grown from new to full. The Sun is still near the summer solstice point of the ecliptic.

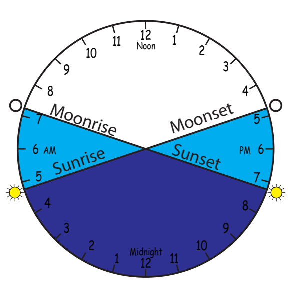
Now the Moon follows the path that the Sun follows in winter. While the Sun is still above the horizon for the majority of the 24-hour day, the full Moon is only visible during the relatively short night.

The Moon only reaches the Sun's winter maximum altitude.

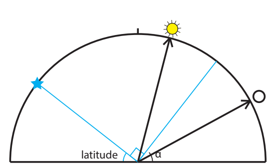
The Moon rises and sets toward the south, just as the Sun does in winter.



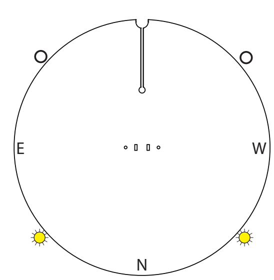
Summer full Moon acts like winter Sun



rises and sets the times of winter Sun

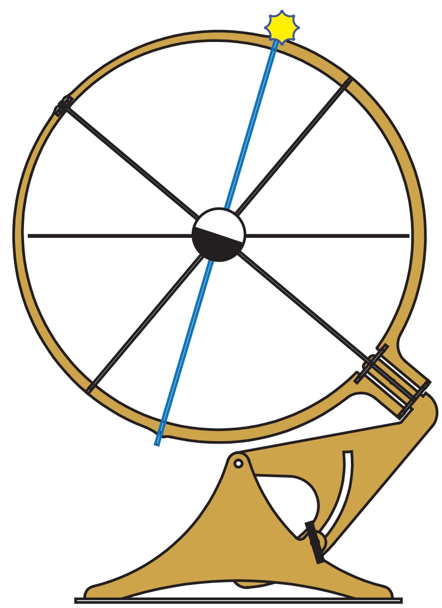


reaches winter Sun's maximum altitude



rises and sets in the same direction as winter Sun

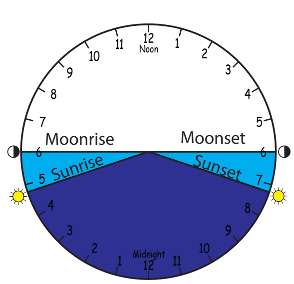
Quarter Moon



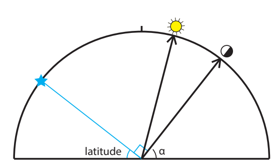
Another week later (three weeks past the new Moon) the Moon reaches a waning quarter phase. The Sun is still near the summer solstice point of the ecliptic, but the Moon has moved to the spring equinox position.

At this point the Moon behaves as the Sun would on the spring equinox: it is above the horizon for 12 hours, it attains a meridian altitude of the celestial equator, and it rises and sets due east and west, respectively.

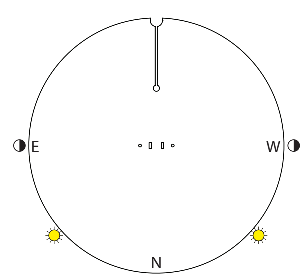
Summer quarter Moon acts like equinoctial Sun



rises and sets the times of equinoctial Sun



reaches equinoctial Sun's maximum altitude



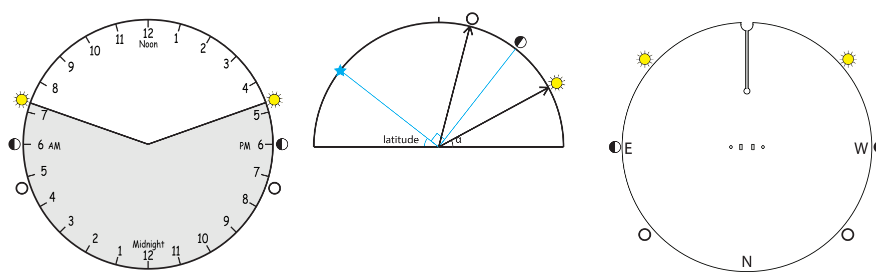
rises and sets in same direction as equinoctial Sun

The same pattern continues through all the seasons. When the Moon is near the Sun forming a crescent phase, it is above the horizon for about the same amount of time as the Sun, it rises and sets near the Sun, and it reaches almost the same maximum altitude.

The waxing quarter Moon predicts the next season for the Sun. A full Moon always follows the rules for the season opposite the Sun. A waning quarter Moon shows where the Sun was one season ago.

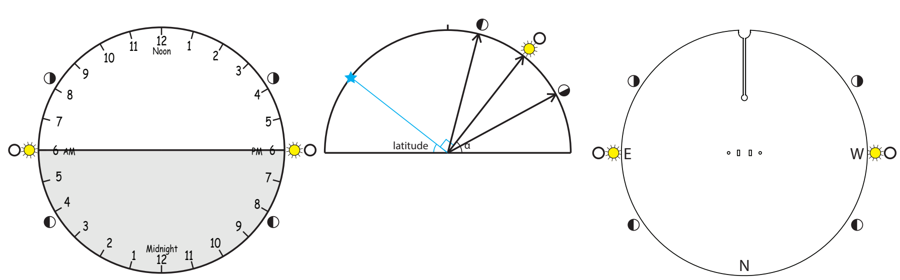
In winter, when the Sun spends less time above the horizon, the full Moon spends more. The full Moon travels high across the sky, and it rises and sets to the north. The quarter Moons are on the equinox part of the ecliptic, and so follow the spring or fall pattern of the Sun, as shown below.

Winter full and quarter Moons



At the equinoxes, the quarter Moons show the extreme limits of the ecliptic. In spring the waxing quarter Moon marks the high point of the ecliptic and the waning quarter Moon marks the low. The full Moon follows the Sun's patterns. This is illustrated below.

Spring and Fall full and quarter Moons

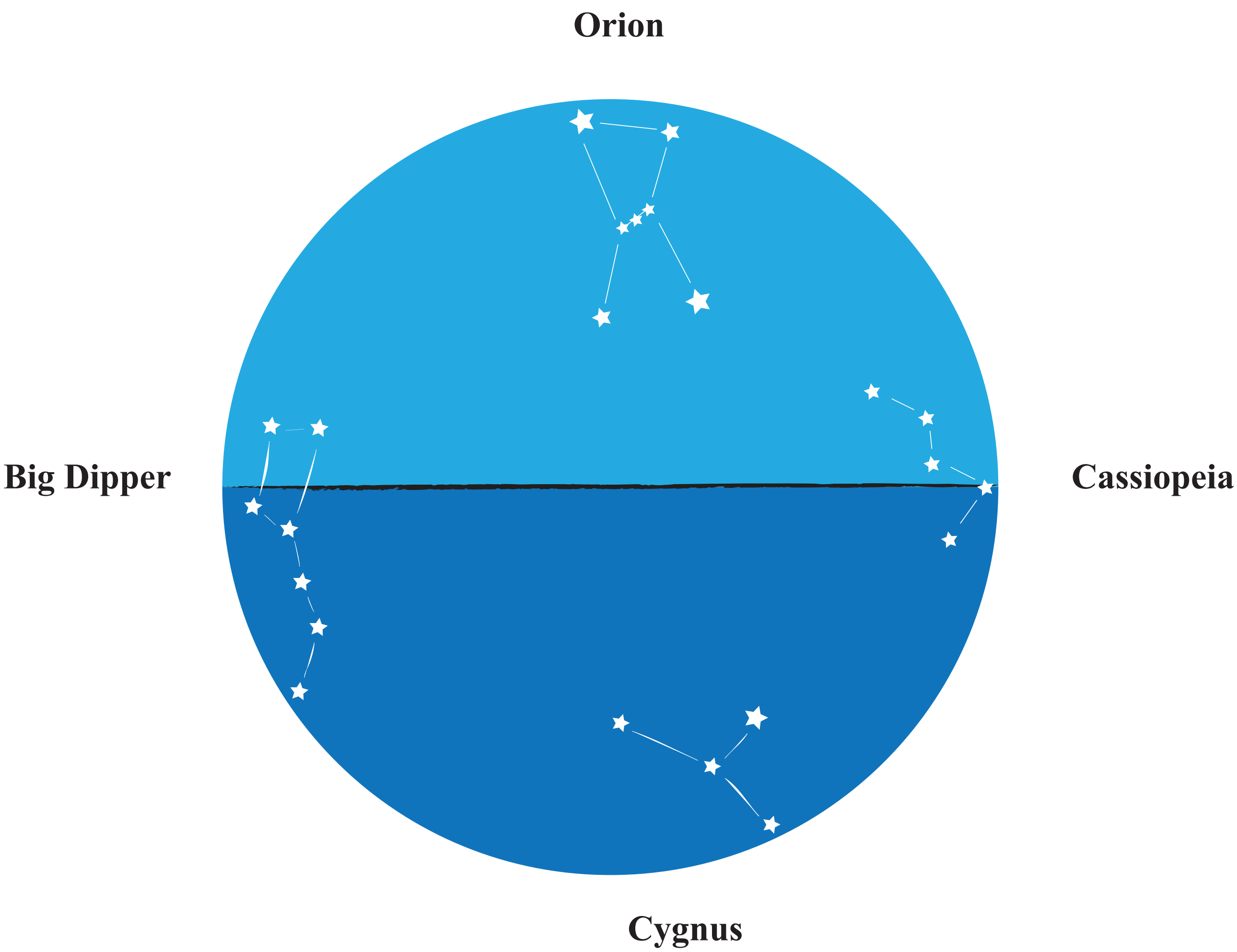


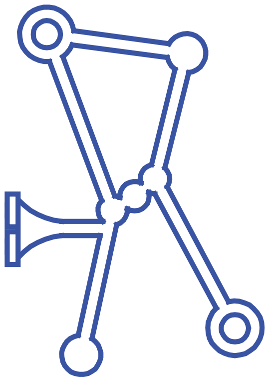
Guidepost Constellations

The guidepost constellations are special groups of stars that are easy to identify and occupy strategic positions in four quadrants of the sky. We use these guideposts to orient ourselves and provide a framework for remembering the surrounding constellations.

The four guidepost constellations that anchor quadrants of the sky are shown in the diagram on the facing page. They are Orion, the Big Dipper, the Summer Triangle (featuring Cygnus), and Cassiopeia.

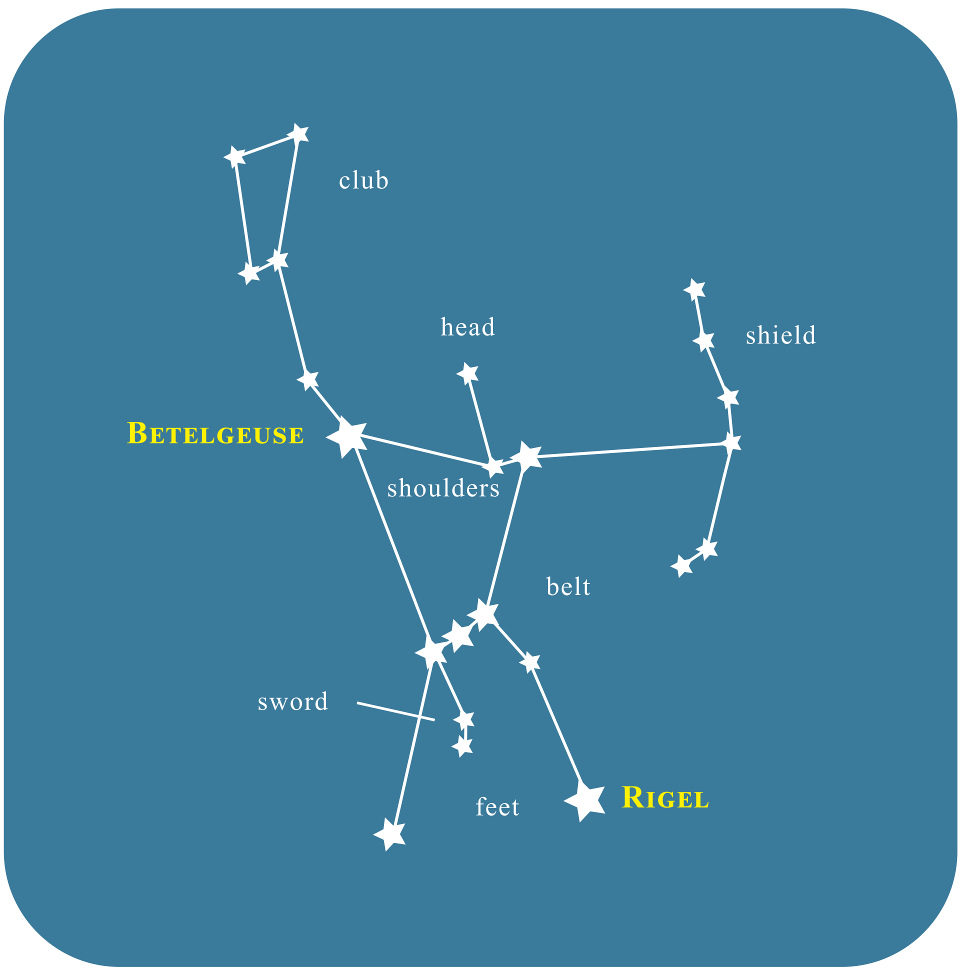
We will begin placing constellations with these four, then place the rest of the constellations with respect to these. Let's start with Orion, Guidepost #1, on the following pages.


Orion
Big Dipper
Cassiopeia
Cygnus

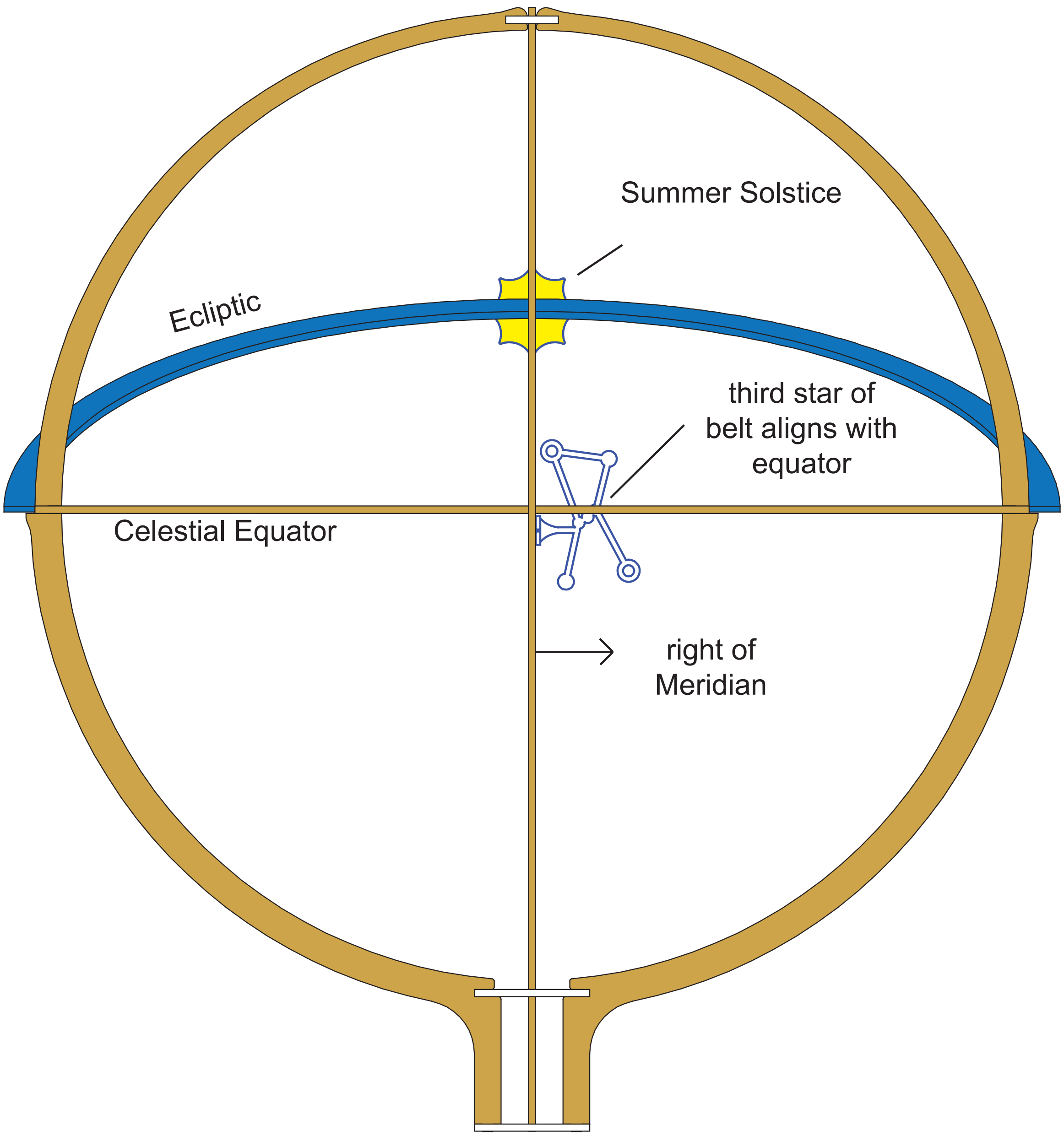


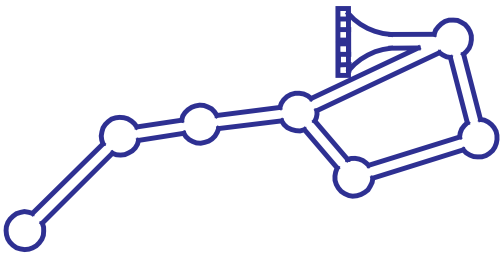
The first guidepost is Orion.

To place Orion, locate the point of the summer solstice, the highest, or most northern, part of the ecliptic. Position Orion so that the third star of his belt is on the equator. As the sphere turns, the bright star in Orion's right foot, Rigel, leads the way and the bright star in his shoulder, Betelgeuse, trails.



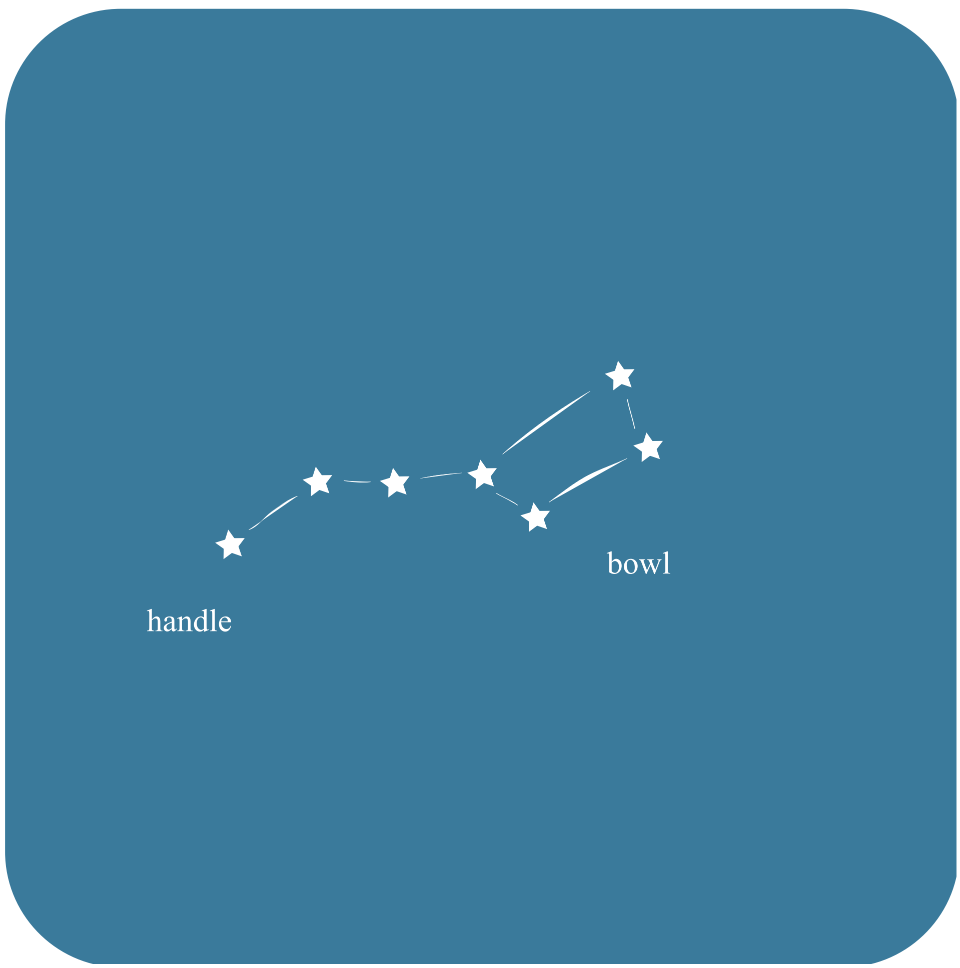
Guidepost #1
Orion



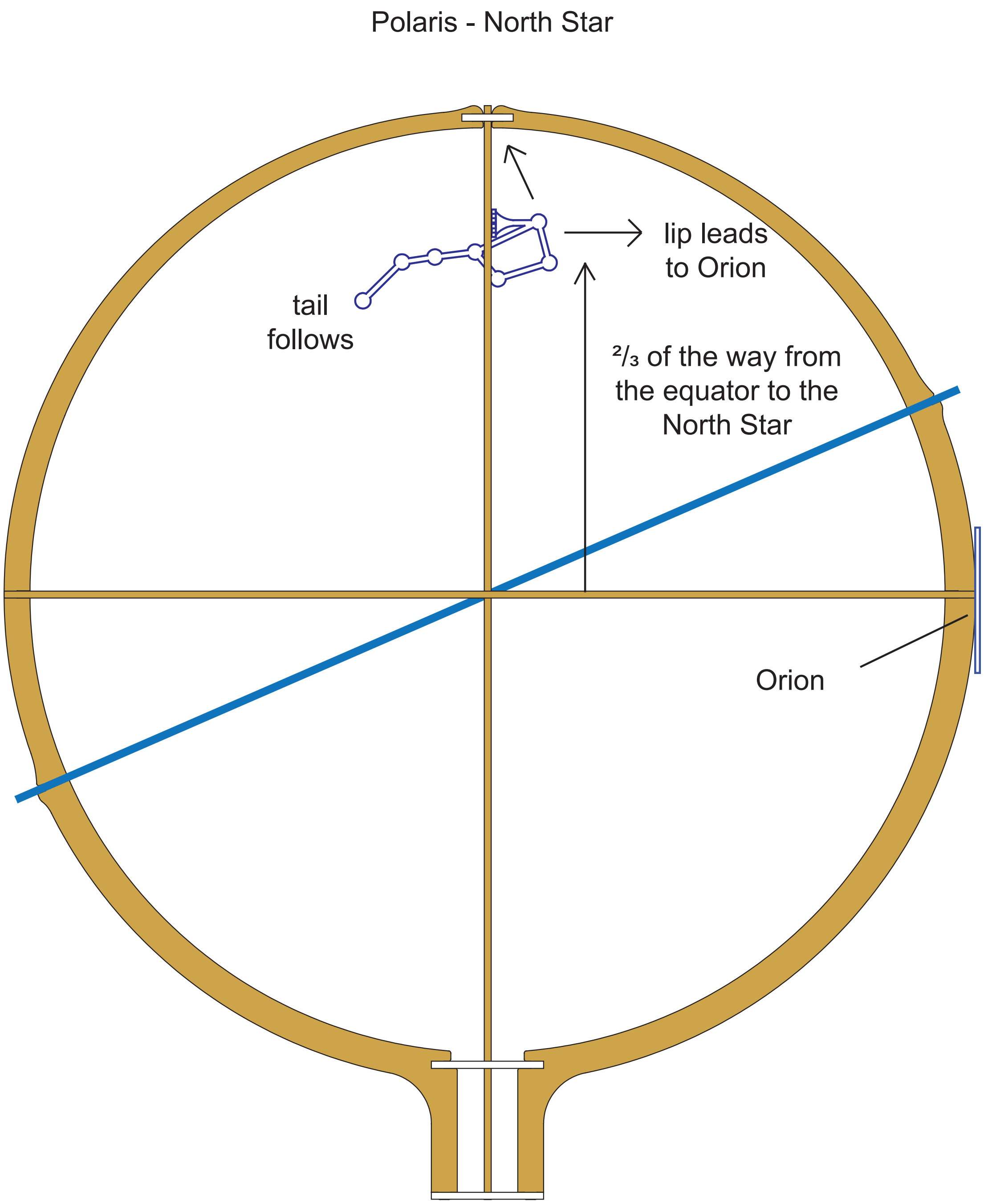


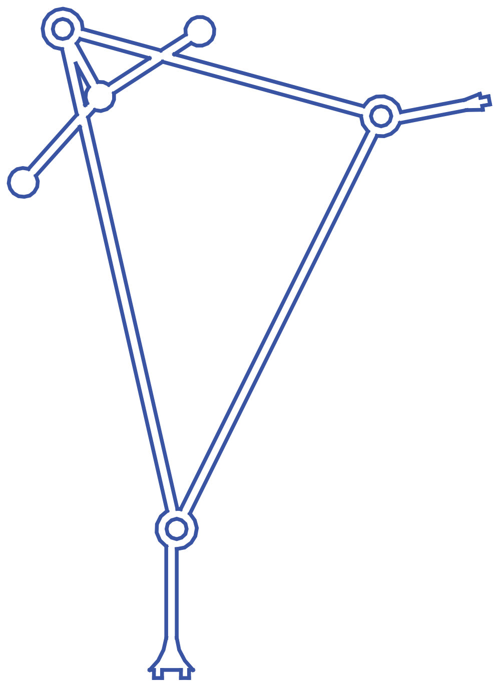
The second guidepost is the Big Dipper.

To place the Big Dipper, after placing Orion, rotate the globe ¼ turn clockwise from south-facing TOM's perspective. The Dipper is upright, with the lip leading and the handle following.



Guidepost #2
Big Dipper

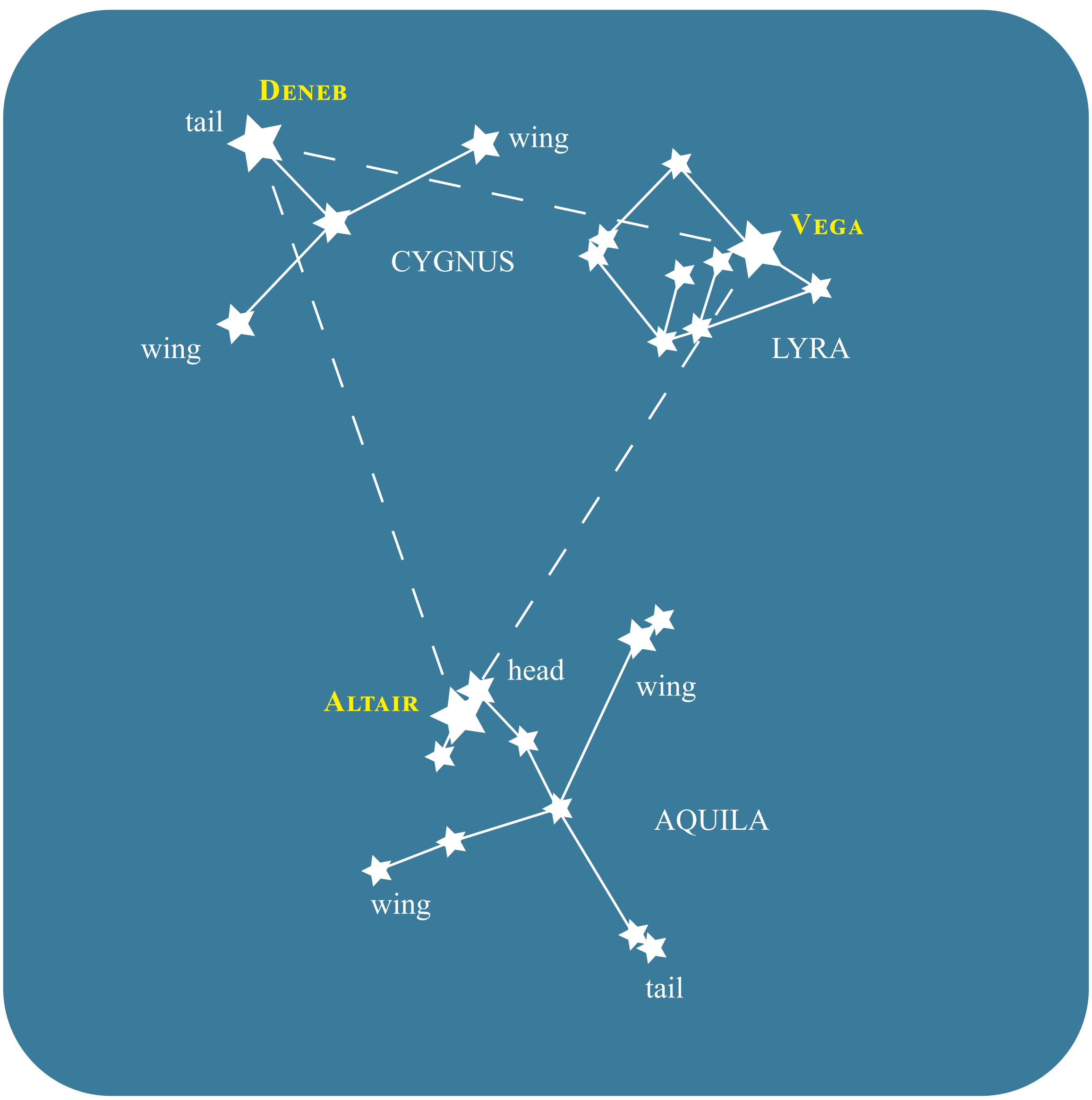




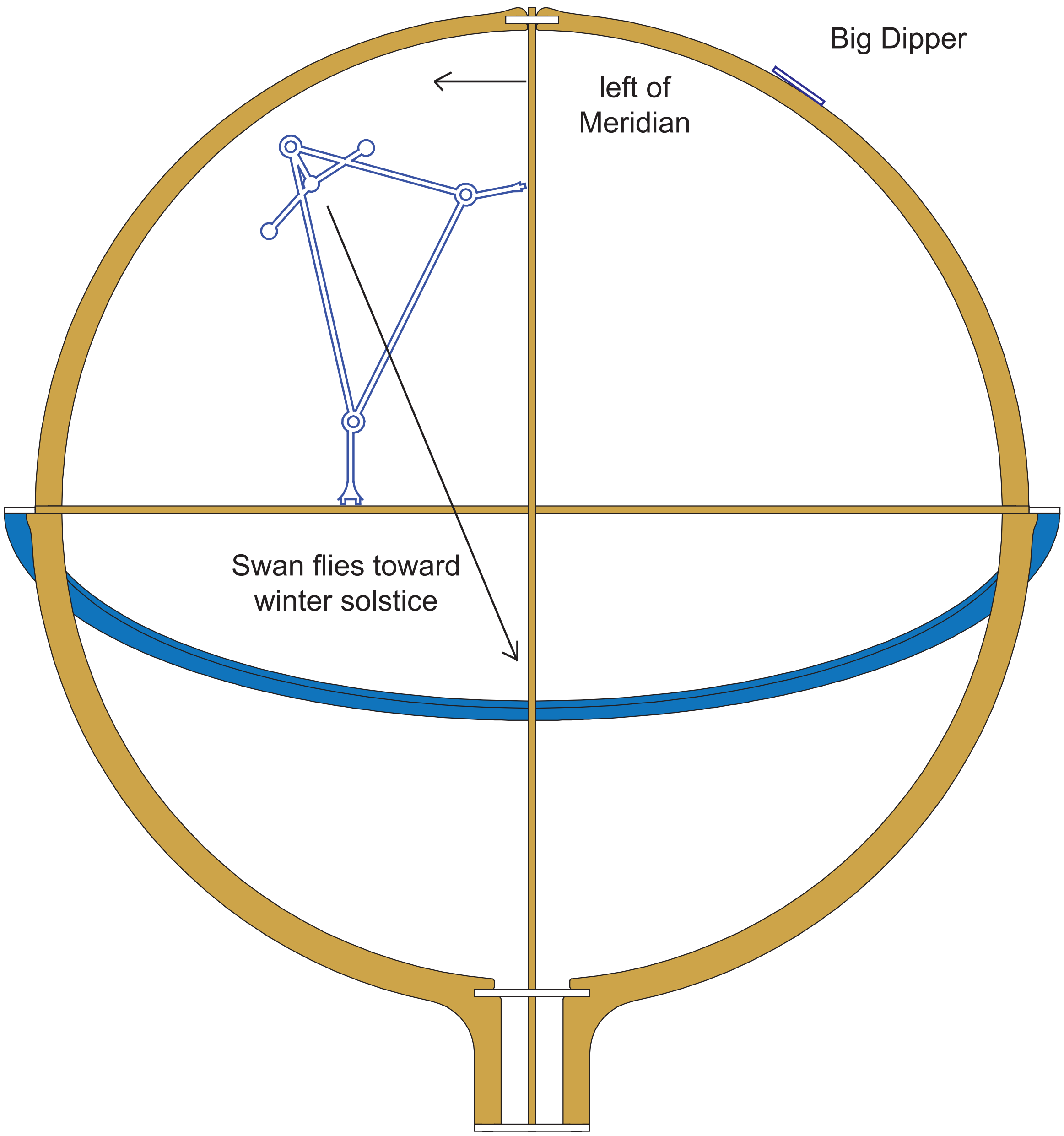
The third guidepost is Cygnus, the Swan, part of the Summer Triangle.

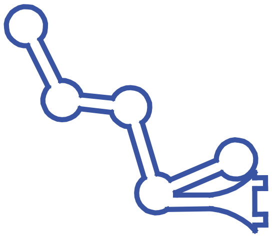
To place Cygnus, after placing the Big Dipper, rotate the globe ¼ turn clockwise, from south-facing TOM's perspective.

Vega leads Cygnus and Altair points south.



Guidepost #3
Summer Triangle/Cygnus the Swan

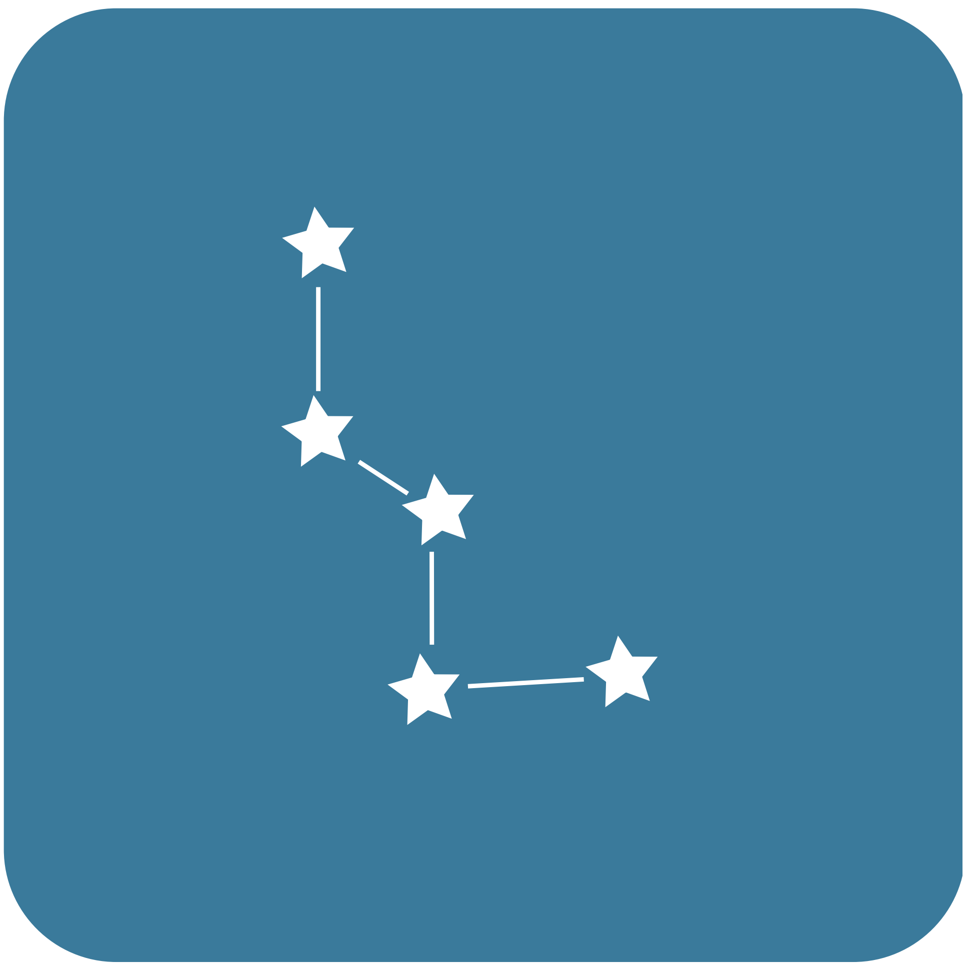




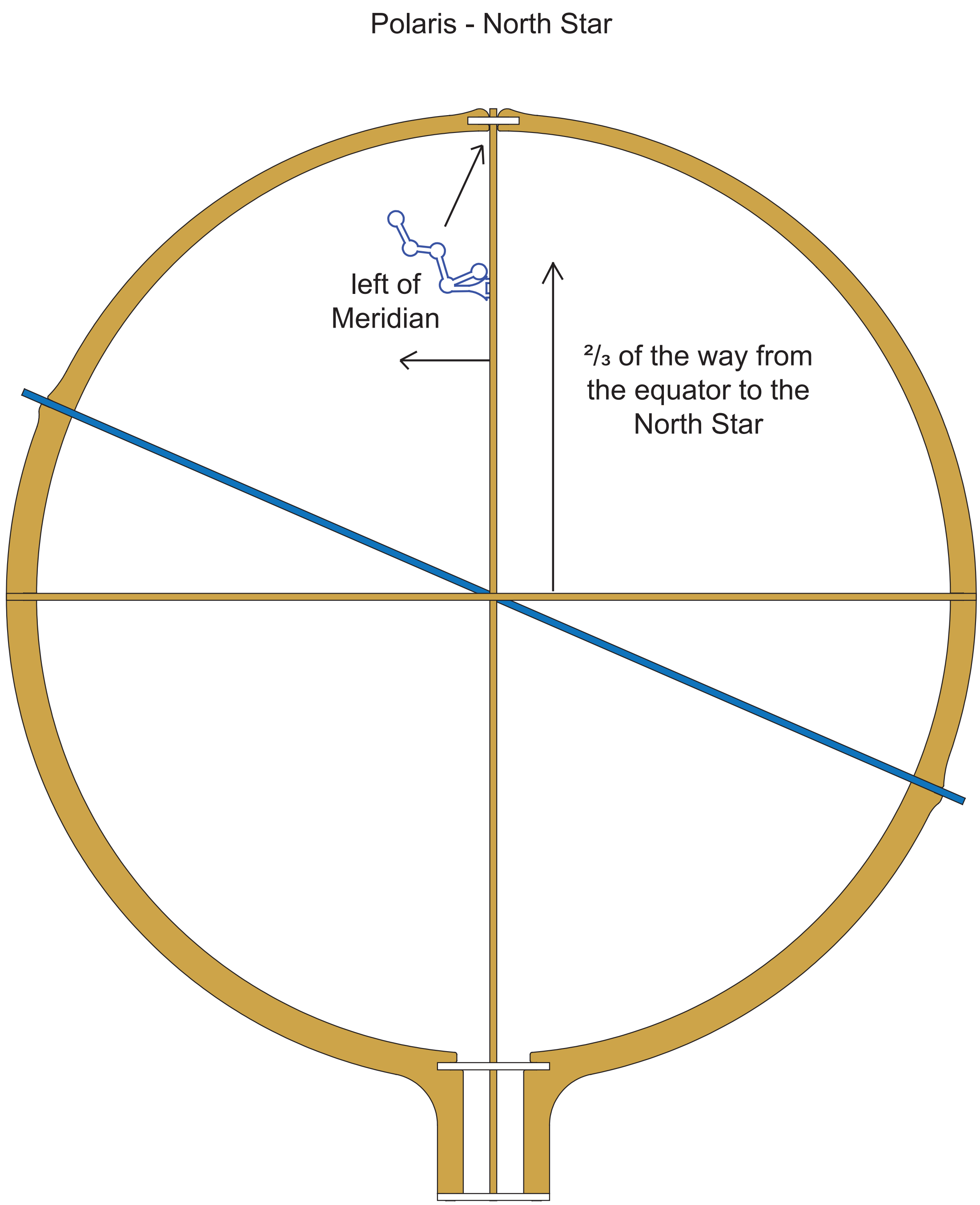
The fourth guidepost is Cassiopeia.

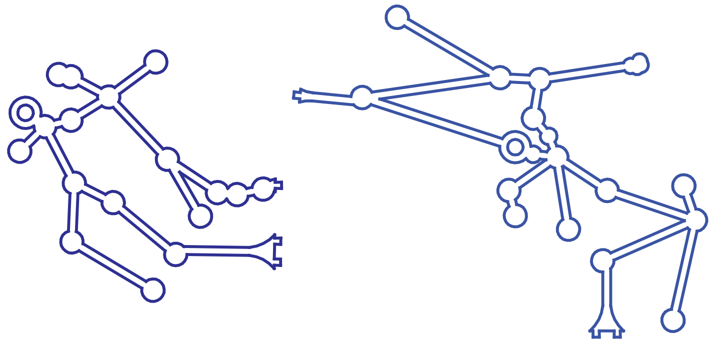
To place Cassiopeia, after placing Cygnus, rotate the globe ¼ turn clockwise from south-facing TOM's perspective.

Cassiopeia forms an upright W-shape in this position.



Guidepost #4
Cassiopeia

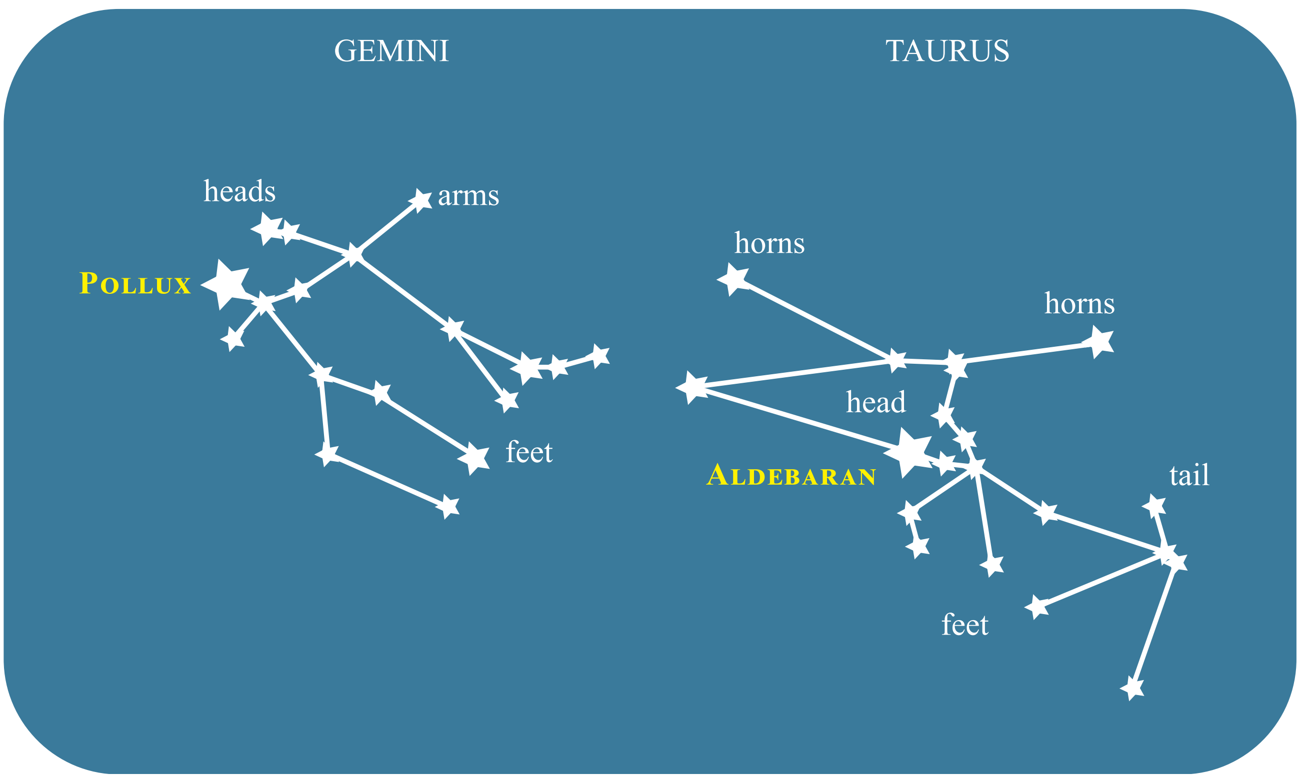


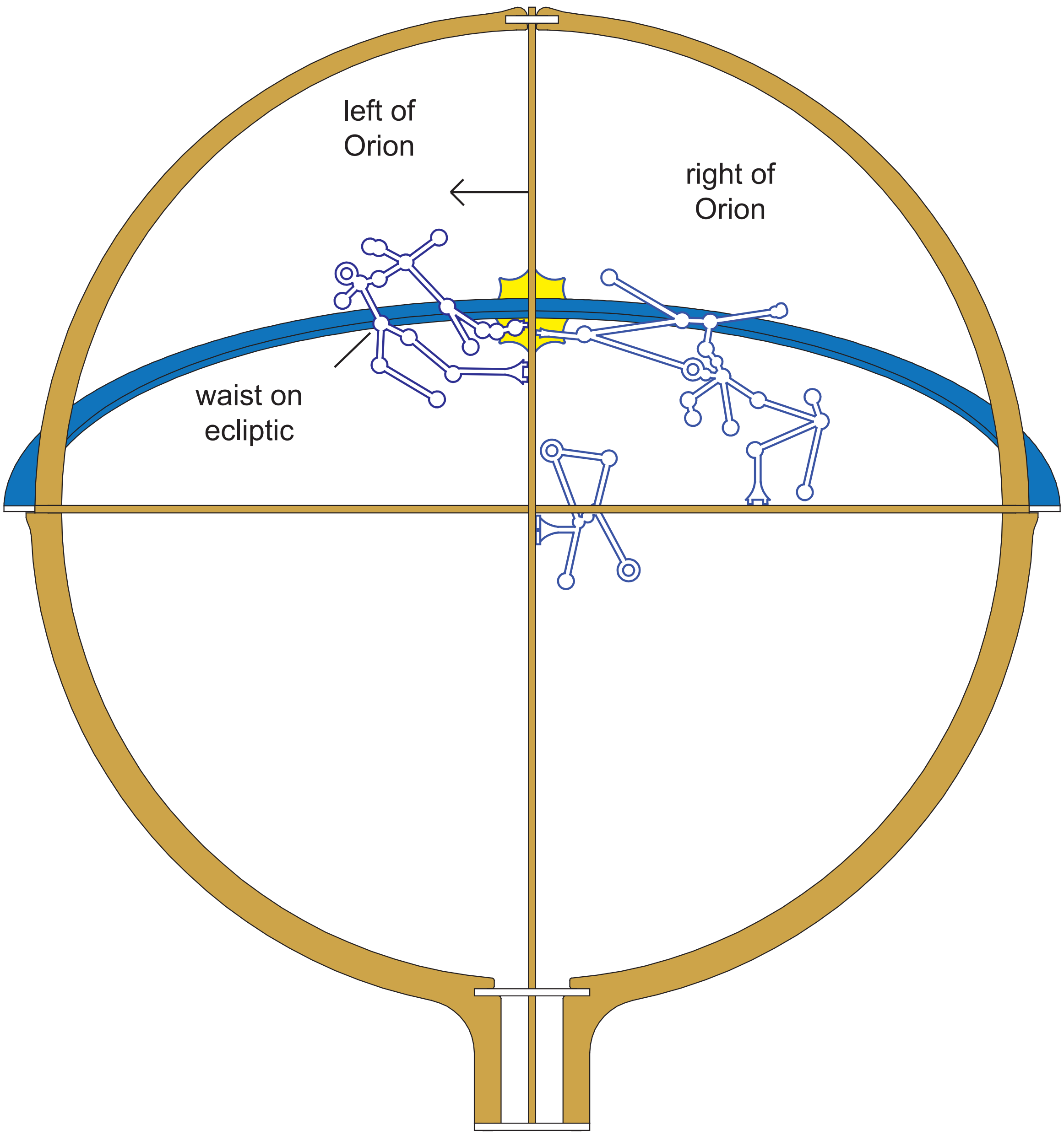


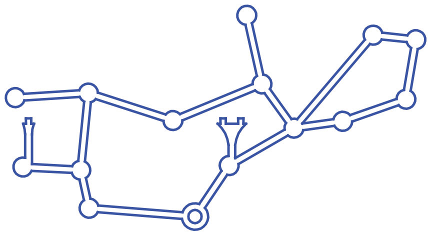
Two of the most prominent and easiest-to-find zodiac constellations are Taurus and Gemini.

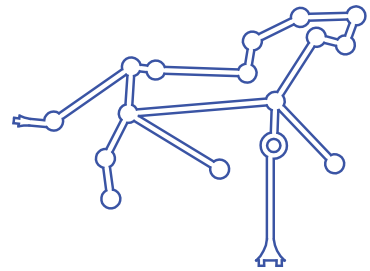
To place Taurus, rotate the globe so that Orion is up. Taurus leads Orion, traveling backwards.

Gemini follows Orion. The waist star of the twin Pollux is on the ecliptic. It looks as if the twins are fleeing from the Bull.




left of
Orion
right of
Orion
waist on
ecliptic

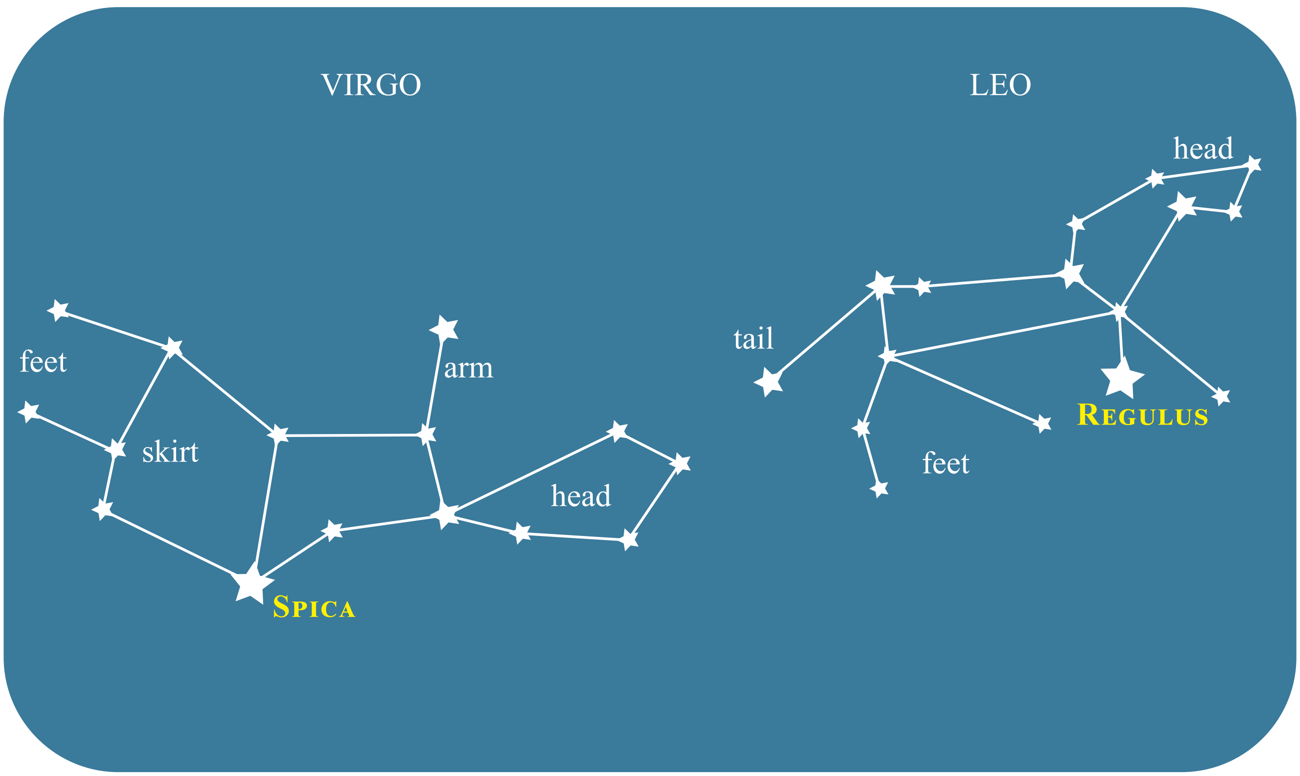


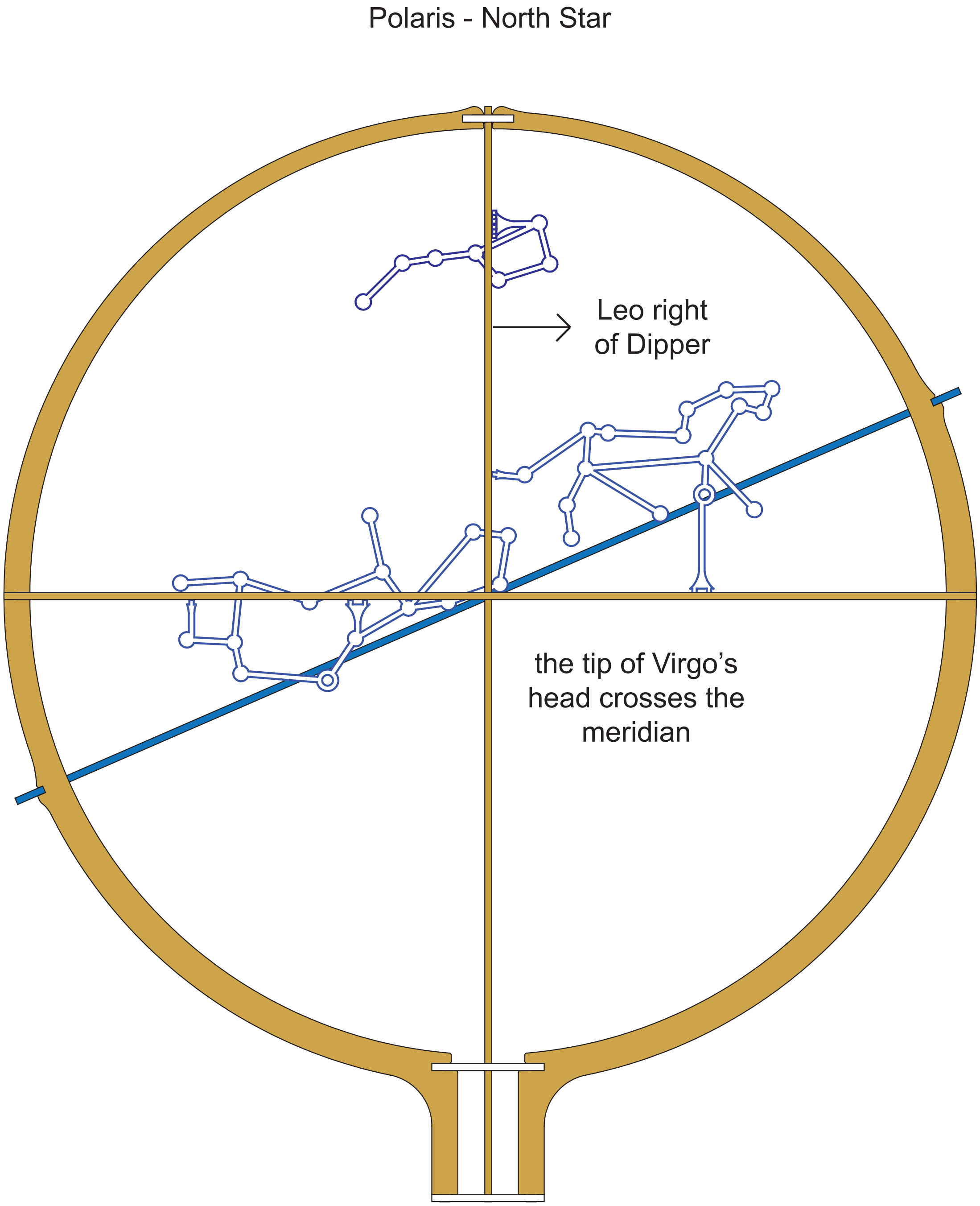


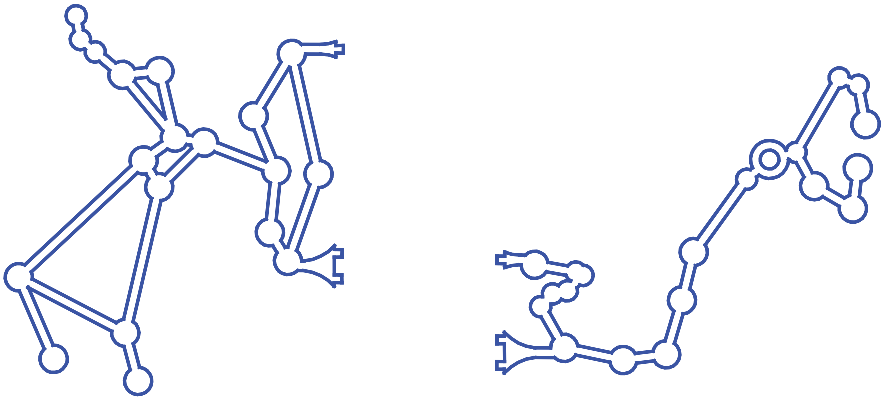
Leo and Virgo dominate the spring sky.

To place Leo rotate the globe so that the Dipper is up. Leo leads the Dipper. Regulus has his front foot on the ecliptic.

Virgo trails the lion, lying on her back and traveling head-first. Her head just crosses the meridian.



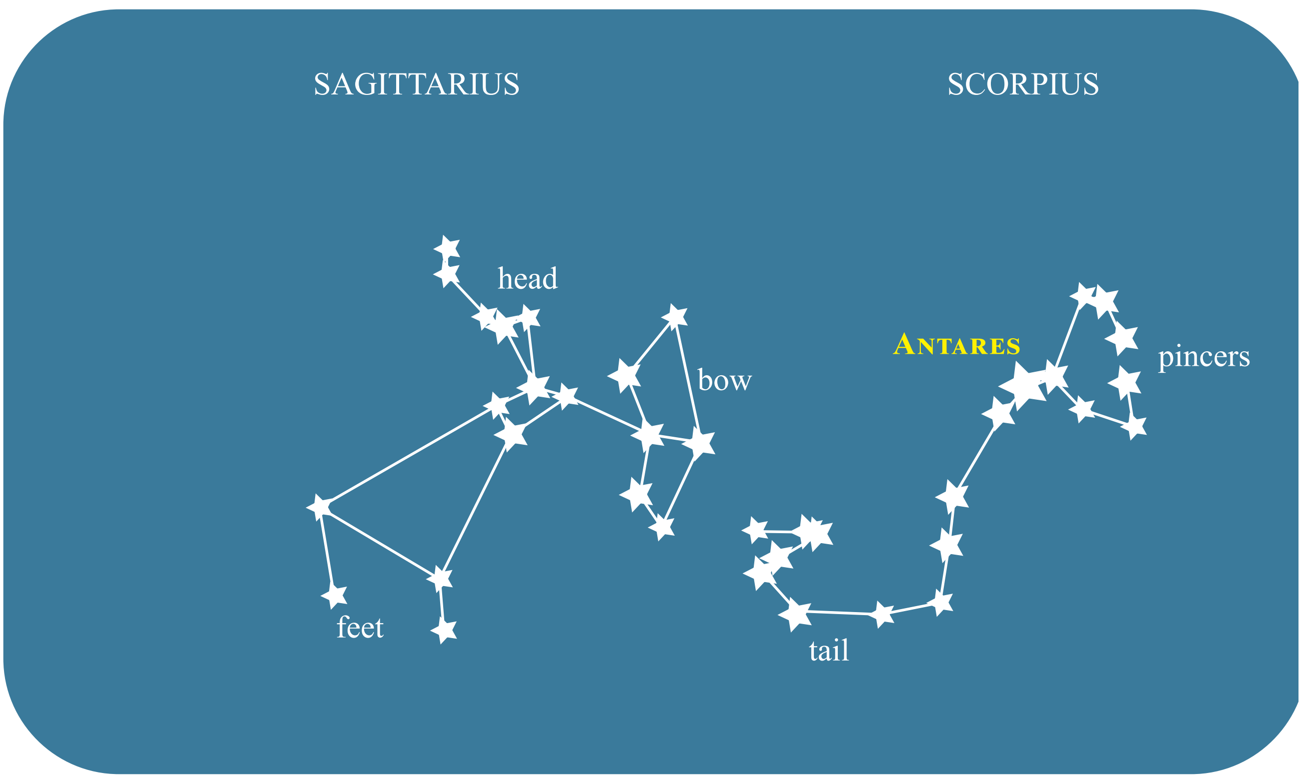

Polaris - North Star
Leo right of Dipper
the tip of Virgo's head crosses the meridian

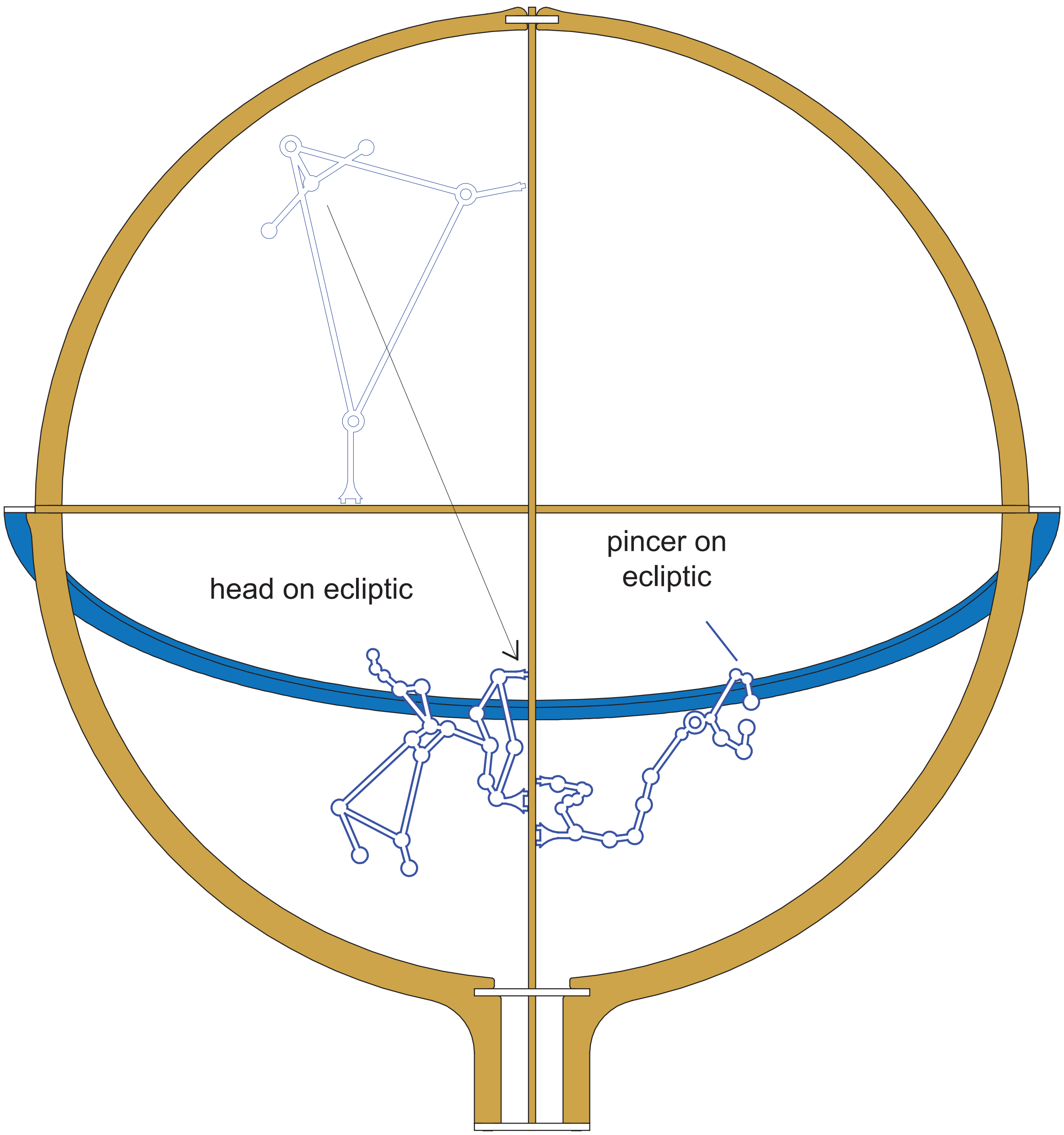


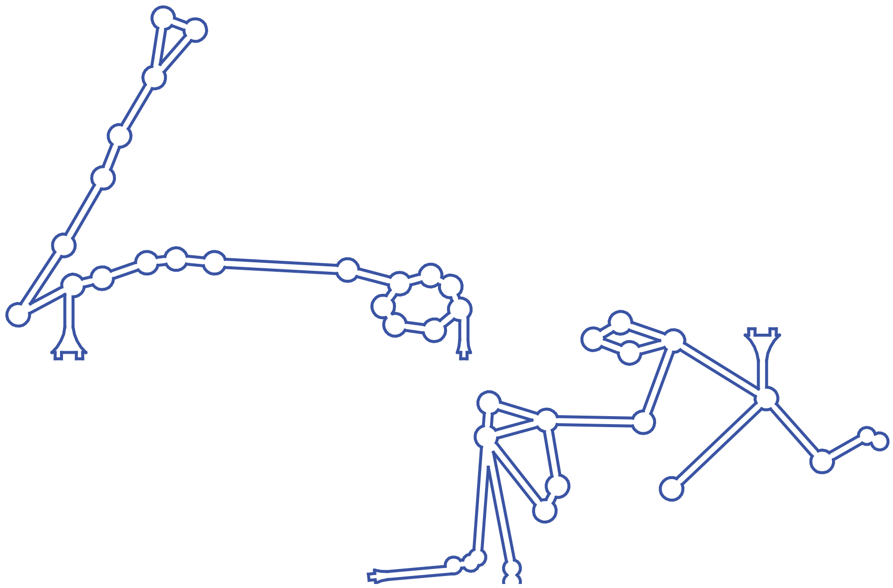
The Summer Triangle helps to locate Scorpius and Sagittarius.

Rotate the globe so that Cygnus is up. Scorpius is ahead of the meridian, with his top pincer on the ecliptic.

Sagittarius follows as if hunting the Scorpion. The Archer's head is on the ecliptic.



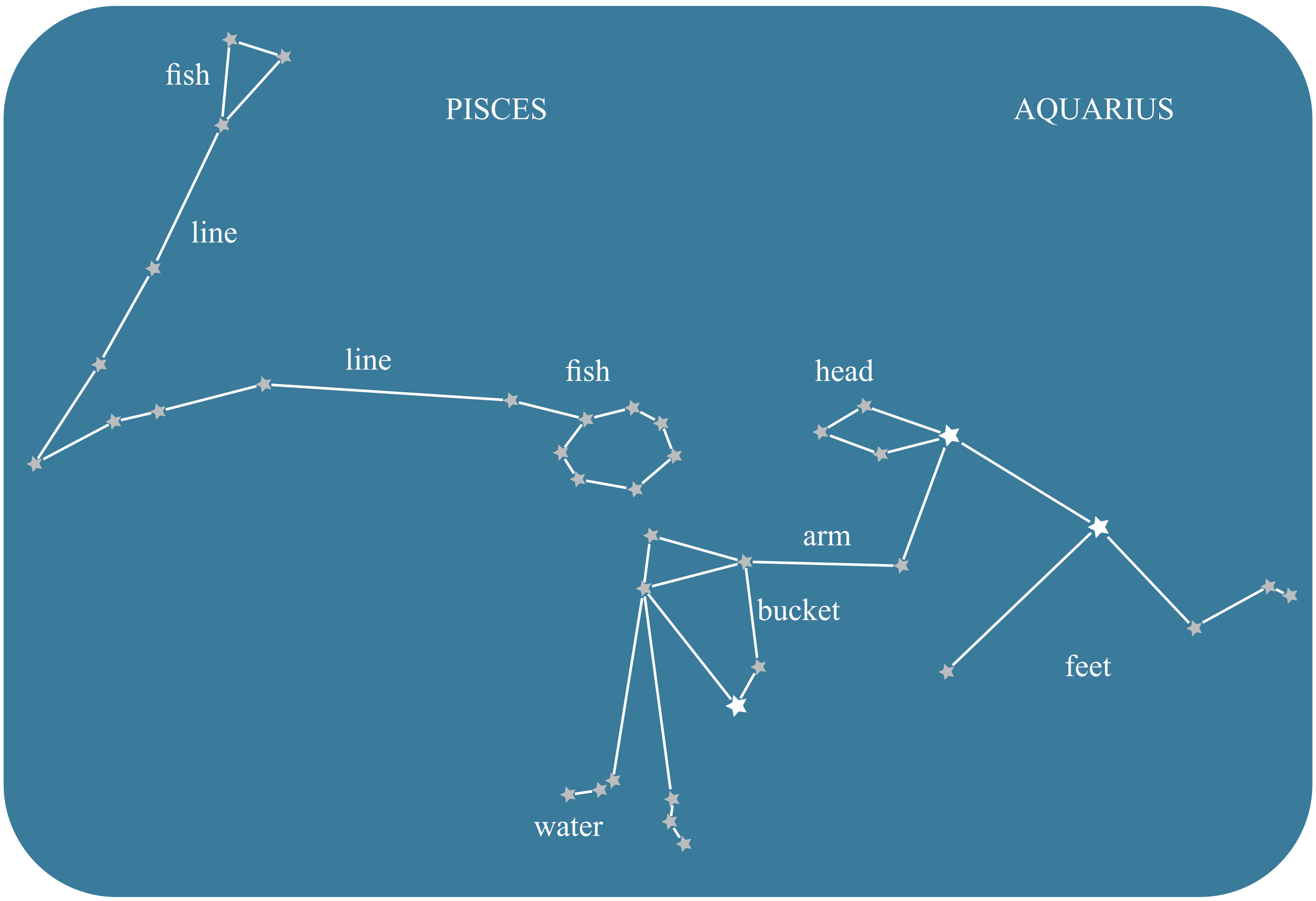

head on ecliptic
pincer on
ecliptic

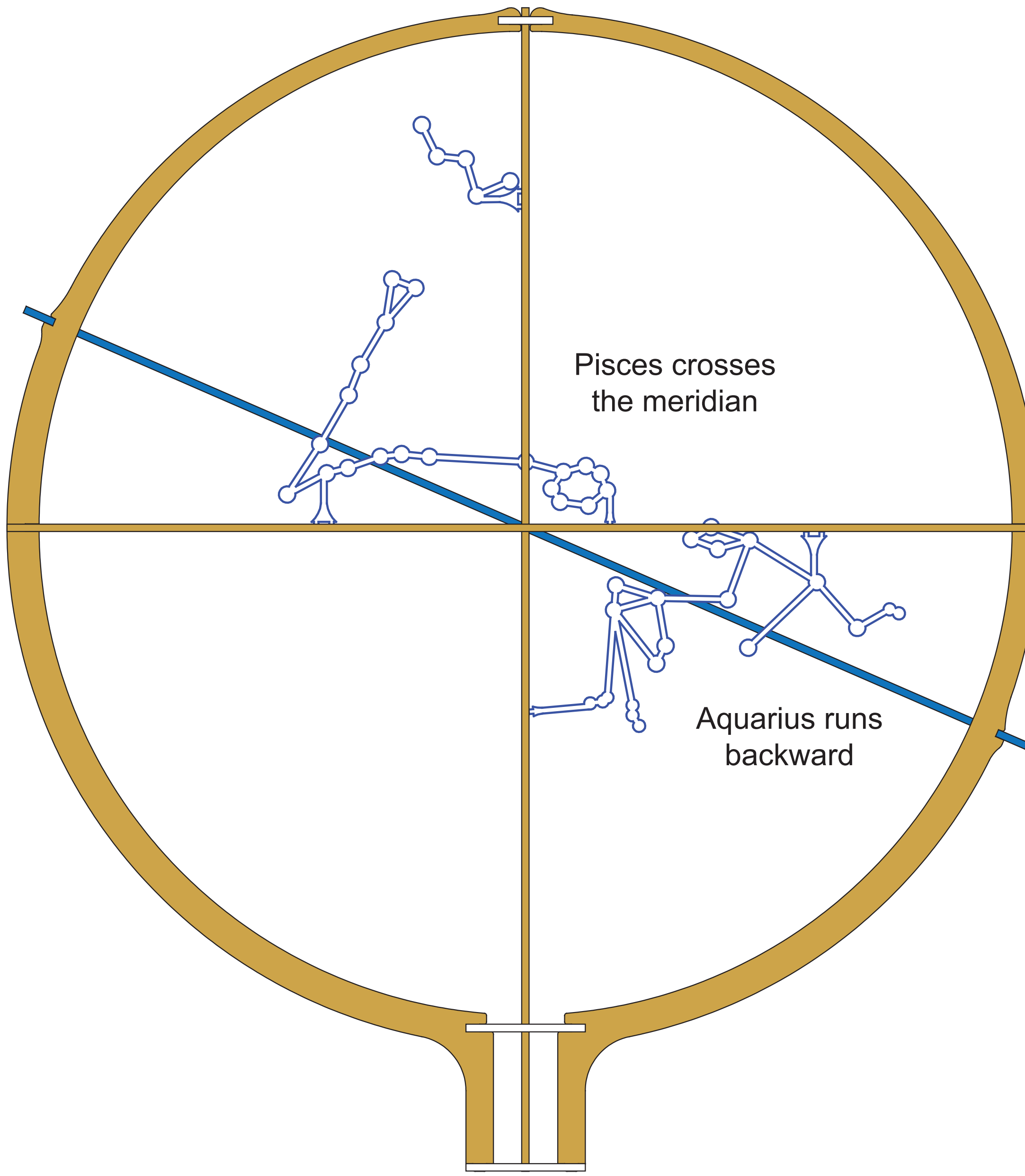


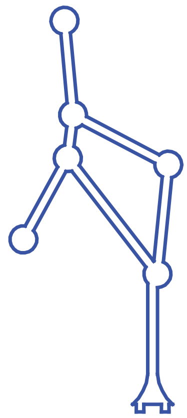
Aquarius and Pisces occupy the autumn quadrant of the sky, but are difficult to actually see.

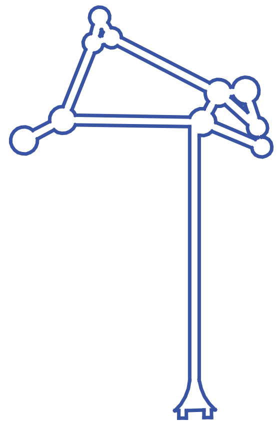
Rotate the sphere so that Cassiopeia is up. Aquarius leads Cassiopeia, facing backwards just below the celestial equator.

Pisces is just below Cassiopeia and above the celestial equator, with one of the fish ahead of the meridian.




Pisces crosses the meridian
Aquarius runs backward

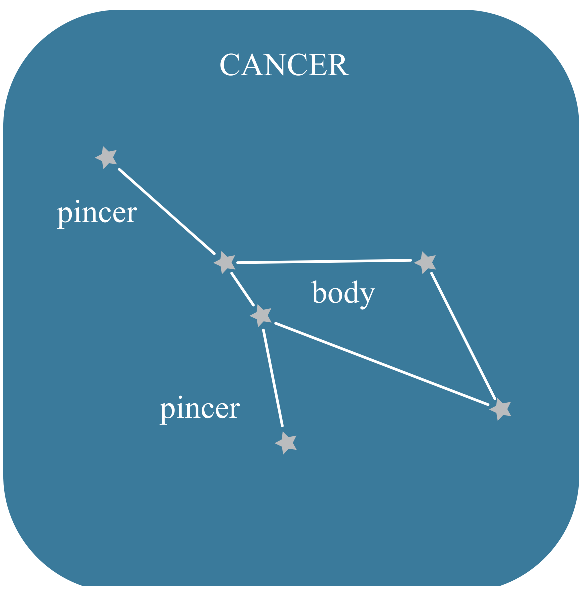


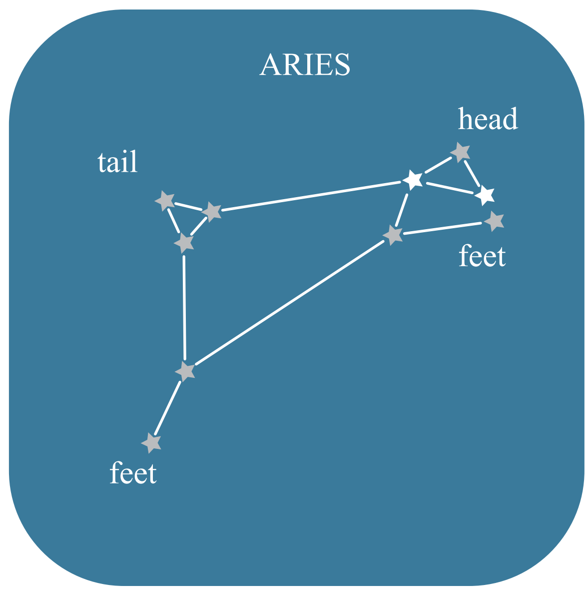


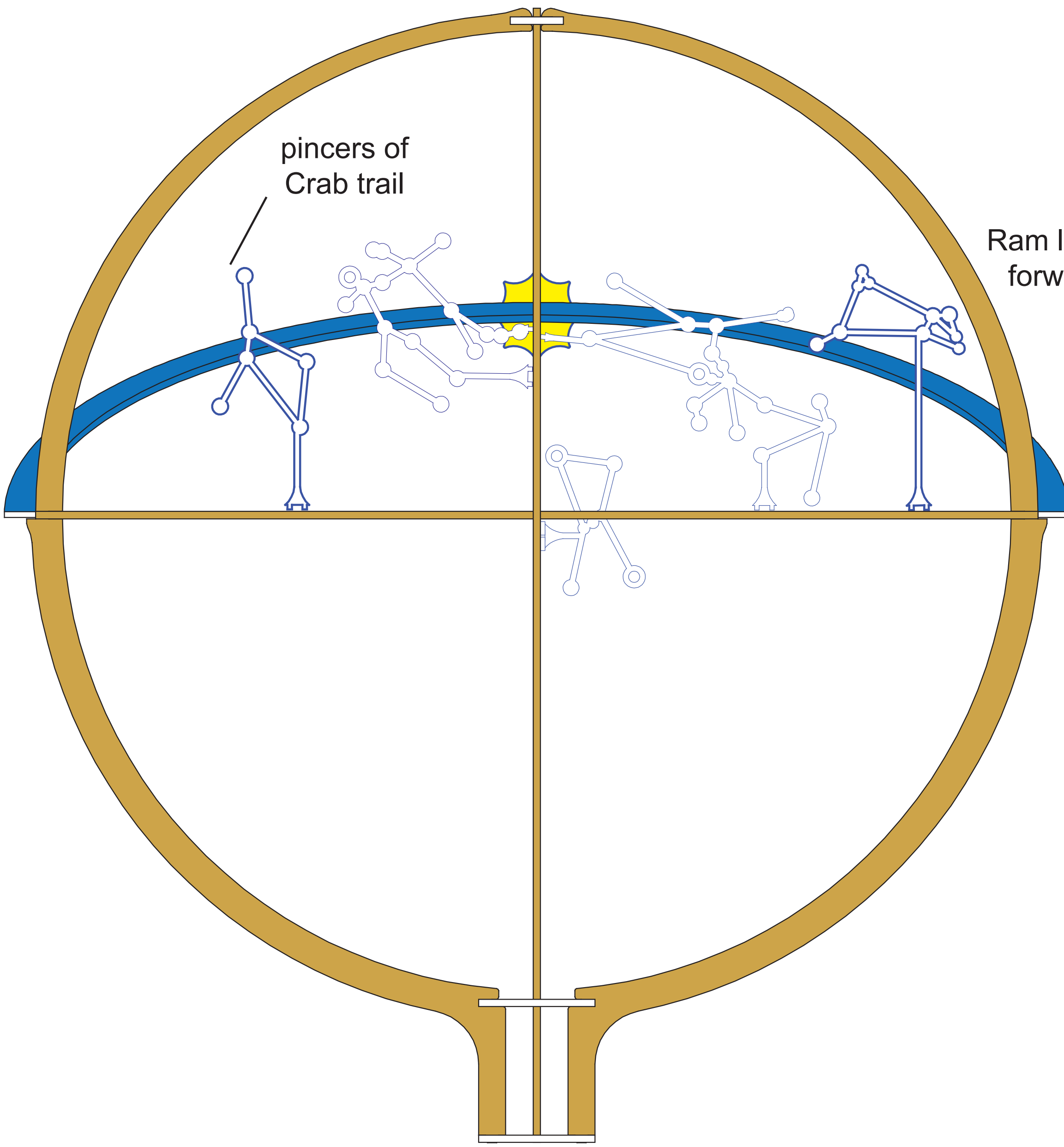
The remaining four Zodiac constellations fit in between the dominant eight we have already placed in the four quadrants.

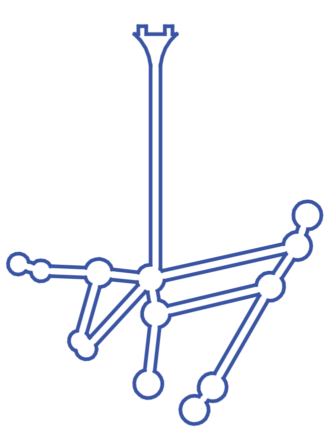
Aries leads Taurus in Orion's quadrant. The Ram leaps forward, his rear leg just above Taurus' tail.

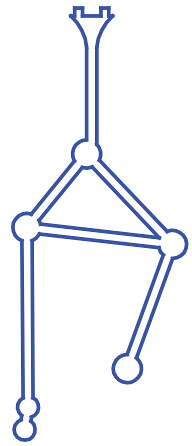
Cancer follows the Twins, leading with its body with pincers trailing.





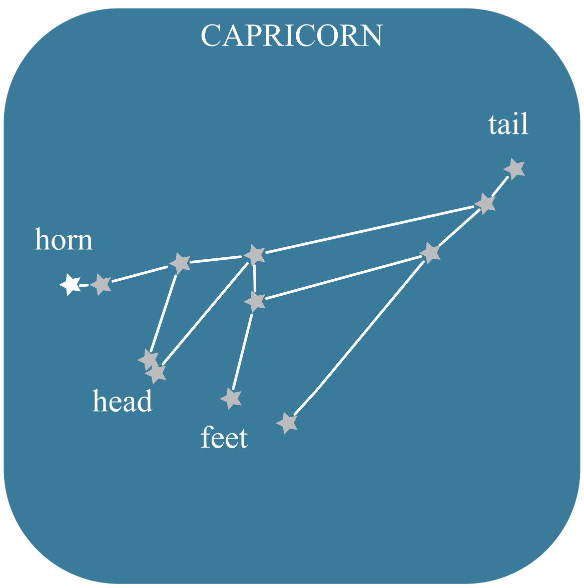

pincers of
Crab trail
Ram leaps
forward

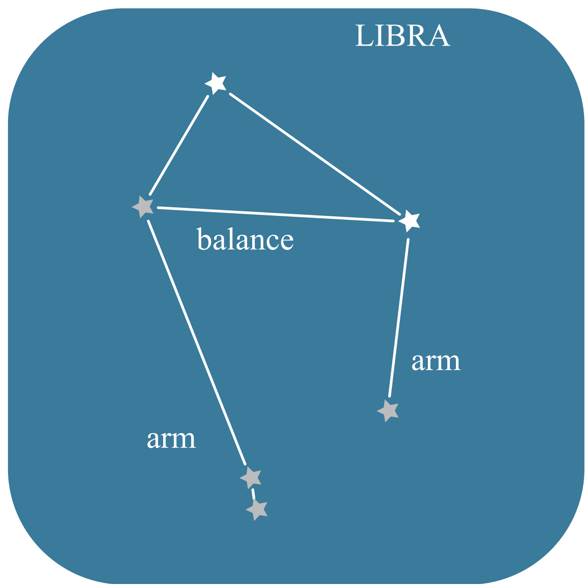


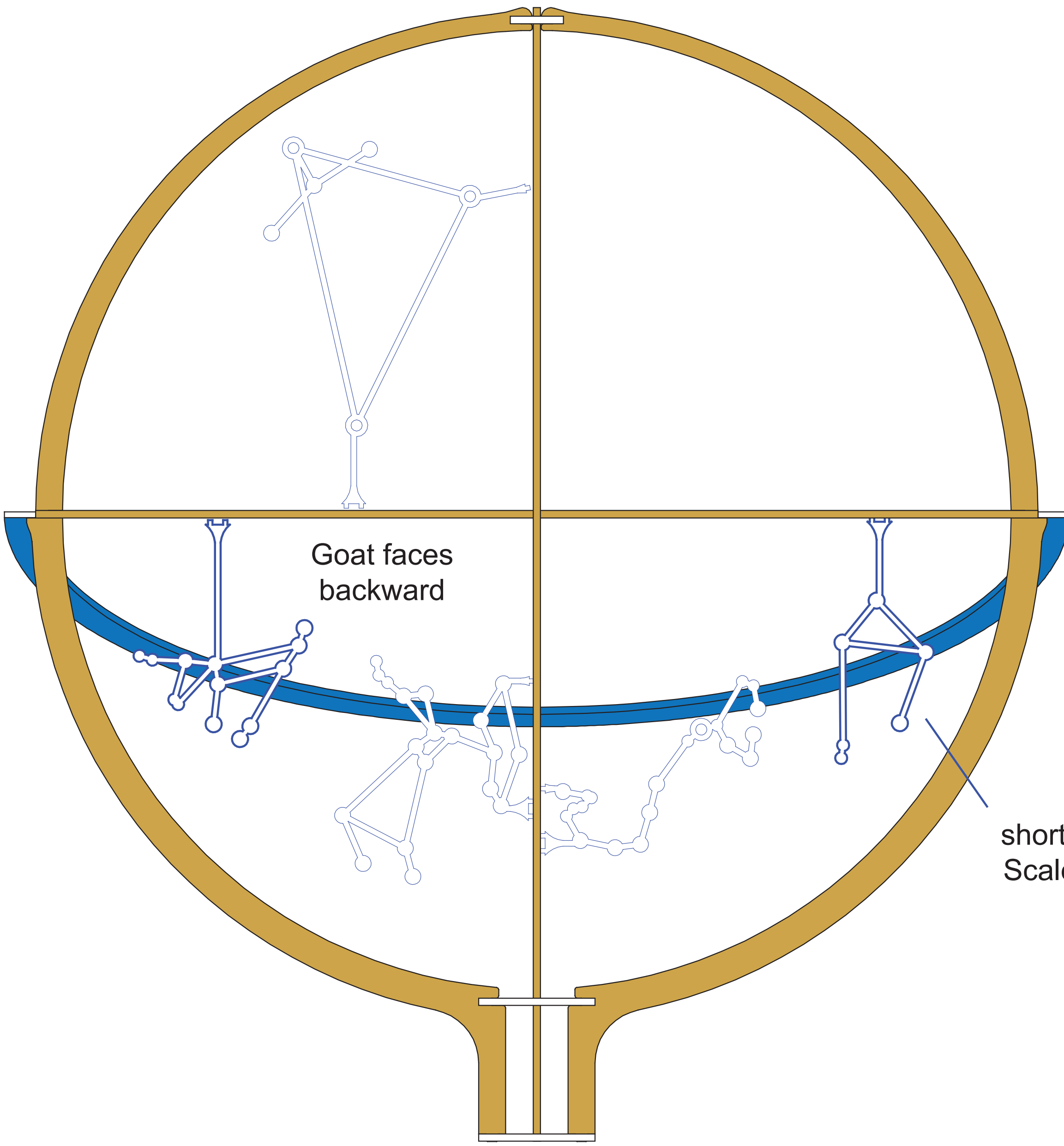


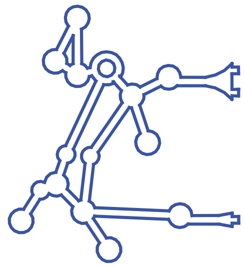
Libra leads Scorpius. Dangling from the celestial equator, Libra lead with the shorter arm.

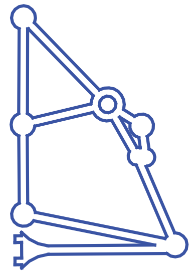
Capricorn faces backward, following the Archer. He is also anchored on the celestial equator.






Goat faces backward
short arm of Scale leads



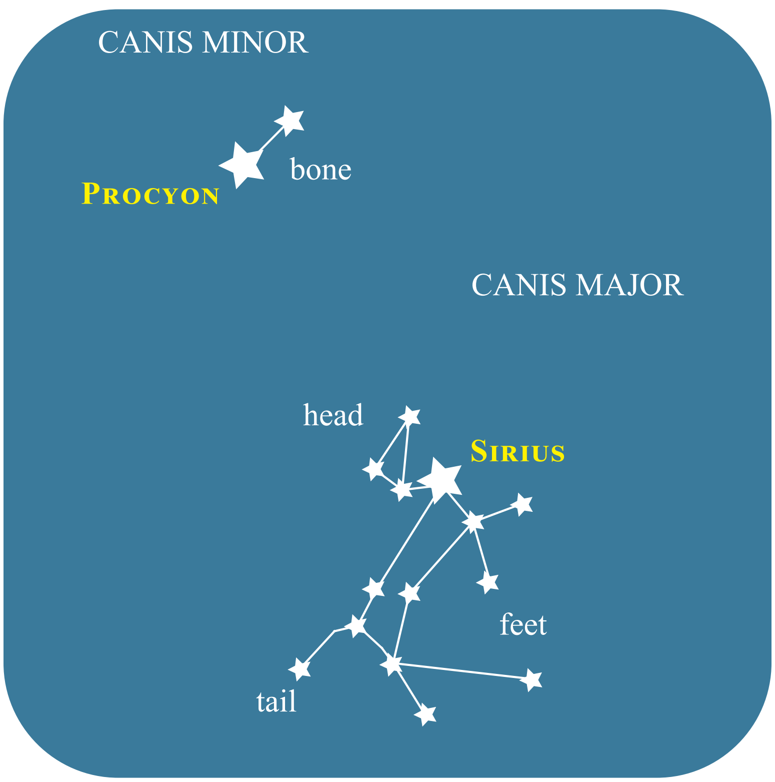


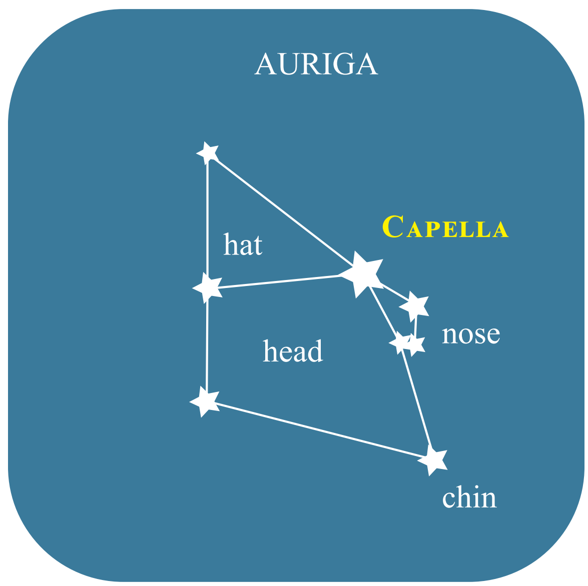
Auriga, Canis Major and Canis Minor fill out the sky around Orion.

Auriga is directly above Orion, attached to the meridian in the same way. Place him halfway between the equator and the pole.

Canis Major trails Orion on the meridian, his nose just lower than Orion's foot.

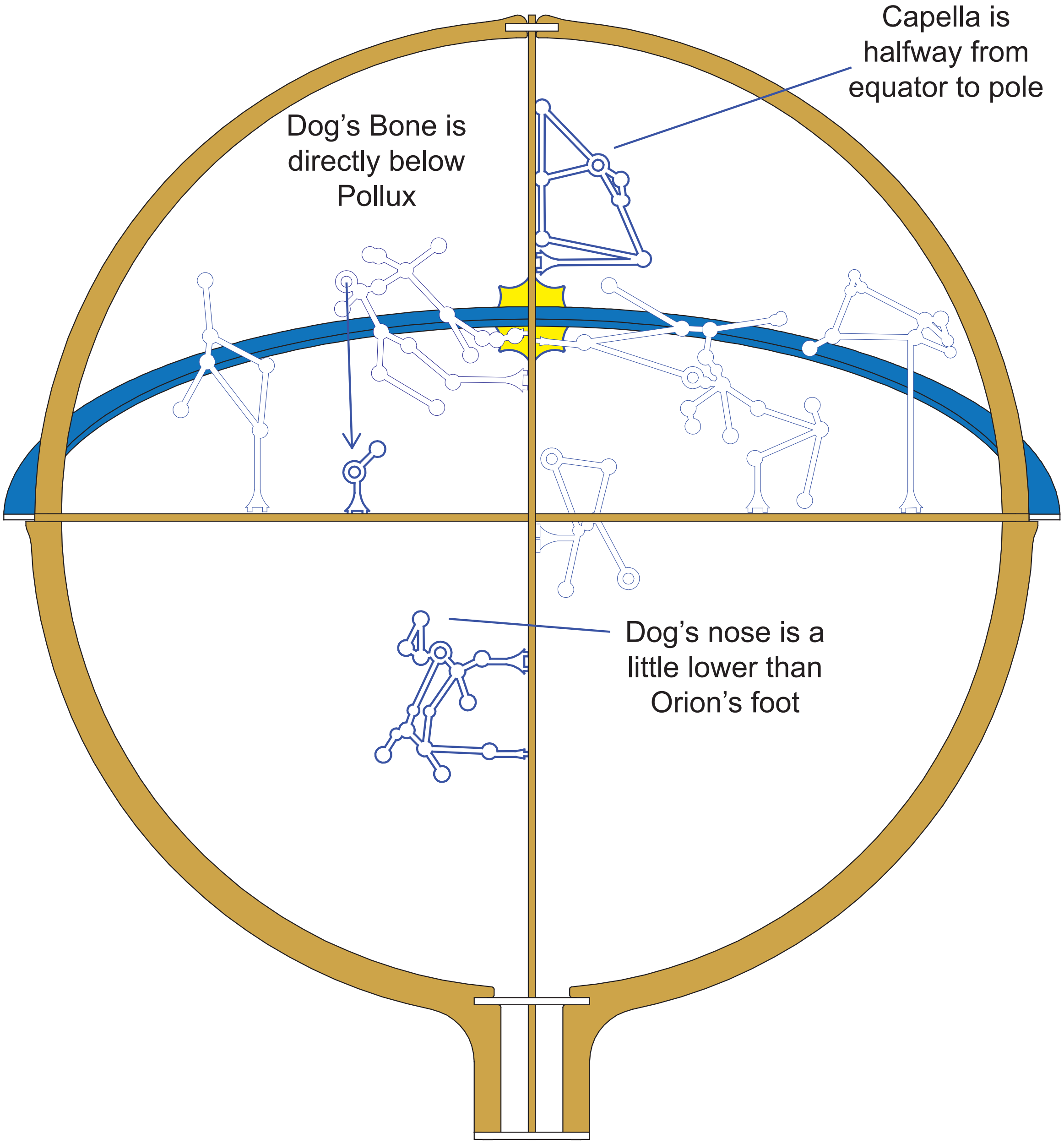
Canis Minor is the little dog, but calling it the dog's bone makes it easy to remember and find. It is placed on the celestial equator, directly below Pollux.

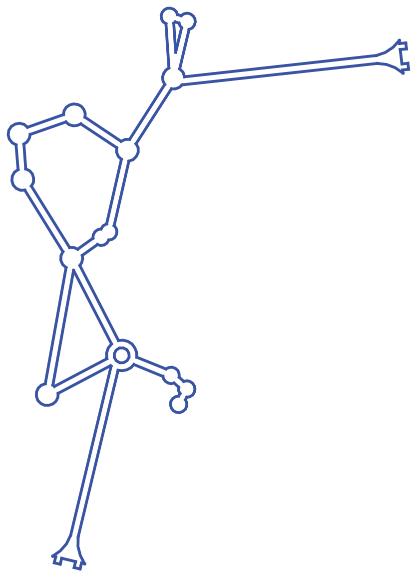




Constellations near Guidepost #1

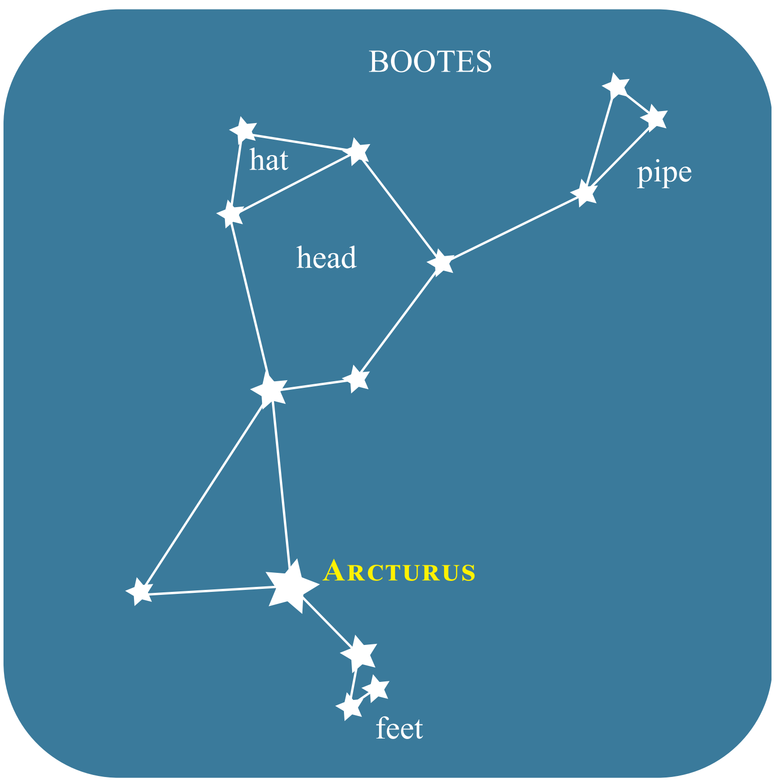
Charioteer, Dog & Bone

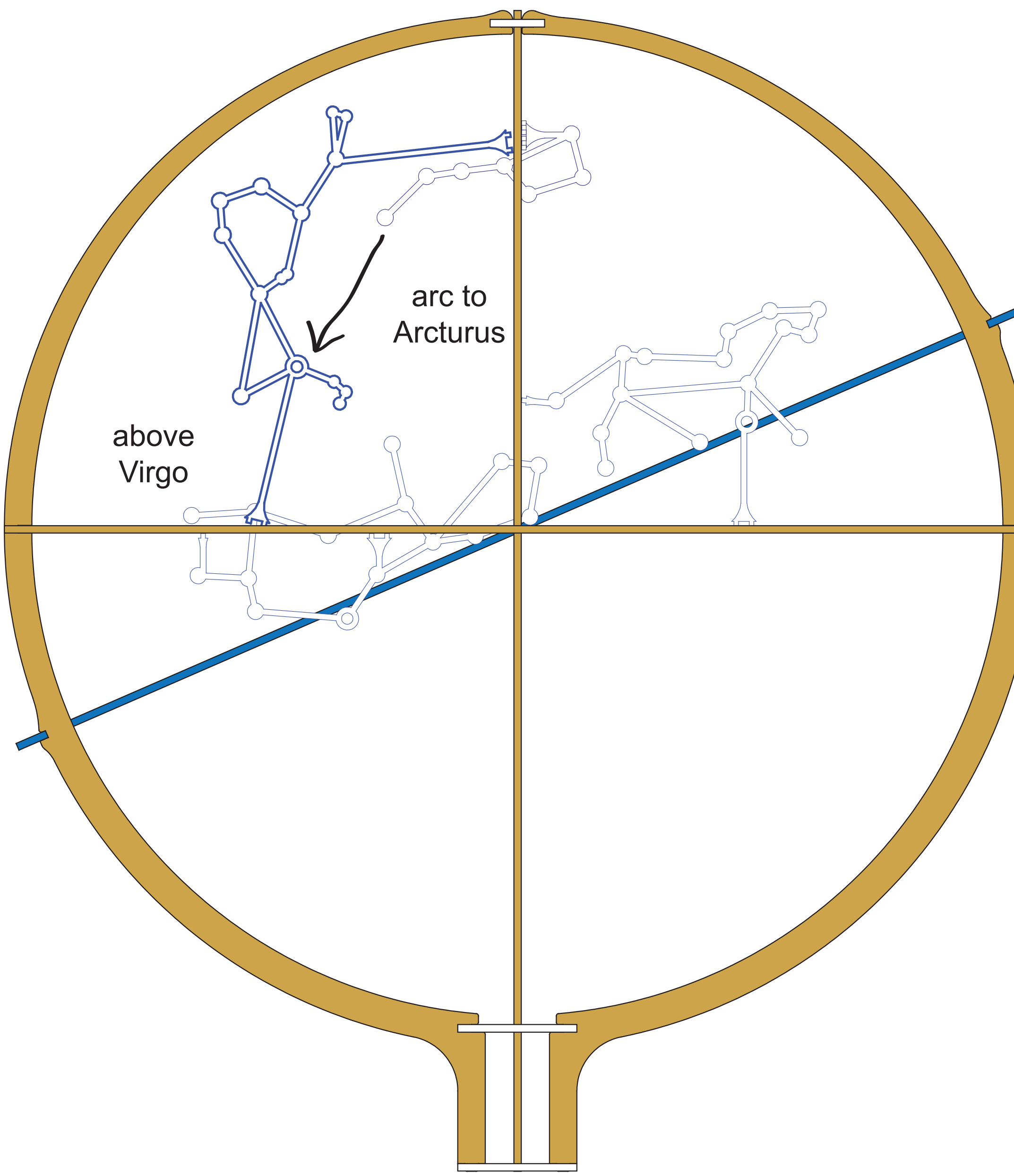


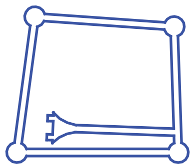


Bootes is the fourth major constellation in a grouping of the Big Dipper, Leo and Virgo.

Bootes sits above Virgo and trailing the dipper. The Dipper's handle points toward Arcturus.

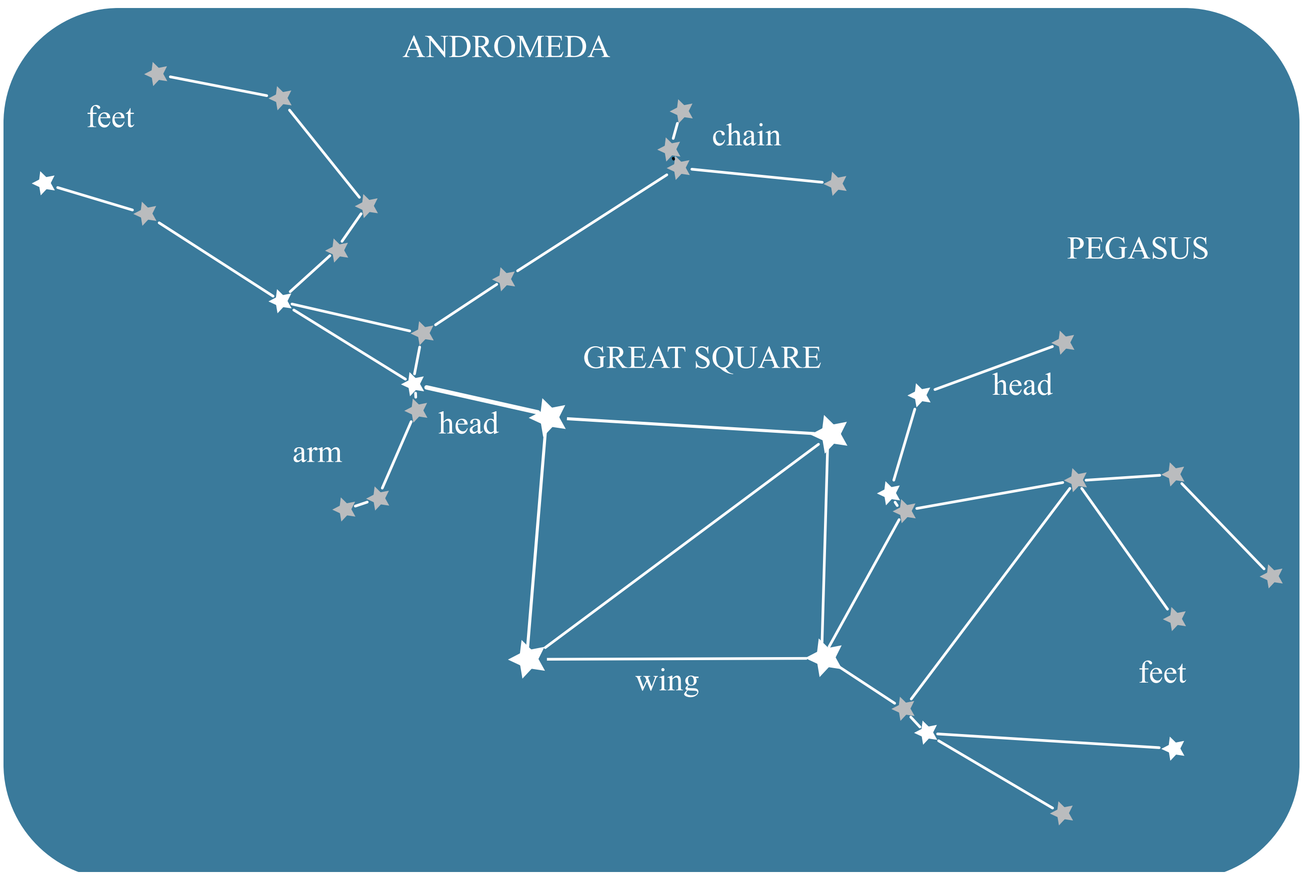



arc to
Arcturus
above
Virgo



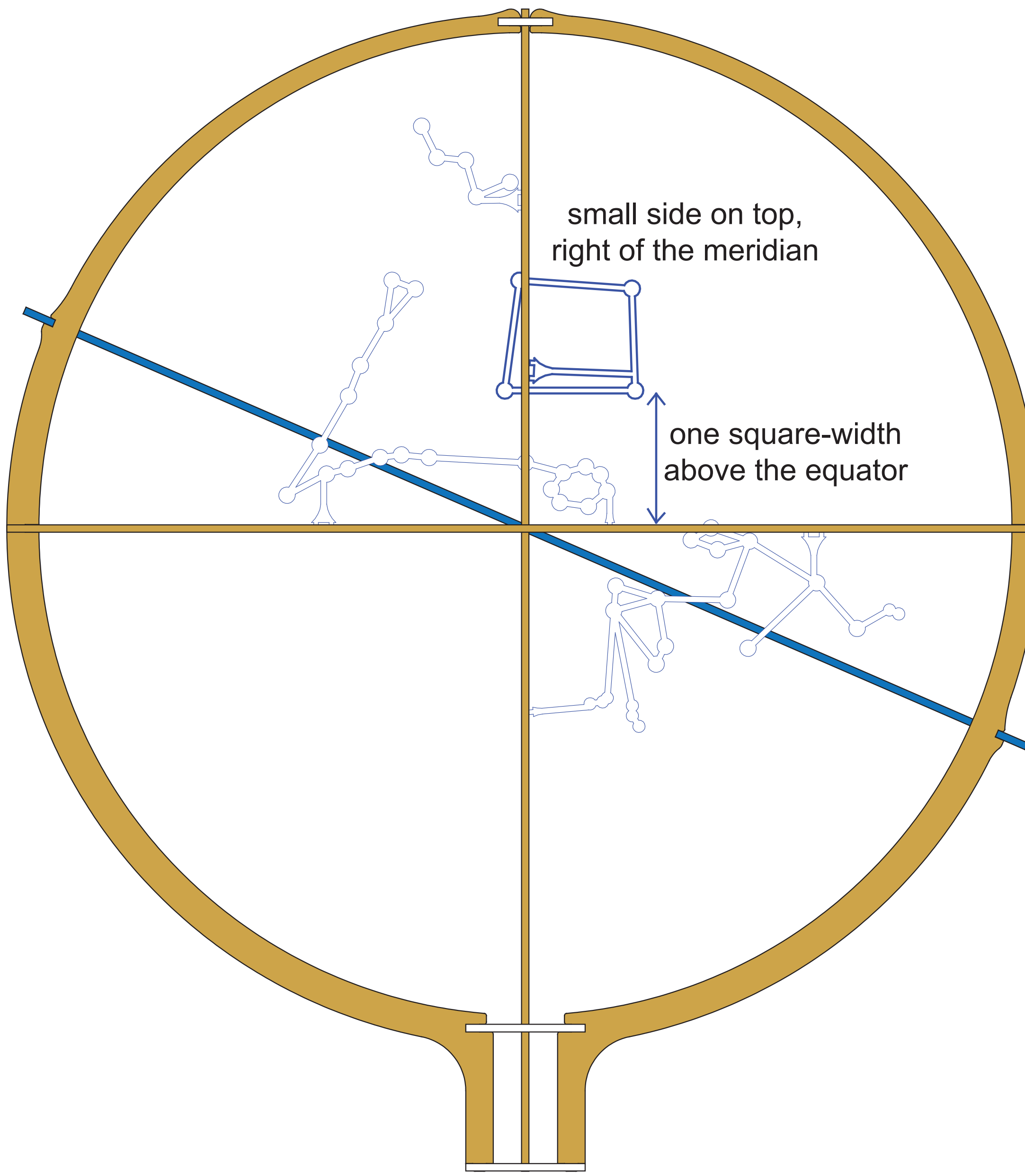
The Great Square fills out the sky near Cassiopeia. The Square is formed by Pegasus and Andromeda.

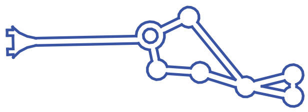
Place the square ahead of the meridian below Cassiopeia. The small side of the Square points North.



Constellations near Guidepost #4

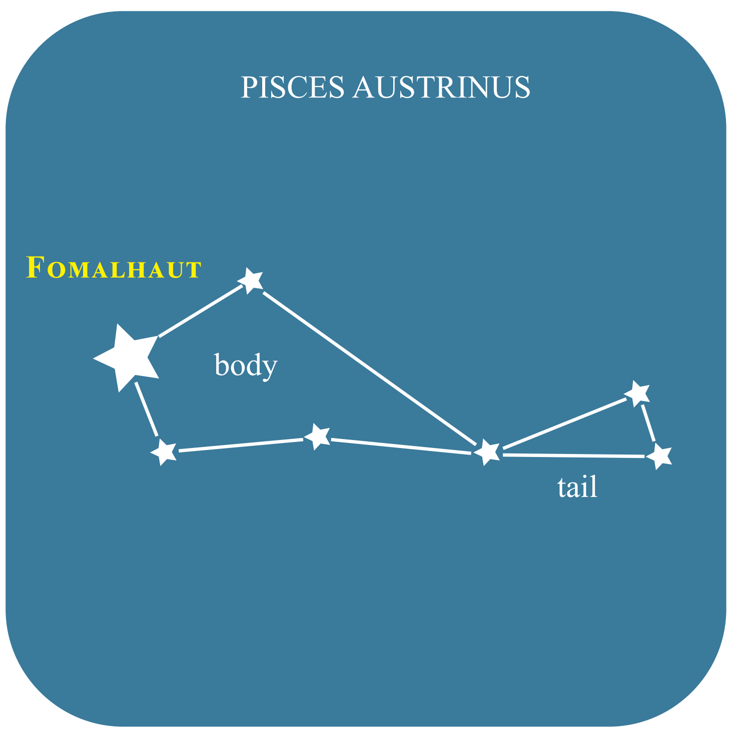
Great Square

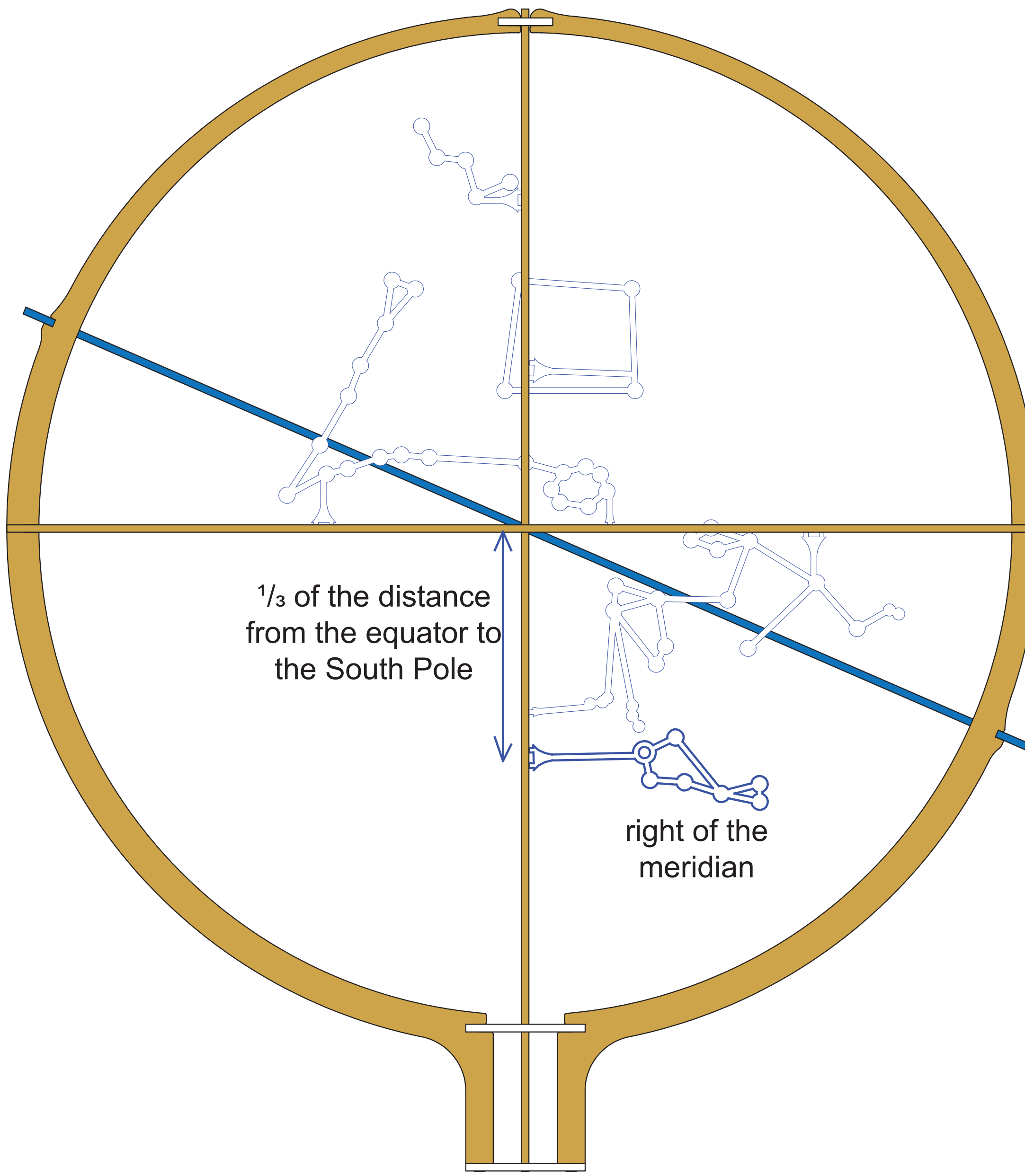




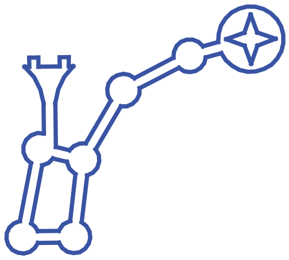
Pisces Austrinus fits below the Great Square. The fish swims backward, about $^{1}/_{3}$ of the way from the equator to the South Pole.

Fomalhaut is the only bright star in this quadrant of the sky, and is called the lonely star of autumn.



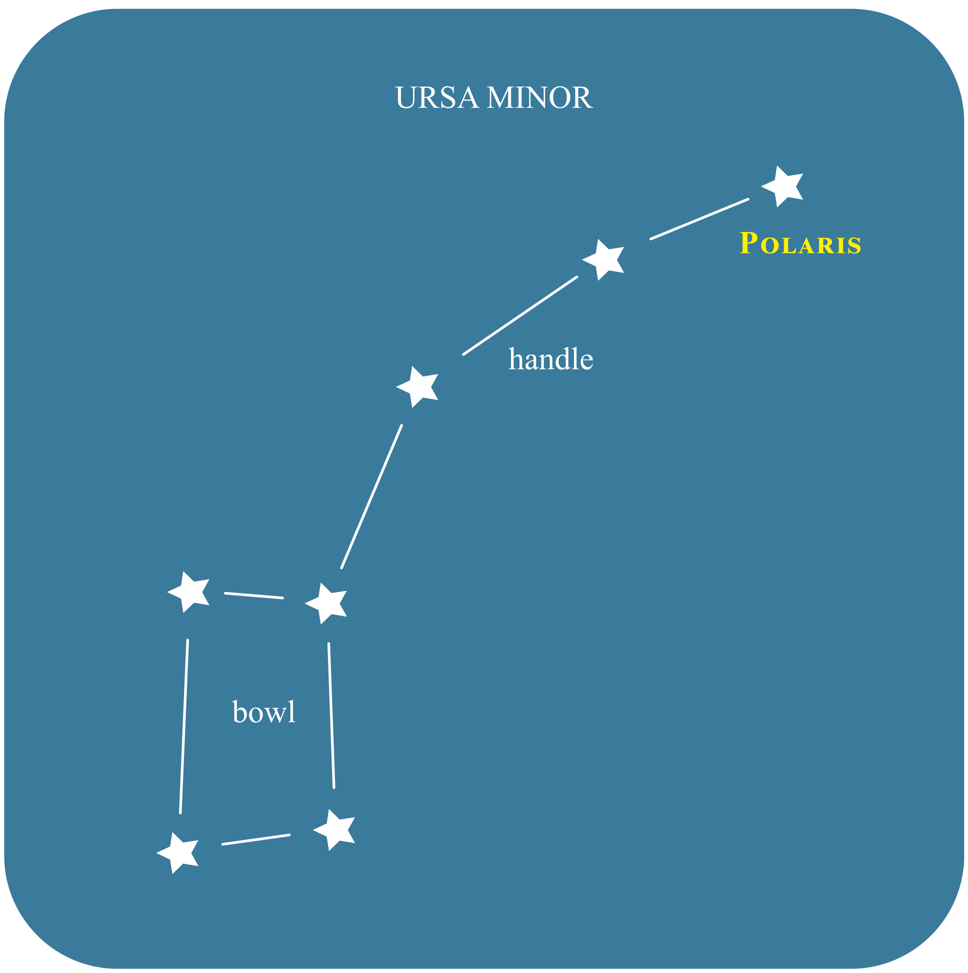


1/3 of the distance from the equator to the South Pole
right of the meridian

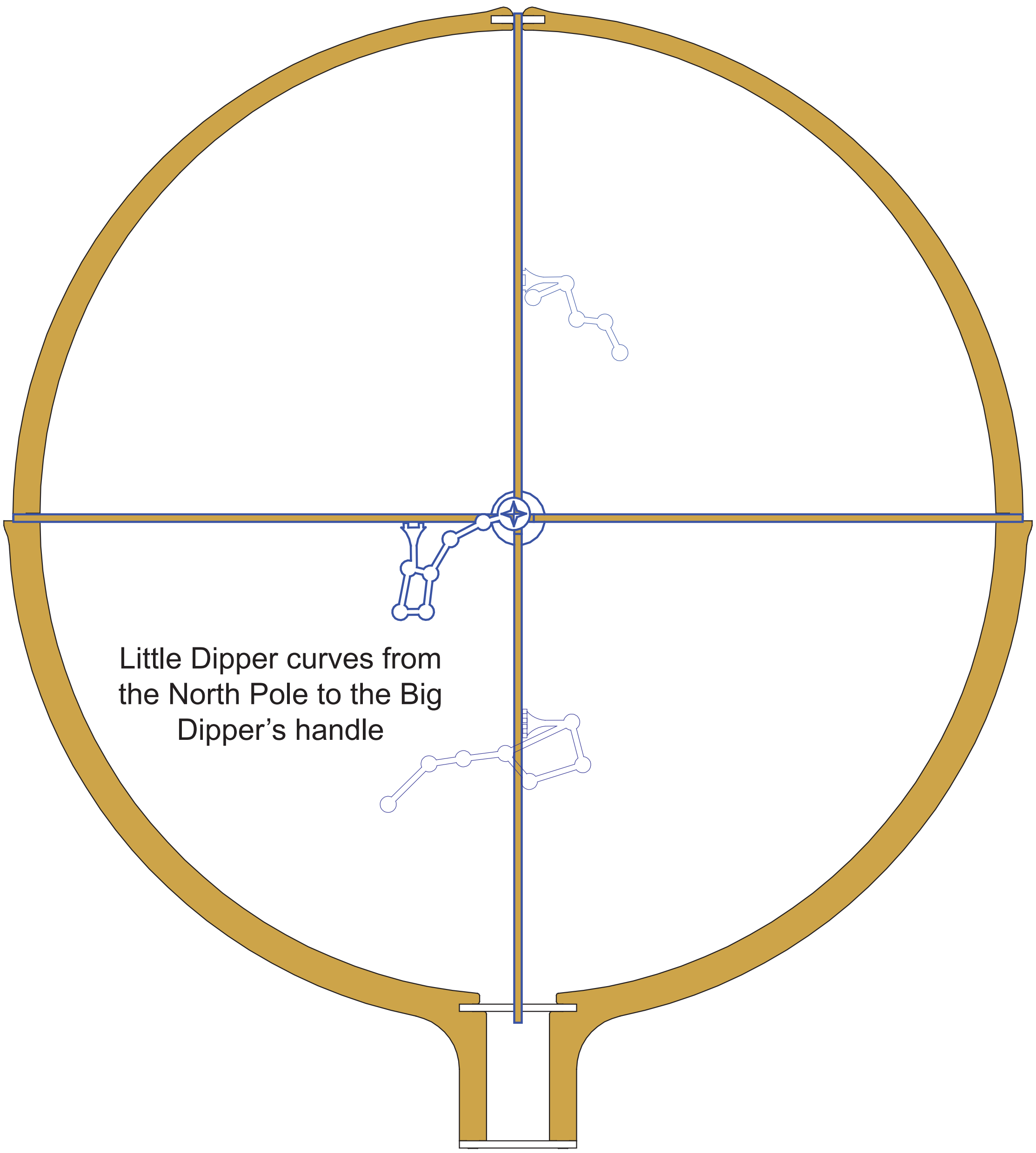


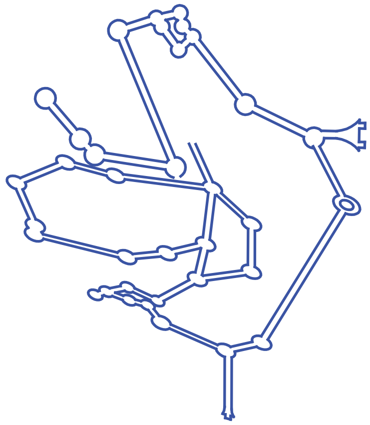
Ursa Minor's claim to fame is that it contains the pole star, Polaris.

Place Polaris on the pole, with the cup of the little dipper curving toward the handle of the Big Dipper.



Little Dipper

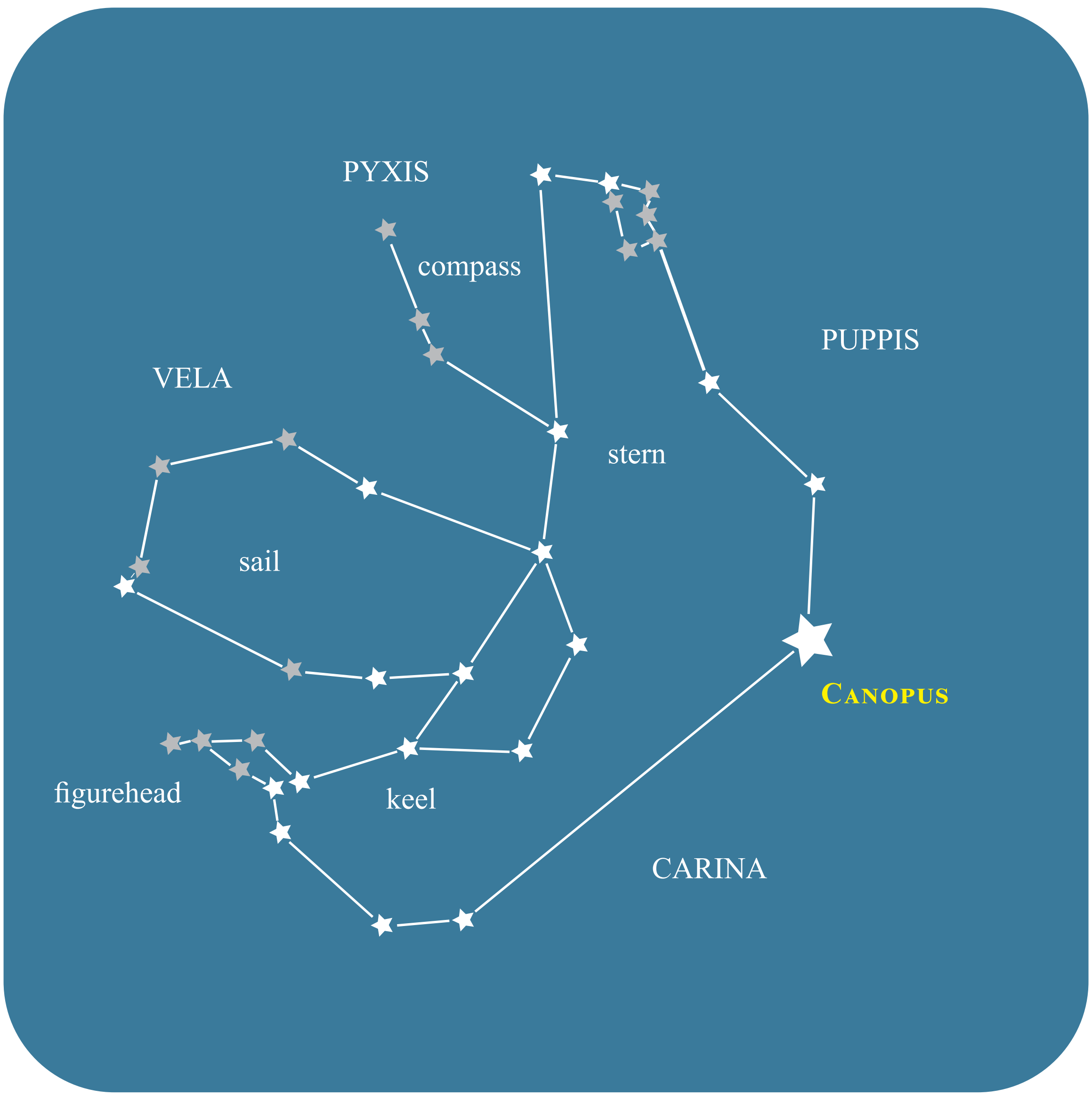


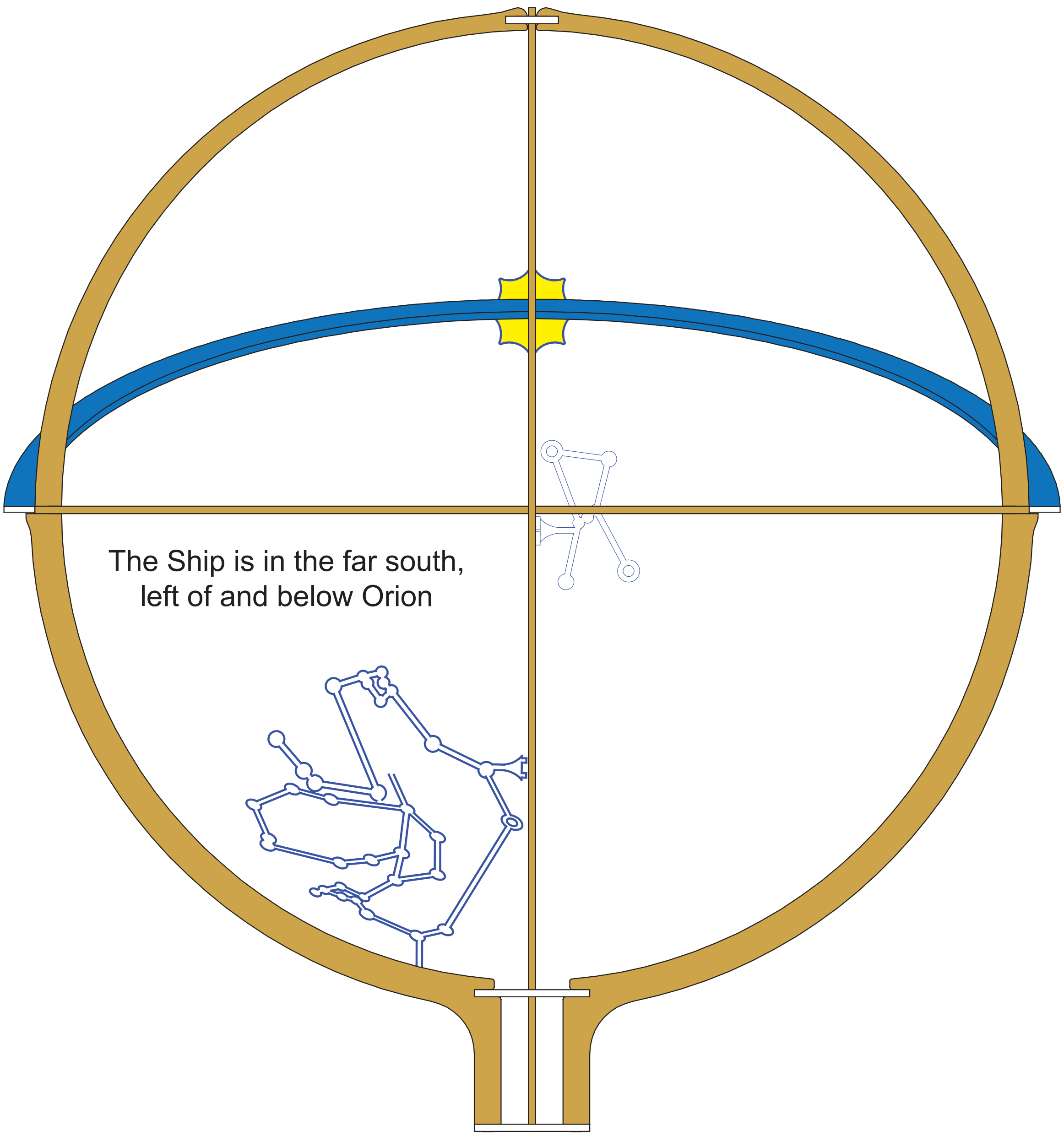


The majority of the Ship remains below the horizon for observers in mid-north latitudes. It comprises four separate constellations: Puppis the stearn, Carina the hull, Vela the sail, and Pyxis the compass.

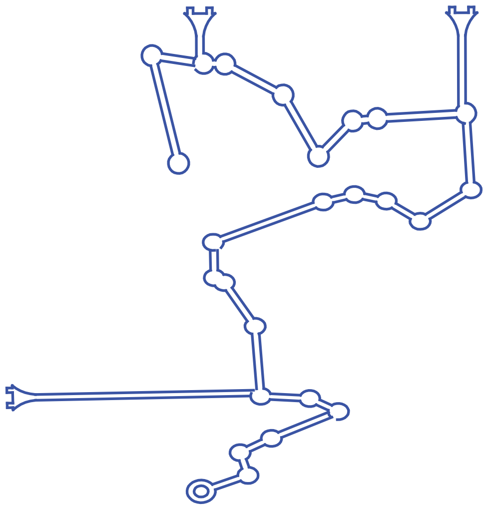
The Ship anchors on the same meridian as Orion. Since the Ship occupies such a large area, it needs to be curved substantially to turn with the sphere without interference.

Stainless steel construction allows you to easily hand-form constellations to fit properly.



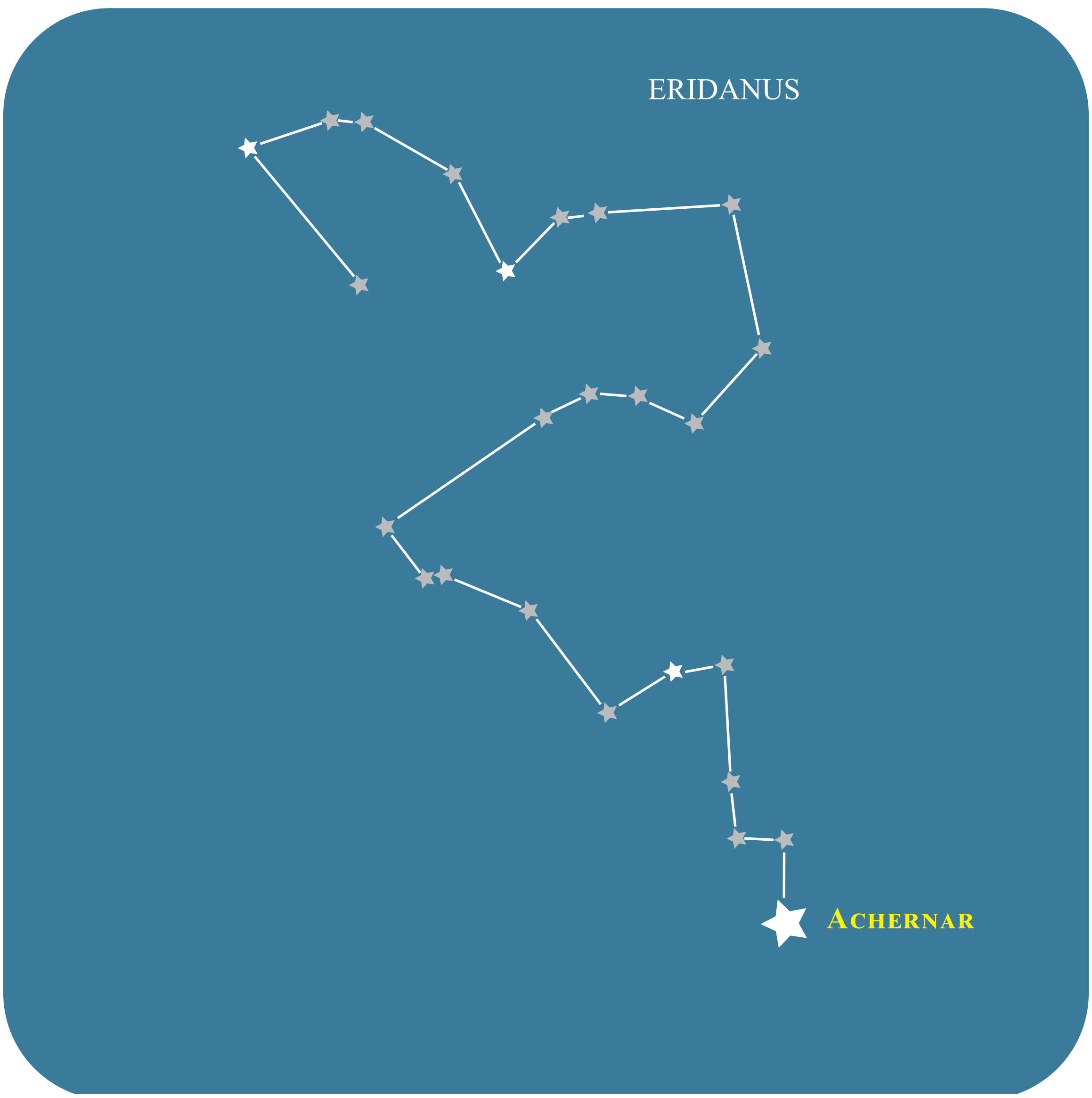


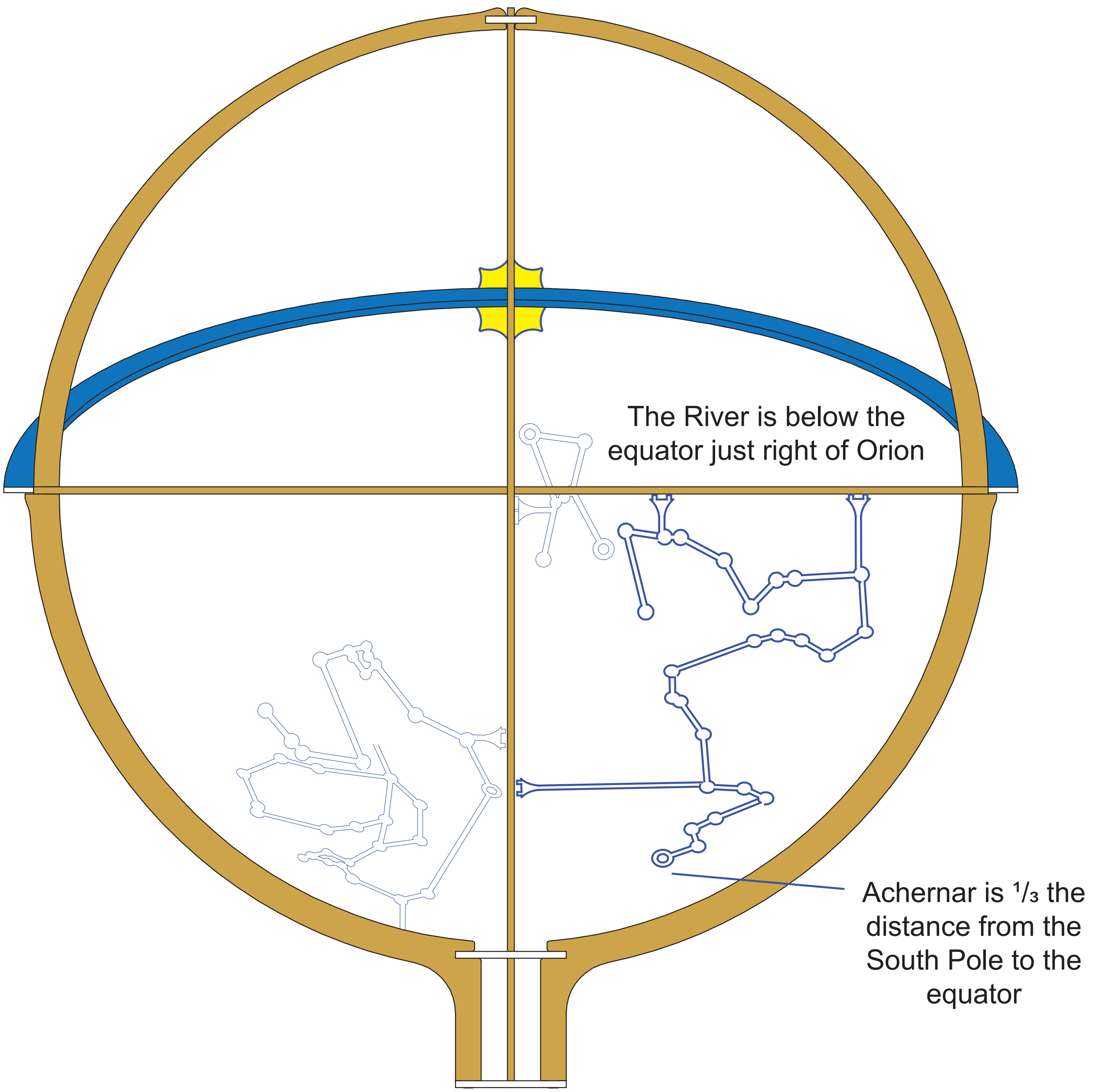
The Ship is in the far south,
left of and below Orion

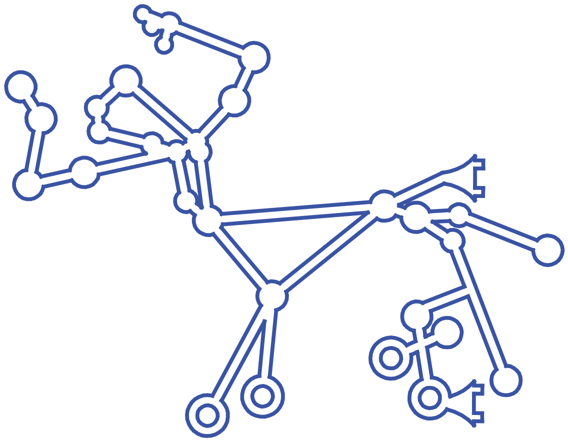


Eridanus is another large-area constellation that will need substantial hand-forming.

It fits below Orion on the leading edge of the meridian. Achernar should be about $^{1}/_{3}$ of the way between the South Pole and the equator.

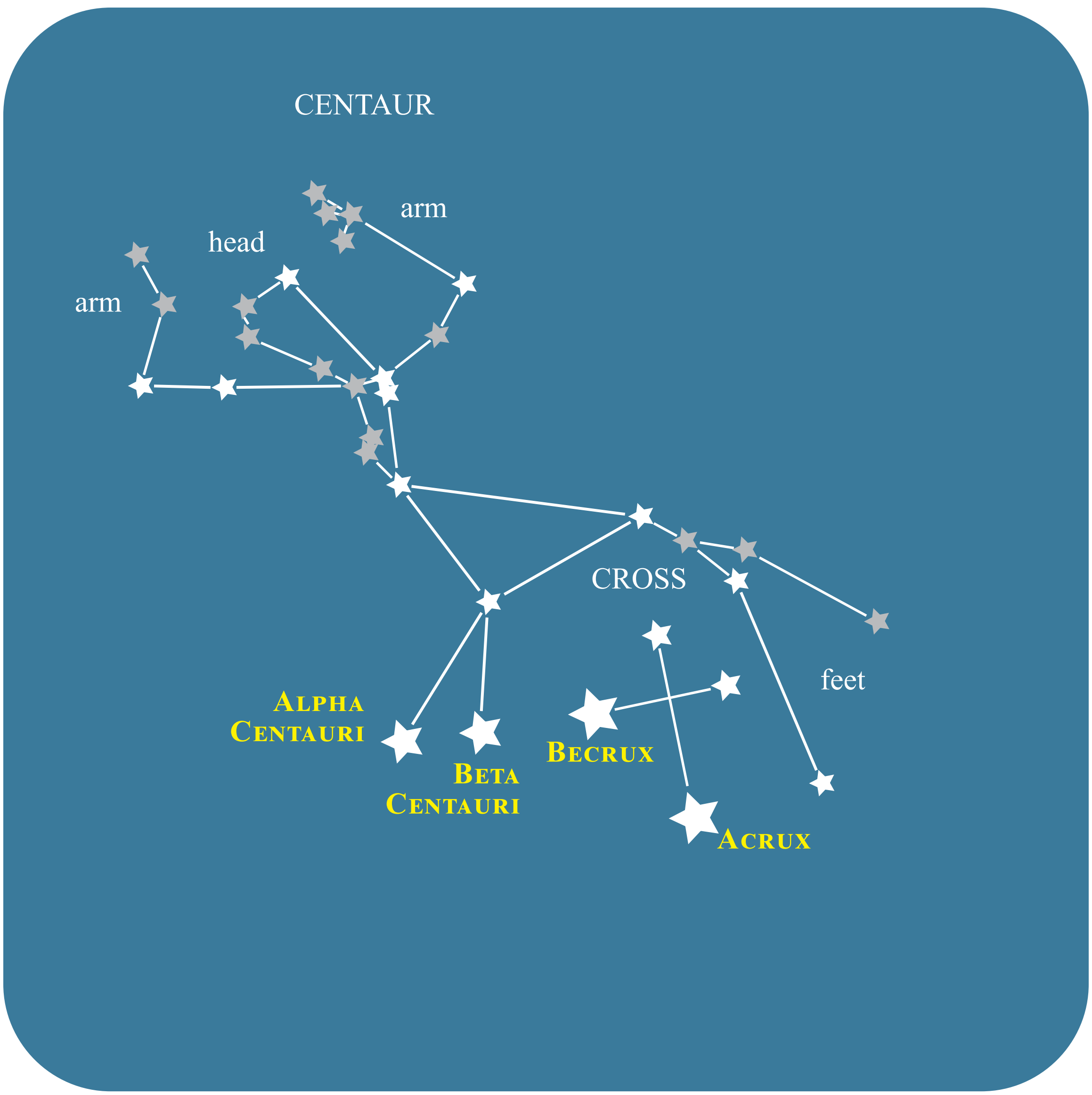


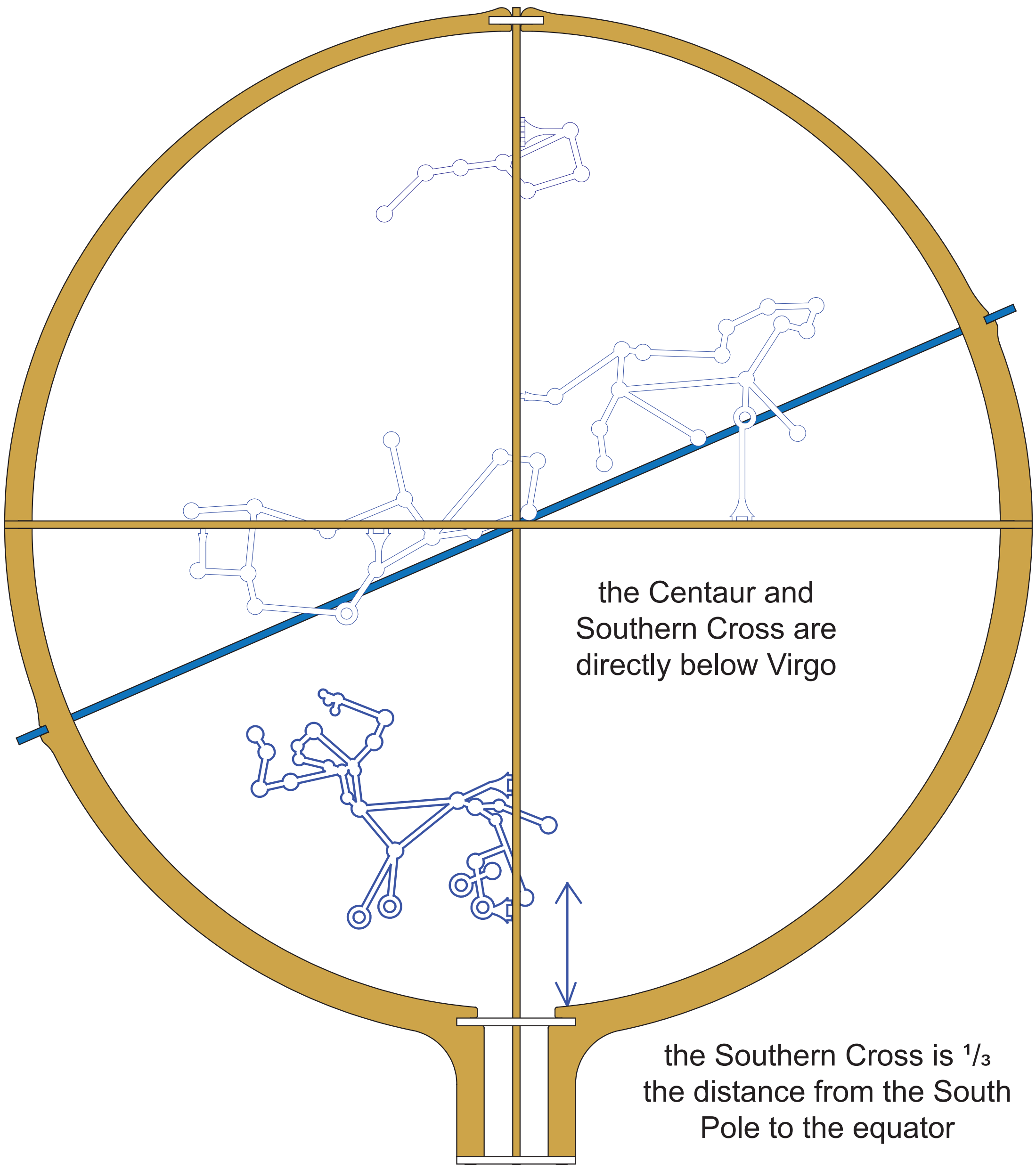

The River is below the equator just right of Orion
Achernar is ¹/₃ the distance from the South Pole to the equator



Centaurus and Crux are combined into one constellation piece. They anchor on the same meridian as the Big Dipper, with the Southern Cross about 1/3 of the way between the South Pole and the equator.

Viewers south of the equator would use the Cross as a guidepost rather than the Dipper.



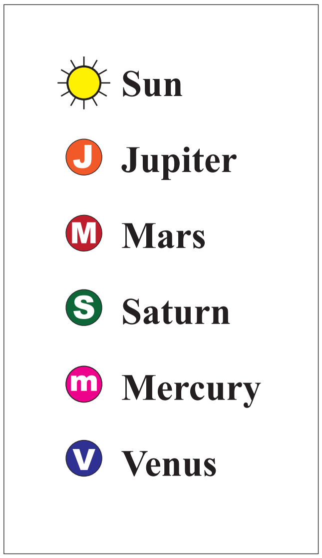

the Centaur and
Southern Cross are
directly below Virgo
the Southern Cross is ¹/₃
the distance from the South
Pole to the equator

The planets all travel on the ecliptic, just like the Sun and Moon. However, each planet travels on its own schedule. To assist in arranging the planets for a particular time, a calendar of planet positions is included in this section.

Here is a quick review of each planet's motion:

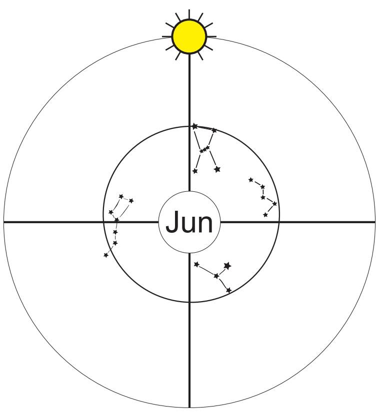
> **Jupiter** catches and passes the Sun in one year, one month. The Zodiac constellations pass Jupiter at a rate of one per year, so Jupiter stays in one constellation for about a year.
>
> **Saturn** moves a little faster, catching and passing the Sun in one year, two weeks. It spends more than two years in each Zodiac constellation. It takes a particular star about 30 years to lap Saturn.
>
> **Mars** catches and passes the Sun in two years, two months, and is lapped by a particular star in one year, 11 months.
>
> **Venus** and **Mercury** are tied to the Sun, so when they appear in a constellation, it is one of the Zodiac constellations just leading or just trailing the Sun.
>
> Venus moves from leading the Sun, to trailing it and back in one year, seven months and Mercury does so in four months. Venus is never more than three hours from the Sun and Mercury is never much more than one and a half hours away.

Keeping track of all five planets, each traveling on a different schedule, can get confusing. A pictorial calendar, which is developed for you in the following exercise, can help keep all the information organized.



A pictorial calendar of planetary positions has been developed to aid in planet placement.

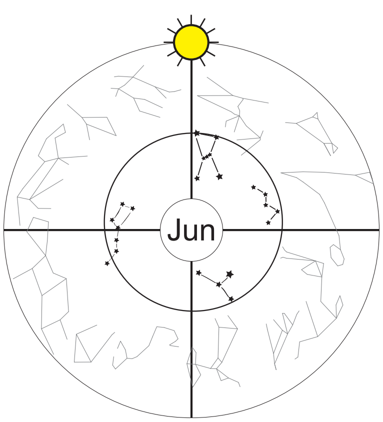
The box on the left displays the Sun and the icons used for each planet. Following is a guide to reading the calendars.



1

Begin with a circle that shows the four Guidepost constellations and the position of the Sun at a particular time.

We've started here with the third week of June (shown in the center of the circle) when the Sun is at the summer solstice and just over Orion's head.

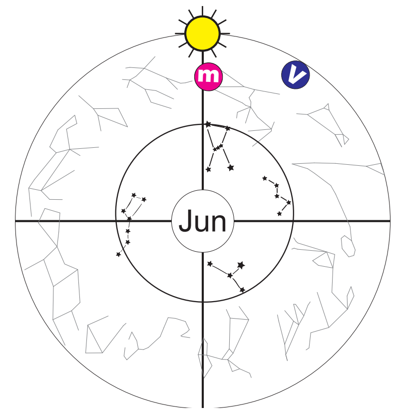


2

Next, add the Zodiac constellations. Since the Zodiac constellations show the location of the ecliptic, this will show us where on the ecliptic a particular planet is at a given time.

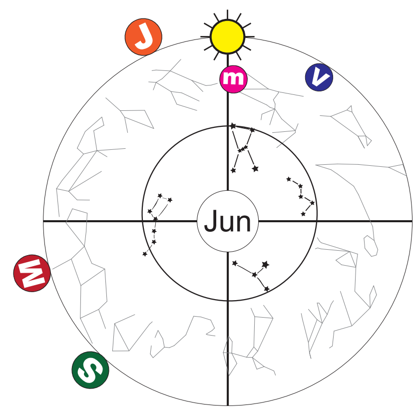
3

The inner planets, Mercury and Venus, are shown as small circles inside of the outer circle. Mercury is shown in pink and Venus in blue.



4

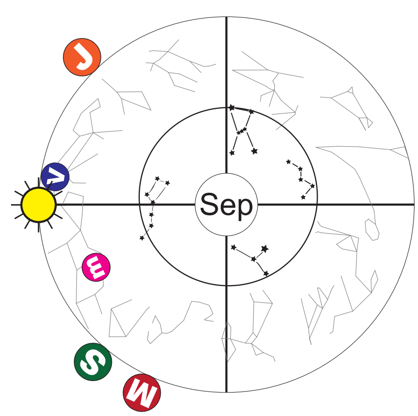
The outer planets are shown as larger colored circles around the circumference. Jupiter is orange, Mars red, and Saturn green.



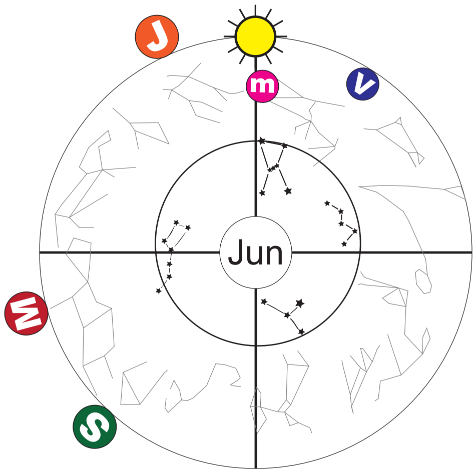
5

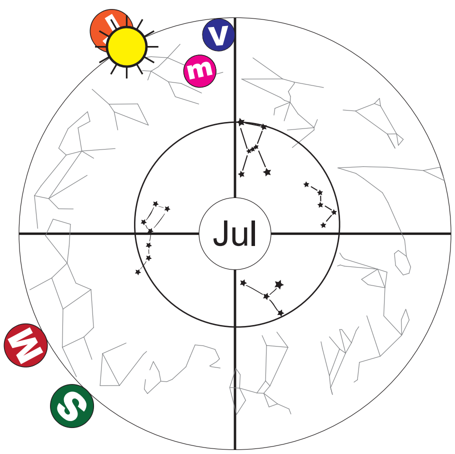
Planet calendars are given in the following pages for each month of the years mid-2014 through mid-2020.

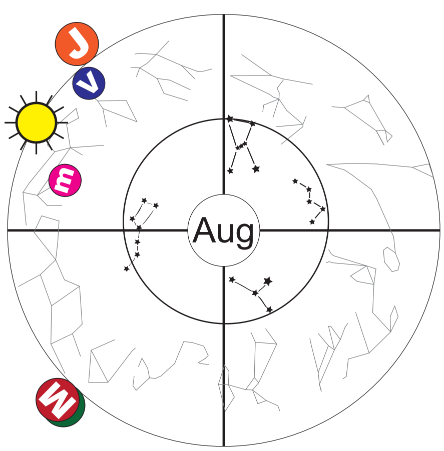
In the calendar pages, the stars are held constant, while the Sun and planets are shown in their relative positions for that month. The third week of each month is shown, so that the times of the solstices and equinoxes are captured.



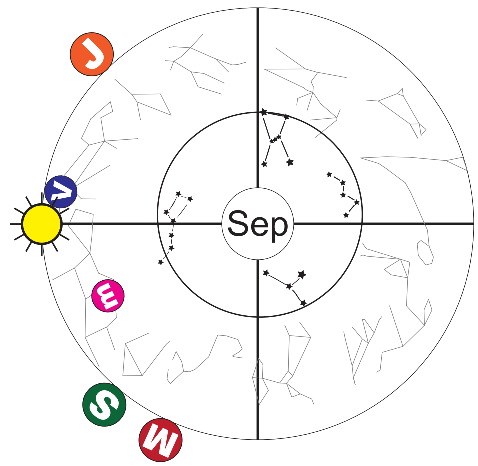
Summer 2014

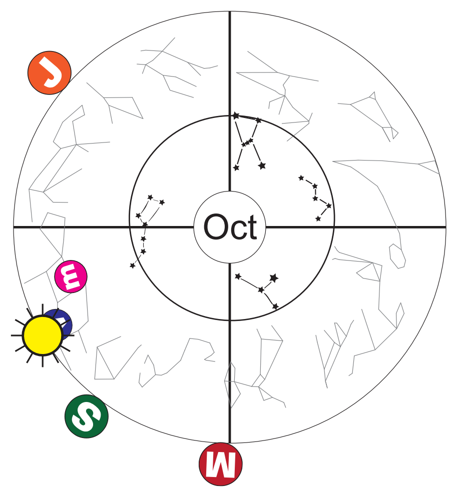


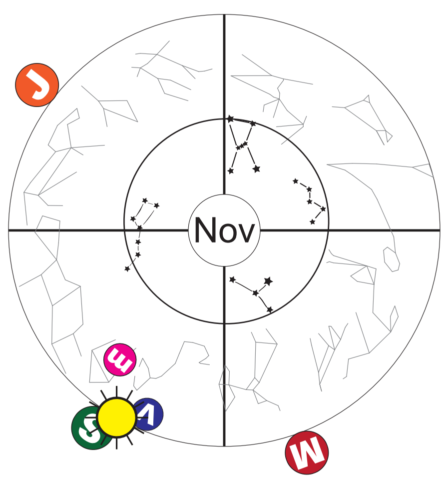




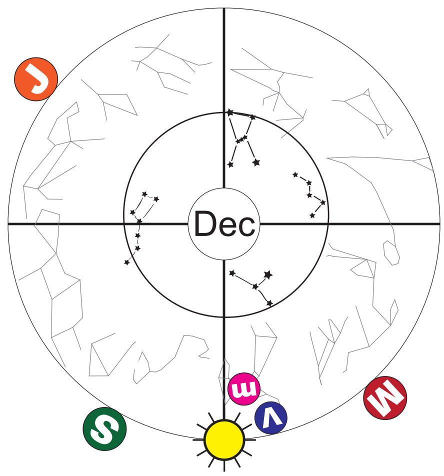
Autumn 2014

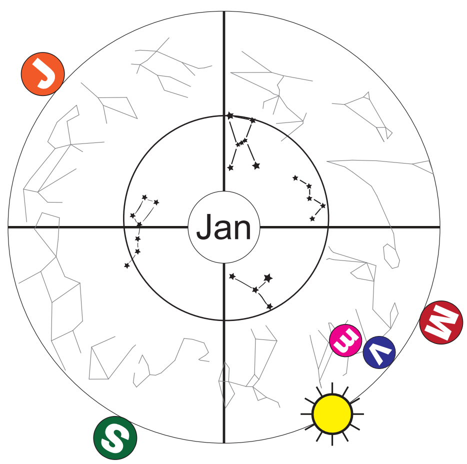


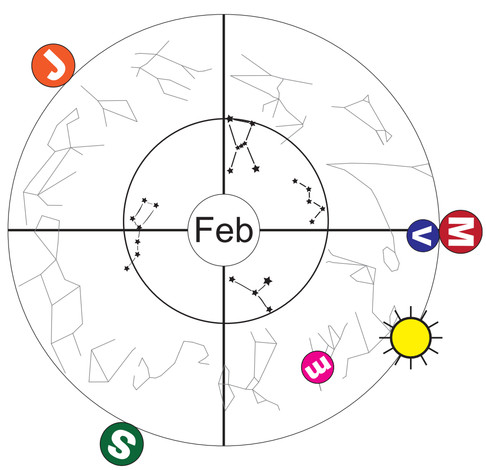




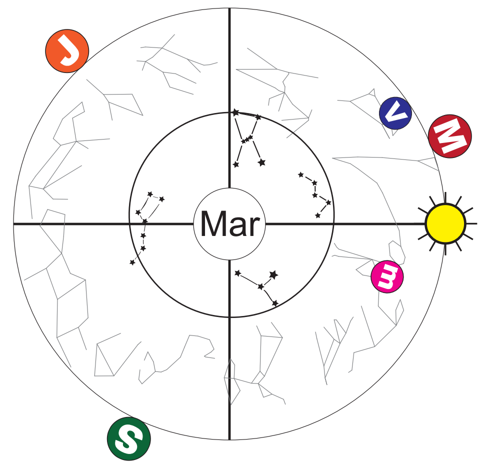
Winter 2014 - 2015

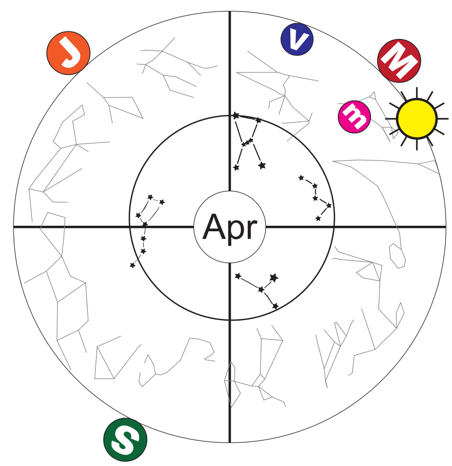


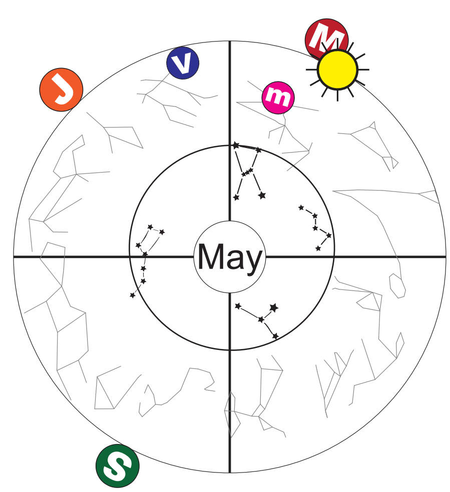




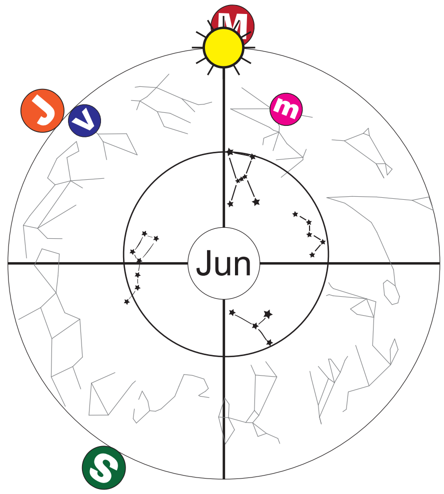
Spring 2015

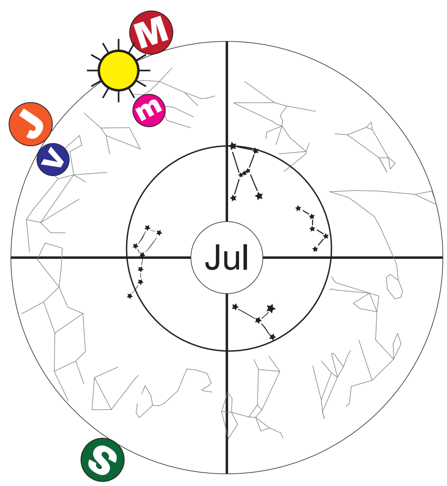


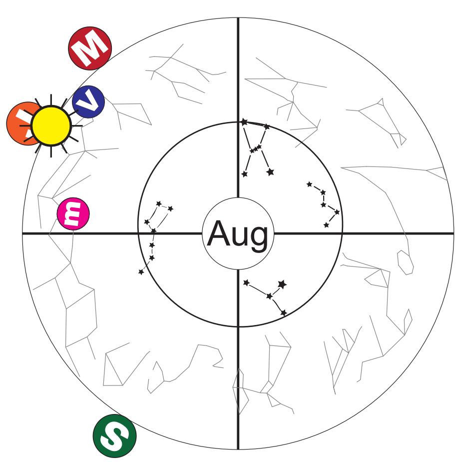




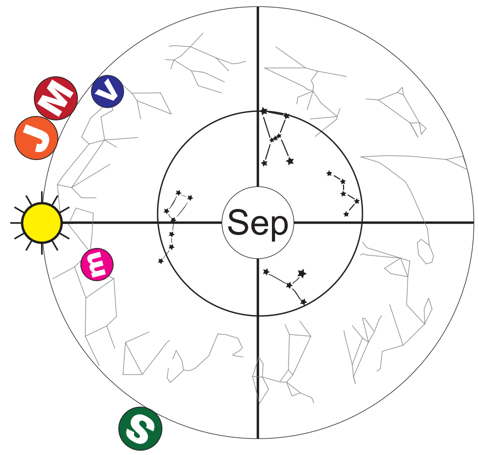
Summer 2015

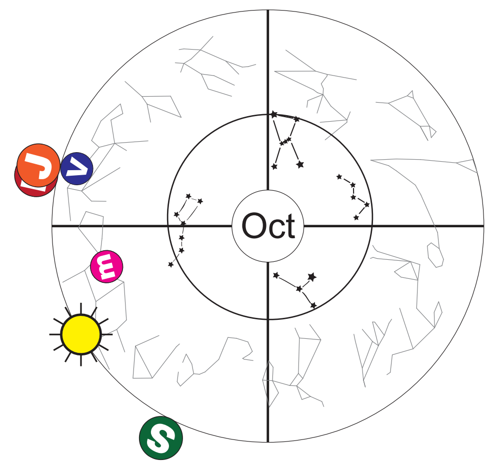


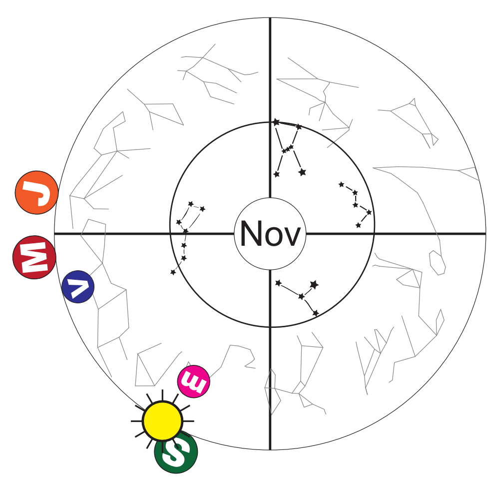




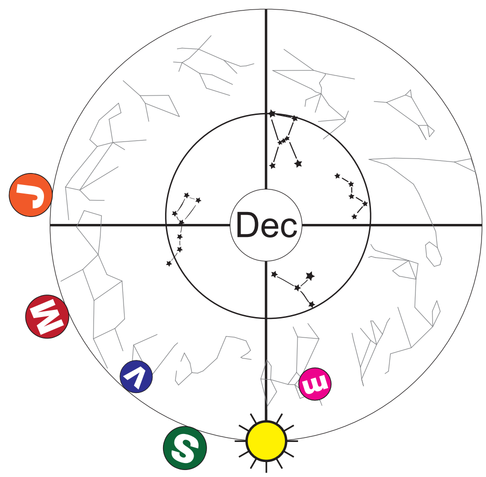
Autumn 2015

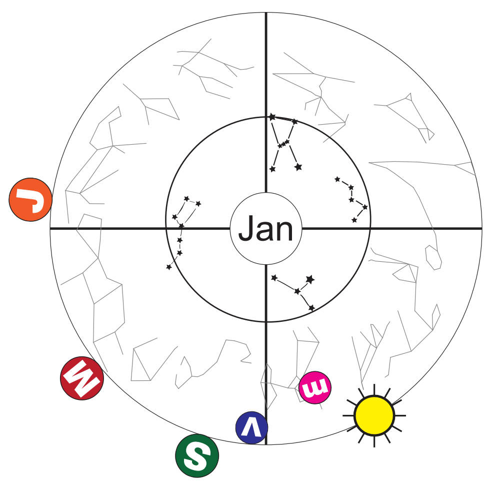


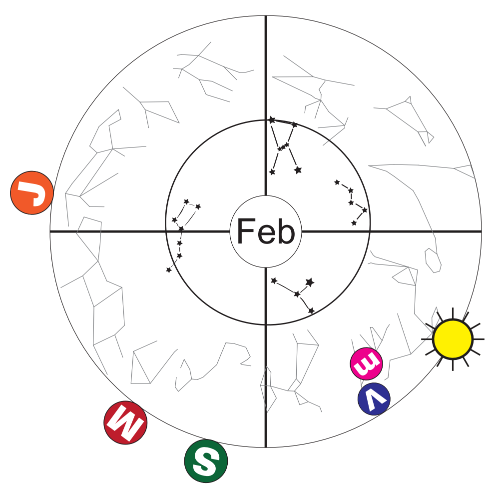




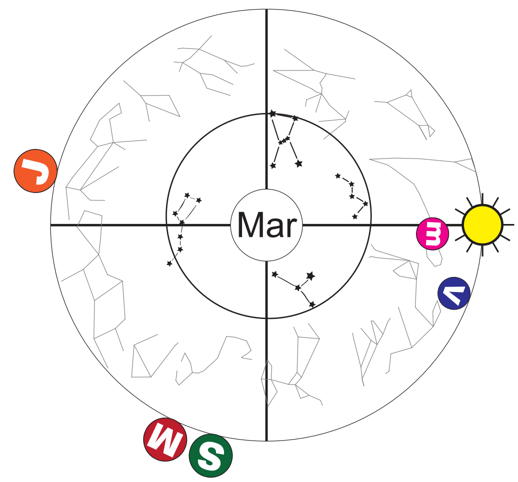
Winter 2015 - 2016

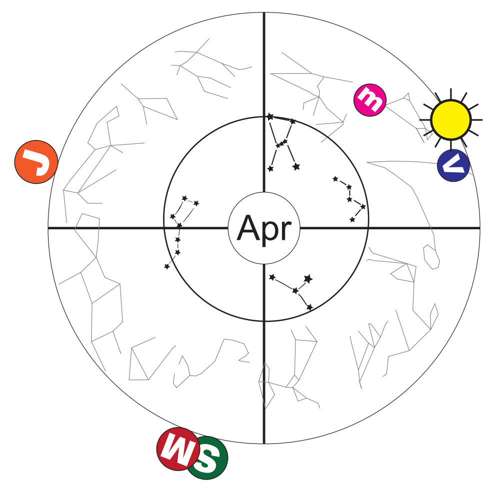


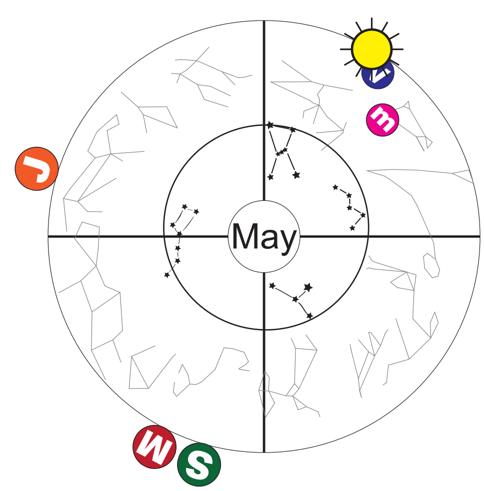




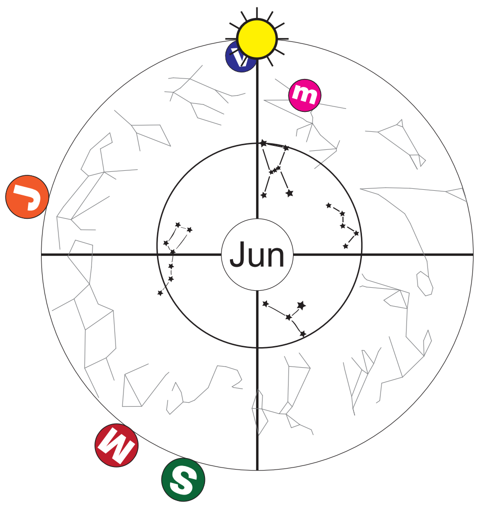
Spring 2016

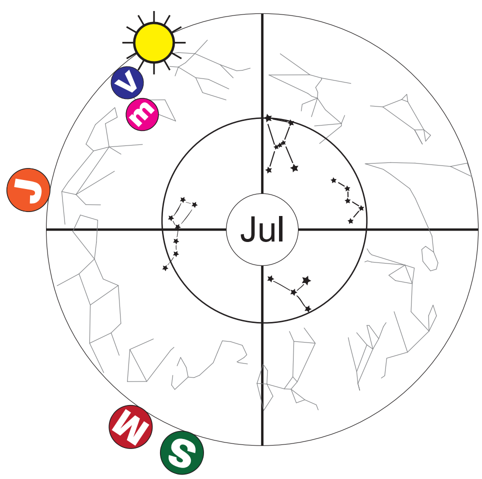


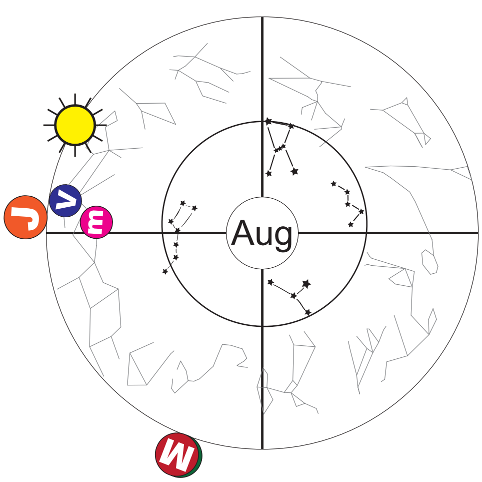




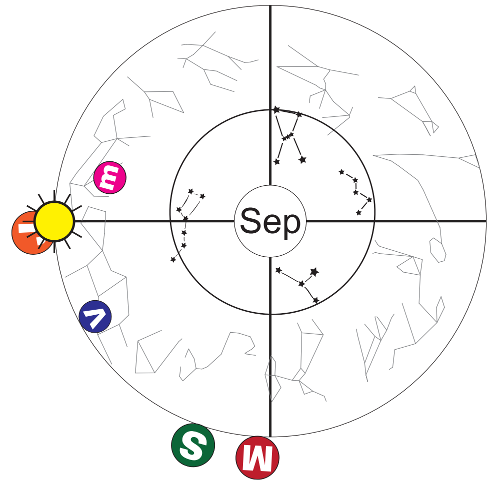
Summer 2016

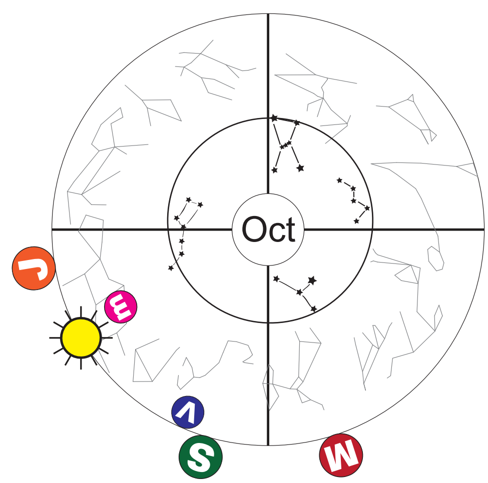


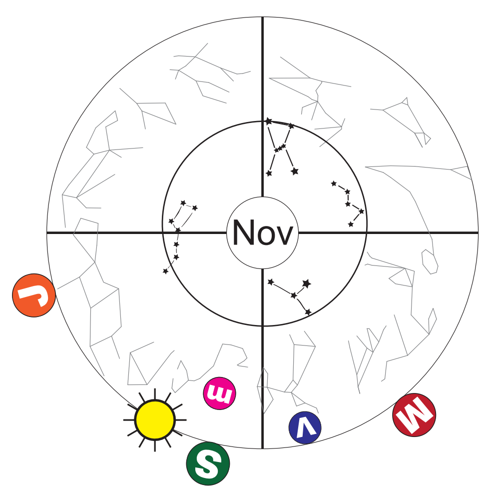




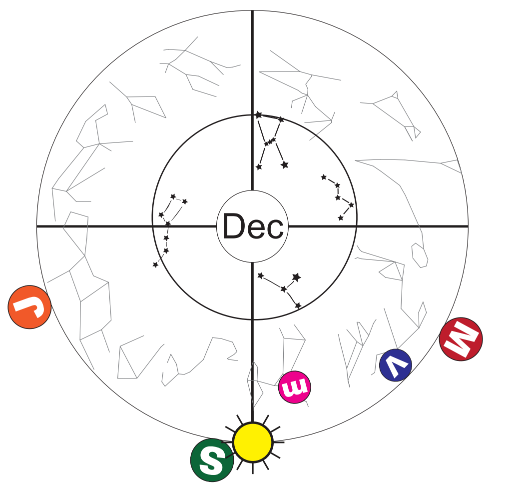
Autumn 2016

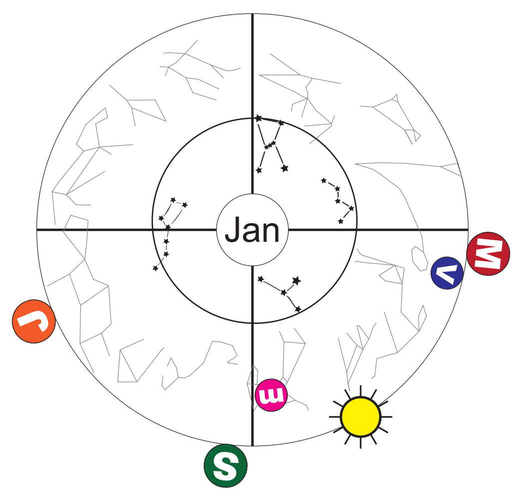


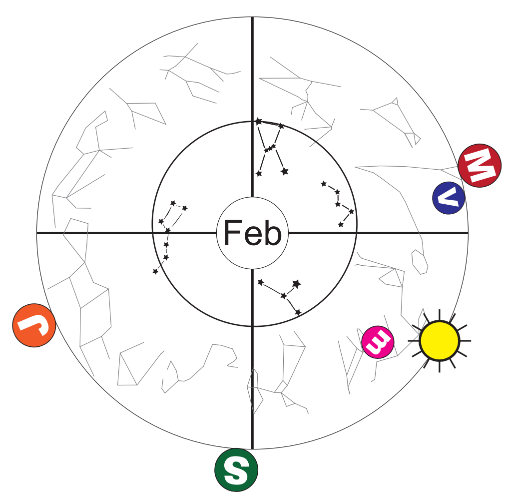




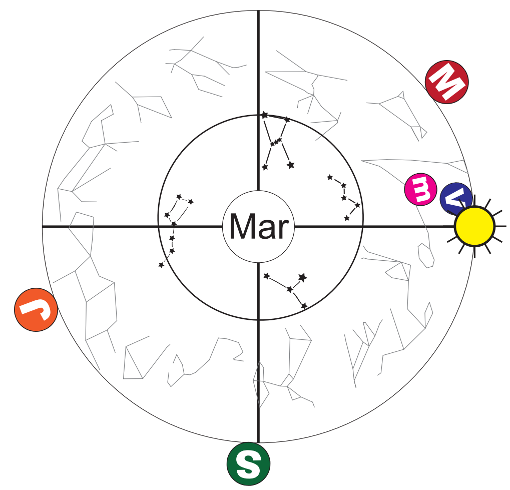
Winter 2016 - 2017

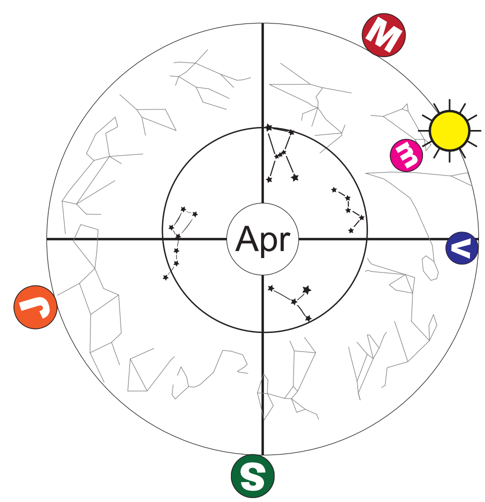


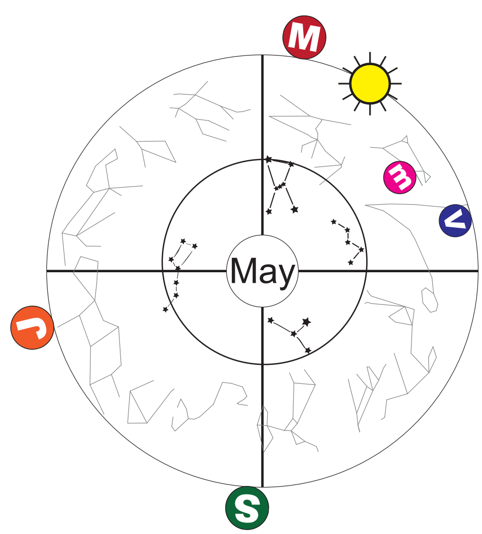




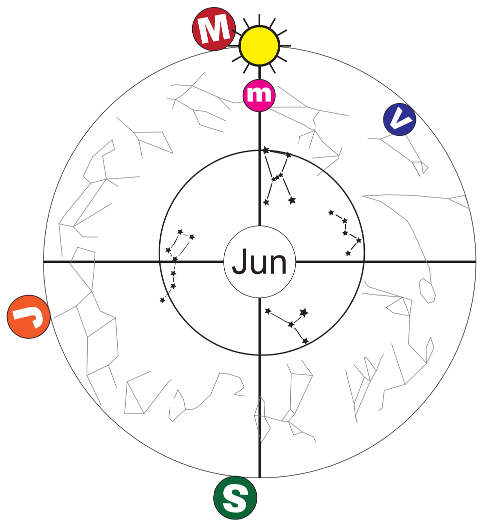
Spring 2017

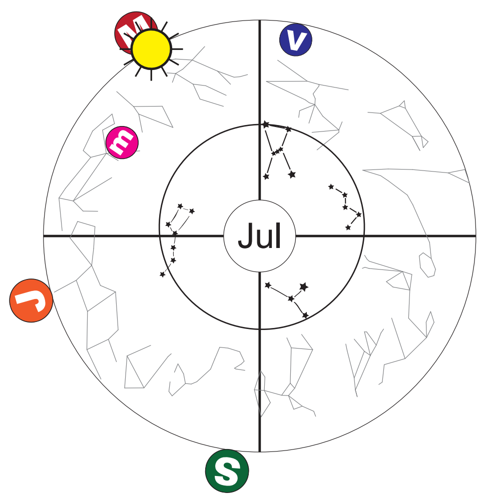


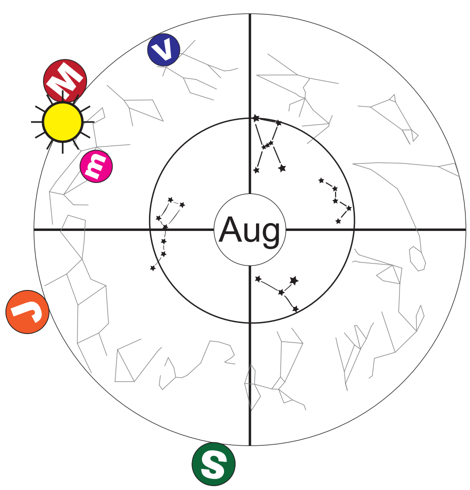




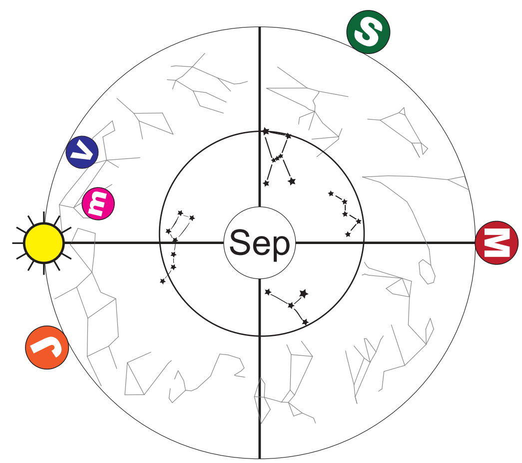
Summer 2017

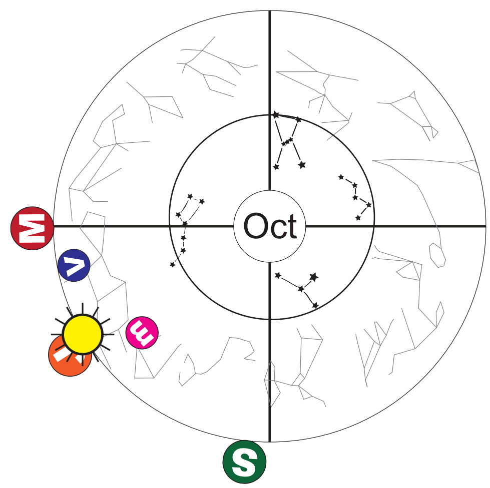


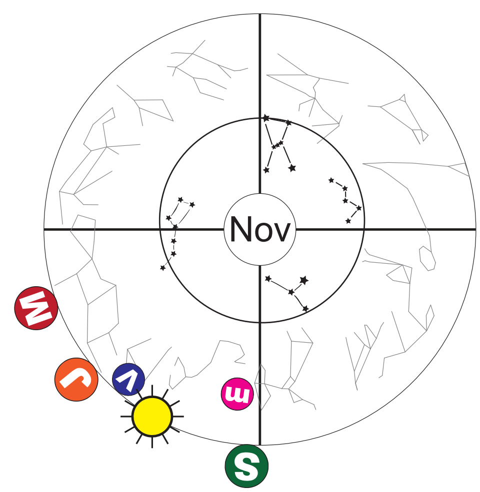




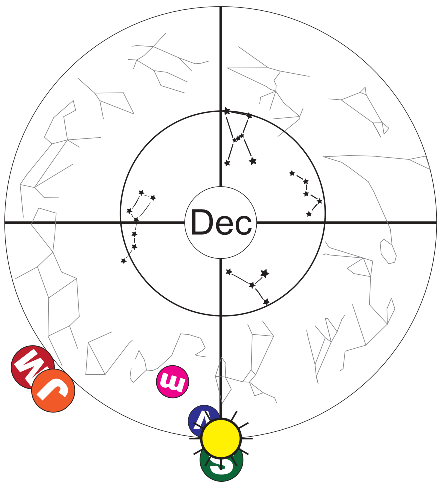
Autumn 2017

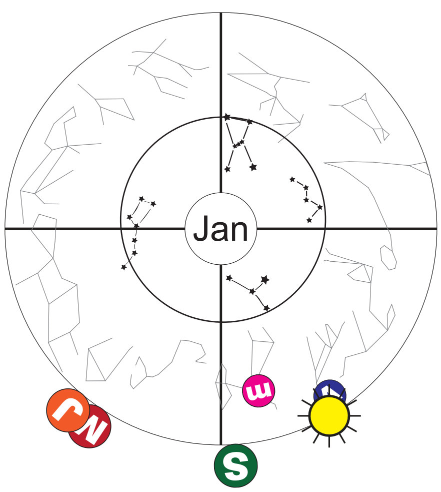


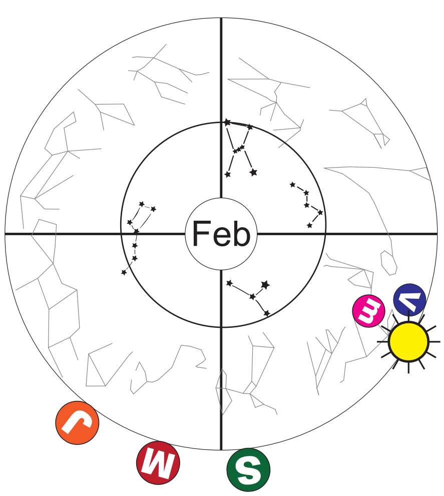




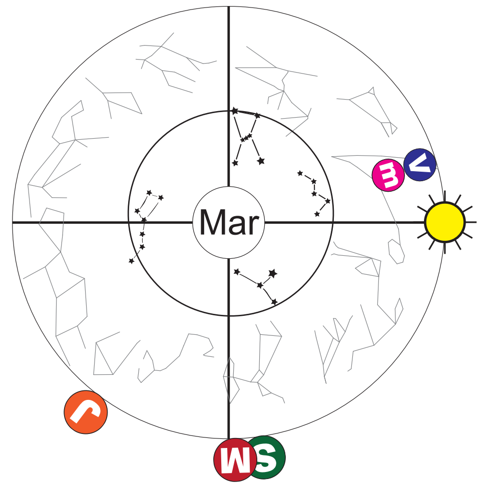
Winter 2017 - 2018

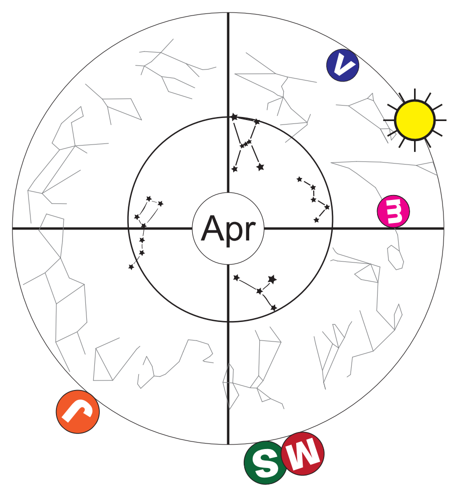


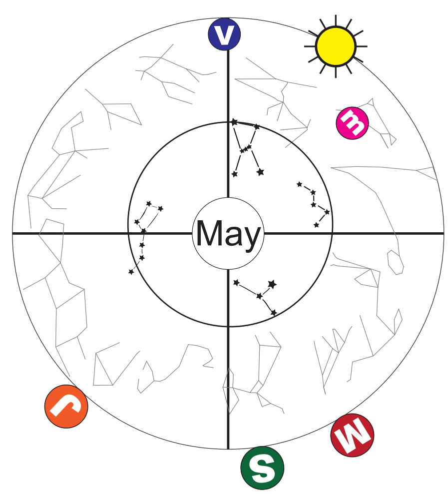




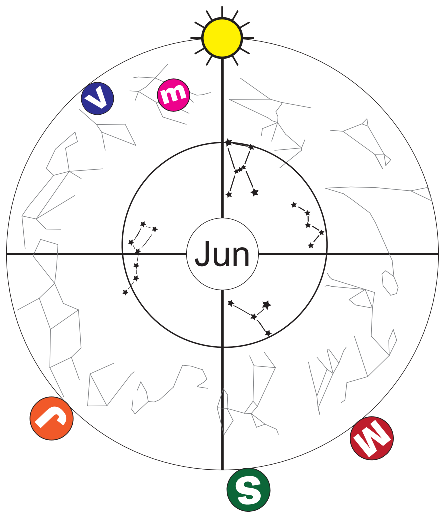
Spring 2018

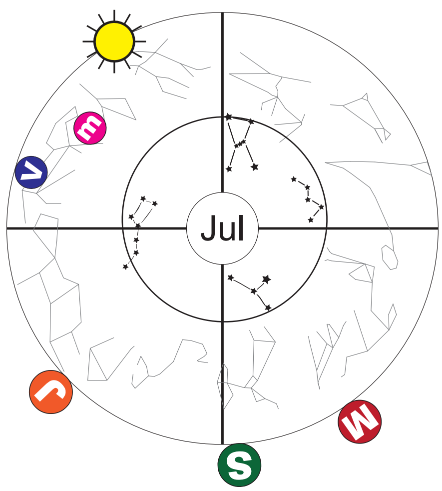


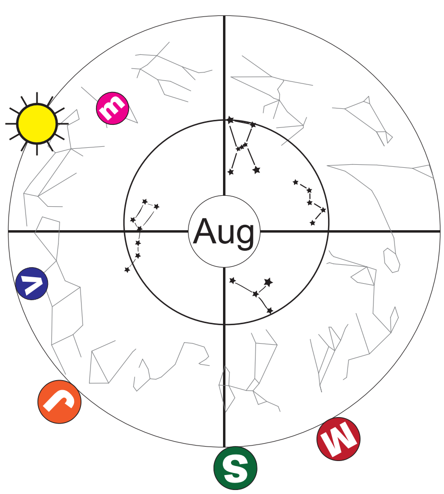




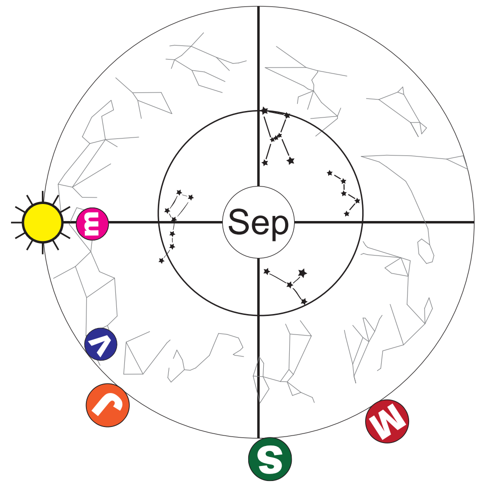
Summer 2018

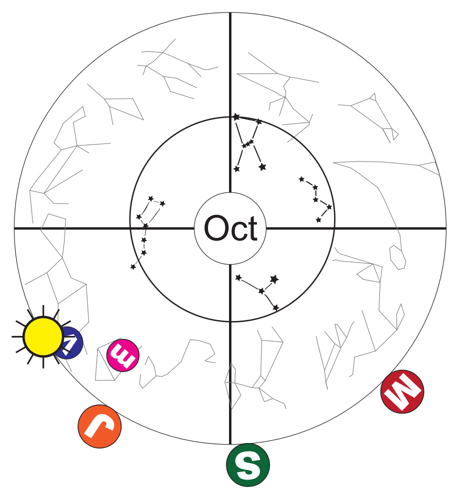


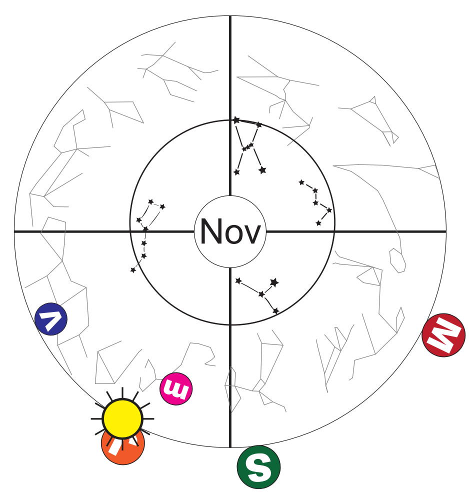




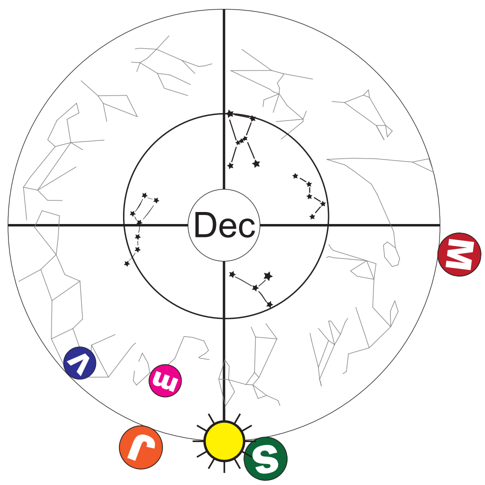
Autumn 2018

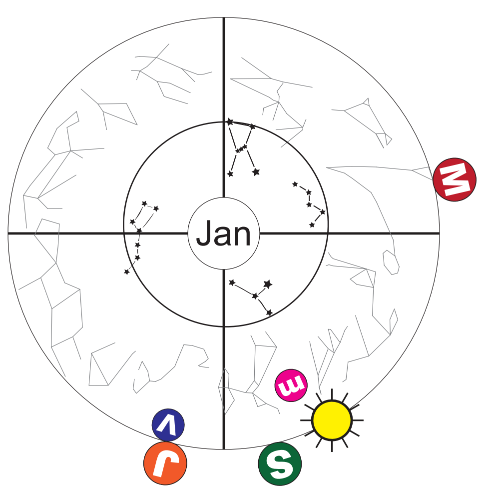


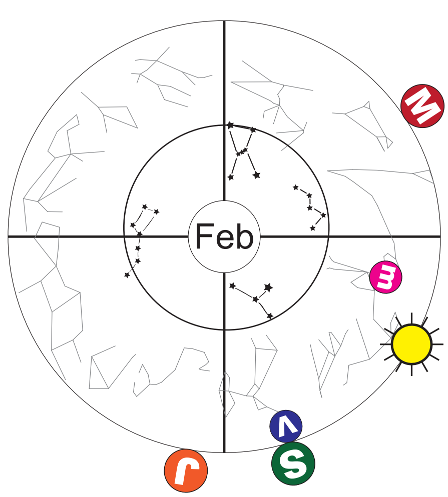




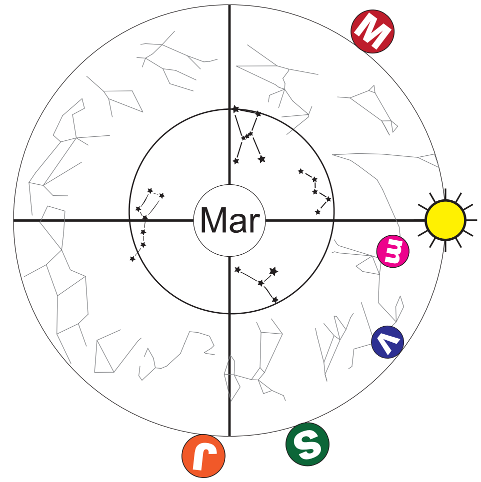
Winter 2018 - 2019

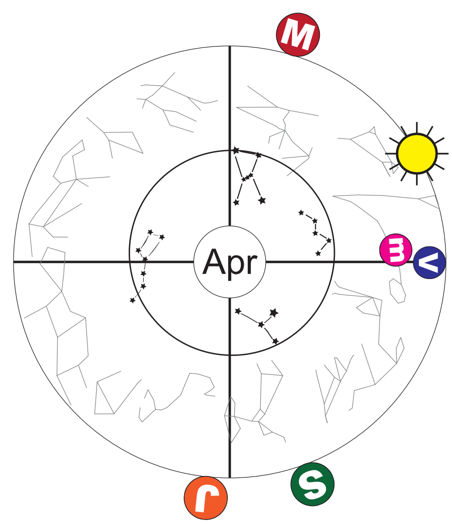


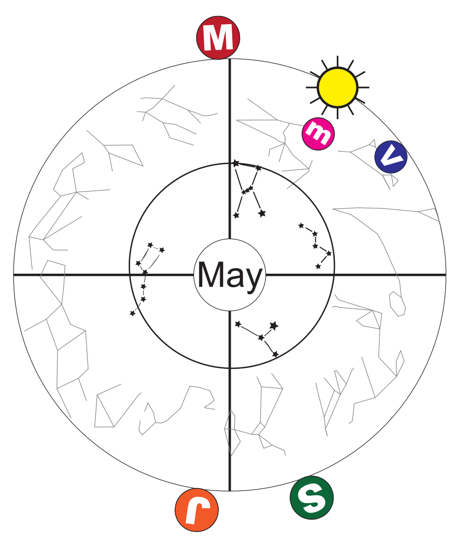




Spring 2019







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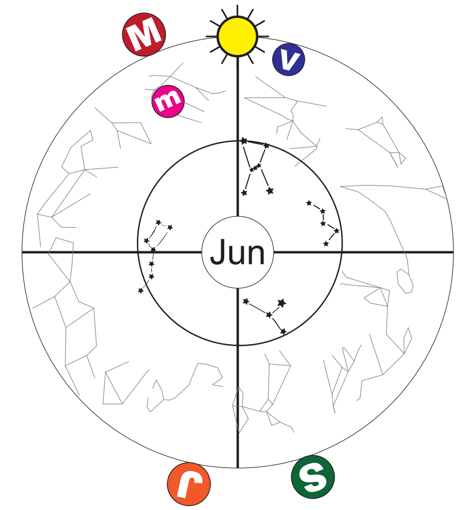

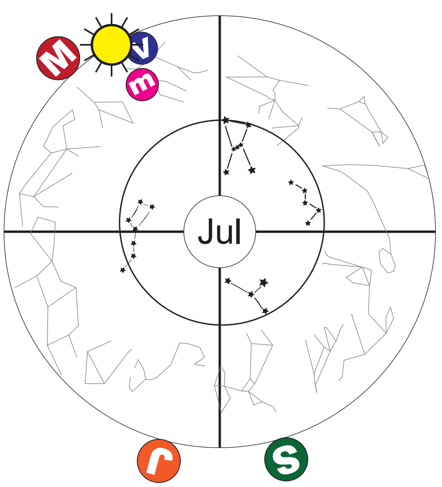

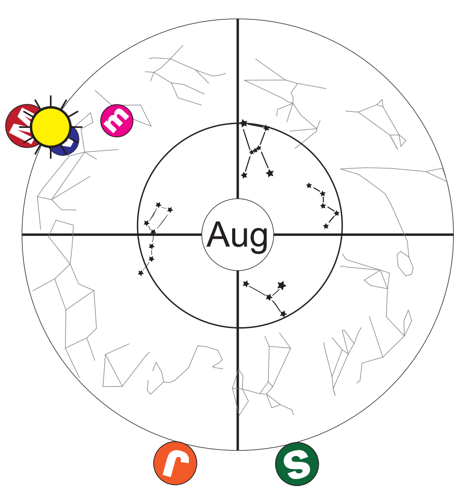

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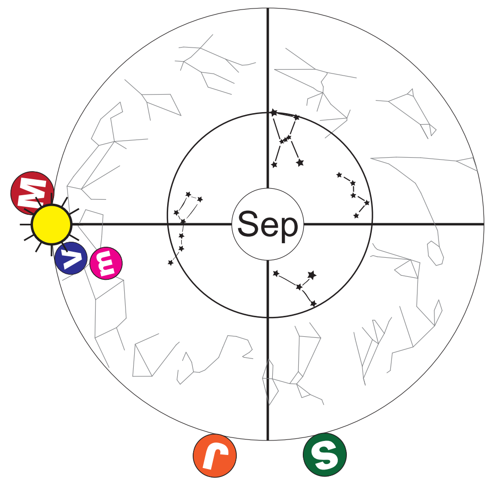
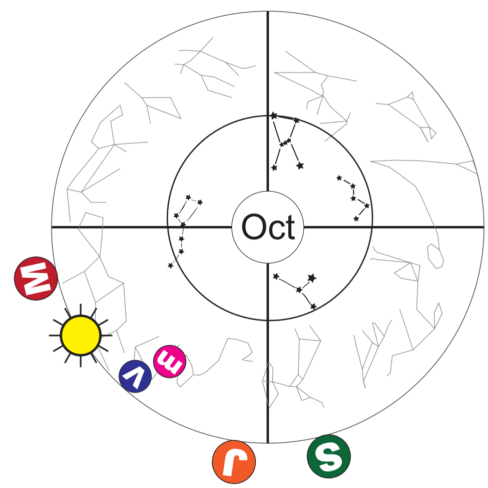
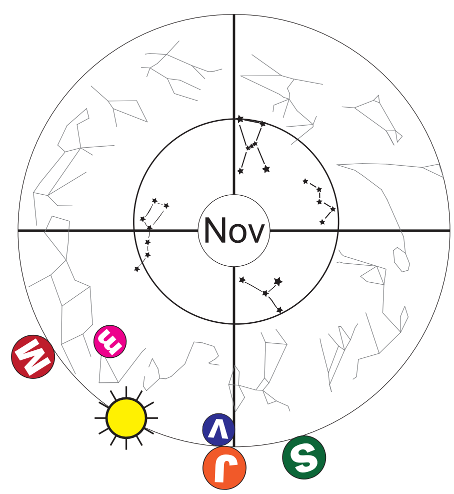
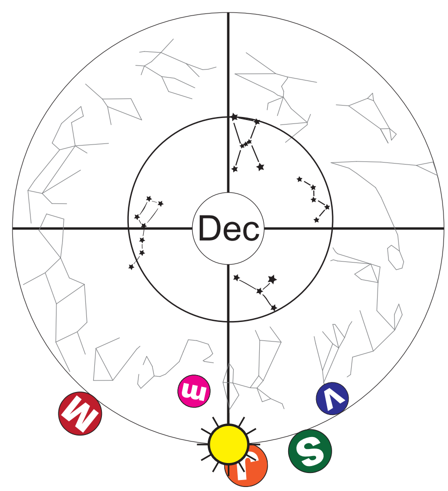
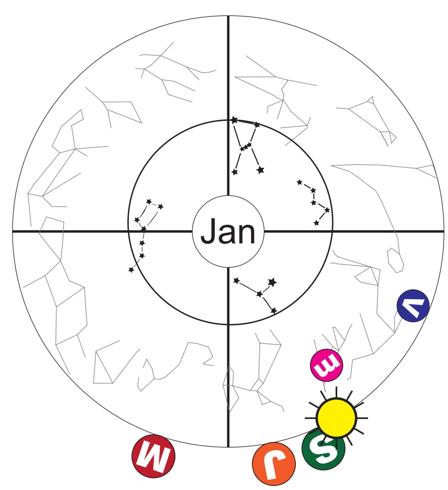


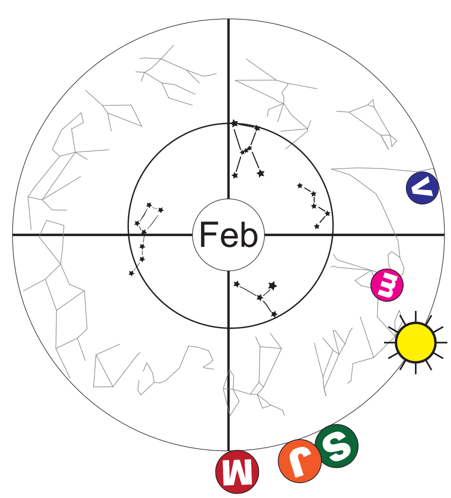




Winter 2019 - 2020







Spring 2020