STARGAZING FOR BEGINNERS

A BINOCULAR TOUR OF THE SOUTHERN NIGHT SKY

Section 1: Basics

Introduction
Choosing Binoculars for Stargazing
Star Names
Stellar Brightness and Magnitudes
Measuring Angles in the Sky

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Introduction

This course introduces you to the bright stars and major constellations visible from the Southern Hemisphere, along with dozens of deep-sky sights of interest within each constellation, such as galaxies, binary stars, nebulae, and star clusters. It assumes you are equipped with nothing more than a simple pair of binoculars, and that you know nothing of astronomy or the layout of the night sky. The course is inspired by the 19th century book entitled *Astronomy with an Opera Glass* by Garrett Serviss, but has been completely updated with new star maps and descriptions, and up-to-date scientific information.

Once you tour the sky through all four seasons with this course, not one person in a thousand will know more about the night sky than you do.

The course begins with a few words about how to select and use a good pair of binoculars. An entirely adequate new pair of binoculars costs the equivalent of US$100-$200, and it's often possible to find a used pair for much less. Binoculars are ideal for beginning stargazers because they are intuitive to use and show a wide area of sky at one time. And they bring into view hundreds of deep-sky objects and thousands of stars that cannot be seen with the unaided eye.

One of the first things you'll notice when you look at the night sky is the amazing variation in brightness of stars. Astronomers use the so-called "magnitude scale" to describe stellar brightness. I offer a few words about how this scale works so you can better understand the sky tours later in the book. If you don't quite follow stellar magnitudes at first, don't worry. After a few nights under the stars, try returning to this section again. It will make more sense.

I've also included a short section that gives you a simple way to measure angular distances using nothing more than your hands and fingers held at arm's length. While simple, this is an essential skill for finding your way around the night sky.

The sky tours cover four three-month seasons starting from June through August, which marks the late Autumn and winter in the southern hemisphere. This starting point is almost completely arbitrary. I decided to begin in June because the constellation Crux, the Southern Cross, is high in the sky and serves as a good starting point for finding your way around. And the brightest, thickest part of the Milky Way is high overhead this time of year, which makes for lovely viewing.

Instead of the standard cramped circular maps of the full sky, I include five basic sky maps for each season: one each looking south, west, north, and east, and one looking overhead. These maps will give you an clear idea of what to expect when you see the sky for yourself each season. And I also include more close-up, detailed maps to accompany each of the dozens of sky tours.

All maps are accurate for a latitude of 35°S, but can be used in most parts of the southern hemisphere with modest mental adjustments.

All maps in this course have been created using the application *SkyX* by Software Bisque Incorporated, and Stellarium version 0.10.6. SkyX is a professional-grade application, but Stellarium is free, and it's a wonderful tool for all amateur astronomers. While it's not required to use this book, you can download Stellarium at www.stellarium.org. It's a great personal planetarium and learning tool and you'll turn to it frequently.

While this course makes it easier for you, it still takes a little effort to learn the stars of the deep southern sky. Take it slowly, and just try to learn a little more each night. After a few nights, you will be amazed at how much you've learned.

And above all, as Garrett Serviss said, so many years ago…

"Do not be afraid to become a star-gazer. The human mind can find no higher exercise. He who studies the stars will discover, 'An endless fountain of immortal drink; Pouring unto us from heaven's brink.'"

Brian F. Ventrudo, Ph.D.
Publisher, One-Minute Astronomer
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Choosing Binoculars for Stargazing

Why Binoculars ?

A century ago, many casual stargazers explored the night sky with an "opera glass", a pair of small side-by-side telescopes used to get close-up views of indoor events. These were simple instruments by today's standards. The objective lenses of an opera glass had diameter of 30-40 mm. And their magnification was perhaps 3-4x: quite reasonable for watching La Boheme from the balcony, but minimally acceptable even for casual astronomy. Today, such an instrument would be considered a toy, not a serious piece of optics.

Few could afford a pair of "field glasses", what we call binoculars, a century ago. But today, a good pair of new binoculars can be purchased for less than $100-200, and a quality second-hand pair for considerably less. And the materials and manufacturing techniques used today far exceed the capabilities of the even a few decades ago. The stars remain the same, but optical technology moves ahead.

Opera glasses in their natural environment

Modern hand-held binoculars have objective lenses of at least 35-70 mm aperture, and use internal prisms to allow wide separation of the objectives while keeping the eyepieces close enough for comfortable viewing. The generous aperture of most binoculars helps bring out fainter objects than opera glasses. And magnification of 7-15x makes binoculars more effective in resolving fine detail and rendering a darker background in light polluted sky.

But if you're learning the night sky, why use binoculars at all? Why not a telescope?

Binoculars are less expensive than a telescope, of course. And they are easier and more intuitive to use: you just grab a pair and head outside and start looking.

But for beginning stargazers, the biggest advantage of binoculars is their large field of view. A typical pair lets you see 5 to 8 degrees of sky, about the width of four fingers held at arms length. A telescope lets you see a field of view of less than one degree, which is like looking at the sky through a drinking straw. It's confusing and frustrating for beginners because you can't see very much at once.

Despite their small size, as you'll learn in this course, a modest pair of binoculars lets you see as many as 100,000 stars, hundreds of star clusters and nebulae, supernovae remnants, and galaxies. Yes, a telescope is essential for the serious amateur astronomer. But binoculars are the place to start.

Binocular Basics

All binoculars are marked with two key numbers: magnification and aperture. A pair marked "7×50″, for example, magnifies 7 times (or 7x) and has objective lenses 50 mm in diameter. The bigger the lenses, the fainter the objects you can see. A pair of 50 mm lenses will collect 50-60 times as much light as your dark-adpated eye.

For astronomy, more aperture is better. A 10×80 pair lets you see fainter objects than a 10x50 pair. The trade-off? Bigger lenses means more weight, and anything larger than 50 mm makes them hard to hold for any length of time.

Higher power means you'll see more detail and a darker background sky. But you'll see a narrower field of view, and it's harder to keep a high-power pair of binoculars steady enough to see fine detail, since the shaking of your arms is also magnified. For hand-held use, magnification of 7-8x is optimum.

Mounting binoculars on a camera tripod helps a lot, and lets you use higher power and larger lenses… you get the best of both worlds. Some binoculars come with a pre-drilled hole for mounting. But most smaller binoculars do not, and you have to buy an adapter for your binoculars with the correct ¼-20 mounting hole if you want to mount them on a tripod.

Some binoculars are marked with the size of the field of view, either in degrees or "feet at 1000 yards". This tells you how wide a scene you'll see. For a fixed lens size, higher power means the field of view is lower. So you'll

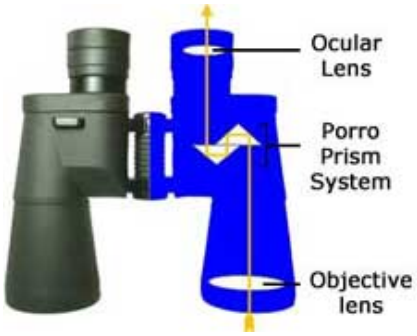
see less sky with 10x50 binoculars, for example, than you will with 7x50 binoculars.

A pair of binoculars with porro-prisms: ideal for astronomy

Another key measure of binoculars is the "exit pupil", the size of the bright disks of light you see in the eyepieces when you hold the binoculars at arms length. For astronomy, you want the size of these disks to be no larger your eye's pupils when dark-adapted. Otherwise the light collected by the lenses doesn't enter your eye. It's not a problem if this happens: you're just wasting light.

The exit pupil is simply the ratio of aperture to magnification. So a 7×50 pair has an exit pupil of 50/7 = 7 mm (roughly), and a 7×35 pair has a 35/7=5 mm exit pupil.

Under age 30, most people have a dark-adapted exit pupil of 7 mm. But we lose about 1 mm every 10-15 years. At age 50, for example, it may not make sense to use binoculars with an exit pupil larger than 5-6 mm. So if you're older, a pair of 7×35's might be a better choice than a pair of 7×50's. The extra light from the 7x50's won't reach your eye, and they're more expensive and heavier.



The light path of porro-prism binoculars

How To Choose Binoculars

How do you select a pair of binoculars? Some may disagree, but if you pay less than $75 for a new pair of binoculars, you'll be disappointed with the quality of what you get. On the other hand, almost no one needs to pay more than $300-$400 for an excellent pair. Between $100-200, you'll be spoiled for choice.

Stick with binoculars that use porro-prisms, the classic type of binocular where the objective lens and eyepiece are offset. Binoculars that have a "straight-through" view use roof prisms, and a good pair is expensive. You don't need to pay the premium.

Avoid binoculars with a zoom feature or a built-in camera. They don't make the grade for astronomical use.

When selecting a pair, pick up the binoculars and look at light reflected in the objective lenses. If the lenses have a good anti-reflection coating, they'll appear mostly dark, with a bit of reflected color. If the lenses appear white, or ruby red, don't buy them.

Next, look through the lens at the prisms inside. A good anti-reflection coating shows a colored prism surface. A white surface means no AR coating, which is not recommended.

Now hold the pair away from your face with the eyepieces toward you. Look at the bright disk of the exit pupil. The disk appears round if the prisms use a high-grade glass called BAK-4. If the disk appears squared-off, the prisms are made from lower-grade BK-7 glass, which is acceptable, but not optimum.

If you're near or far sighted, you don't need to wear your glasses when looking through binoculars. You can simply adjust the focus of the binoculars to compensate. But if you have astigmatism, you will need your

glasses. Make sure you can see right to the edge of the field of view of the binoculars while wearing your glasses.

Now look through the binoculars, and bring an object into focus at the centre of the field of view. A decent set of optics will hold focus out to the edge of the field. It may not be perfectly focused at the edge, and that's alright. But if the edge of the field is way out of focus or highly distorted, move on to another pair.

What separates a $200 pair of binoculars from a $2000 pair with the same magnification and aperture? The complexity of the AR coatings, the quality of lenses and prisms, and the precision of the lens shape. An expensive pair gives crisp, high-contrast views without distortion right out to the edge of the field. Nice to have, especially for daylight use, but not critical for casual astronomical use.

Image-Stabilized Binoculars

Although they are expensive, image-stabilized (IS) binoculars give stunning low power views of the sky without the dreaded image shake of standard binoculars. And no tripod is required.

Many rave about these technical wonders for astronomy or terrestrial use. In IS binoculars, piezoelectric motion sensors detect pitch and yaw movements. The motion signal feeds into a microprocessor, which initiates image stabilization by controlling a vari-angle prism-- a pair of glass plates joined by flexible bellows. The space between the plates is filled with a silicon-based oil to maximize image deflection.

The motion sensors work in light or total darkness and operate at any orientation, so there are no restrictions on where the binoculars can be pointed… up, down, sideways, anywhere.

When you switch on the IS feature, the image does not "freeze", but rather wanders slowly enough for your eye to follow. And the IS works when you sweep across a field of view, although there is a slight hesitation.

IS binoculars are battery hogs. You can burn through a pair of alkaline batteries in 5 minutes on a cold night. With rechargeables, you might get 2 hours. Of course, you can turn off the IS feature when you're not using it.

Nikon, Canon, and Fujinon, among others, offer some type of image stabilization. Canon models seem to have the widest following among amateur astronomers. A reviewer said of Canon's 10×42 IS binoculars, "These are simply the finest binoculars I have ever used for astronomy". At

the time of publishing, these binoculars cost about US$1,200. But smaller pairs are available for as little as $300.

If you have dark sky and if you can afford a pair of IS binoculars, they are highly recommended.

Canon 12x36 image-stabilized binoculars

Star Names

Bright stars such as Rigel, Sirius, Aldebaran, and Capella were named by classical Greek and Arabic astronomers thousands of years ago. But fainter stars went unnamed until Renaissance astronomers and their heirs began to formalize star names in each constellation by assigning lower-case Greek letters in order of brightness. So, for example, the brightest star in Cygnus, Deneb, is assigned the name α Cygni (alpha Cygni), and the second brightest star in Cygnus, Albireo, is assigned the name β Cygni (beta Cygni), and so on, through gamma and delta and the entire Greek alphabet. If you're rusty with Greek, a summary of the letters is found on the next page.

In some cases, either because of error or otherwise, the stars do not always follow the order of brightness. Castor is the brightest star in Gemini, for example, yet it's labeled β (Beta) Geminorum. It's a little confusing at first, but the designations have stuck.

As the sky was mapped more fully, astronomers ran out of Greek letters and turned to numbers for the stars, then finally to a more complex scheme based on formal catalogs of the stars made by various astronomers. But that's more than you need to know. Just remember than each star has a name and number, and its position is faithfully reproduced for your benefit on star maps.

α	alpha	ν	nu
β	beta	ξ	xi (‘shi’)
γ	gamma	ο	omicron
δ	delta	π	pi
ε	epsilon	ρ	rho
ζ	zeta	σ	sigma
η	eta	τ	tau
θ	theta	υ	upsilon
ι	iota	φ	phi
κ	kappa	χ	chi (‘ki’)
λ	lambda	ψ	psi (‘si)
μ	mu	ω	omega

Stellar Brightness and Magnitudes

To describe the brightness of objects in the sky, astronomers often use a numerical measure called “magnitude”.

In this system, first worked out by ancient Greek astronomers, brighter stars and planets have a smaller numerical value of magnitude than fainter objects. So, for example, a star with magnitude 4 is brighter than a star with magnitude 5.

To be more exact, an object with magnitude 1.0 is 100 times brighter than an object with magnitude 6.0. So each step of 1.0 in magnitude is the fifth root of 100. That means a star of magnitude 3.0 is 2.512 times as bright as a star of magnitude 4.0, which is 2.512 times as bright as a star of magnitude 5.0, and so on. Try it yourself, if you have a calculator handy.

With your unaided eye, you can see objects down to 6th magnitude; with a pair of 7×50 binoculars you can see down to 10.5 or so; and with an 8-inch telescope, perhaps 13.5. Using sophisticated cameras and software, the Hubble Space Telescope can detect objects to about 30th magnitude… about 4 billion times fainter than you can see with your eye.

An object brighter than 0th magnitude has a negative magnitude; the brightest star, Sirius has an apparent magnitude -1.4; the full moon has apparent magnitude -13, and the Sun has apparent magnitude of -26. Don't let negative magnitude confuse you: an object of magnitude -1.0 is simply 2.512 times brighter than an object of magnitude 0.0.

Usually, backyard stargazers talk about "apparent" magnitude, which measures how bright a star appears in the sky, regardless of how bright is truly is.

But "absolute" magnitude is a measure of the true, intrinsic brightness of a star. It's defined as the apparent magnitude of an object if it was 32.616 light-years away.

So while the sun has an apparent magnitude of -26, if we could see it at a distance of 32.616 light-years, it would shine at a very modest magnitude 4.7.

Deneb, the brightest star in Cygnus, has an absolute magnitude of -8.73, more than 250,000 times as bright as our Sun. But its apparent magnitude is only 1.25 because it's so far away, roughly 3,200 light-years from Earth.

Here are some apparent and absolute magnitudes of the 25 brightest stars as seen from Earth, other than the Sun, for reference:

Star Name	Designation	Apparent Magnitude	Distance (light years)	Absolute Magnitude
Sirius	Alpha CMajoris	-1.44	8.6	1.45
Canopus	Alpha Carinae	-0.62	309	-5.53
Rigel Kent	Alpha Centauri	-0.28	4.32	4.11
Arcturus	Alpha Bootes	-0.05	36.7	-0.35
Vega	Alpha Lyrae	0.03	25	0.6
Capella	Alpha Aurigae	0.08	4208	-0.51
Rigel	Beta Orionis	0.18	863	-6.93
Procyon	Alpha CMinoris	0.4	11.5	2.67
Achernar	Alpha Eridini	0.45	139	-2.7
Betelguese	Alpha Orionis	0.45	498	-5.47
Hadar	Beta Centauri	0.61	392	-4.79

Star Name	Designation	Apparent Magnitude	Distance (light years)	Absolute Magnitude
Altair	Alpha Aquilae	0.76	16.7	2.21
Acrux	Alpha Crucis	0.77	322	-4.2
Aldebaran	Alpha Tauri	0.87	66.6	-0.68
Spica	Alpha Virginis	0.98	250	-3.44
Antares	Alpha Scorpii	1.05	554	-5.09
Pollux	Beta Geminorum	1.16	33.8	1.08
Fomalhaut	Alpha P. Austr.	1.16	25.1	1.74
Mimosa	Beta Crucis	1.25	279	-3.41
Deneb	Alpha Cygni	1.25	1412	-6.93
Regulus	Alpha Leonis	1.36	79.3	-0.57
Ahdara	Epsilon CMajoris	1.5	405	-3.97
Castor	Alpha Geminorum	1.58	50.9	0.61
Gacrux	Gamma Crucis	1.59	88.6	-0.58
Shaula	Lambda Scorpii	1.62	571	-4.6

Measuring Angles in the Sky

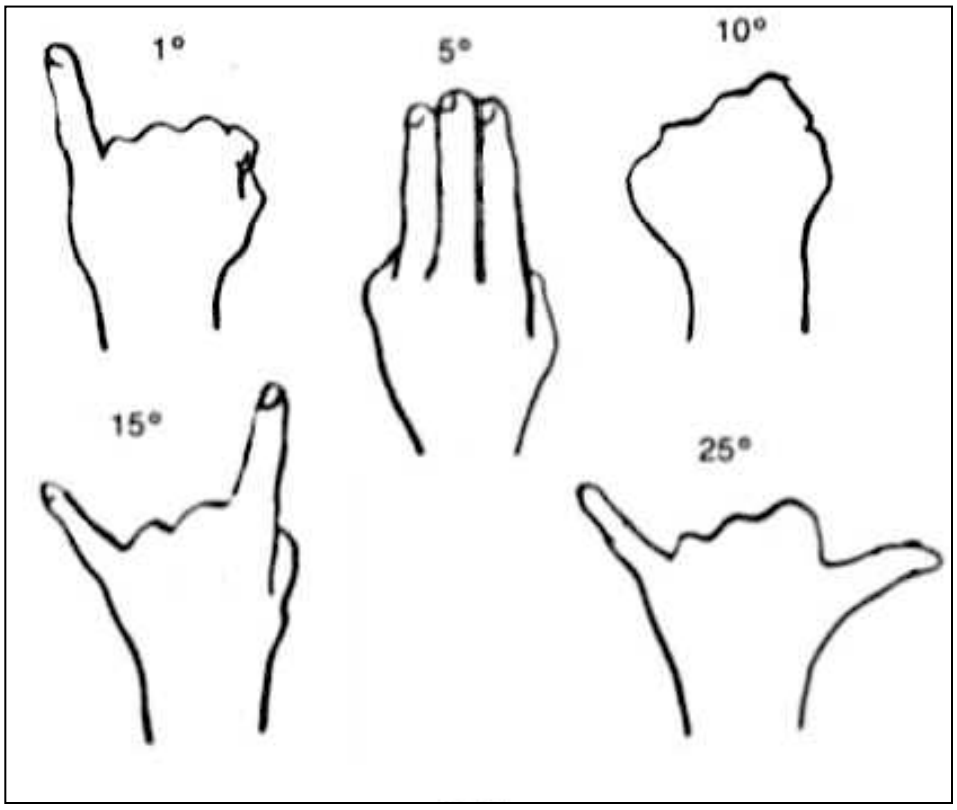
As you find your way around the sky, it will be useful if you understand how to measure angles in terms of degrees, and perhaps fractions of degrees called “arc minutes” and “arc seconds”. It’s not as hard as it sounds, and you need no special tools.

Astronomers measure angular separation of objects in degrees. There are 360 degrees in a circle. And the angular separation of any point on the horizon and the point directly overhead (the zenith) is 90 degrees. Halfway from the zenith to the horizon is 45 degrees.

Smaller angles are a little trickier. But your hands and fingers are remarkably accurate (and convenient) measuring tools. When you hold your hand at arm’s length, you can estimate angles like this:

- Stretch your thumb and little finger as far from each other as you can. The span from tip to tip is about 25 degrees

- Do the same with your index finger and little finger. The span is 15 degrees
- Clench your fist at arms length, and hold it with the back of your hand facing you. The width is 10 degrees
- Hold your three middle fingers together; they span about 5 degrees
- The width of your little finger at arms length is 1 degree.



Common measures of angles using your hand held at arm's length

Now let's go smaller. When you look through a telescope, you see a field of view of 1 degree or less… a very small slice of sky.

Astronomers measure angles smaller than 1 degree in arcminutes, or "minutes of arc". There are 60 arcminutes in one degree, so 1 arcminute is 1/60 degree. The symbol for arcminutes is '. So the full Moon, for example, is about 30′ (thirty arcminutes) across. Coincidentally, so is the Sun.

Each arcminute is divided into 60 arcseconds, or "seconds of arc". So 1 arcsecond is 1/60 arcminute and 1/3600 degree. The symbol for arcseconds is ". The face of Jupiter is about 50″ across. The two components of the double star alpha Herculi are 4.6″ apart. A good optical telescope in steady skies can resolve down to about 1″ (one arcsecond). A

pair of 8x42 binoculars can resolve perhaps 120 arcseconds, which is 2 arcminutes.

STARGAZING FOR BEGINNERS

A BINOCULAR TOUR OF THE SOUTHERN NIGHT SKY

Section 2
“The Stars of Southern Winter”

Finding Your Way Around The Sky
Crux, the Southern Cross
Centaurus, the Centaur
Scorpius, the Scorpion
The Wonders of Sagittarius
Ophiuchus and Serpens
Hercules, and the Great Cluster

The Stars of Winter.

Finding Your Way Around The Sky

Now it is time to find the stars. Of course, you could sweep over the heavens at random on a starry night and see many interesting things, but you would soon tire of such aimless occupation. You must know what you are looking at in order to derive any real pleasure or satisfaction from the sight.

It really makes no difference at what time of the year such observations are begun, but for convenience I will suppose that they are begun in June. We can then follow the revolution of the heavens through a year, at the end of which, if you are diligent, you will have acquired a competent knowledge of the southern constellations, and some northern stars too.

The series of Maps 1(a)-1(e) represents the appearance of the heavens from 35°S latitude at a local time of midnight on the 1st of May, at eleven o'clock on the 15th of May, at ten o'clock on the 1st of June, at nine o'clock on the 15th of June, and at eight o'clock on the 1st of July.

The reason why a single map can thus be made to show the places of the stars at different hours in different months will be plain upon a little reflection. In consequence of the earth's annual journey around the sun, the whole heavens make one apparent revolution in a year. This revolution, it is clear, must be at the rate of 30 degrees in a month, since the complete circuit comprises 360 degrees.

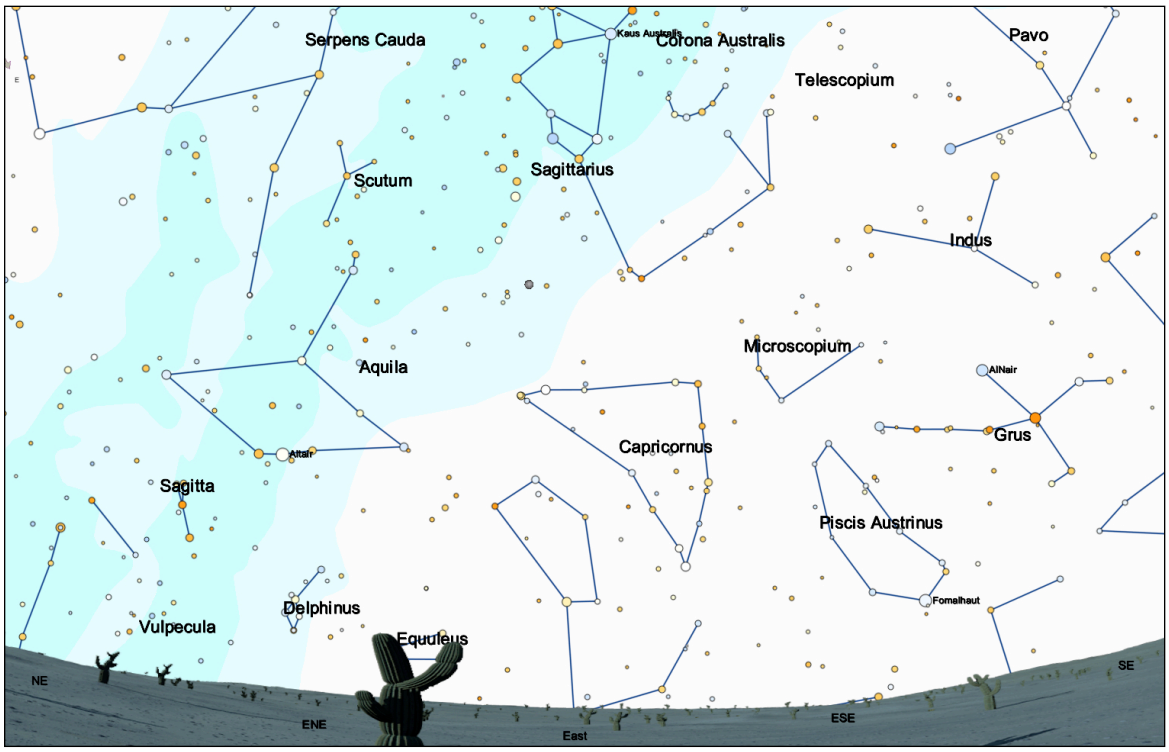
But, in addition to the annual revolution, there is a daily revolution of the heavens which is caused by the earth's daily rotation upon its axis, and this revolution must, for a similar reason, be performed at the rate of 15 degrees for each of the twenty-four hours.

It follows that in two hours of the daily revolution the stars will change their places to the same extent as in one month of the annual revolution.

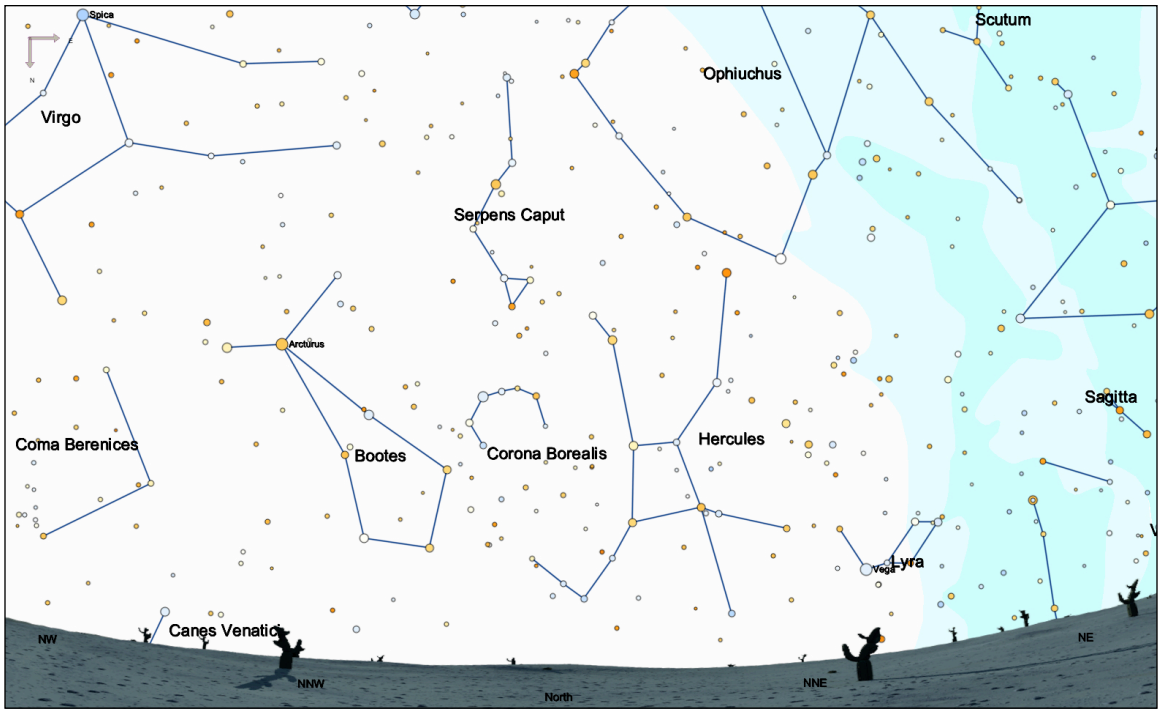
It follows also that, if we could watch the heavens throughout the whole twenty-four hours, and not be interrupted by daylight, we would behold the complete circuit of the stars just as we would do if, for a year, we should look at the heavens at a particular hour every night.

Suppose that at nine o'clock on the 1st of June we see the star Spica on the meridian (when it’s at its highest point in the sky); in consequence of the rotation of the earth, two hours later, or at eleven o'clock, Spica will have moved 30 degrees west of the meridian. But that is just the position which Spica would occupy at nine o'clock on the 1st of July, for in one month

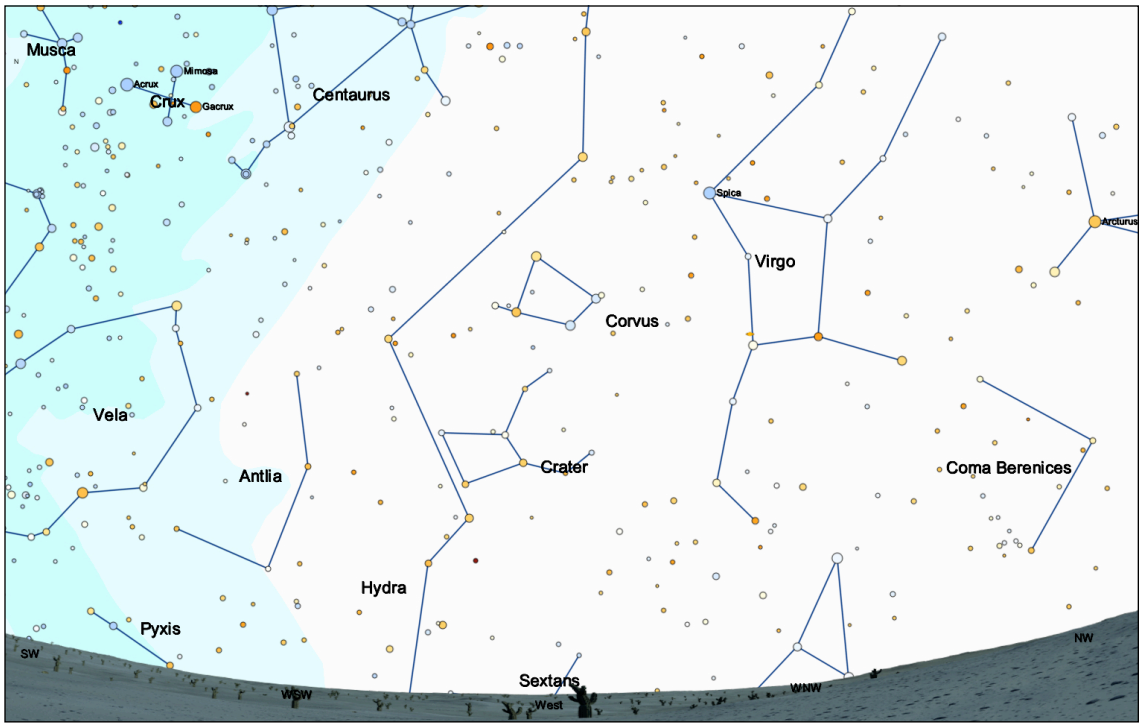
(supposing a month to be accurately the twelfth part of a year) the stars shift their places 30 degrees toward the west. If, then, we should make a map of the stars for nine o'clock on the 1st of July, it would answer just as well for eleven o'clock on the 1st of June, or for seven o'clock on the 1st of August.



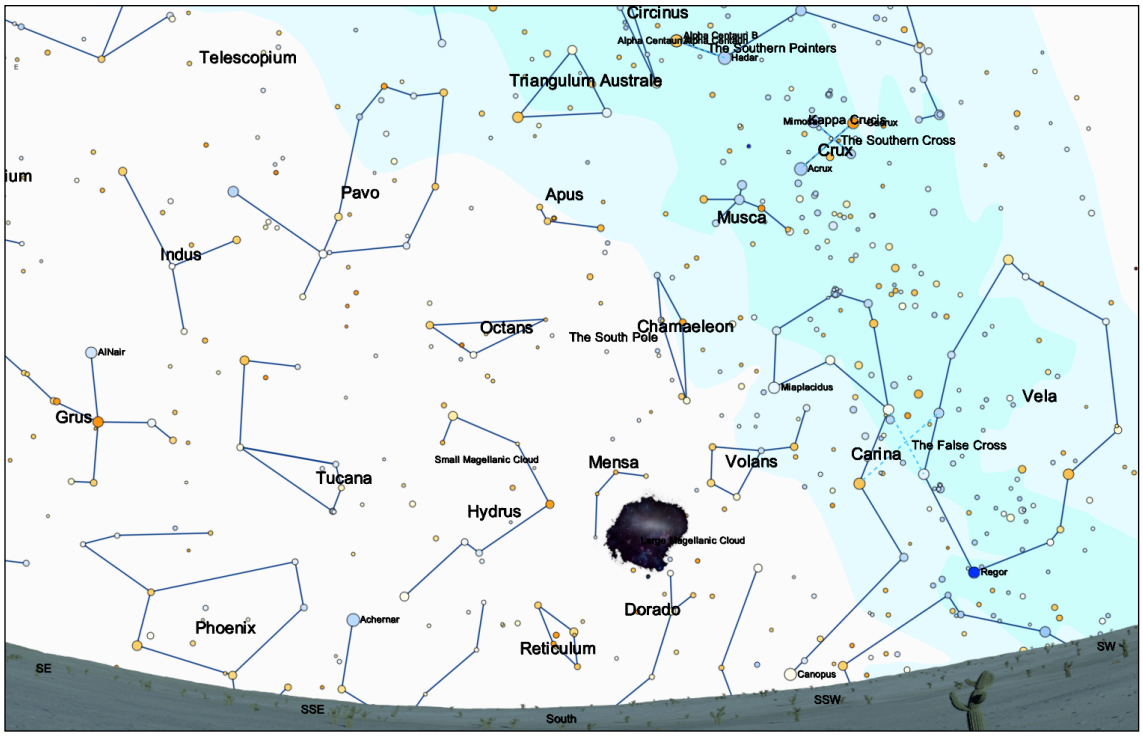
Map 1a - The Winter Constellations (looking EAST at 35 degrees S latitude, at 9 p.m. on June 15)



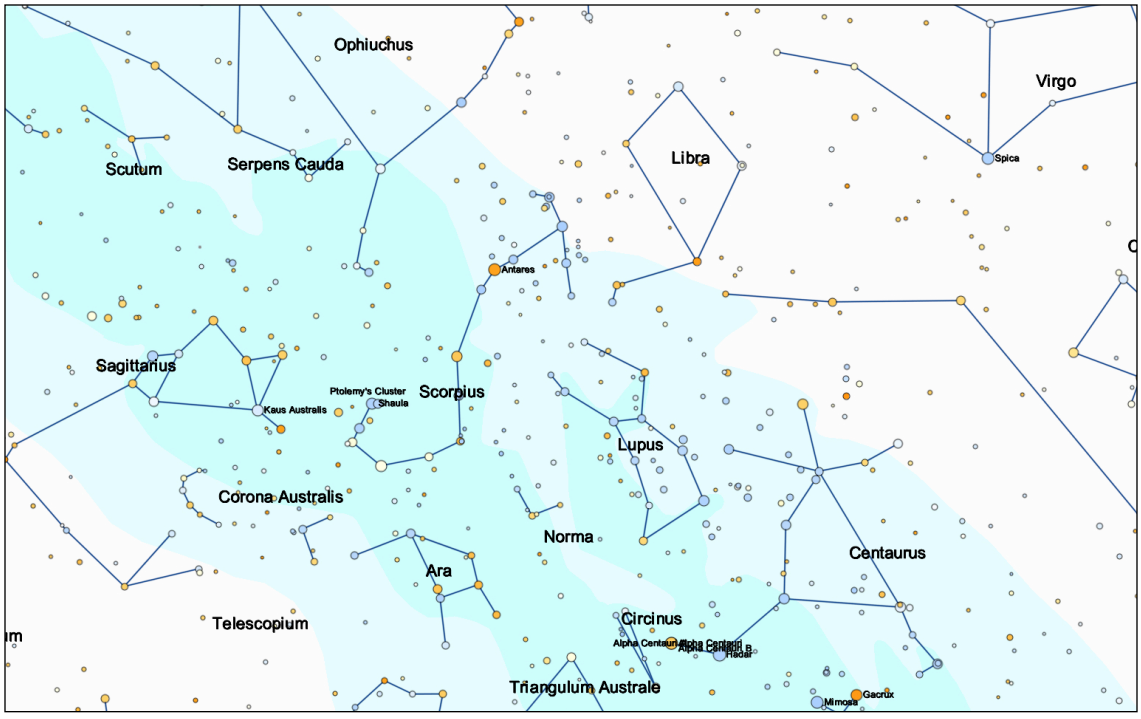
Map 1b - The Winter Constellations (looking NORTH at 35 degrees S latitude, at 9 p.m. on June 15)



Map 1c - The Winter Constellations (looking WEST at 35 degrees S latitude, at 9 p.m. on June 15)



Map 1d - The Winter Constellations (looking SOUTH at 35 degrees S latitude, at 9 p.m. on June 15)



Map 1e - The Winter Constellations (looking OVERHEAD while facing south at 35 degrees S latitude, at 9 p.m. on June 15)

Let's start with a look at Map 1d, which shows the stars as they appear when you face south. Look upward and slightly to the west at a splendid grouping of bright stars set in the star clouds of the Milky Way. Here is the famous constellation Crux, also known as the "Southern Cross". Having fixed the appearance of this constellation in your mind, go outside when it's dark, face south (with the help of a compass if necessary) and try to find the constellation in the sky. With a little application you will be sure to succeed.

Using Crux as a basis of operations, your understanding of the sky will now proceed more rapidly. By reference to Map 1d you will be able to recognize the starry stream of the Milky Way rising from the southwestern horizon to nearly overhead. Just above Crux are the two bright stars Rigil Kent and Hadar in the constellation Centaurus. Below Crux are the large constellations Carina and Vela, which we will meet later. Two stars in each of these constellations form a grouping called the "False Cross", which superficially resembles Crux but is slightly larger. Remember that the true Southern Cross lies closer to Rigil Kent and Hadar, which point generally in its direction.

Turn now to the west to take in an area of the sky with few bright stars, save for the blazing white star Spica in the constellation Virgo. Map 1c helps you find this lovely star. The yellow-orange star north of Virgo is Arcturus, and the two dim constellations south of Virgo are Corvus, the Crow, and Crater, the Cup. If your sky is free from light pollution, you may glimpse the small grouping of stars of the northern constellation Coma Berenices.

Now make a quarter turn to face north. Map 1b will help you see the kite shape of the constellation Bootes, of which Arcturus is the brightest star, and the keystone shape of the constellation Hercules. Between the two is the small constellation Corona Borealis, the Northern Crown.

Turn once again to face east. Here, as you see in Map 1a, is the Milky Way overhead sinking into the northeast. The most distinctive star pattern in the northern sky is the constellation Capricorn, which spans some 30 degrees of sky. Look also for the white star Altair in Aquila, the Eagle. And further up the river of the Milky Way, find the teapot shape of Sagittarius.

Finally, turn south again and look overhead. Here you see the grandest spectacle in the heavens: bright and colourful stars set in the thickest section of our Milky Way towards the centre of our galaxy. Here is Sagittarius, and the long winding constellation Scorpius, the Scorpion. With the help of Map 1e, you will also find the constellations Lupus and Centaurus and Corona Australis. Don't expect to find all the stars and constellations mentioned here in an hour. You may have to devote two or three evenings to such observation, and make many trips indoors to consult

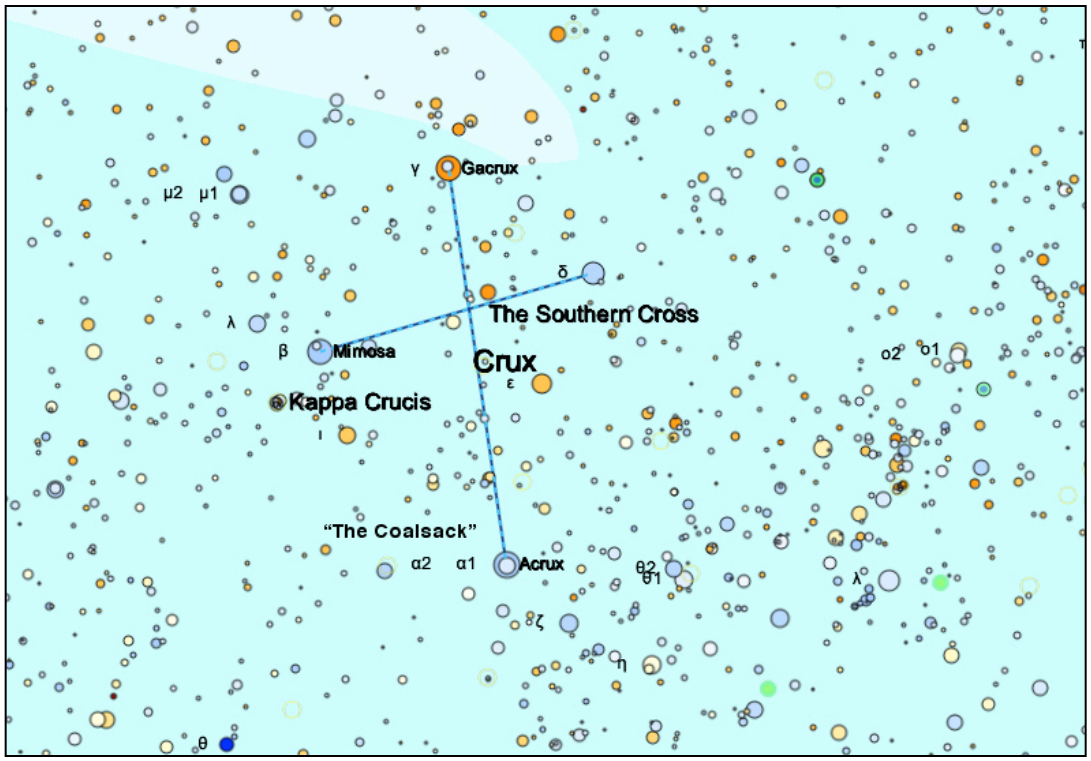
the map, before you have mastered the subject. But when you have done it you will feel amply repaid for your exertions, and you will have made for yourself silent friends that will beam kindly upon you, like old neighbors, on whatever side of the world you may wander.

Now let's take a closer look at our starting point: the constellation Crux.

Crux, the Southern Cross

With the help of Rigil Kent and Hadar, fix your attention once again on the Southern Cross. Crux lies under the hind legs of the much larger constellation Centaurus, and its four bright stars, Acrux, Mimosa, Gacrux, and delta Crucis, mark a kite-like shape about 6 degrees long. Some observers are disappointed at first seeing Crux, because it's so small. But there are enough fine sights here to last for many nights of patient contemplation.

Map 2 shows you the layout of the constellation, along with the names of its bright stars.



Map 2 - The Constellation Crux, the Southern Cross

The primary stars of Crux are Acrux, Mimosa, Gacrux, and delta (δ) Crucis. The fifth-brightest star, epsilon (ε) Crucis, is found between delta and Acrux.

The brightest star, Acrux, at the base of the cross, gets its name from a combination of "Alpha" and "Crux". Its blue-white color is a consequence of its high temperature of nearly 30,000 K (degrees Kelvin). A close look with a small telescope reveals Acrux as a pleasing double star. The brighter of the two stars, which itself has another stellar companion too close to resolve, shines some 25,000x brighter than our sun. The fainter star outshines our sun by 16,000x. Like most hot, massive stars, each component of Acrux is burning furiously through its store of fuel. They will likely end their lives in supernova explosions in several million years, and since they are just 320 light years from Earth, will grow bright enough for a few weeks to cast shadows at midnight.

Mimosa, or beta (β) Crucis, is also a hot blue star. It lies 280 light years away. The star takes its name from the Mimosa flower found in Central and South America. Mimosa, Acrux, and delta Crucis likely share a common origin 10 million years ago with many other stars in Scorpius and Centaurus.

The red-orange Gacrux, or gamma (γ) Crucis, makes a striking color contrast with the other bright blue-white stars of the constellation. The star has burned through most of its nuclear fuel and has swollen and cooled to just 3,500K. Gacrux lies fairly to Earth– just 88 light years– so it's intrinsically much fainter than the Acrux and Mimosa. It will expire gently, casting off its outer layers as a planetary nebula and leave behind a dim white dwarf.

During southern sea voyages of the 16th century, European explorers assigned the constellation's present name. Northern seafarers were unsettled by the disappearance of the north star as they sailed south across the equator. But they saw Crux as a good omen. In the early 16th century, Amerigo Vespucci noted two of the bright stars, Acrux and Mimosa, and Andrea Corsali mapped the full constellation, which he described as *'so fair and beautiful that no other heavenly sign may be compared to it'*. Vespucci recalled Dante's reference to these four stars in his Divine Comedy. When Dante and Beatrice finally ascended from Hell on the far side of the world, they saw four brilliant stars which they took to represent the four principal virtues, Justice, Prudence, Fortitude, and Temperance:

> *"To the right hand I turn'd and fix'd my mind*
> *On the other pole attentive where I saw*
> *Four stars ne'er seen before save by the ken*
> *Of our first parents. Heaven of their rays*
> *Seem'd joyous. Oh thou northern site, bereft*
> *Indeed, and widow'd, since of these deprived"*

Dante may have known of Crux from historical records of classical observations. Or he may have learned of the stars from the 13th-century travelogues of his contemporary Marco Polo, who likely saw them as he sailed south around the Malay peninsula on the way to China. But of course, Crux has been known as long as humans have looked at the sky, and many indigenous cultures includes these stars in their legends…

- Australian Aborigines saw the dark nebula in Crux called the Coalsack as the head of a great, evil emu.

- In Indonesia and Malaysia, and some coastal Australian Aborignal tribes, Crux was a stingray

- The Maori of New Zealand see Crux as an anchor called "Te Punga"

- The /Xam bushmen of southern Africa thought the three brightest stars of Crux were celestial female lions

- And to the !Kung bushmen, the Coal Sack in Crux was "Old Bag of the Night"

If you will sweep carefully with your binoculars over the whole extent of Crux, you will be amazed with the power of your optics to bring into sight many faint stars in regions that seem barren to the naked eye. Binoculars of just 30-35 mm aperture will show twenty times as many stars as the naked eye can see. The region about 5 degrees west of Acrux is particularly rewarding with binoculars. Recall that five degrees is about 3 finger widths held at arm's length.

One of the brightest stars of the storied Southern Cross isn't a star at all, but splendid cluster of young stars aptly called the "Jewel Box". This star cluster, one of the treasures of the southern sky, is unforgettable in binoculars or a small telescope. You can see it just a finger-width southeast of Mimosa.

Since they had no telescopes to resolve it, early European navigators mistakenly classified the Jewel Box as the star kappa Crucis. And that's exactly how it looks to the unaided eye-- stellar-- even to a keen observer. Nicolas de Lacaille, who systematically mapped the southern sky with a tiny half-inch telescope in the mid-18th century, noticed the star was a "nebulous cluster". Further observation with larger telescopes revealed a rich star cluster of almost 300 blue-white stars with a wide range of luminosity.

A good pair of binoculars reveals kappa Crucis, also called NGC4755, as a pyramid of four bright stars. A small telescope at 25-50x reveals dozens

more stars in two distinct clumps. It's almost as if there are two overlapping star clusters, one with a half-dozen bright stars and one with scores of much fainter stars. The stars of the Jewel Box are young... just 10 million years old. They still burn blue-white, for the most part, although there is an orange supergiant star that's evolving away from its youthful phase.

The other grand site of Crux is the Coalsack, a dark cloud of cold gas and dust that blocks the background star clouds of the Milky Way like black smoke. The Coalsack is the most famous example of a "dark nebula".

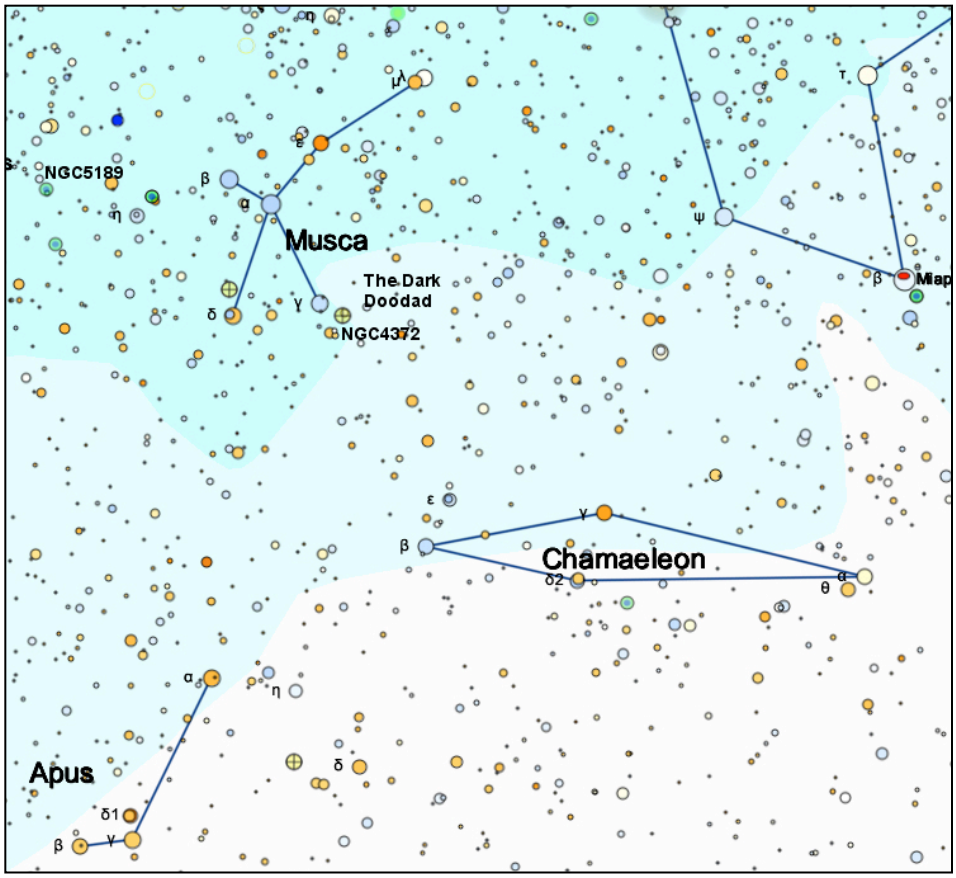
Look for the dark blotch of the Coalsack with your unaided eye between Mimosa and Acrux. The nebula is large enough to fill the field of view of your binoculars. When looking at the Coalsack with your optics, try to see a subtle rib-like structure among the blackness.

While it looks like a patch of unoccupied space, the Coalsack is the quite the opposite. It's made of the mass of thousands of suns of gas molecules and cold dust grains which scatter starlight out of our field of view, much like dust in our atmosphere dims the setting Sun.

Directly south of Crux you'll find the tiny and obscure constellation Musca, the Fly, which first appeared on star charts in the 18th century. The fly's head is marked by λ Musci, his tail by 3rd magnitude α Musci, and his wings by β and γ Musci. While the constellation is not particularly striking, it is set in a rich star field and there are many star clusters and nebulae in this area. In binoculars, they appear as fuzzy and indistinct stars. Of particular interest is the odd little nebula NGC 5189 just 5 degrees north of β Musci. Sometimes called the "Spiral Planetary Nebula", it appears as a slightly oval disk immersed in a lovely star field.

Just southwest of γ Musci, scan with your binoculars for the "Dark Lane", also known as the "Dark Doodad", which like the Coalsack is a dark nebulae of cold gas and dust. It appears as a dark finger in a rich star field. You may see a fuzzy star in the same field of view. This is the globular cluster NGC 4372, a tight ball of very old stars left over from the formation of the Milky Way 12 billion years ago.

Southeast of Musca, you will find the even fainter constellation Apus, the Bird of Paradise. It has little of interest, save for the fine pair of red-orange stars δ1 and δ2 just north of γ. The pair looks lovely in any pair of binoculars. To the west of Apus lies the small constellation Chamaeleon, but it holds little of interest.



Map 3 - The constellations Musca, Apus, and Chamaeleon, south of Crux.

Centaurus, the Centaur

Look now above and all around Crux. Here, on all sides, is the grand constellation Centaurus, the Centaur. Centaurus is one of the largest constellations in the heavens, and holds ample bright stars and deep-sky sights for stargazers of all skill levels.

The Roman poet Ovid suggested this constellation represents the centaur Chiron, an immortal son of Cronos, the king of the Titans, and the sea nymph Philyra. Chiron had an unusual start in life. During the act of conception, Cronus was caught by his wife Rhea and turned himself into a horse to escape her wrath. But it meant poor Chiron was born half man and half horse… a centaur.

Most centaurs were boorish, fond of wine and trouble making. But Chiron was different. His wisdom and knowledge gained the respect of the gods, and he was made tutor to many legendary Greek heroes including Heracles, Jason, Achilles, and Asclepius, a son of Apollo.

Sadly, Chiron met a tragic fate. During a struggle between Heracles and a group of rowdy centaurs, the noble (and innocent) Chiron was accidentally struck with one of the great hero's poison arrows. Heracles apologized and pulled the arrow from his old teacher, but it was too late. The immortal centaur was stricken with great pain from the poison and faced an eternity of suffering. Zeus took pity and allowed the centaur to die, then placed him among the stars.

The full constellation Centaurus is now visible only from far-southern latitudes. So how did the Greeks know its stars?

The reason is that Centaurus, like Crux, was not always hidden to northern-hemisphere observers. Ptolemy included a version of this constellation in his original 48, so it was visible from Egypt two millennia ago. And it was mentioned three centuries earlier by Eudoxus and the Greek poet Aratus. But the slow precession of Earth's equinoxes, which changes the positions of the celestial poles, has carried the mighty centaur out of view from the north for the next many thousands of years.

In Ptolemy's maps, Centaurus was even larger than today. It included the stars of Lupus, the Wolf, along with Circinus and Crux itself. It doesn't take too active an imagination to see a centaur amongst these stars. The star Menkent (θ Centauri) marks the centaur's head, zeta (ζ) and epsilon (ε) its torso, and Rigil Kent and Hadar the front leg of the noble creature.

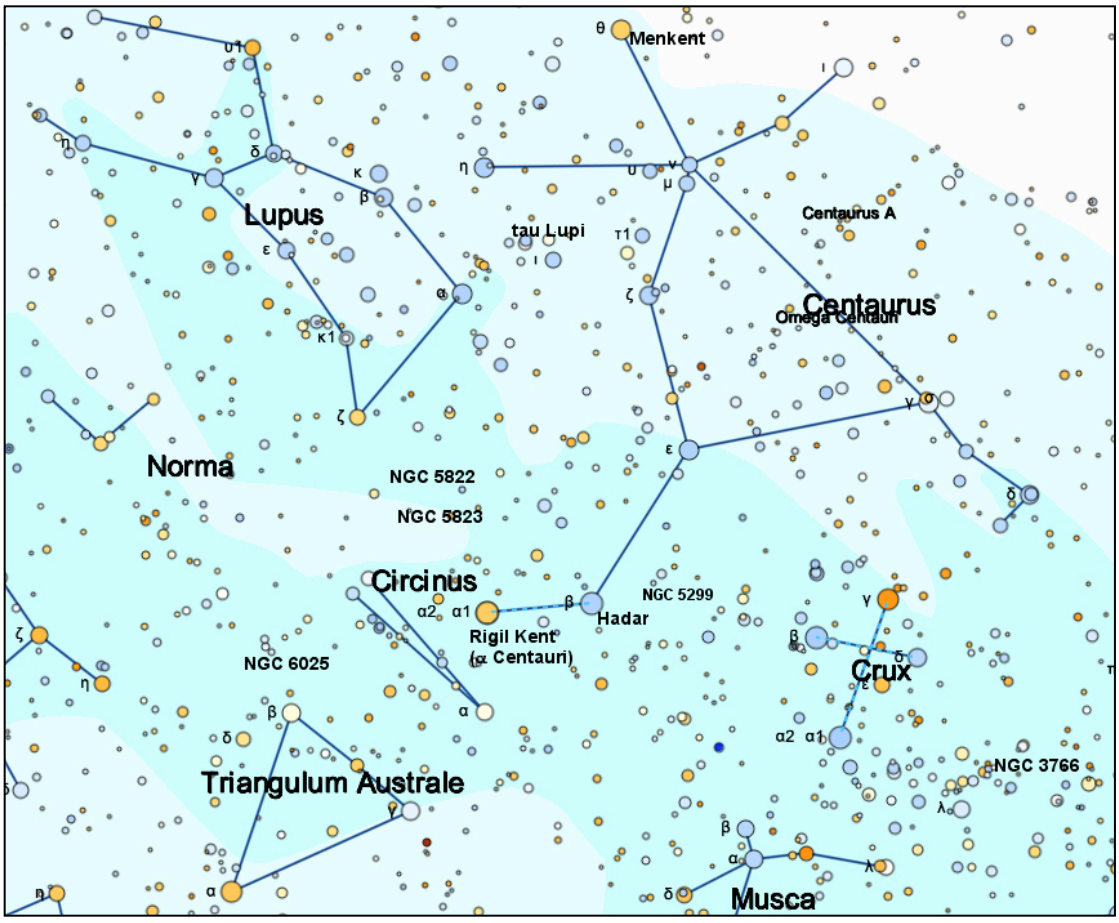
The brightest star in Centaurus, alpha Centauri, is the 4th-brightest star in our skies and, at a distance of 4.3 light years, the closest star system to Earth. A small telescope reveals this star as a fine double. There's a third star here too, the red dwarf Proxima Centauri, too dim to see in a small telescope. Alpha Centauri's more common name is Rigil Kentaurus, or Rigil Kent, the "foot of the Centaur".

Hadar, or beta (β) Centauri, is fainter than alpha, but only because it's 80x farther away. This intrinsically bright blue-giant star is really 10,000x brighter than alpha! Hadar is sometimes called Agena, which means "knee" (of the centaur). Hadar is also a 3-star system, though binoculars cannot resolve these stars. Just 2 degrees west of Hadar, with your binoculars, look for NGC 5299, which is an open star cluster, or perhaps just a rich region of the Milky Way.

Perhaps the most famous object in Centaurus is the globular star cluster omega (ω) Centauri. It is the grandest globular cluster visible from Earth. Like all globular clusters, this is a grand ball of ancient stars more than 12 billion years old. This cluster has more than a million stars packed into a diameter of 150 light years. The stars within the cluster are, on average, just 0.1 light years apart, which is 40 times closer than the nearest star to

Earth. Omega Centauri is one of the few globular clusters visible to the unaided eye. It is also one of the nearest to Earth, just 17,000 light years away. Look for the cluster between the stars zeta (ζ) and gamma (γ) Centauri. In binoculars, you will notice a slightly grainy appearance, as the cluster begins to resolve into individual stars.

An odd-looking garbled galaxy that's also a strong radio source, NGC 5128 (also called Centaurus A) may be an elliptical galaxy that's merging with a flat dusty spiral. It's the 5th brightest galaxy in our sky, easily visible with binoculars as a fuzzy star just 4 degrees north of omega Centauri. You can see the dust lane in a small telescope, or possibly a large pair of binoculars. A smaller pair will at least show the galaxy as a fuzzy star. The light from this galaxy left some 18 million years ago.



Map 4 - The constellation Centaurus and region.

Perhaps the loveliest view in Centaurus for stargazers with binoculars is the dazzling Pearl Cluster, NGC 3766. Set in the most splendid star field in all the heavens, the Pearl Cluster looks like a bright nebulous glow, with just a few of its more than 100 stars clearly resolved. A small telescope gives a

better view of this cluster. But binoculars show a breathtaking stellar panorama in this part of the sky. It is not to be missed!

NGC 3766 is an example of an open star cluster. Unlike ancient globular clusters, open star clusters are relatively young, just 10-100 million years old. The stars in open clusters were formed together from a common cloud of gas and dust in the arms of the Milky Way, and will, over time, become dispersed into the galaxy. Globular star clusters, on the other hand, do not disperse and remain stable over billions of years.

East of Centaurus, look for the smaller, dimmer constellation Lupus, the Wolf. This constellation was included on Ptolemy's list of 48 constellations from the second century A.D. It represents a wolf or a mad dog at battle with the centaur. Lupus contains no stars of first magnitude, but has some thirty stars of 2nd and 3rd magnitude. Like Centaurus and Crux, Lupus lies in the plane the Milky and therefore holds many star clusters and sites of interest. The star tau (τ) Lupi is a fine target for binoculars. It is an optical double star, which means the stars are close by chance alignment, but they are not gravitationally bound to each other like true double stars. This pair of white stars is 3 degrees northeast of alpha (α) Lupi. At the southern end of Lupus, look for the attractive open cluster NGC 5822. The cluster is spread out over a patch of sky as wide as the full Moon, so it is an excellent target for binoculars.

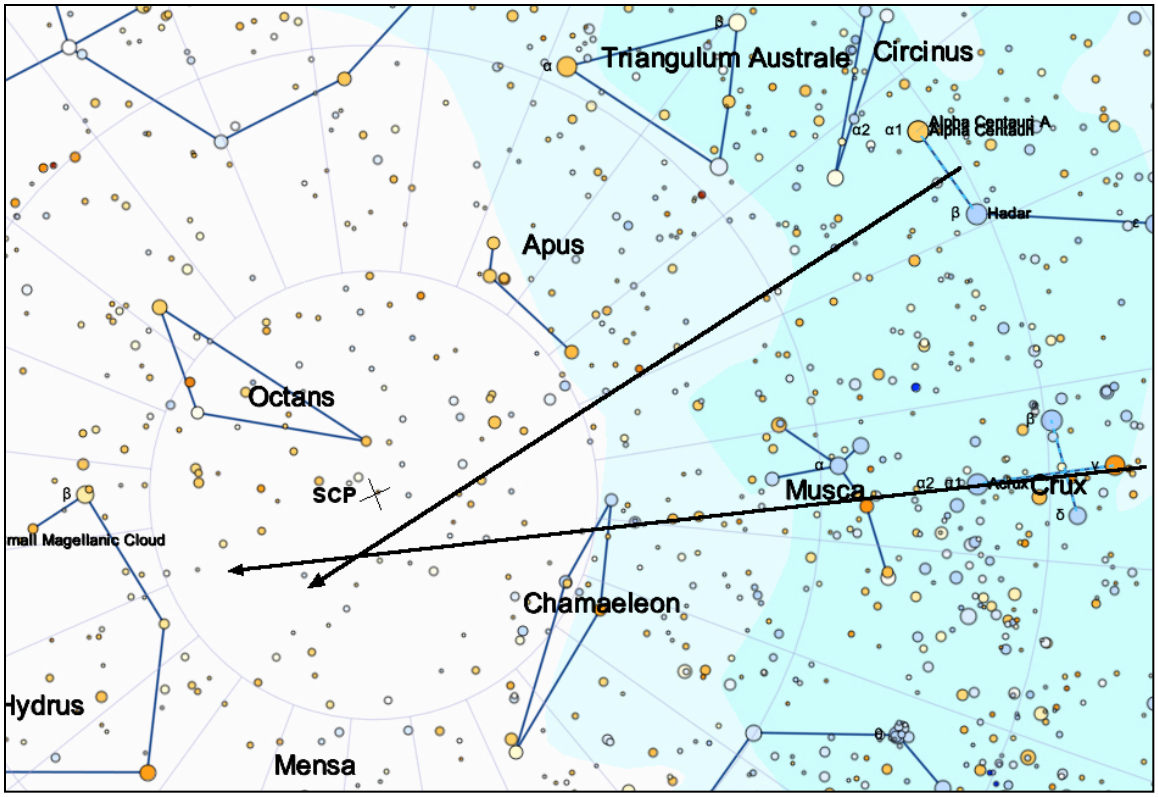
Below Lupus and just east of Rigil Kent, look for the tiny constellation Circinus, the Compass. This constellation was coined by the French astronomer Lacaille in the 18th century. Observing from South Africa, the industrious Lacaille catalogued thousands of southern stars, and named a handful of constellations after scientific instruments including the compass, the air pump (Antlia), the hourglass (Horologium), and the reticle (Reticulum). It's no wonder a northern astronomer once gazed upon these constellations and suggested parts of the southern sky look like someone's attic! Circinus holds a lovely open cluster NGC 5823, which is worthy target for binocular stargazers.

Now look just southeast of Circinus. Here you see the tiny constellation Triangulum Australae, the Southern Triangle. The constellation holds few sights of interest, save for the star cluster NGC 6025, a rich group of two dozen 9th magnitude stars set off by a much brighter star of 7th magnitude. A marvelous sight in binoculars.

Before we leave Centaurus, a word about how to locate the south celestial pole (SCP), which is a point in the sky directly above the Earth's south pole, and around which all stars on the celestial sphere appear to rotate. In the northern hemisphere, the bright star Polaris nearly marks the position of the north celestial pole. In the south, there is no such luck. But the stars

Hadar and alpha Centauri, along with Crux, help point the way. Here's how...

Hadar and alpha Centauri are sometimes called the "Southern Pointers". Extend an imaginary line between the Southern Pointers, then a second line perpendicular to the first. Now find Crux, and extend a line through the long axis of the cross, from the star at the top (Gacrux) through the star at the bottom (Acrux). The line from Crux intersects the line perpendicular to the pointers about 5 degrees northwest of the south celestial pole (see Figure 5).



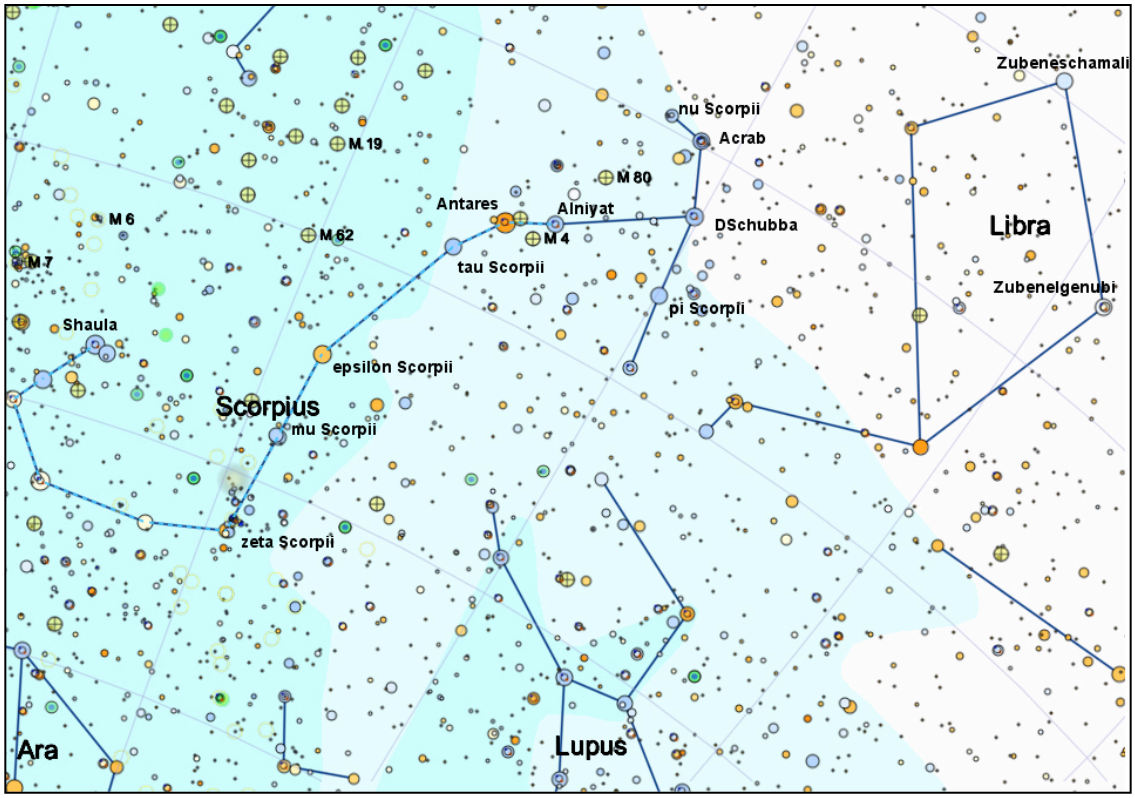
Map 5 - Finding the South Celestial Pole (SCP)

Scorpius, the Scorpion

Now find the constellation Scorpius, and its chief star Antares. Map 1e shows the constellation high overhead at 9 p.m. local time on the 15th of June. You will recognize Antares by its fiery color, as well as by the striking arrangement of its surrounding stars. There are few constellations which bear so close a resemblance to the objects they are named after as Scorpius. It does not require much exercise of the imagination to see in this long, winding trail of stars a gigantic scorpion, with its head to the west, and

flourishing its upraised sting that glitters with a pair of twin stars, as if ready to strike. Readers of the old story of Phaeton's disastrous attempt to drive the chariot of the Sun for a day will remember it was the sight of this threatening monster that so terrified the ambitious youth as he dashed along the Zodiac, that he lost control of Apollo's horses, and came near burning the earth up by running the Sun into it.

Antares rather gains in redness when viewed with binoculars. Its color is very remarkable, and it is a curious circumstance that with powerful telescopes a small star is seen apparently almost touching it. Spectroscopic measurements of Antares suggest the existence of an absorptive atmosphere, much cooler than our own Sun. This great, red-giant star exceeds our sun in size, and is entering the final stages of its life. Antares will one die explode as a supernova, the largest known explosion in the universe, and will grow in brightness to become visible in the daytime sky for a few weeks. Astronomers cannot say when this will happen.



Map 6 - The constellations Scorpius and Libra

Your binoculars will show a number of faint stars scattered around Antares. Turn now to Beta (β) Scorpii, also called Achrab or Graffias. A very pretty pair of stars will be seen hanging below Beta. Sweeping southward from this point some ten degrees you will find many beautiful star fields. The star marked Nu (ν) is a double which you may able to separate with binoculars,

the distance between its components being 40 arcseconds (one arcsecond is 1/3600 of a degree).

And next let us look at a star cluster. You will see on Map 6 an object marked M4, near Antares. Its designation means that it is number 4 in Messier's catalogue of nebulae, although we now know it is not a nebula but a star cluster. With binoculars, if you are looking in a clear and moonless night, you will see it as a curious nebulous speck. You may see it blaze brighter toward the center. It is, in fact, a globular star cluster, like omega Centauri, in which thousands of suns are associated together into splendid assemblages. The object above and to the right of Antares, marked in the map as M80, is a also a globular cluster, although it will appear in binoculars as a mere wisp of light. Yet there is a pretty array of small stars in its neighborhood worth looking at. Besides, this cluster is of special interest, because in 1860 a star suddenly took its place. At least, that is what seemed to have happened. What really did occur, probably, was that a variable or temporary star, called a nova, and ordinarily too faint to be perceived, blazed up as to shine as brightly as the entire cluster. If this star should make its appearance again, it could easily be seen with binoculars.

The part of the heavens with which we are now dealing is famous for these celestial conflagrations. The first temporary star of which there is any record appeared in the constellation of the Scorpion, near the head, in 134 B.C. It must have been a most extraordinary phenomenon, for it attracted attention all over the world, and both Greek and Chinese annals contain descriptions of it. In 393 A.D. a temporary star shone out in the tail of Scorpius. In 827 A.D. Arabian astronomers, under the Caliph Al-Mamoun, the son of Haroun-al-Raschid, who broke into the great pyramid, observed a temporary star, that shone for four months in the constellation of the Scorpion. In 1203 there was a temporary star, of a bluish color, in the tail of Scorpio, and in 1578 another in the head of the constellation. Besides these there are records of the appearance of four temporary stars in the neighboring constellation of Ophiuchus, one of which, that of 1604, is very famous, and will be described later on. It is conceivable that these strange outbursts in and near Scorpius may have had some effect in causing this constellation to be regarded by the ancients as malign in its influence.

Let us follow the bending row of stars from Antares toward the south and east. When you reach the star Mu (μ) you are likely to stop with an exclamation of admiration, for the glass will separate it into two stars that, shining side by side, seem to rival each other in brightness. But the next star below marked Zeta (ζ), is even more beautiful. It also separates into two stars, one being reddish and the other bluish in color. The contrast on a clear night is very pleasing. But this is not all. Above the two stars you will notice a curious nebulous speck. Now, if you have powerful binoculars, here is an opportunity to view one of the prettiest sights in the heavens. The

glass not only makes the two stars appear brighter, and their colors more pronounced, but it shows a third, fainter star below them, making a small triangle, and brings other still fainter stars into sight, while the nebulous speck above turns into a charmingly beautiful little star-cluster, whose components are so close that their rays are inextricably mingled in a maze of light.

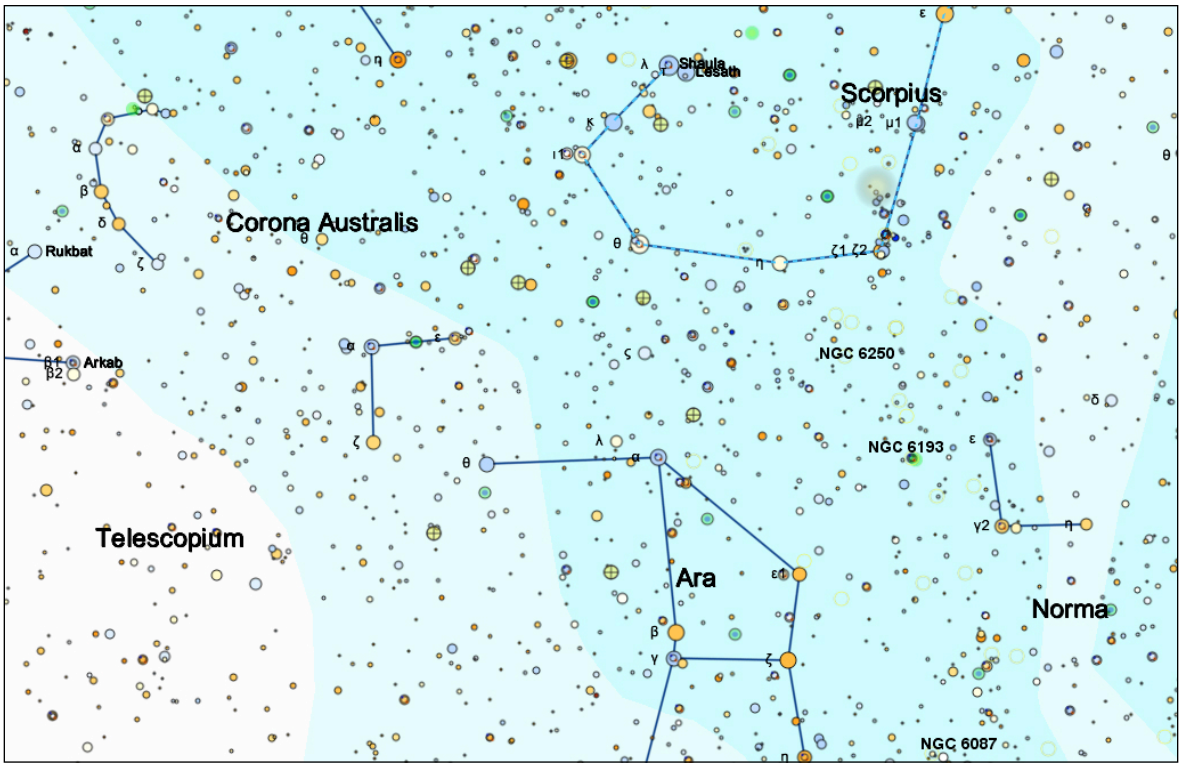
Following the bend of the Scorpion's tail upward, we come to the pair of stars in the stinger. These, of course, are separated well by binoculars. Then let us sweep off eastward a little way and find the cluster known as M7. You will see it marked on the map. Above it, and near enough to be included in the same field of view, is M6, a smaller star cluster sometimes called the “Butterfly Cluster”. Both of these have a sparkling appearance with binoculars, and by close attention some of the separate stars in M7 may be detected. These clusters become much more striking and starry looking at higher power, and the curious radiated structure of M7 comes out in a telescope.

In looking at such objects we cannot too often keep in mind the significance of what we see in the night sky across inconceivable tracts of space. Our Sun and our planet are not alone in the heavens, and all around us, and even on the distance scale of the galaxy, Nature is busy, as she is on Earth, and the laws of light, heat, gravitation (and perhaps of life?), are fully active.

The constellation Libra, lying west of Scorpius (see Map 6), does not contain much to attract your attention. Its two chief stars, beta (Zubeneschamali) and alpha (Zubenelgenubi), may be readily recognized west of and above the head of Scorpius. The upper one of the two, Zubeneschamali, has a singular greenish tint, while the lower one, Zubenelgenubi, is a very pretty double for binoculars.

The constellation of Libra appears to have been added later than the other eleven members of the zodiac. Its two chief stars at one time marked the extended claws of Scorpius, which were afterward cut off (perhaps the monster proved too horrible even for its inventors) to form Libra. As its name signifies, Libra represents a balance, or scale, and this fact seems to refer the invention of the constellation back to at least three hundred years B.C., when the September equinox occurred at the moment when the sun was just crossing the western border of the constellation. The equal length of days and nights at that season suggests the idea of a balance.

South and east of Scorpius you will find the tiny constellations Norma (the Carpenter’s Square), Ara (the Altar), and Telescopium (the Telescope). These constellations are small and dim compared to Scorpius, but their position in the plane of our Milky Way Galaxy offers a handful of splendid sights (Map 7).



Map 7 - The small constellations Ara, Norma, and Telescopium.

In Ara, the highlight is the open cluster NGC 6193. In total, it has only 15-20 stars. But this is a beautiful object for connoisseurs of open star clusters. This cluster and the surrounding patch of sky contain new stars just 10 million years old, glowing gas from which the stars formed, dust clouds that reflect the blue light of the new stars, and dark clots of dust that linger about the region. It is not to be missed. Also inspect the area around NGC 6250. Although the cluster itself is relatively sparse, it is set in a stunning star-clogged region of sky along the Ara-Scorpius border.

Norma was another of the utilitarian constellations devised by Lacaille in the 18th century. It features the striking but little-known star cluster NGC 6087. Of the cluster's 40 stars, look to resolve 5-10 with binoculars. The brightest is a golden-yellow star called S Normae. Its brightness varies from magnitude 6.1 to 6.8 over a 10-day period.

The Wonders of Sagittarius

And now to the second celestial centaur, the constellation Sagittarius. Some legends have it that this constellation represents Chiron, not Centaurus. Others say Sagittarius is simply a less distinguished centaur from ancient Greek legend. But it matters not: there is so much of beauty

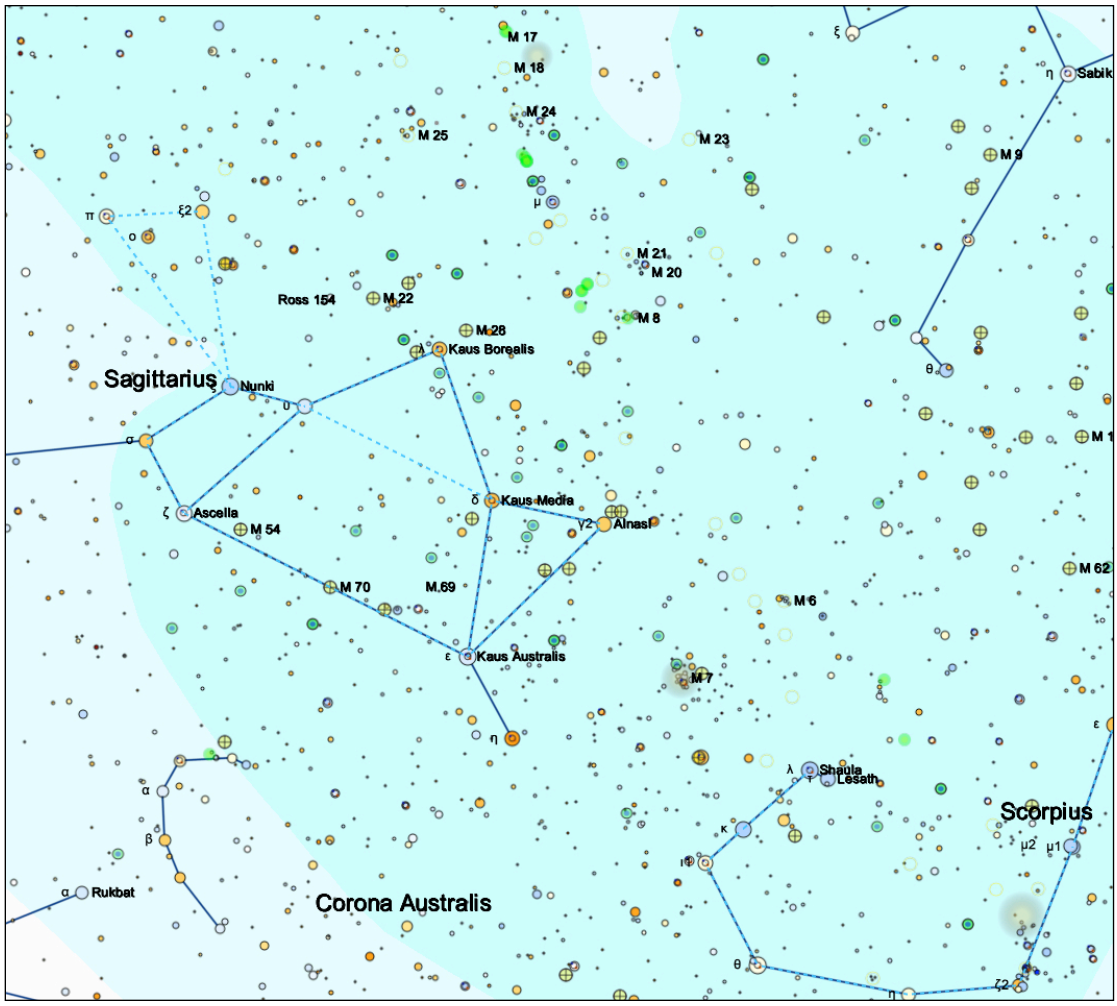
to be seen in Sagittarius, the legends are but a distraction from the delightful celestial sights at hand.

We are now in another, and even a richer, region of wonders than nearby Scorpius. The Milky Way, arcing high overhead in a luminous flood through Sagittarius, inundates the whole region of the heavens with seeming deeps and shallows. There are few sights like this in all the heavens. The view of this part of the sky in the southern hemisphere is not equalled in the north, because the thickest, brightest part of the Milky Way is low on the horizon, where thick air degrades the clarity of the sky.

Now, with the help of Map 8, look for the major stars of Sagittarius. The stars Ascella (Zeta, ζ), Tau (τ), Nunki (Sigma, σ), Phi (φ), Kaus Australis Epsilon (ε), Kaus Media Delta (δ), Kaus Borealis Lambda (λ), and Alnasl Gamma (γ), indicate the outlines of a figure sometimes called, the “Tea Pot”, which is very evident when the eye has once recognized it. Above the top of the Teapot lies another star Mu (μ). In the region around Mu lie some of the most interesting objects in the sky.

Let us start at Mu (μ). Sweep downward and to the right a little way, and you will be startled by a most singular phenomenon that has suddenly made its appearance in the field of view of your glass. You may, perhaps, be tempted to congratulate yourself on having got ahead of all the astronomers, and discovered a comet. It is really a combination of a star cluster with a nebula, and is known as M8, the “Lagoon Nebula”. Sir John Herschel has described the "nebulous folds and masses" and dark oval gaps which he saw in this nebula with his large telescope at the Cape of Good Hope. But no telescope is needed to make it appear a wonderful object; binoculars reveal much of its marvelous structure.

The position of the December solstice is near a star cluster in this region. It is here the Sun is to be found on or about December 21 when summer begins in the southern hemisphere. The solstice is to be found near a line drawn from M8 to the star Mu (μ), and about one third of the way from the cluster to the star. There is another less conspicuous star cluster still closer to the solstitial point here, for this part of the heavens teems with rich fields of stars.



Map 8 - The rich region around the constellation Sagittarius.

On the opposite side of the star Mu, that is to say, above and a little to the left is an entirely different but almost equally attractive spectacle, the Sagittarius Star Cloud M24. Here, again, simple binoculars bring out the innumerable points of light of which the cluster is composed. Do not fail to gaze long and steadily at this island of stars, for much of its beauty becomes evident only after the eye has accustomed itself to disentangle the glimmering rays with which the whole field of view is filled.

Just to the east and a little northwards from *Kaus Borealis,* at the tip of the Tea Pot, look for a tiny hazy patch of stars, which was labeled by Messier as M22.

When looking for a faint and difficult object, the plan pursued by stargazers is to avert the eye from the precise point upon which the attention is fixed, in order to bring a more sensitive part of the retina into play. Look toward

the edge of your field of view, while the object you are seeking is in the center, and then, if it can be seen at all, you will catch sight of it, as it were, out of the corner of your eye. When you use this method of averted vision, hundreds of faint stars will seem to spring into view out of the depths of the sky. This technique works with your unaided eye and with binoculars or a telescope.

The necessity of a perfectly clear night, and the absence of moonlight, cannot be overemphasized for observations such as these in Sagittarius. Everybody knows how the moonlight blots out the smaller stars. A slight haziness or smoke in the air produces a similar effect. It is as important to the observer with binoculars to have a transparent atmosphere as it is to one who would use a telescope; but, fortunately, the work of the former is not so much interfered with by currents of air. Always avoid the neighborhood of any bright light. Electric lights in particular are an abomination to stargazers.

The cloud of stars we have just been looking at is in a very rich region of the Milky Way, in the little group called “Sobieski's Shield”, which we have not named upon our map. Sweeping slowly upward from Mu (μ), a little way with the binoculars, we will pass in succession over three nebulous-looking spots. The second of these, counting upward, is the famous Swan (or Horseshoe) nebula (M17). Its wonders are beyond the reach of our instrument, but its place may be recognized. Look carefully all around this region, and you will perceive that the old gods, who traveled this road (the Milky Way was sometimes called the pathway of the gods), trod upon golden sands. Off a little way to the east you will find the rich cluster M25. But do not imagine the thousands of stars that your binoculars reveal comprise all the riches of this region of the heavens. You can ply the powers of the greatest telescope and still not exhaust its wealth.

The milky look of the background of the Galaxy is, of course, caused by the intermingled radiations of inconceivably numerous stars, thousands of which become separately visible, the number thus distinguishable varying with the size of the instrument. Binoculars or a small telescope cannot sound these starry deeps to the bottom.

The groups of stars forming the eastern half of the constellation of Sagittarius are worth sweeping over with binoculars, as a number of pretty pairs may be found there. Sagittarius stands in the old star-maps as a centaur, half-horse-half-man, facing the west, with bow drawn, and arrow pointed at the Scorpion.

To the south of Sagittarius, look for the elongated semi-circle of Corona Australis. The constellation makes for pleasant viewing within the field of

view of most binoculars. Look for the lovely color contrasts of the orange-red and blue-white stars.

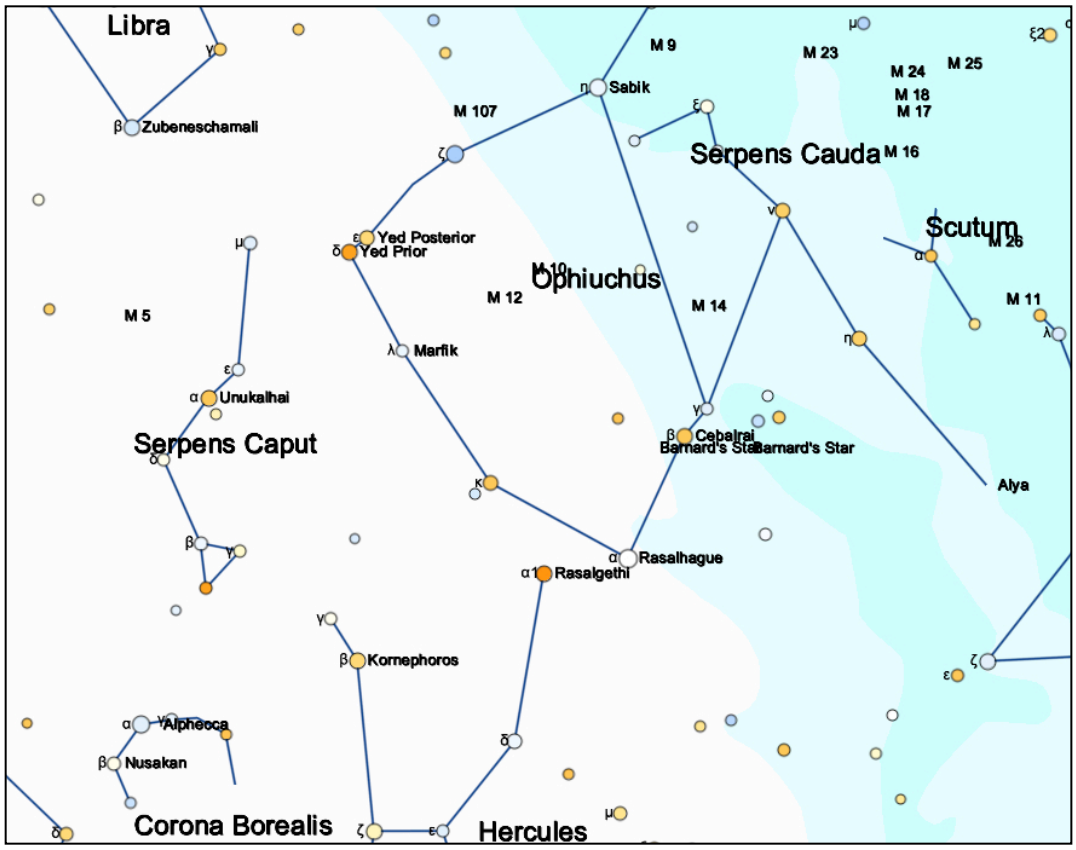
Ophiuchus and Serpens

Next, turn north to see the constellations Ophiuchus and Serpens, the Serpent, adjoining Scorpius and Sagittarius. These constellations, as Map 1b shows, are curiously intermixed. Serpens is unique among constellations in that it's split in two. The imagination of the old stargazers, who named them, saw here the figure of a giant grasping a writhing serpent with his hands. The head of the serpent is under the Corona Borealis, the Northern Crown, and is called Serpens Caput. Its tail ends over the star-gemmed region that we have just described, called "Sobieski's Shield", and is called Serpens Cauda. Ophiuchus stands, as figured in some star atlases, upon the back of the Scorpion, holding the serpent with one hand below the neck, and with the other near the tail. The giant's face is toward the observer, and the star Alpha (α), also called Ras Alhague, shines in his forehead, while Cebalrai, or Beta, (β) and Gamma (γ) mark his right shoulder. Ophiuchus has been held to represent the famous physician Aesculapius. One may well repress the tendency to smile at these fanciful legends when he reflects upon their antiquity. There is no doubt that this double constellation is at least three thousand years old, which means for thirty centuries the imagination of men has continued to shape these stars into the figures of a gigantic man struggling with a huge serpent. Like many other of the constellations it has proved longer-lived than the mightiest nations. While Greece flourished and decayed, while Rome rose and fell, while the scepter of civilization has passed from race to race, these starry creations of fancy have shone on unchanged.

Just south of the star Sabik in Ophiuchus lies the spot where one of the most famous temporary stars on record appeared in the year 1604. At first it was far brighter than any other star in the heavens, but it quickly faded, and in a little over a year disappeared. It is particularly interesting, because the great astronomer and mathematician Kepler wrote a curious book about it. Some of the philosophers of the day argued that the sudden outburst of this wonderful star was caused by the chance meeting of atoms. Kepler vigorously disagreed, and his reply was characteristic, as well as amusing:

"I will tell those disputants, my opponents, not my own opinion, but my wife's. Yesterday, when I was weary with writing, my mind being quite dusty with considering these atoms, I was called to supper, and a salad I had asked for was set before me. 'It seems, then', said I, aloud, 'that if pewter dishes, leaves of lettuce, grains of salt, drops of water, vinegar and oil, and slices of egg, had been flying about in the air from all eternity, it might at last happen by chance that there would come to be a salad. 'Yes,' says my wife, 'but not so nice and well-dressed as this of mine is.' "

Investigation by modern astronomers into the nature of stars revealed that Kepler's star was one of the most violent events in all the heavens: a supernova, the dying remnant of a massive star which has finally run out of fuel to hold itself up from the relentless force of gravity.



Map 9 - The constellations Ophiuchus, Serpens Caput, and Serpens Cauda .

While there are few objects of special interest for the observer with binoculars in Ophiuchus, you will find it worth while to sweep over it for what you may pick up, and, in particular, you should look at the group of stars southeast of Beta (β) and Gamma (γ). These stars have been shaped into a little modern asterism called Taurus Poniatowskii, and it will be noticed that five of them mark the outlines of a letter "V", resembling a bull's head, much like the Hyades in the constellation Taurus.

Also look at the stars in the head of Serpens, several of which form a figure like the letter X. A little west of Eta (η), in the tail of Serpens, is a beautiful swarm of little stars, called M11, the "Wild Duck" cluster in the neighboring constellation Scutum.

An do not fail to notice the remarkable subdivisions of the Milky Way in this neighborhood. Its current seems divided into numerous channels and bays, interspersed with gaps that might be likened to islands. This complicated structure of the Milky Way extends across the sky high overhead and into Centaurus and Crux.

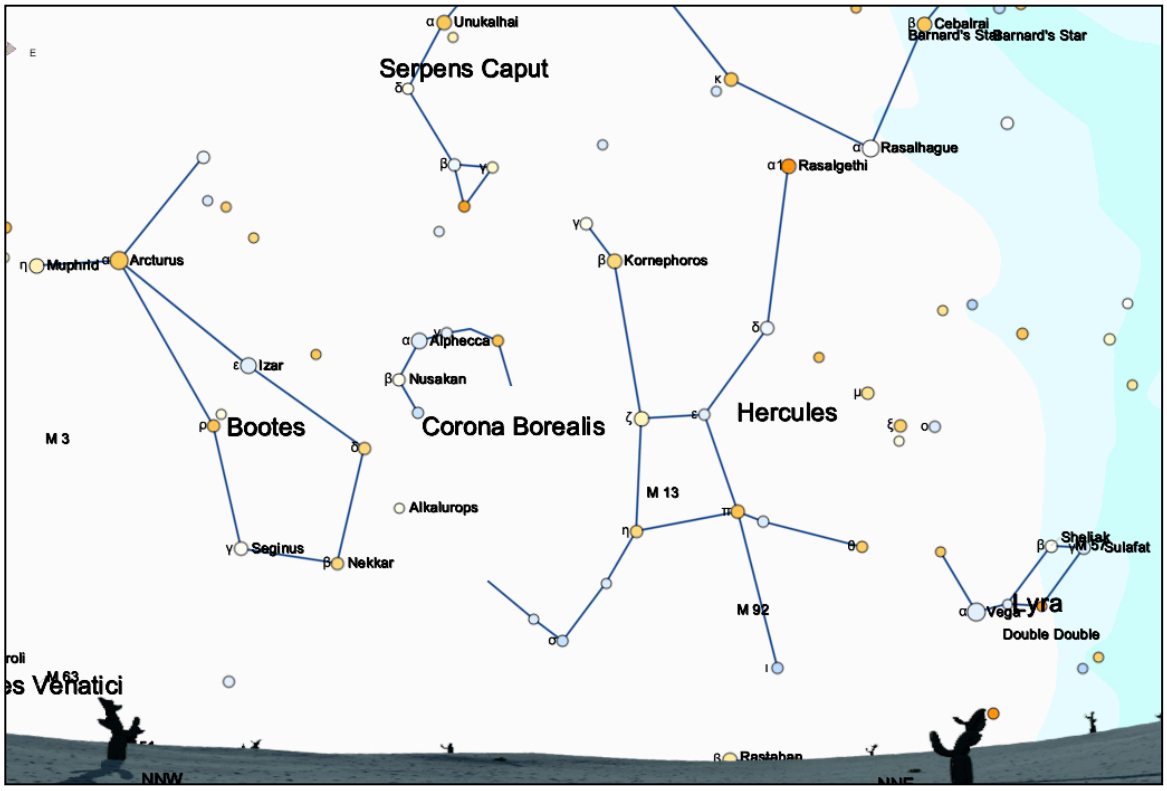
Hercules, and the Great Cluster

Directly north of Ophiuchus is the constellation Hercules, interesting as occupying that part of the heavens toward which the proper motion of the Sun is bearing the Earth and its fellow planets, at the rate of 16.5 kilometers per second in a stupendous voyage through space.

In the accompanying Map 10 we have represented the beautiful constellations Lyra and the Northern Crown, lying on either side of Hercules over the northern horizon. The brightest star in Lyra is the lovely blue-white Vega, which just skirts the northern horizon this time of year in the southern hemisphere.

The name Hercules indicates the mythological origin of the constellation, and yet the Greeks did not know it by that name, for the poet Aratus calls it "the Phantom whose name none can tell." Corona Borealis, the “Northern Crown”, according to fable, was the celebrated crown of Ariadne, and Lyra was the harp of Orpheus himself, with whose sweet music he charmed the hosts of Hades, and persuaded Pluto to yield up to him his lost love Eurydice.

With the aid of the map you will be able to recognize the principal stars and star-groups in Hercules, and will find many interesting combinations of stars for yourself. An object of special interest is the celebrated globular star cluster M13. You will find it on the map between the stars Eta (η) and Zeta (ζ). While binoculars will only show it as a nebulous and minute speck, lying nearly between two little stars, it is nevertheless well worth looking for, on account of the great renown of this wonderful congregation of stars. Sir William Herschel computed the number of stars contained in it as about fourteen thousand. More recent calculations estimate several hundred thousand stars belong to this cluster. It is roughly spherical in shape, though there are many straggling stars around it evidently connected with the cluster. In short, it is a ball of suns. These suns are probably very much older than our sun, some 10-12 billion years of age. The cluster lies some 25,000 light-years from earth, and spans more than 150 light-years from end to end. M13 is only exceeded in grandeur by Omega Centauri and 47 Tucanae (which you will meet later).



Map 10 - The constellation Hercules, Corona Borealis, and Lyra.

It is evident, too, that an observer on a planet in the Great Hercules Cluster or in the Omega Centauri cluster would enjoy the spectacle of a starry firmament incomparably more splendid than that which we behold. Only about three thousand stars are visible to our unaided eyes at once on any clear night, and of those only a few are conspicuous, and two thirds are so faint that they require some attention in order to be distinguished. But the spectator at the center of the Hercules cluster would behold some ten thousand stars at once, the faintest of which would be five times as brilliant as the brightest star in our sky, while the brighter ones would blaze like nearing suns. One effect of this flood of starlight may be to shut out from our observer's eyes all the stars of the outside universe. They would be effaced in the blaze of his sky, and he would be, in a manner, shut up within his own little star system, knowing nothing of the greater universe beyond, in which we behold the blazing stars in his sky, diminished by distance into a faint speck, floating like a silvery mote in a sunbeam.

If our observer's planet, instead of being situated in the center of the cluster, circled around one of the stars at the outer edge of it, the appearance of his sky would be, in some respects, still more wonderful. Less than half of his sky would be filled, at any time, by the stars of the cluster, the other half opening upon outer space and appearing by comparison almost starless a

vast, cavernous expanse, with a few faint glimmerings out of its gloomy depths. The plane of the orbit of his planet being supposed to pass through the center of the spherical system, our observer would, during his year, behold the night at one season blazing with the splendors of the clustered suns, and at another empty and faintly lighted with the soft glow of the Milky Way and the feeble flickering of distant stars, scattered over the dark sky. The position of the orbit, and the inclination of the planet's axis might be such that the glories of the cluster would not be visible from one of its hemispheres, necessitating a journey to the other side of the globe to behold them.

Larger binoculars will give you a more satisfactory view of M13, and there can be no possibility of mistaking it for a star. Compare this compact cluster, which only a 6 or 8-inch telescope can partially resolve into hundreds of component stars, with M7 and M24, described before, in order to comprehend the wide variety in the structure of these aggregations of stars.

And, after all, no one can expect to derive from astronomy any genuine pleasure or satisfaction unless he is mindful of the real meaning of what he sees. The actual truth seems almost too stupendous for belief. The mind must be brought into an attitude of profound contemplation in order to appreciate it. From this globe we can look out in every direction into the open and boundless universe. Blinded and dazzled during the day by the blaze of that star, of which the earth is a near and humble dependent, we are shut in as by a curtain. But at night, when our own star is hidden, our vision ranges into the depths of creation, and we behold them sparkling with a multitude of other suns. With so simple an aid as that of binoculars we penetrate still deeper into the profundities of space, and thousands more of these strange, far-away suns come into sight. They are arranged in pairs, sets, rows, streams, and clusters. Here they gleam alone in distant splendor, there they glow and flash in mighty swarms. Here is a celestial city whose temples are suns, and whose streets are the pathways of light.

STARGAZING FOR BEGINNERS

A BINOCULAR TOUR OF THE SOUTHERN NIGHT SKY

Section 3
"The Stars of Southern Spring"

Tucana, the Toucan
Dorado and the Large Magellanic Cloud
Capricorn, and Piscis Australis
Aquarius, Cetus, and Pisces
Pegasus, The Winged Horse

The Stars of Spring

In the this section you will learn the stars of the southern hemisphere as seen in spring, from September through mid-December.

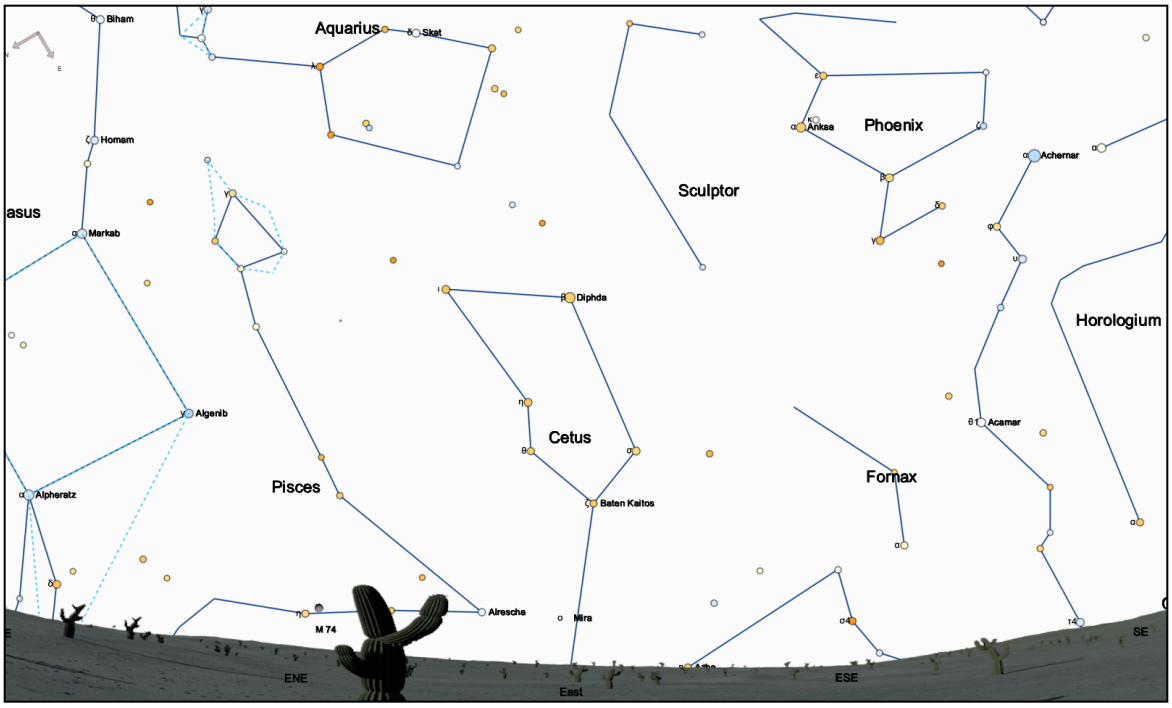
Since you learned the stars of winter, from June through September, the Earth has advanced for three months in its orbit, and as a consequence, the heavens have made one quarter of an apparent revolution. You'll find the stars which in June shone above the western horizon have been carried down out of sight, while the constellations that were then in the east have now climbed to the zenith, or passed over to the west, and a fresh set of stars has taken their place in the east. You will notice in particular that Crux and Centaurus are much lower in the southwest. The Milky Way, along with Sagittarius and Scorpius, are also sinking lower, though they are still well placed for observing.

Rising in the east is a new group of constellations, most of which have few bright stars and a fairly sparse background compared to the rich region of the Milky Way now sinking in the west.

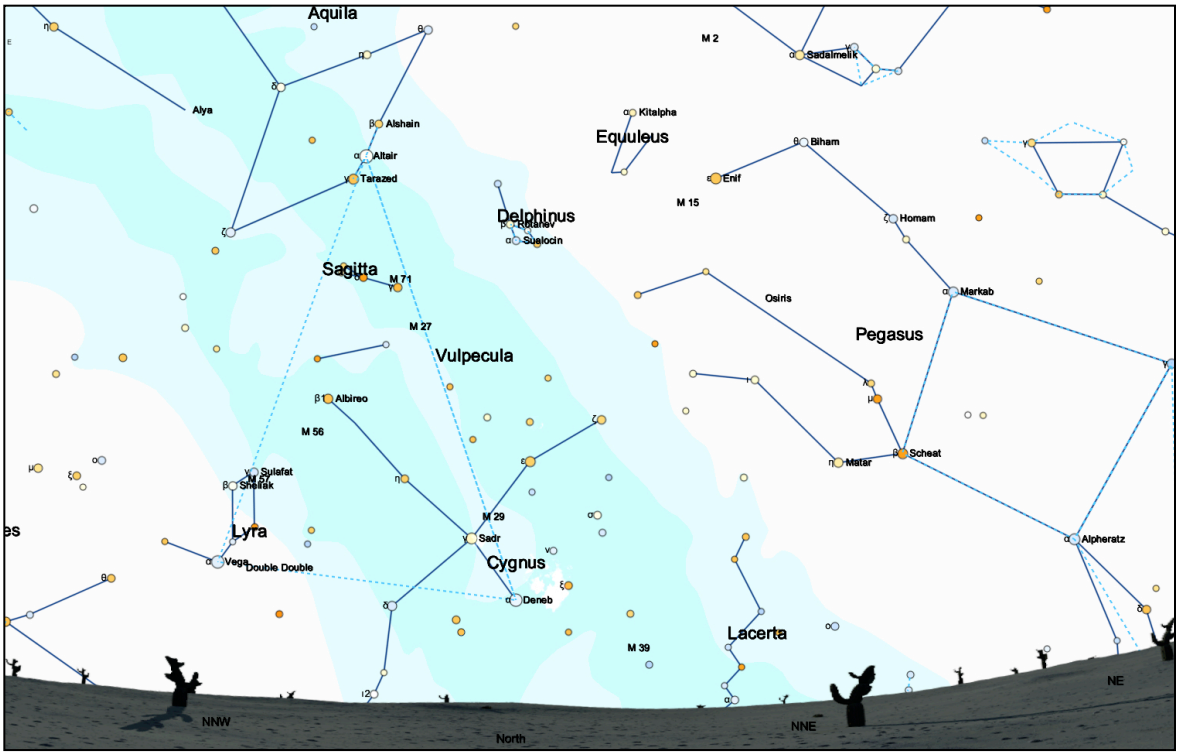
The reason for this is easy to understand. Our Milky Way galaxy is a flat spiral disk of stars. So when you look at the sky, the dense star clouds of our galaxy appear along a flat plane of sky. There are many bright foreground stars along this plane, too, and these stars make up outlines of the major constellations such as Sagittarius, Scorpius, Crux, and Centaurus. When we look away from the plane of the Milky Way, we see fewer foreground stars, no distant star clouds, and fewer nebulae and star clusters. Instead, we look into the depths of intergalactic space towards other galaxies, some of which are like the Milky Way, and some of which are quite different indeed.

Maps 11(a) through 11(e) show the sky as seen looking south, west, north, east, and directly overhead. The maps are accurate for a latitude of 35^{o} S at 9 p.m. on September 15 local time. As you learned in Section 2, the apparent motion of the sky means the maps are also accurate on September 1 at 10 p.m., on August 15 at 11 p.m, and on September 30 at 8 p.m.

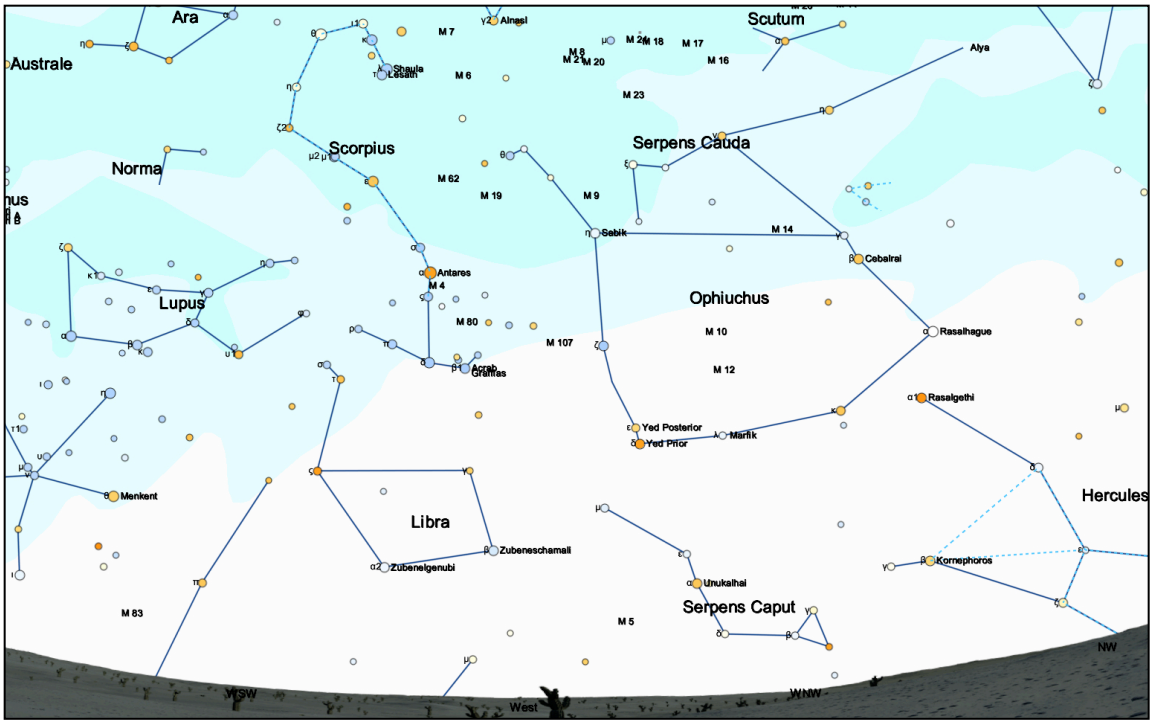
You can use the maps at other times, as well. Earlier in the evening on September 15, say at 8 p.m., you will be able to see many of these constellations, but you must look for them farther toward the east than they are represented in the map. And if you are further south than 35 degrees latitude, some stars on the northern horizon will not be visible, while the stars on the southern horizon will be higher.



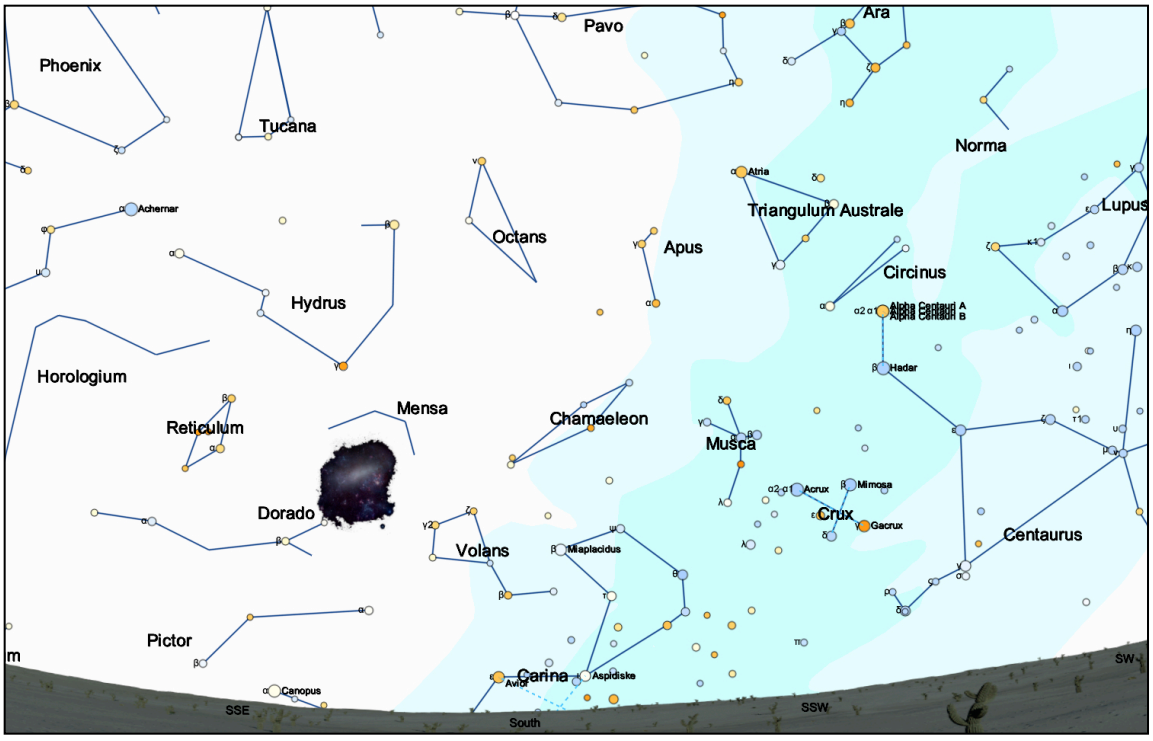
Map 11a - The Spring Constellations (looking EAST at 35 degrees S latitude, at 9 p.m. on September 15)



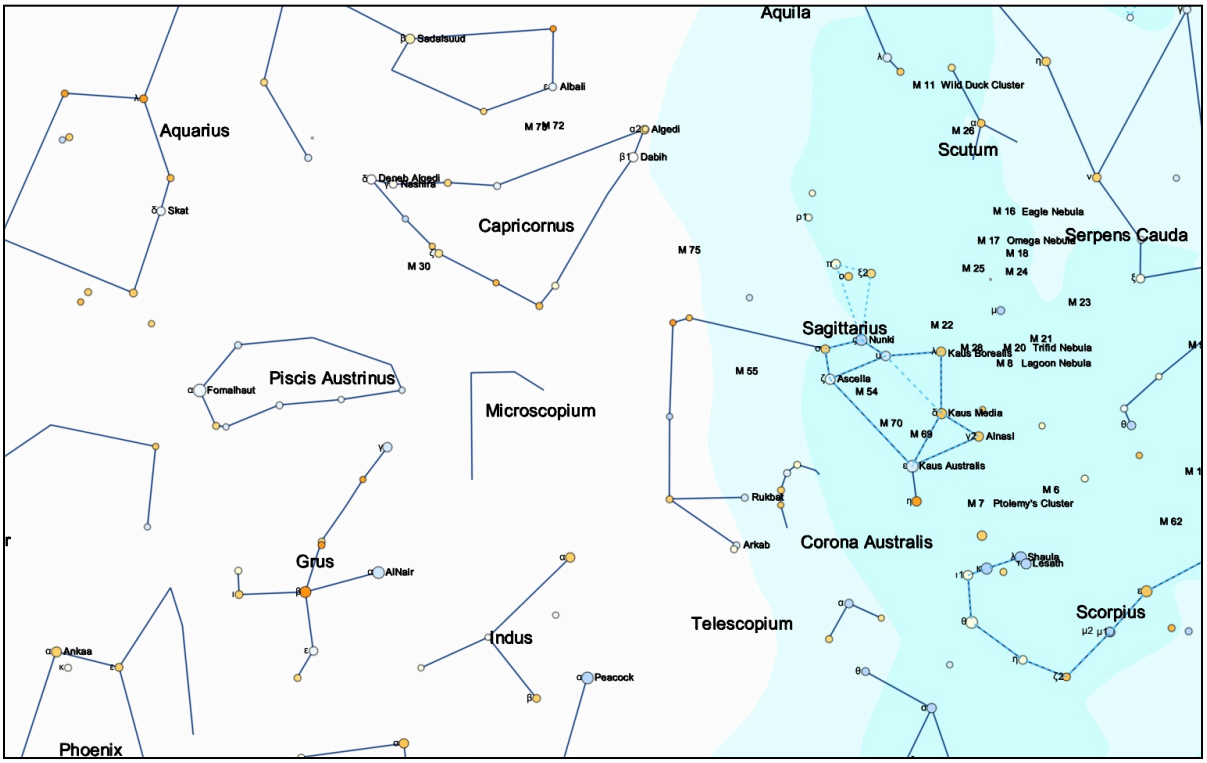
Map 11b - The Spring Constellations (looking NORTH at 35 degrees S latitude, at 9 p.m. on September 15)



Map 11c - The Spring Constellations (looking WEST at 35 degrees S latitude, at 9 p.m. on September 15)



Map 11d - The Spring Constellations (looking SOUTH at 35 degrees S latitude, at 9 p.m. on September 15)



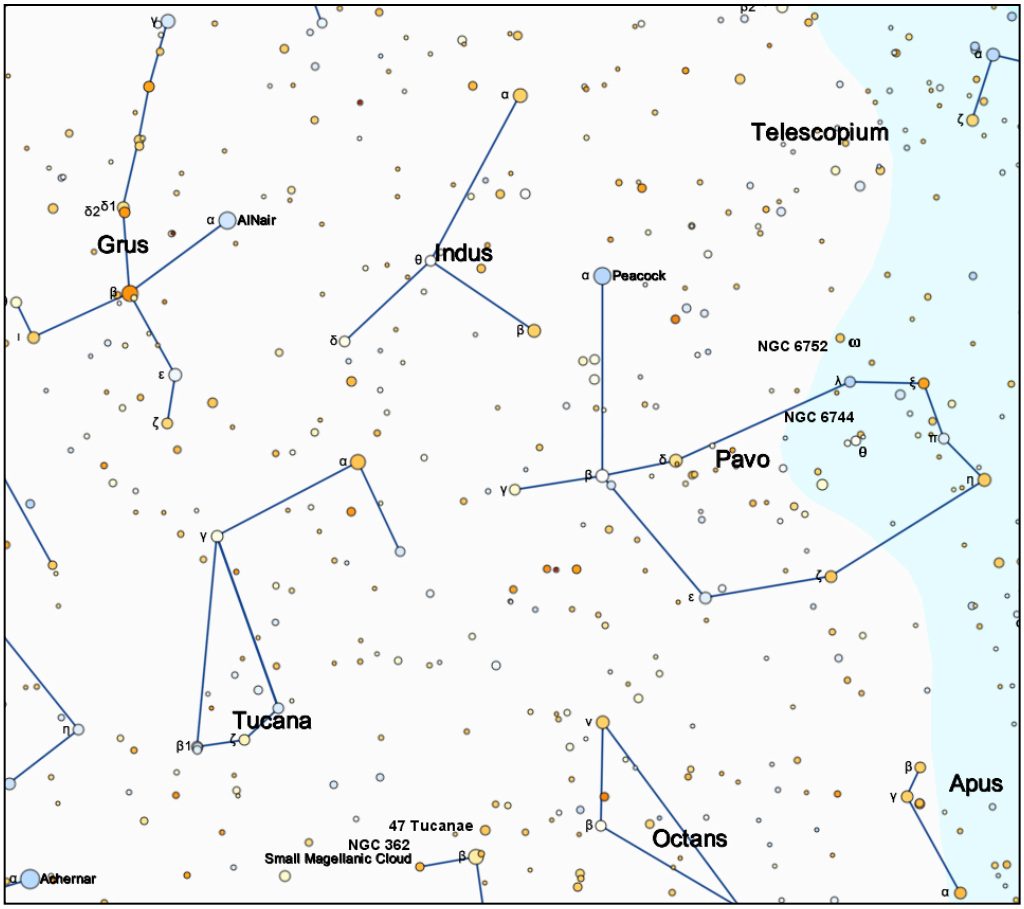
Map 11e - The Spring Constellations (looking OVERHEAD while facing south at 35 degrees S latitude, at 9 p.m. on September 15)

Tucana, the Toucan

As European explorers and astronomers traveled south of the equator, they assigned shapes and names to the unfamiliar star groupings of the deep southern sky, just as ancient Greek astronomers had done with the northern sky more than 18 centuries earlier. The constellation Tucana is one such star southern grouping. It was devised by Pieter Dirkszoon Keyser in the late 1500's during a voyage to the East Indies, and included on a star globe in 1598. Keyser had visited South America, and named this star grouping after the toucan, a large long-billed bird found in the jungles of that continent.

Not that Tucana at all resembles a toucan. The constellation has just three main stars, none of which is brighter than 3rd magnitude. From light-polluted city skies, the constellation may be hard to see at all. Look for it high above the southern horizon, just to the upper right of the bright star Achernar, the only bright star in this part of the sky (see Map 11d). The stars beta (β) Tucanae, zeta (ζ), and epsilon (ε) form the body of the toucan, the star gamma (γ) marks the eye, and the brightest star alpha (α) forms the beak.

While the constellation is unremarkable, there are a number of fascinating sights in Tucana for a stargazer equipped with binoculars. Perhaps the most intriguing is the globular star cluster 47 Tucanae. While the globular cluster omega Centauri is the largest and brightest in the night sky, some believe that 47 Tuc is the prettiest. Before telescopes, astronomers thought the cluster was a star, and assigned it a catalog number like a star: the "47" comes from the catalog number assigned to it by Johan Bode in 1801. Through binoculars, the cluster appears like an off-white ball of fluff, with some graininess visible in larger optics.



Map 12 - The deep southern constellations Tucana, Pavo, Octans, Indus, and Grus

Like omega Centauri, the cluster spans a patch of sky as large as the full Moon. 47 Tuc appears more concentrated near the core than omega Centauri. Through an 8-inch or larger telescope, the center of 47 Tucanae seems to burn like a flame. Astronomer Steven James O'Meara says the sight of 47 Tucanae through a telescope is like "cracking open a geode and finding it filled with gold dust".

In a telescope and larger binoculars, 47 Tucanae is bright enough to display a yellowish hue. That's not surprising since, like most globular clusters, the stars in 47 Tuc are ancient, low-mass reddish-orange stars. But the Hubble Space Telescope discovered dozens of blue stars, although blue stars burn hotter and should have disappeared long ago from this cluster. It seems these hotter stars formed by the slow merger of two low-mass red stars into massive hot blue stars.

47 Tucanae is one of the closest globular clusters to the Sun. It is just 14,700 light years away.

Tucana also hosts the smaller of the two Magellanic Clouds just to the east of 47 Tuc. Named after navigator Ferdinand Magellan, the clouds are small neighboring galaxies of our own Milky Way and two of the very few galaxies visible to the unaided eye. The Small Magellanic Cloud (SMC) in Tucana is some 22 degrees west of the Large Magellanic Cloud (LMC) in Dorado, which you will tour in the next section.

Without optics, the SMC appears as a hazy patch some 4x3 degrees across. To some, in binoculars, it takes on the shape of a comma or a “fish hook”. The SMC is an irregular galaxy, too small to form the elegant spiral shape of larger galaxies like the Milky Way. The SMC is just 7,000 light years wide compared to the diameter of 100,000 light years of our own galaxy.

The wider, brighter part of the SMC extends slightly to the south. In binoculars, few of the SMC’s stars can be resolved. It is simply too far away, roughly 200,000 light years. But there is some subtle structure to be observed in binoculars. Look especially at the northern edge of the SMC for four or five faint nebulae and unresolved star clusters. The brightest is NGC 346, a star-forming region and open star cluster.

The Magellanic Clouds were once called the “Cape Clouds” by Dutch and Portuguese navigators after the Cape of Good Hope in South Africa, a major point of navigation. And in Johann Bayer’s famous 1603 star atlas *Uranometria*, the cloud was called *Nubecula Minor* (the “little cloud”).

Off the northern edge of the Small Magellanic Cloud, look for the bright grainy smudge of the globular cluster NGC 362. This cluster is often overlooked for the more famous 47 Tucanae. But it’s a fine object in its own right. Compare the subtle differences between these two clusters. It will help sharpen your observing skills.

Before you leave the Toucan, inspect the two stars beta (β) and gamma (γ) Tucanae. Beta is a six-star system. A telescope resolves the brightest star into a double star, and each of these stars is itself a closer double star. Binoculars will show a more distant star, called beta-3, some 1/6 degree

away from the brighter system of stars. Gamma Tucanae also splits into a wide double star in binoculars, though these two stars are not associated and form a chance alignment.

Just northwest of Tucana, pause to note the constellation Indus, the Indian. This was also first included on Bayer's Uranometria in 1603, and extends across a long gap from Octans in the south to Microscopium in the north. Indus holds many faint galaxies accessible with large telescopes, but holds few sights of interest to binocular stargazers. East of Indus lies the indistinct constellation Grus, the Crane. It also holds little of interest, though the region around the red-orange star delta Gruis is a charming sight in even the smallest pair of binoculars.

Now to the constellation Pavo, the Peacock, another exotic celestial bird of the deep southern sky. Just west of Tucana and Indus, Pavo harbors two deep-sky delights. One is the grand spiral galaxy NGC 6744, which some astronomers consider to be a near twin of our own Milky Way. Long-exposure images of NGC 6744 reveal a wondrous sight, with multiple spiral arms, dust lanes, and star forming regions. In binoculars, the view is far more modest, but it's a great joy to glimpse a small stream of photons from this galaxy that have been traveling through the depths of intergalactic space for some 30 million years. Look for NGC 6744 a few degrees northeast of the lovely little group of stars that contains theta (θ) Pavonis. The galaxy will appear as a delicate oval glow with a slightly brighter core.

The second delight in the Peacock is the globular cluster NGC 6752. Just 2 degrees east of the star omega (ω) Pavonis, this lovely "glob" is visible in dark sky without optics. Binoculars reveal a yellowish but unresolved globe about 1/10 of a degree across. The cluster contains some 100,000 stars.

While 17th-century astronomers saw a Peacock when they looked at the stars of Pavo, some see a different shape. The open oval of stars adjoining the "handle" formed by alpha and beta remind Australian stargazers of a "saucepan".

The last stop in this part of the sky is the constellation Octans, the Octant. There's not much to see here with binoculars. There are few bright stars, star clusters, and galaxies in this part of the sky. But this constellation is as far south as you can go, so it contains the location of the South Celestial Pole (SCP), an imaginary point directly above the Earth's south pole. The SCP lies 1.5 degrees from the star sigma Octanis, which might be considered the "South Star", although at magnitude 5.6, it's not nearly as bright as Polaris, the North Star. As a consequence of its proximity to the stationary SCP, sigma Octanis barely moves as the celestial sphere makes its daily rotation. You learned how to find the position of the SCP in the section on the Spring Stars, on Map 5.

Dorado and the Large Magellanic Cloud

Twenty degrees east of the Small Magellanic Cloud lies its companion, the Large Magellanic Cloud (LMC), one the finest sights in the heavens. Sometimes called *Nubecula Major* (the "big cloud"), the LMC spans 11 degrees of sky across the constellations Dorado and Mensa. Dorado, the Swordfish, is itself a dim constellation first included in Bayer's *Uranometria.* The constellation has few sights of interest for binocular observers except for the LMC.

The LMC is easy to find, and may be seen even at Full Moon. At a distance of 160,000 light years, the LMC is closer than the SMC, and much larger. Its apparent size is a consequence not only of its proximity, but of its size: the LMC has a mass of some 10 billion suns, about 1/10 to 1/50 the mass of the Milky Way. The LMC is the 4th largest galaxy of the so-called Local Group of Galaxies behind the Andromeda Galaxy, the Milky Way itself, and the Triangulum Galaxy.

South of 20 degrees south latitude, the LMC is *circumpolar*, which means it never sets below the horizon at any time of year. But it's highest in the sky and best placed for frequent observation during these spring months.

Like the SMC, the LMC is an irregularly-shaped galaxy. But a closer look, even with binoculars, reveals a prominent bar in its middle. Some astronomers suggest the LMC once had more structure, and was perhaps a spiral galaxy which was scrambled by gravitational interactions with the Milky Way.

Perhaps as a consequence of this gravitational prodding, the Large Magellanic Cloud is wracked with star forming activity. There are dozens of bright nebulae where new stars are in the process of forming. And there are dozens more open clusters of brand new blue-white stars. This is a rich zone for exploring with a telescope, but a good pair of binoculars will still reveal many wonders in the LMC.

The most prominent object within the LMC is NGC 2070, the "Tarantula Nebula". You can glimpse this massive star-forming area as a bright patch along the eastern edge of the LMC. With binoculars, look for a network of swirling channels of darker dust and gas that give the region a spider-like appearance. Like all so-called "emission nebulae", the gas of the Tarantula is set aglow by a central cluster of hot blue stars.

With an apparent diameter of 0.7 degrees, the Tarantula Nebula must span some 1,000 light years, which makes it the largest known star forming region in the universe. If the nebula was the same distance from Earth as

the Great Orion Nebula, it would span 30 degrees of our sky and shine bright enough to cast shadows at night!

Look around the Tarantula for other faint nebulous specks, all of which are smaller emission nebulae in the LMC.

Now scan the northern edge of the LMC for the faint patch of star cluster NGC 1910. This is a rich cluster with dozens of stars. None are resolved in binoculars except for one: the star S Doradus, one of the most intrinsically brilliant stars known. This star is likely the most distant star visible in binoculars. It shines nearly a million times brighter than our Sun.

Another easy target in the LMC is the nebula NGC 1763. It's the brightest of a number of patches of nebulosity along the northeast edge of the Cloud.

Sorting out which object is which within the LMC is a difficult task, especially when you use a telescope. The link below will give you a detailed annotated image of the Large Magellanic Cloud from the European Southern Observatory. It will help you find the amazing number of clusters and nebulae in this nearby galaxy.

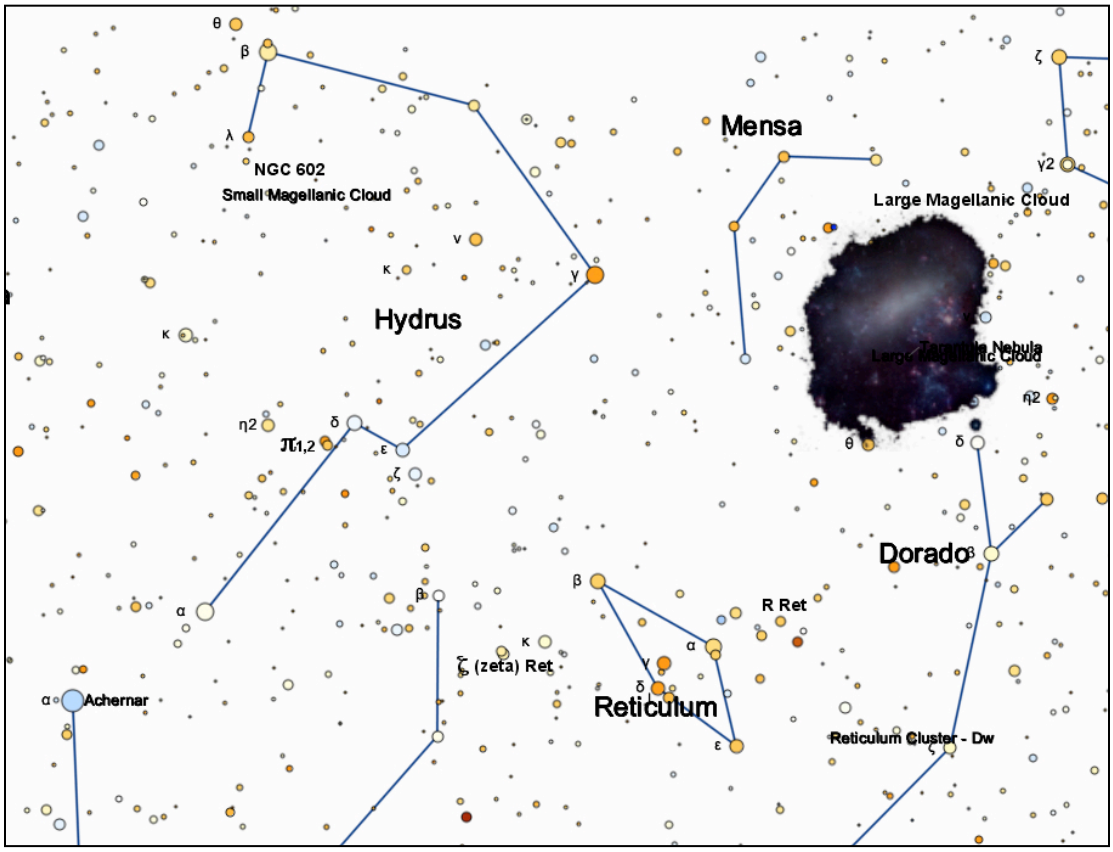
http://ace-spacetelescope.hq.eso.org/static/archives/images/screen/heic1011d.jpg

It surely stirs the imagination to think what an observer in the LMC would see from their vantage point of our own much larger galaxy. Astronomers calculate that the Milky Way, as seen from the LMC, would shine some 14 times brighter than the LMC shines in our own skies and stretch more than 1/5 of the way across the sky. And our fortunate hypothetical observer in the LMC would see the entire disk of our galaxy at an oblique angle… a much better view than we enjoy of the Milky Way from our place on the outskirts of its dusty plane.

Most of the Large Magellanic Cloud lies in Dorado, but its southern edge overlaps into the dim constellation Mensa, the Table. This is one of many southern constellations created by the French astronomer Lacaille during his star-mapping expedition to South Africa in 1752. Mensa was named after Table Mountain near Cape Town, and it's the only constellation named after a geographic landmark. It extends from the LMC nearly to the south celestial pole, but holds few sights of interest to binocular observers.

To the west of Mensa lies Hydrus, the Water Snake, which winds from the bright star Achernar in the constellation Eridanus towards the south celestial pole. The constellation was one of the exotic animals included by Bayer in his 1603 *Uranometria*. The Small Magellanic Cloud borders the constellation. The nebula NGC 602 resides in the SMC. This small oval patch, which appears devoid of stars, is just a few degrees from the Cloud.

NGC 602 is what stargazers call a “challenge object”. It is difficult to see with binoculars, and can be seen only in dark, clear sky away from artificial light.



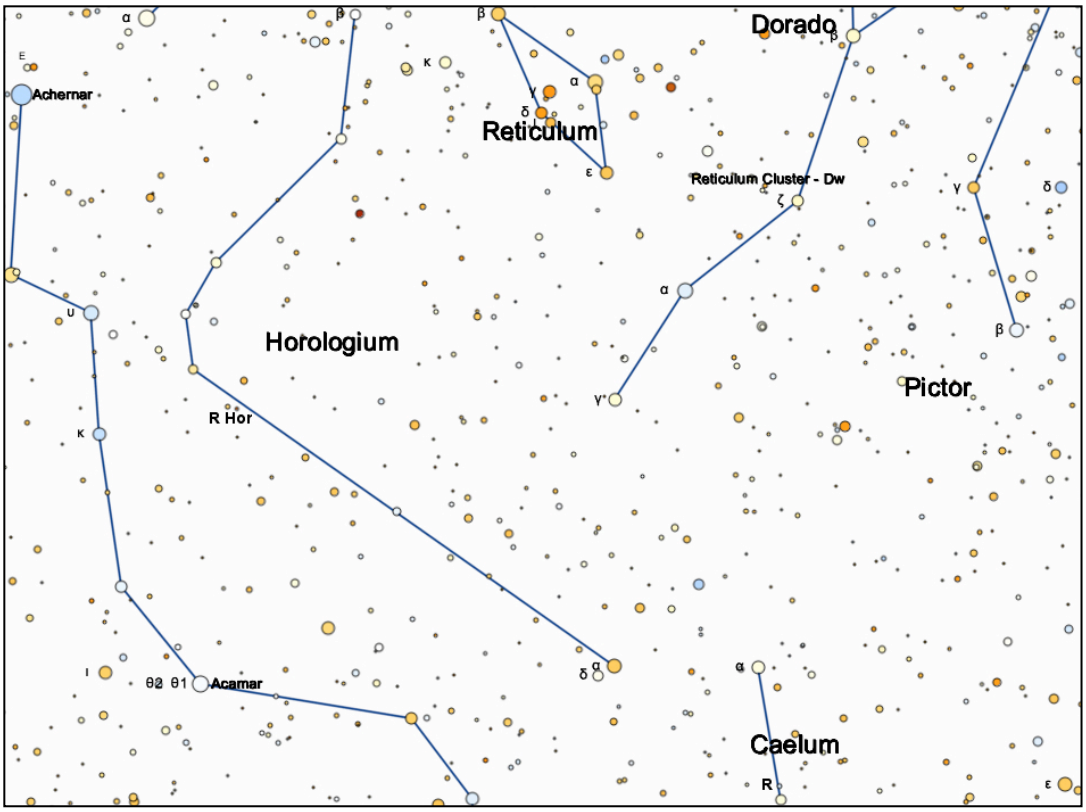
Map 13 - Dorodo, Hydrus, Mensa, Reticulum, and the Large Magellanic Cloud

The fine star pairing of pi (π) Hydrii presents a far easier sight. This lovely double star lies just a degree northwest of delta (δ) Hydrii, and about halfway between alpha (α) and gamma (γ). The stars are 1/4-degree apart, far enough to see without optics. In binoculars, the pair of 6th magnitude suns glow a vivid red-orange. Both stars are red giants... older stars that have burned through the store of hydrogen in their cores and have swollen as they burn helium and heavier elements.

On now to the small constellation Reticulum, the Reticle. Despite its diminutive size, the quadrilateral of Reticulum stands out quite nicely in this star-poor part of the sky, and there is a lovely field of isolated stars just east of alpha (α) Reticuli. In your binoculars, linger over these stars and look for the differences in color. There are orange stars here mostly, with one or two red and blue stars. The color of stars reveals their surface temperature. Red stars are cool, perhaps 3,500 K to 4,000 K. Orange stars a little warmer, yellow warmer still, and white and blue stars are hottest,

with temperatures of 10,000 K to 20,000 K depending on their mass. It is an astonishing feat that with a keen eye and a pair of binoculars, you are able to discern the temperature of a burning ball of gas dozens or hundreds of light years away!

Reticulum has a lovely double star for binoculars. It is zeta (ζ) Reticuli, located on the western end of the constellation. The pair is not separable without optics, but binoculars show a pair of golden-yellow stars about 1/10 degree apart. Astronomers have determined that each component of zeta Reticuli is very much like our own Sun. The pair lies nearly 40 light years from Earth.



Map 14 - The constellations Reticulum, Horologium, and Caelum

The variable star R Reticuli presents a wonderful show over the course of several months, and makes a good project for longer-term observation. R Ret is an example of a long-period variable, a type of red-giant star than pulsates over the course of nearly a year and varies in brightness by a thousand times or more. Near its peak brightness, R Reticuli shines at magnitude 6.5 and is easily seen in binoculars. Then it drops by 8 magnitudes to magnitude 14.5, virtually invisible in small optics, before rising again to its peak brightness. The full period from peak to peak is approximately 278 days. If you choose to follow the oscillations of R

Reticuli, there are many stars in the same field of view that serve as comparison stars.

You'll find a similar long-period variable star in the constellation Horologium, the Clock, to the west of Reticulum. The star, R Horologii, has a period of 408 days and changes from magnitude 4.7 to 14.3, a variation in brightness of 8000 times! The star is about 10 degrees south of theta (θ) Eridani, and just 1 degree north of a dim optical binary star. Horologium itself is a long thin constellation parallel to Eridanus (which you will meet in a later section). The constellation is another construct of Lacaille, who named his constellations after scientific and technical tools popular in his time.

Finally, take in the small Lacaille constellation Caelum, the Chisel, just north of Reticulum. With only two 4-th magnitude stars, it offers little of interest for binocular stargazers. The only exception is yet another long-period variable star R Caeli, which varies from magnitude 6.7 to a dim magnitude 13.7 over 391 days.

Capricorn, and Piscis Australis

Now face south and look up. To your right, you see the rich star fields towards the center of the Milky Way, and the constellation Sagittarius, which you have already toured. To your left, you see a region nearly devoid of bright stars except for one, the star Fomalhaut in the constellation Piscis Australis (the Southern Fish). The constellation is also called Piscis Austrinus on some star charts. Map 11e will help you with orientation in this part of the sky.

The star Fomalhaut is the brightest star in Piscis Australis. At magnitude 1.2, it is the 18th brightest star in the sky. But it seems brighter, perhaps because of the lack of any other bright stars nearby. Its name, from Arabic, means "mouth of the fish". Northern-hemisphere observers refer to Fomalhaut as "the lonely star of autumn", and its low elevation sometimes lends it a reddish color as its white light is scattered by atmospheric dust.

With binoculars, you will see Fomalhaut's companion star, a magnitude 6.5 red dwarf. Astronomers have determined the stars do not revolve around each other as do true binary stars. The stars are separated by more than a light year. But they do travel through space together, and may have formed in the star open star cluster millions of years ago. Fomalhaut is also interesting for having a debris ring with an embedded planet, which itself was imaged by astronomers with the Hubble Space Telescope.

Now look to Capricorn, the Goat, one of the zodiacal constellations (see Map 15).

Capricorn is very interesting on many accounts, though by no means a striking constellation to the unassisted eye. The stars Alpha (α), called Giedi, and Beta (β), called Dabih, will be readily recognized, and a keen eye will see that Alpha really consists of two stars. They are about six minutes of arc apart (about 1/10 of a degree), and are of the third and the fourth magnitude respectively. These stars, which to the naked eye appear almost blended into one, really have no physical connection with each other, and are slowly drifting apart. The ancient astronomers make no mention of Giedi being composed of two stars, and the reason is plain: in the time of Hipparchus, their distance apart was not more than two thirds as great as it is at present, so that the naked eye could not have detected the fact that there were two of them; and it was not until the seventeenth century that they got far enough asunder to begin to be separated by eyes of unusual power. With binoculars, they are thrown well apart, and present a very pretty sight. Considering the manner in which these stars are separating, the fact that both of them have several faint companions, which more powerful telescopes reveal, becomes all the more interesting.

The star Beta, or Dabih, is also a double star. The companion is of a beautiful blue color, generally described as "sky-blue." It is of the seventh magnitude, while the larger star is of magnitude three and a half. The latter is golden-yellow. The blue of the small star can be seen with binoculars, but it requires careful looking and a clear and steady atmosphere. The color is even more distinct, although the small star is more or less enveloped in the yellow rays of the large one. The distance between the two stars in Dabih is such that keen eyes are required to separate it. The difficulty is increased by the effect of a brighter star overwhelming its fainter companion.

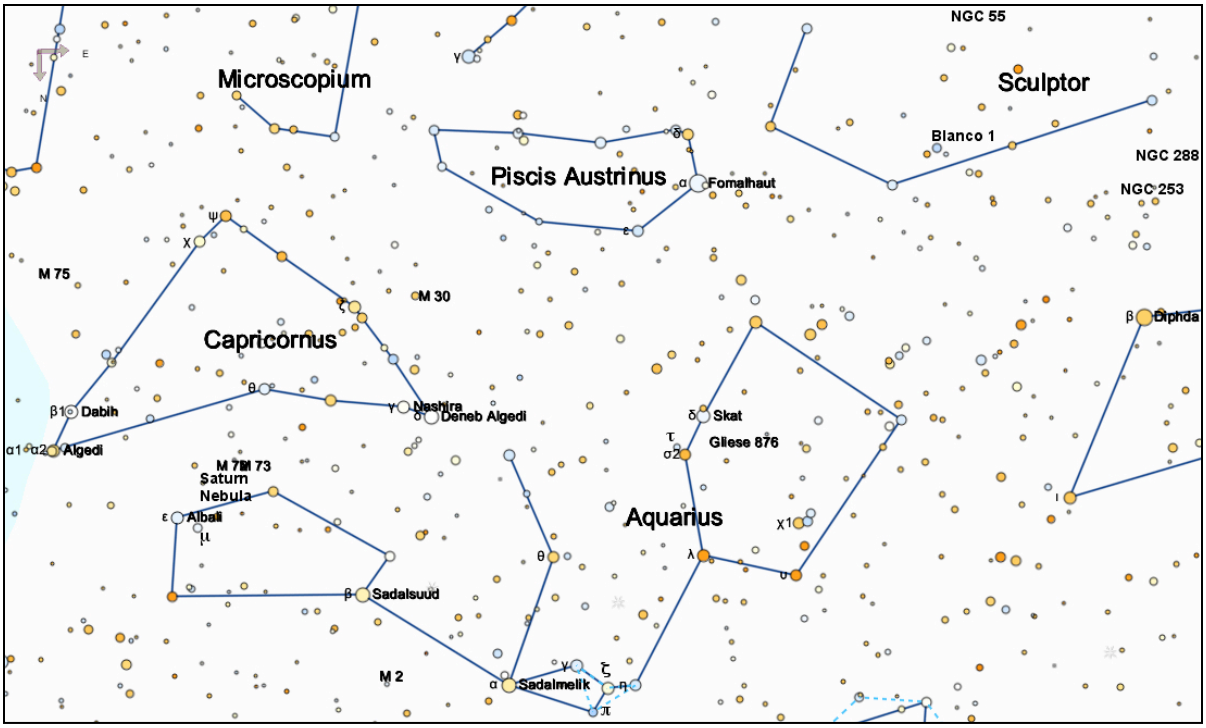
Now sweep from the star Zeta (ζ) eastward a distance somewhat greater than that separating Alpha and Beta, and you will find a fifth-magnitude star beside a little nebulous spot. This is the cluster known as M30, a faint globular cluster, at least in binoculars. A telescope reveals its individual stars. M30 is about 28,000 light years from Earth.

The mythological account of Capricorn is that it represents the goat into which Pan was turned in order to escape from the giant Typhon, the most fearsome of the monsters of Greek mythology. Typhon, at the will of Gaia, turned on Zeus for imprisoning the Titans. All the Greek gods were scared out of their wits and changed themselves into animals, even Zeus, who assumed the form of a ram. According to some authorities, Piscis Australis represents the fish into which Venus changed herself on that interesting occasion.

To the south of Capricorn lies the extremely dim constellation Microscopium. It appears as a dim patch of sky and harbors few sights for

binoculars, though there are a few appealing groups of two or three colorful stars set off by the black of the background sky.

South and east of Capricorn lies Phoenix, one of Bayer's exotic creatures of the southern sky. While the constellation holds many dim galaxies, none are visible in binoculars. But there's more to see in the constellation Sculptor just to the east. One of Lacaille's inventions, it is home to the Sculptor Group of Galaxies, one of the closest groups of associated galaxies to our own Milky Way. Some of its members, which are more than 12 million light years away, are visible in binoculars.



Map 15 - Capricorn, Sculptor, and Aquarius

NGC 55 is an edge-on spiral galaxy, with some irregularity to its structure. Even a pair of 7x binoculars reveal its ghostly, needle-like appearance. A recent measurements suggests this galaxy is not associated with the Sculptor Group, and may simple lie in the foreground.

NGC 253 is perhaps the most splendid spiral galaxy south of the celestial equator. It is called the "Silver Coin" galaxy because of its appearance in a small telescope. It looks like a frosted coin tilted at an angle. This spiral galaxy appears brighter near the core. Look for it about 7 degrees due south of the star beta Ceti in the constellation Cetus. Larger binoculars may reveal a hint of texture in this fine celestial sight. This galaxy is currently undergoing an intense period of star formation. Just 2 degrees

southeast of the Silver Coin, look for the dim glow of the loosely-packed globular cluster NGC 288.

Try also to find the curious sight of the open star cluster Blanco 1. Unlike many other such clusters, this is a very tenuous grouping of stars near zeta (ζ) Sculptoris. Look for about 30 dim 8th-magnitude stars scattered over 1.5 degrees in this otherwise sparse region.

Aquarius, Cetus, and Pisces

North and east of Sculptor are two more constellations of the zodiac: Aquarius, the Water Bearer and Pisces, the Fishes. Some say Aquarius commemorates Ganymede, the cup-bearer of the gods. It is represented in old star maps by the figure of a young man pouring water from an urn. The star Sadalmelik marks his right shoulder (see Map 15), and Sadalsuud his left, and Sadachbia, Zeta (ζ), Eta (η), and Pi (π) indicate his right hand and the urn. From this group a current of small stars will be recognized, sweeping with a curve toward the east, and ending at Fomalhaut; this represents the water poured from the urn, which the Southern Fish appears to be drinking. In fact, according to the pictures in the old maps, the fish succeeds in swallowing the stream completely, and it vanishes from the sky in the act of entering his distended mouth! In Greek, Latin, and Arabic this constellation bears names all of which signify "a man pouring water." The ancient Egyptians imagined that the setting of Aquarius caused the rising of the Nile, as he sank his huge urn in the river to fill it. Alpha was called by the Arabs Sadalmelik, which means the "king's lucky star," but what particular king enjoyed its benign influence and recorded his gratitude in its name, we are not told.

Starting from the group of stars just described as forming the Water-Bearer's urn, follow with a glass the winding stream of small stars that represent the water. Several very pretty and striking assemblages of stars will be encountered in its course. The star Tau (τ) is double and presents a beautiful contrast of color, one star being white and the other reddish-orange.

Aim your binoculars upon the star marked Nu (ν), and you will see, somewhat less than a degree and a half to the west of it, what appears to be a faint star of between the seventh and eighth magnitudes. You will have to look sharp to see it. Pristine dark sky is essential. The faint speck is a planetary nebula, unrivaled for interest by many of the larger and more conspicuous objects of that kind. In a telescope, it resembles the planet Saturn; in other words, that it consists apparently of a ball surrounded by a ring. But the spectroscope proves that it is a gaseous mass, and its size is sufficient to fill the orbit of Neptune! The shape of the Saturn Nebula proclaims unmistakably the operation of great metamorphic forces there.

This planetary nebula, like others of its kind such as the Ring Nebula in Lyra, is the consequence of a dying star which is throwing off its outer layers into space. Of course, with binoculars, you can see nothing of the strange form of this object, the detection of which requires the aid of powerful telescopes, but it is much to know where that unfinished destruction lies, and to see it, even though diminished by distance to a mere speck of light.

Further westward by a degree, and slightly southward, you will see M73, which was once believed to be a cluster of young stars, but which is now know to be only a chance alignment of stars in space. And a degree further to the west, you will glimpse the fuzzy speck of another globular cluster M72.

Turn your glass upon the star shown in Map 15 just above Mu (μ) and Epsilon (ε). You will find an attractive arrangement of small stars in its neighborhood. One is double to the naked eye, and the row of stars below it is well worth looking at. The star Delta (δ), called Skat, indicates the place where, in 1756, Tobias Mayer narrowly escaped making a discovery that would have anticipated that which a quarter of a century later made the name of Sir William Herschel world-renowned. The planet Uranus passed near Delta in 1756, and Tobias Mayer saw it, but it moved so slowly that he took it for a fixed star, never suspecting that his eyes had rested upon a member of the solar system whose existence was, up to that time, unknown to the inhabitants of this world.

Cetus is a very large constellation, and from the peculiar conformation of its principal stars it can be readily recognized. Although Map 11a shows the constellation just rising at 9 p.m. on September 15, the group fully emerges above the horizon by midnight on that date, or by 10 p.m. on October 15. Map 16 shows the full constellation. The head is to the east, the star Alpha (α), called Menkar, lies in the nose of this imaginary inhabitant of the sky-depths. The constellation is supposed to represent the monster that, according to fable, was sent by Neptune to devour the fair Andromeda, but whose bloodthirsty plan was gallantly frustrated by Perseus, as we shall learn from starry mythology further on.

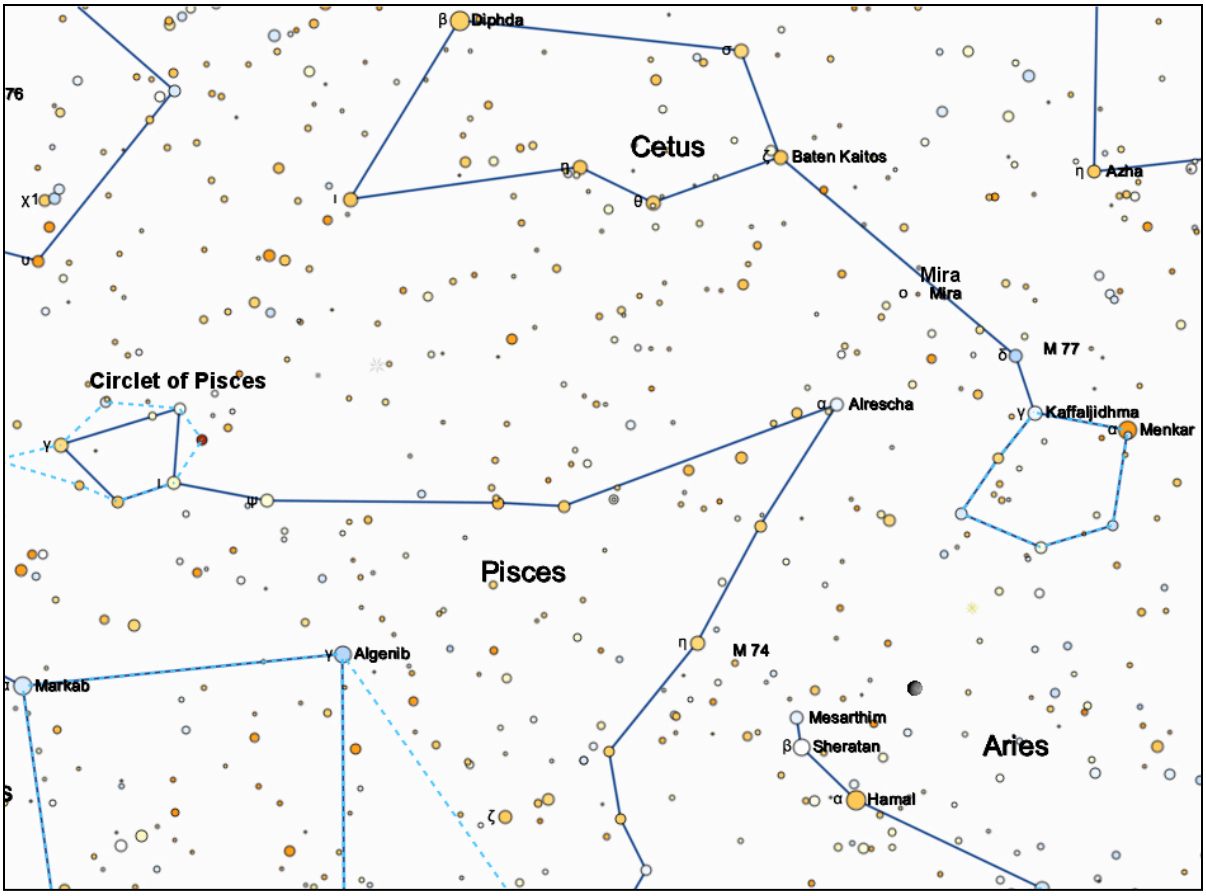
Although bearing the name Cetus, the Whale, the pictures of the constellation in the old maps do not present us with the form of a whale, but that of a most extraordinary scaly creature with enormous jaws filled with large teeth, a forked tongue, forepaws armed with gigantic claws, and a long, crooked, and dangerous-looking tail. Indeed, the ancient Greek poet Aratus does not call it a "whale," but a "sea-monster," whose terrible prowess is celebrated in the book of Job.

By far the most interesting object in Cetus is the star Mira (omicron Ceti). This is a famous variable star that sometimes shines more than a thousand-fold more brilliantly than at others... you have met a few stars of this type already, but Mira is the archetype. The star changes from the second magnitude to the ninth or tenth, its period from maximum to maximum being about eleven months. During about five months of that time it is completely invisible to the naked eye; then it begins to appear again, slowly increasing in brightness for some three months, until it shines as a star of the second or third magnitude, being then as bright as, if not brighter than, the most brilliant stars in the constellation. It retains this brilliance for about two weeks, and then begins to fade again, and, within a few months, once more disappears. There are various irregularities in its changes, which render its exact period somewhat uncertain, and it does not always attain the same degree of brightness at its maximum. For instance, in 1779, Mira was almost equal in brilliance to a first-magnitude star, but frequently at its greatest brightness it is hardly equal to an ordinary star of the second magnitude. Like all such stars, Mira has a slightly reddish tint.

Directly adjacent to Cetus is the long, straggling constellation of Pisces, the Fishes (Map 16). The Northern Fish is represented by the group of stars near Andromeda. A long band or ribbon, supposed to bind the fish together, trends first southeast and then west until it joins a group of stars under Pegasus, which represents the Western Fish, not to be confounded with the Southern Fish described near the beginning of this section, which is a separate constellation. Fable has, however, somewhat confounded these fishes; for while the Southern Fish is said to represent Venus after she had turned herself into a fish to escape from the giant Typhon, the two fishes of the constellation we are now dealing with are also fabled to represent Venus and her interesting son Cupid under the same disguise assumed on precisely the same occasion. If Typhon, however, was so great a brute that even Cupid's arrows were of no avail against him, we should, perhaps, excuse mythology for duplicating the record of so wondrous an event.

Take your glass and, beginning with the attractive little group in the Northern Fish, follow the windings, of the ribbon, with its wealth of tiny stars, to the Western Fish. When you have arrived at that point, sweep well over the sky in that neighborhood, and particularly around and under the stars Iota (ι), Theta (θ), Lambda (λ), and Gamma (γ), called the “Circlet of Pisces”. If you are using a powerful glass, you will be surprised and delighted by what you see. Below the star Omega (ω), and to the left of Lambda, is the place which the sun occupies at the time of the March equinox in other words, one of the two crossing-places of the equator of the heavens, and the ecliptic, or the sun's path. The prime meridian of the heavens passes through this point.

To the left of Pisces, and above the head of Cetus, is the constellation Aries, or the Ram. It rises above the northeastern horizon later in the season. According to fable, this constellation represents the ram that wore the golden fleece, which was the object of the celebrated expedition of the Argonauts. There is not much in the constellation to interest us, except its historical importance, as it was more than two thousand years ago the leading constellation of the zodiac, and still stands first in the list of the zodiacal signs. Owing to the precession of the equinoxes, however, the March equinox, which was formerly in this constellation, has now advanced into the constellation Pisces, as we saw above.



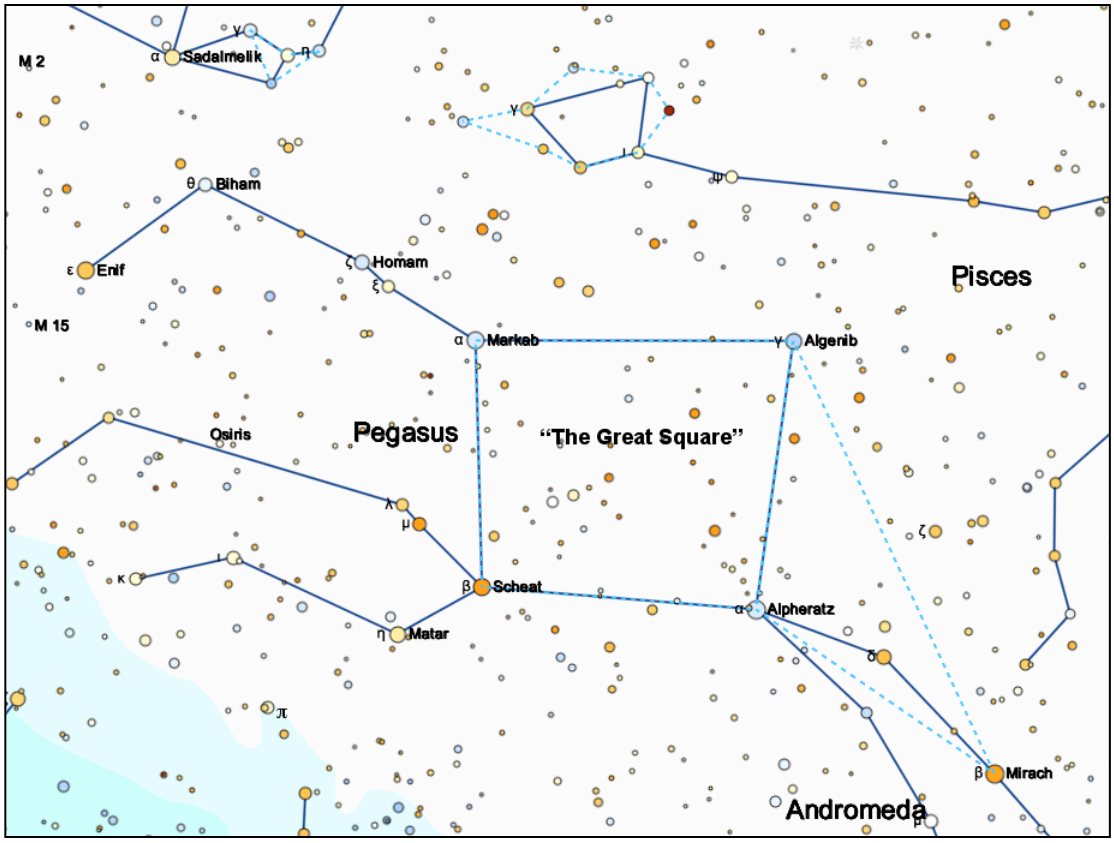
Map 16 - The constellations Pisces and Cetus

Pegasus, The Winged Horse

Below Aquarius you will find the constellation Pegasus. It is conspicuously marked by four stars of about the second magnitude, which shine at the corners of a large square, called the Great Square. This figure is some fifteen degrees square, and at once attracts the eye, there being few stars visible within the quadrilateral, and no large ones in the immediate neighborhood to distract attention from it. One of the four stars, does not belong to Pegasus, but to the northern constellation Andromeda.

Mythologically, this constellation represents the celebrated winged horse of antiquity.

The star Alpha (α) is called Markab; Beta (β) is Scheat, and Gamma (γ) is Algenib; the fourth star in the square, belonging to Andromeda, is called Alpheratz. Although Pegasus presents a striking appearance to the unassisted eye, on account of its great square, it contains little to attract the observer with small binoculars. An exception is the fine globular cluster M15, which resembles the Great Cluster in Hercules, but presents a tighter star-like structure than M13. Make no mistake, it is a majestic cluster of hundreds of thousands of ancient stars. You will easily see M15 in dark sky off the nose of Pegasus by following the line extending from the stars Biham to Enif.



Map 17 - The great winged horse Pegasus

It will also prove interesting, however, to sweep with the glass carefully over the space within the square, which is comparatively barren to the naked eye, but in which many small stars will be revealed, of whose existence the naked-eye observer would be unaware. The star marked Pi Peg (π), in the horse's foot, is an interesting double which can be separated by a good eye without artificial aid, and which, with binoculars, presents a fine appearance.

In Greek legend, Pegasus was the winged horse that carried the heroic Perseus to save the princess Andromeda from the fearsome sea monster Cetus. Andromeda was chained to the rocky shore by the sea-god Neptune, who was offended when Andromeda's mother, Cassiopeia, boasted that her daughter was fairer than all of Neptune's sea nymphs. Perseus happened upon Andromeda after slaying the Gorgon Medusa, and used the Gorgon's head to turn the sea monster to stone. Afterward, Perseus married the princess, and Cassiopeia and her husband Cepheus gave the couple a royal welcome home.

Two of the celestial namesakes of this story, the constellations Cepheus and Cassiopeia, are not visible from most of the southern hemisphere, and even fair Andromeda and mighty Perseus only skirt the northeastern horizon later this season.

Finally, look to the north. With the help of Map 11b, look for the triangle of bright stars Vega, Altair, and Deneb. This is the "Winter Triangle" in the southern hemisphere, and the "Summer Triangle" in the north. This group of stars brings the hope of warmer nights and longer days in the southern summer, to which we turn in the next section.

STARGAZING FOR BEGINNERS

A BINOCULAR TOUR OF THE SOUTHERN NIGHT SKY

Section 4
“The Stars of Southern Summer”

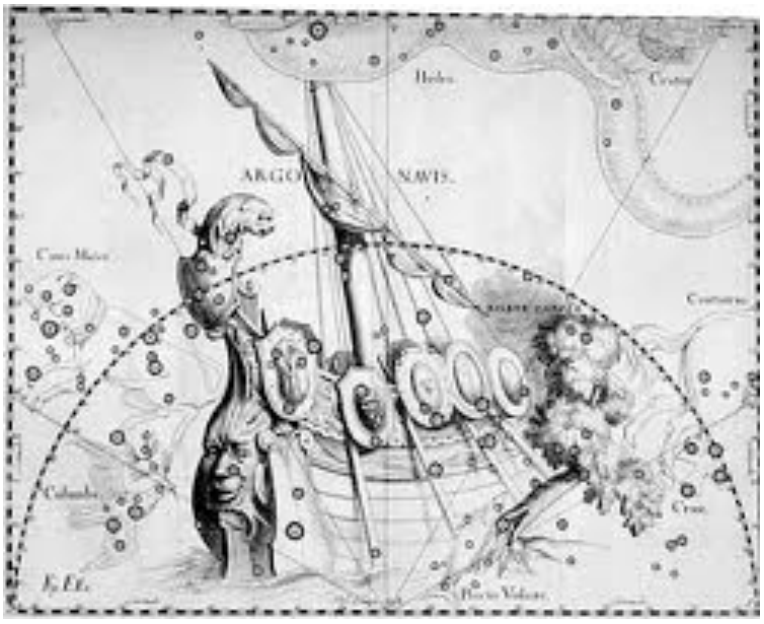
Carina and Puppis
Orion and Lepus; Eridanus
Taurus; the Hyades and Pleiades
Canis Major; Sirius; Monoceros

The Stars of Summer

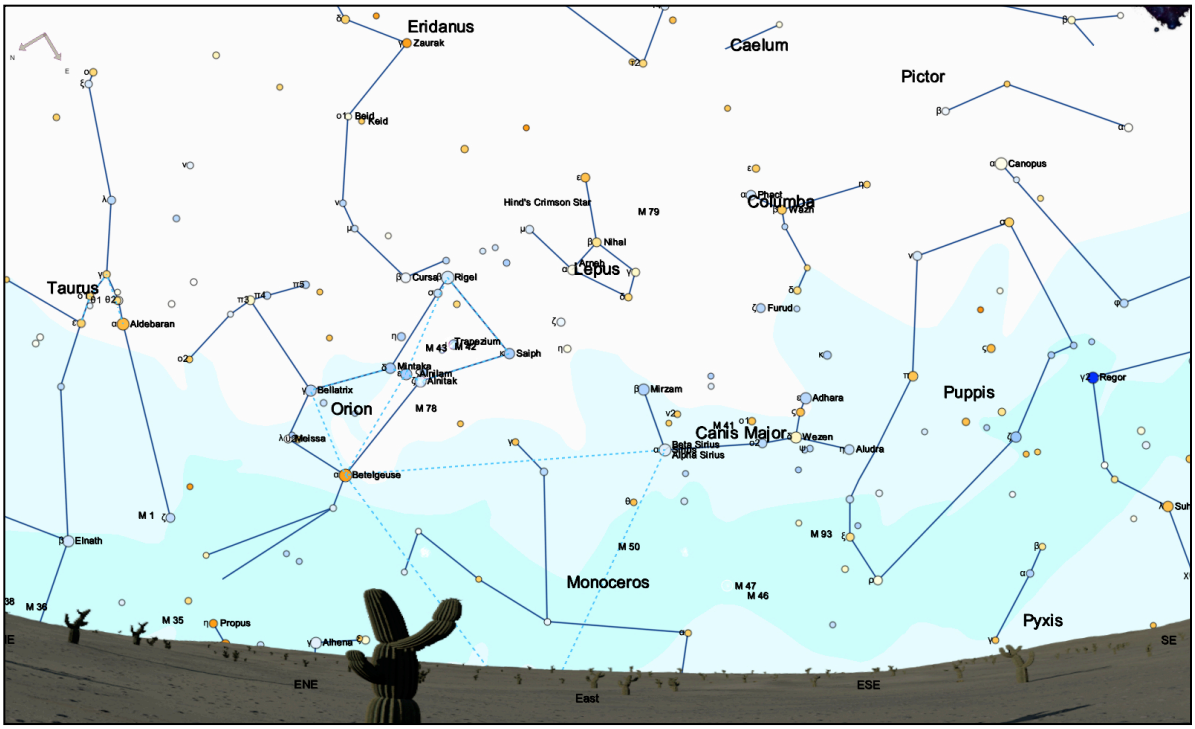
In the this section you will learn the stars of the southern hemisphere as seen in summer, from December through mid-March.

Since you learned the stars of spring, from September through December, the Earth has once again advanced for three months in its orbit, and as a consequence, the heavens have made one quarter of an apparent revolution. You'll find the stars which in September shone high in the sky, such as Scorpius and Capricorn, have been carried down towards the western horizon, while the constellations that were then in the east, such as Eridanus, have now climbed towards the zenith.

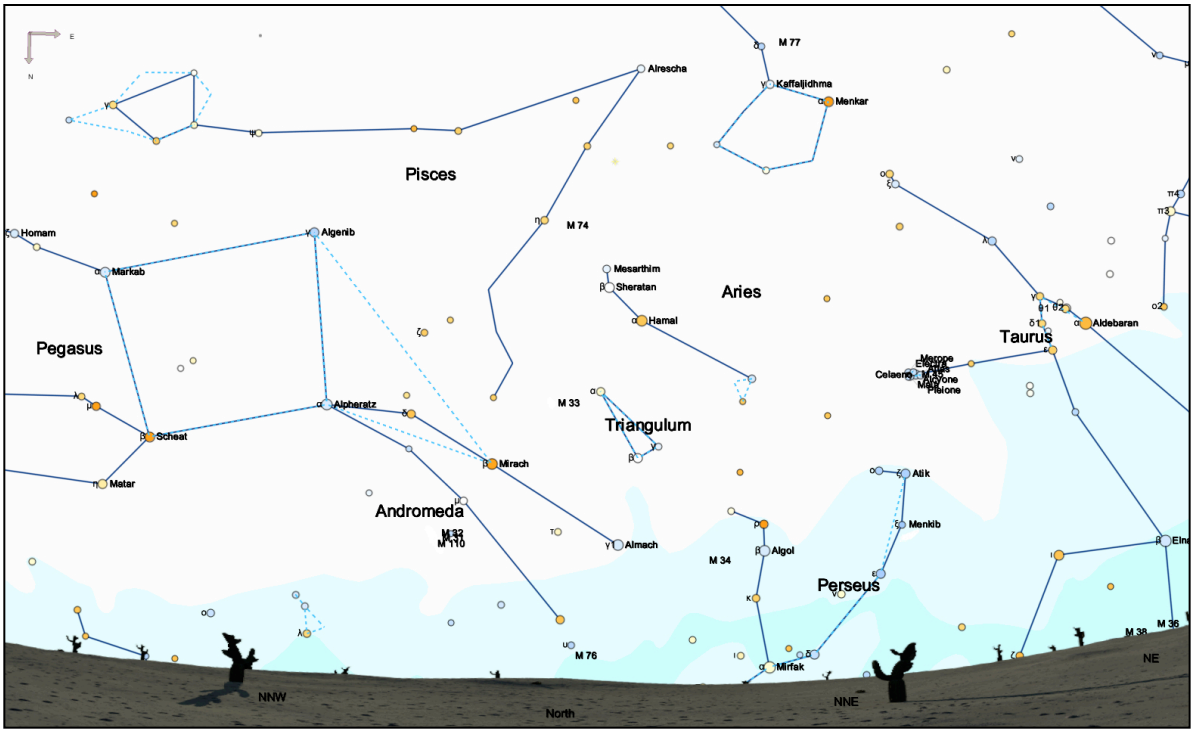
Maps 18(a) through 18(e) show the sky as seen looking south, west, north, east, and directly overhead. The maps are accurate for a latitude of 35 degrees south at 9 p.m. on December 15 local time. As you learned in Section 2, the apparent motion of the sky means the maps are also accurate on December 1 at 10 p.m., on November 15 at 11 p.m, and on December 30 at 8 p.m. You can use the maps at other times, as well. Earlier in the evening on December 15, say at 8 p.m., you will be able to see many of these constellations, but you must look for them farther toward the east than they are represented in the map. And if you are further south than 35 degrees latitude, some stars on the northern horizon will not be visible, while the stars on the southern horizon will be higher.



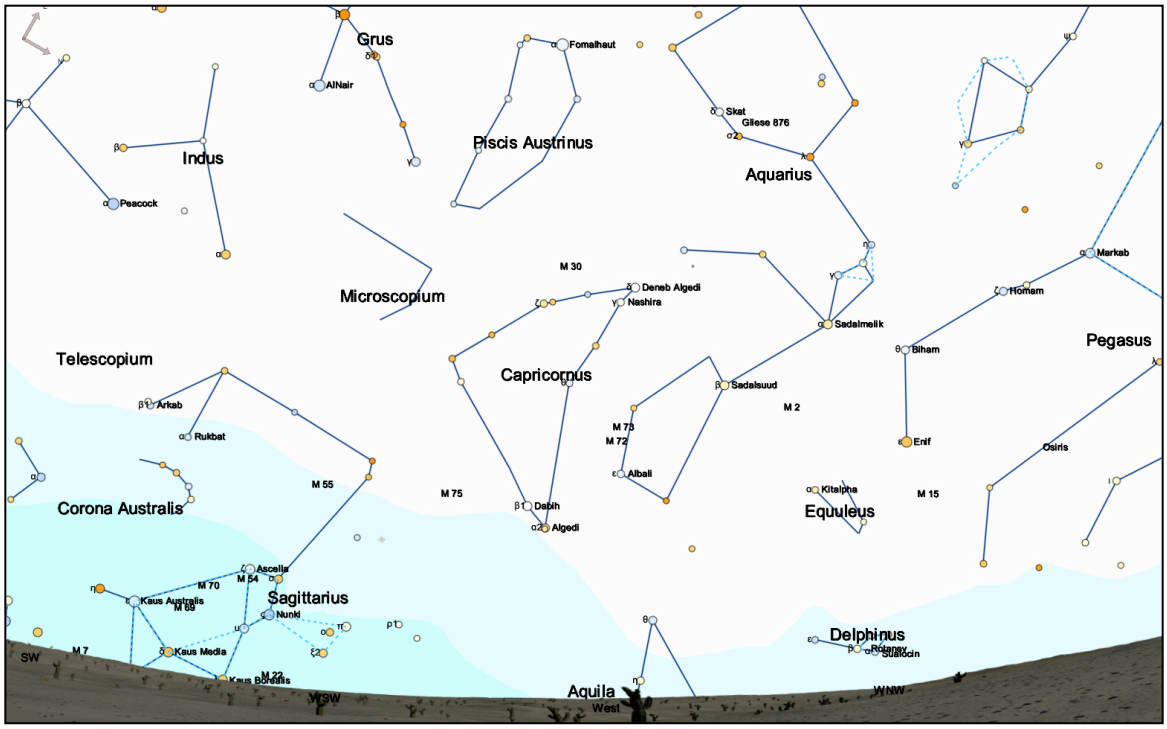
An image of the defunct constellation Argo Navis



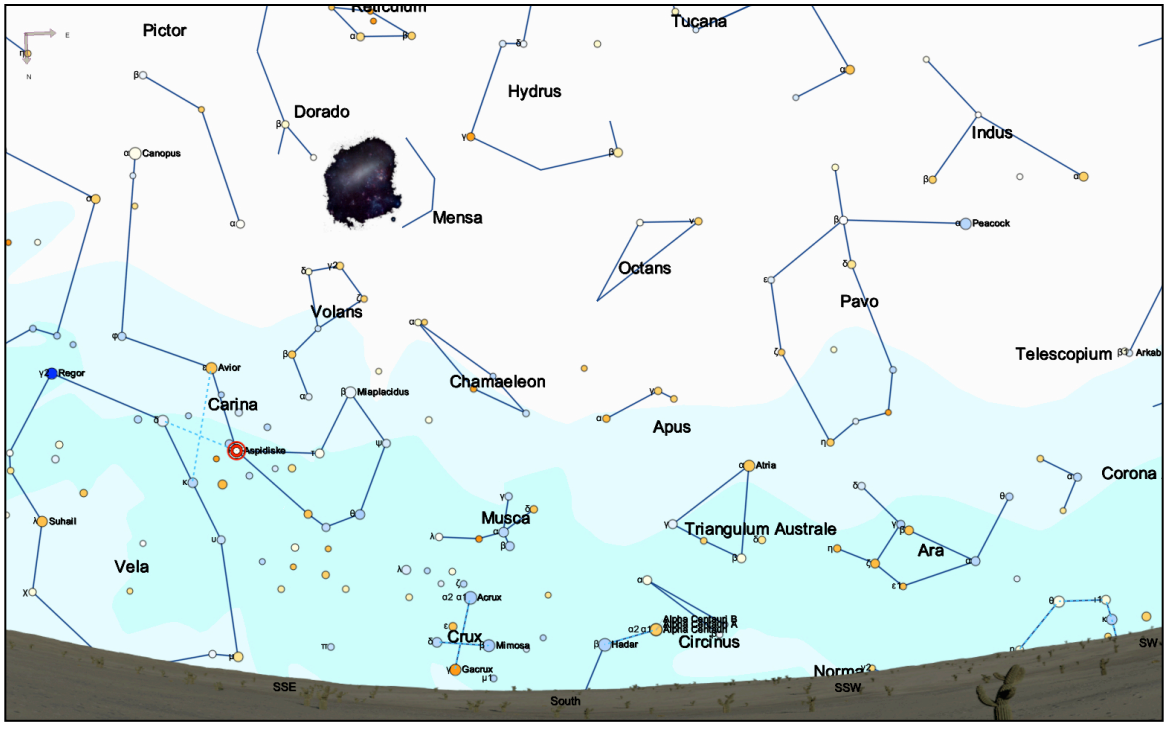
Map 18a - The Spring Constellations (looking EAST at 35 degrees S latitude, at 9 p.m. on December 15)



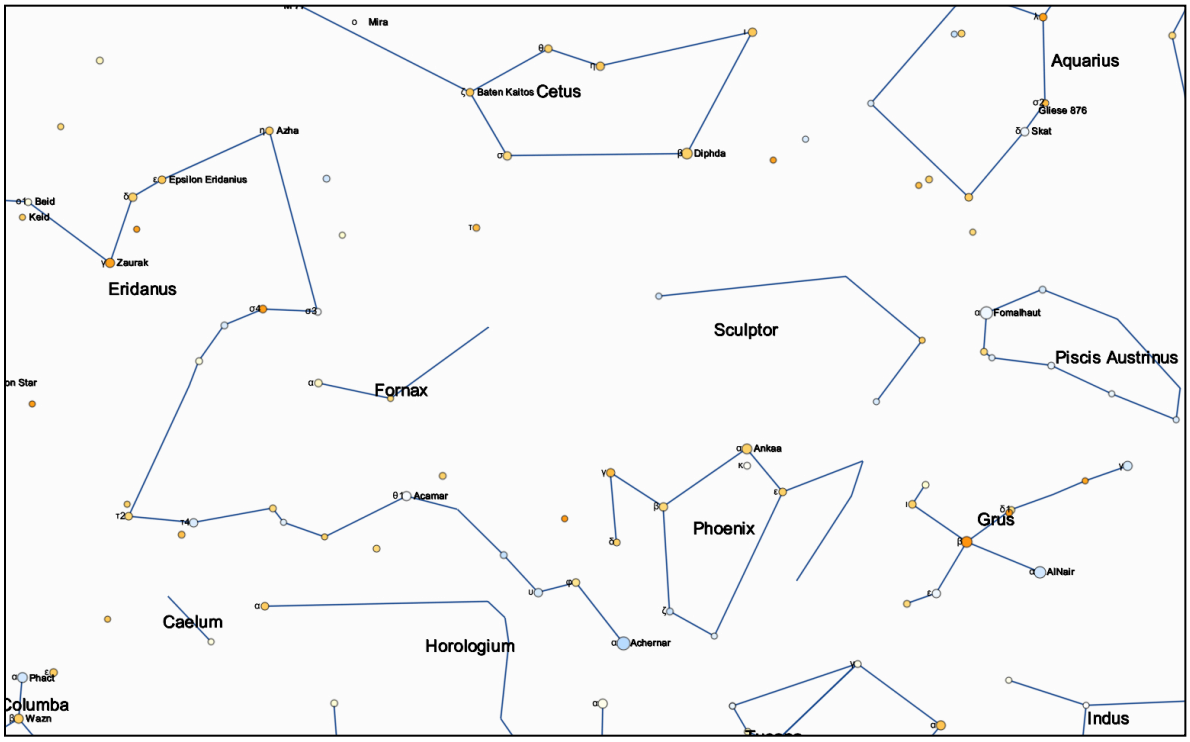
Map 18b - The Spring Constellations (looking NORTH at 35 degrees S latitude, at 9 p.m. on December 15)



Map 18c - The Spring Constellations (looking WEST at 35 degrees S latitude, at 9 p.m. on December 15)



Map 18d - The Spring Constellations (looking SOUTH at 35 degrees S latitude, at 9 p.m. on December 15)



Map 18e - The Spring Constellations (looking OVERHEAD while facing south at 35 degrees S latitude, at 9 p.m. on December 15)

Rising in the east is a new group of stars, including the famous constellations Orion, Taurus, and Canis Major. Further to the southeast, the constellations Carina, Puppis, and Vela begin their journey into the southern summer sky. You will learn these constellations and the stars and deep-sky sights within their boundaries in this section. Map 18a will help you learn the outlines and locations of these important constellations. While these stars are lower on the eastern horizon in mid-December, they will rise towards overhead in the evening hours by February and March.

Towards the north, with the help of Map 18b, you will see the Great Square of Pegasus moving towards the west. And you will see, if you have a clear view of the northern horizon, the bright stars of the far northern constellation Perseus poking up to send their light towards the southern reaches of our small planet.

Turn to the west to see our old friends Aquarius, Capricorn, Piscis Australis, and Sagittarius setting for the season (Map 18c). The Large Magellanic Cloud is still high enough for viewing (Map 18d), while Crux just skirts the horizon for most observers. And overhead, you see the winding constellation Eridanus, the River, come into its prime (Map 18e). The bright star Achernar marks the river's end (or beginning). Like the star Fomalhaut

in Piscis Australis, Achernar is one of the most isolated bright stars in the night sky.

Carina and Puppis

Rising in the east in December, and moving higher in the southeastern sky as summer progresses, you will find the sprawling expanse of sky covered by the constellations Carina, Puppis, Vela, and Pyxis. Until the 18th century, these constellation were once part of a single large constellation called Argo Navis, which was 28% larger than Hydra, which is now the largest constellation in the heavens.

Most of the stars of Argo Navis were known to ancient Greek astronomers. The constellation was included in the original list of 48 constellation developed by Ptolemy in his *Almagest* astronomy treatise in the 2nd century A.D. The constellation represents the massive oar-driven galley in which the legendary Jason and his Argonauts sailed to the Black Sea to find the Golden Fleece. The galley was constructed of sturdy oak beams from trees on Mount Pelion. The prow of the ship was fitted with a beam from the Oracle of Zeus at Dodona in northern Greece. Argo Navis carried many heroes of Greek legend, including Castor, Polydeuces, and Heracles. After a harrowing passage through the Bosporus Strait which was guarded by the Clashing Rocks that ground other ships to bits, Jason recovered the Golden Fleece from King Aeetes,. Once the expedition was over, the Argo Navis was beached at Corinth and dedicated to the sea god Poseidon.

Argo Navis was dismantled into Carina, Puppis, Vela, and tiny Pyxis by Nicholas Lacaille in his southern star catalogue of 1762. This part of the sky is rich with bright stars and deep-sky sights. In this section, we will examine the keel of Argo Navis, now called Carina, and its “poop deck”, called Puppis. In the next section, the Stars of Autumn, we will tour the galley’s sail, now the constellation Vela.

Along with Crux and Centaurus, Carina is the richest region of the deep-southern sky. It offers many hours of pleasant observing for stargazers equipped with binoculars or a small telescope. The constellation is particularly rich with open star clusters that fleck path of the nearby Milky Way. Map 19 helps you orient yourself with this constellation.

The bright star Canopus marks the base of the keel of Argo Navis. Also called alpha (α) Carinae, Canopus is the second brightest star in our skies. Only Sirius, which you meet later in this section, is brighter. Sirius lies about 20 degrees directly north of Canopus, and the pair make a dazzling sight in the southern summer sky. Canopus shines with an apparent magnitude of -0.72, about half as bright as Sirius. But Canopus is

intrinsically far brighter. If Canopus, which is 310 light years away, were moved to the same distance as Sirius, about 8.6 light years, it would shine with an apparent magnitude of -8.5. That's bright enough to clearly see in our daytime skies and cast shadows on moonless nights.

Since it's a bright star off the ecliptic, away from the Sun and bright planets, Canopus often serves as a navigation star for many deep-space probes, which orient themselves relative to Canopus and other guide stars using star-tracking cameras and control systems.

Canopus takes its name from the pilot of the sea ship that carried the legendary Menelaus from Greece to Troy in an attempt to reacquire his beautiful wife, Helen, from the feckless Trojan prince Paris. Much bloodshed and misery ensued for good men, on both sides, as readers of Homer's Odyssey well know.

The Chinese have a different legend for this star, although Canopus is only visible in southern China, and even there would be low on the horizon, shining with a reddened glow. But red is the color of happiness and long life in China and other eastern cultures. That's why Canopus is known as the "Star of the Old Man", or the "Star of Old Age". It's supposed to bring good fortune to those who wish to enjoy the privilege of a long and happy life.

The remainder of the keel of the great ship Argo Navis is traced out by phi Carinae (ϕ), epsilon (ε) also called Avior, iota (ι) also called Aspidiske, and beta (β) Carinae. Beta is also known as Miaplacidus. This unusual name comes from the root *miyah*, which is Arabic for water, and *placidus*, which is Latin for peace.

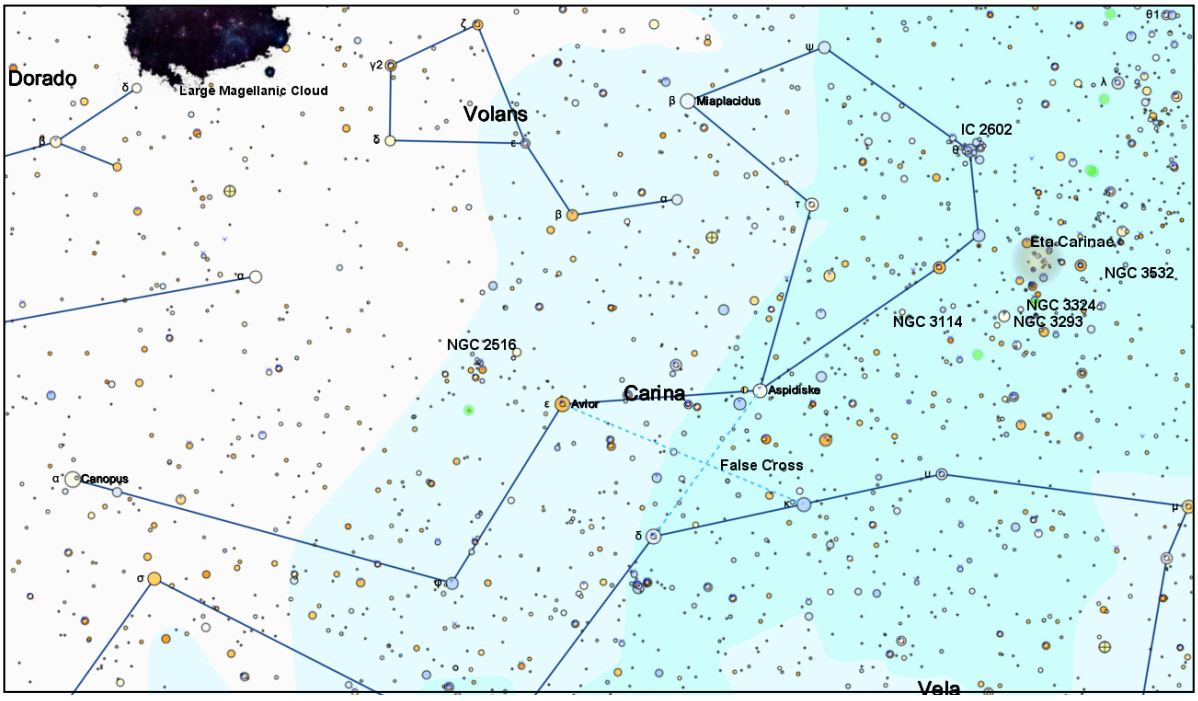
But the primary joy of Carina lies in its many sights of the deep-sky. Look to western Carina for the striking open star cluster NGC 2516. Sometimes called the "Diamond Cluster", it's visible without optics between the stars alpha (α) Pictoris, in Pictor, and epsilon (ε) Carinae. The cluster spans 1/2 a degree, about the same as a full Moon. John Herschel, during his 19th century study of the southern sky, called this cluster "a really superb object". Unlike globular clusters and some tighter open clusters, NGC 2516 resolves well in binoculars: of its 100 component stars, more than 30 are visible in binoculars with 50 mm aperture. Most its stars are white, but look for a single orange star near the middle of the cluster.

NGC 2516 is also called the "Southern Beehive" cluster because of its resemblance to the Beehive Cluster (M44) in the constellation Cancer.

This is also a favorite among professional astronomers. They've determined the cluster is a nest of chemically peculiar stars, meaning there are unusual

amounts of metals in the atmospheres of many of the cluster's constituents. The cluster is some 15 light years across, and lies 1,200 light years from Earth.

Now hop over to the other side of the constellation to see IC 2602, a remarkably beautiful cluster that encompasses the orange 3rd magnitude star theta (θ) Carinae. Sometimes called the "Southern Pleiades", this cluster was discovered by Lacaille in 1755 during his star mapping sessions in South Africa. This star cluster is not dipper-shaped like the Pleiades (M45) in Taurus. It is much less regular, with two distinct groupings of stars. But it resembles the Pleiades in many other ways. Like M45, many of this cluster's brightest constituents, including the star theta Carinae and the 4th magnitude star V518 Carinae, are easily visible with the naked eye. In all, the cluster has about 10 stars brighter than 6th magnitude. Also like the Pleiades, this cluster is quite young... just 30 million years old. It's some 500 light years away versus 450 light years for the Pleiades, and like M45 it's 15 light years across. In many ways, because of its expanse, binoculars give a better view of this cluster than most telescopes. Just like the Pleiades!



Map 19 - The constellation Carina (south is up)

If you have dark sky, look just south of IC 2602 for a faint, elliptical patch of unresolved stars. This is Melotte 101, which is 15 times farther away than its brighter neighbor. In a telescope, the cluster shows some 20-30 dim stars.

If you liked the Southern Beehive and Southern Pleiades, then you will truly appreciate NGC 3532. This brilliant open cluster is sometimes called the "Wishing Well Cluster" because through a telescope it appears like dozens of silver coins twinkling at the bottom of a wishing well. John Herschel described the cluster as one of the most brilliant he had ever seen. In a 50 mm glass, you see 50-60 blue-white stars spread across nearly a full degree of sky. You may also detect the haze of the cluster's 300 fainter stars. The big cluster is more than 1,300 light years from Earth.

Just 2 degrees west of NGC 3532 lies the most famous of Carina's treasures and the brightest emission nebula in the heavens, the Eta Carinae Nebula.

Here, words begin to fail. This is the largest nebula visible to stargazers and the most intricate to examine in binoculars or a small telescope. Within the nebula is one of the most massive stars in all the galaxy, eta Carinae, a monstrous star that shines some one million times brighter than our Sun, and a hundred times as massive. This star has intrigued astronomers for centuries. While currently a fairly faint 6th magnitude, "Eta" has varied in brightness within recent history. When Sir Edmund Halley first noted the star in 1677, it was 4th magnitude. Then it jumped to second magnitude in 1730 before fading again. (Remember than a change of one magnitude means a change in true brightness of 2.5). In 1843, the star shocked astronomers by jumping to magnitude -0.8, more than 80x brighter than when Halley first measured it! We now know Eta is a binary star system, one of which is almost too large to be stable. There are only a few dozen such stars known in the Milky Way.

While the exact behavior and variability of eta Carinae is uncertain, its fate is not. Astronomers know it will one day explode as a supernova, the most massive explosion in the universe. It occurs when a massive star, like eta Carinae, burns through its fuel in its core until it is unable to create more energy. At this stage, there is no light and radiation pressure to push back against the pull of gravity, and the star suddenly collapses. The star's interior will be squeezed into an amazingly dense region that may become a black hole, while the outer layers will bounce back suddenly, releasing more energy than our sun emits in its entire lifetime. The star will grow so bright, it will be visible in the daytime in our skies for several weeks, and may cast enough light to read by at night. As the star is relatively close by, at 7,500 light years, astronomers will measure radiation from the star falling into the upper region of the Earth's atmosphere. But the exploding star will pose no danger to life on our planet. No one knows for sure when the star will explode. It could happen in the next few million years, or few thousand years, or sooner. It will make for a wonderful and awesome sight.

While the star itself is fascinating, the surrounding nebula presents a lovely view for even modestly equipped stargazers. The Eta Carinae Nebula (NGC

3372) is clearly visible without optics as a hazy, silver-white patch of light. At a full two degrees across, the nebula shows some complex structure in even the smallest binoculars. There are dark rifts and folds, embedded clusters of stars newly formed within the nebula, and several distinct regions of gas set aglow by these stars. The whole complex looks like an unruly patch of cosmic blossoms. If you see just one deep-sky sight in your life with your binoculars, this should be it.

The Eta Carinae Nebula

Like all emission nebulae, the Eta Carinae Nebula is a region in which gas and dust has coalesced into denser regions that harbor even smaller globules of gas that collapse into new stars. These "stellar nurseries" fleck the Milky Way. You have met one in Sagittarius (the Lagoon Nebula), and there are many other fainter examples in that constellation. The second brightest such nebula, the Orion Nebula, will come into our sights later this section.

Now turn your glass to another fine open star cluster NGC 3114. Like many clusters in Carina, it is one of the prettiest in the sky for binoculars because it is bright and fairly scattered across a patch of sky as large as the full Moon. A 50 mm pair of binoculars shows three dozen stars between magnitude 6 and 10 just 6 degrees southwest of the Southern Pleiades.

NGC 3293 is a slightly fainter cluster that's more tightly packed than NGC 3114. You might see a dozen white stars here. Just to the southeast, look for a faint region of nebulosity. This is NGC 3324, another emission nebula excited by the double star h4338. There are a half-dozen faint stars within and around the nebula.

Before we leave Carina, make sure you examine the group of stars known as the "False Cross". This group comprises stars from Carina and Vela: delta (δ) Velorum, kappa (ϰ) Velorum, iota (ι) Carinae, and epsilon (ε) Carinae. It often confuses stargazers unfamiliar with the southern sky. They think it is

Crux, the Southern Cross. But the False Cross is somewhat larger and more diamond-shaped than the kite-like Crux. It also lacks the fainter fifth star of Crux, epsilon (ε) Crucis.

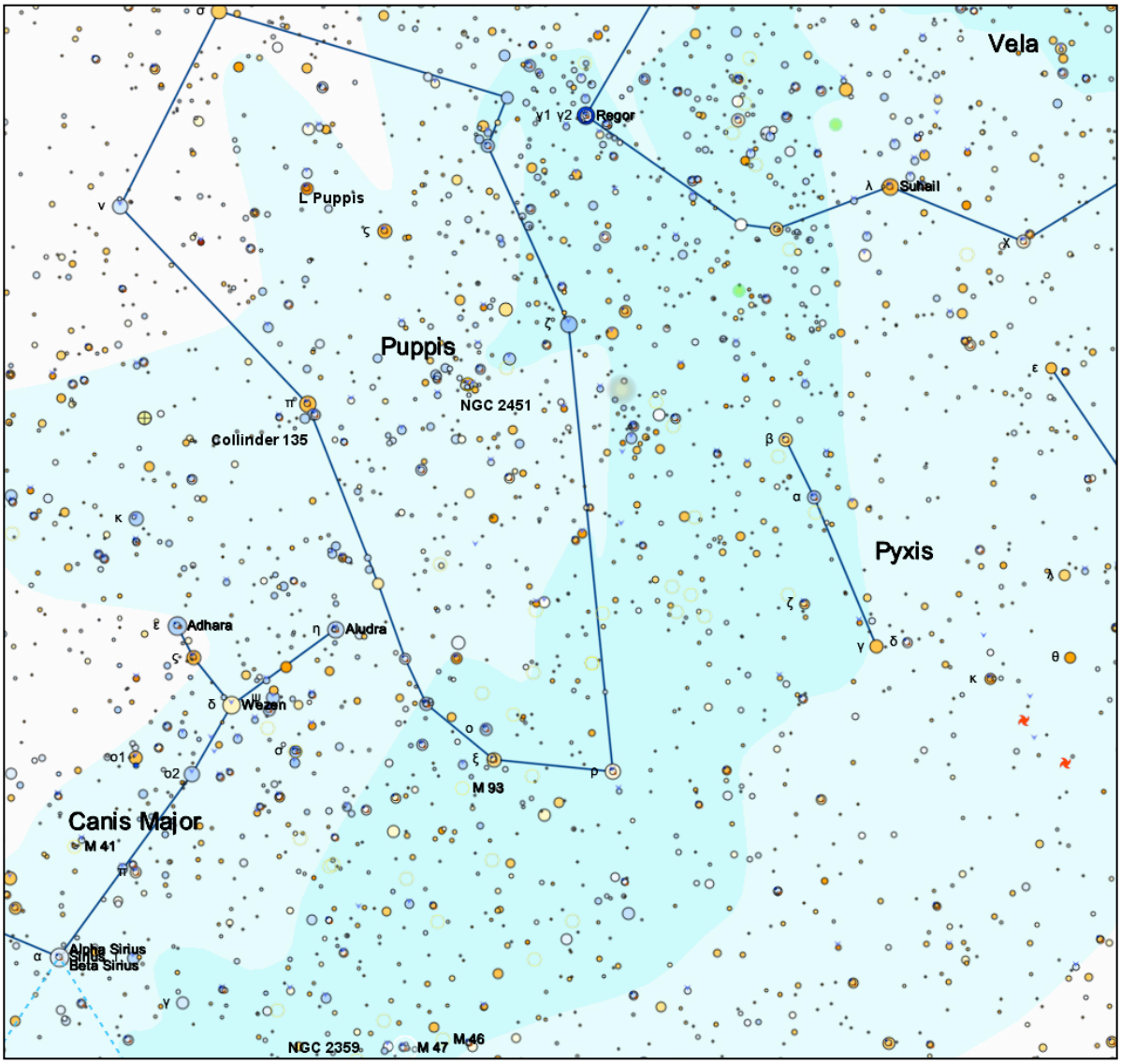
West of Carina, look for two much smaller constellations, Volans, the Flying Fish, and Pictor, the Artist's Easel. While off the plane of the Milky Way, the two constellations offer good star fields to sweep with binoculars. Look especially around the star theta (θ) Pictoris for pleasant viewing. Theta itself can be resolved into a double star with good binoculars and a steady gaze.

After you spend many pleasant evenings touring the constellation Carina with your binoculars, turn your attention Puppis, another part of the archaic constellation Argo Navis. Unlike Carina, Puppis has few bright stars of interest. But the "poop deck" of the great ship is festooned with star clusters and nebulae (Map 20).

Parts of the constellation are visible from the northern hemisphere, so some of its clusters were cataloged by French astronomer Charles Messier from his observatory near Paris. Messier compiled a list of 103 "Messier Objects" that are now on the must-see list of most amateur stargazers; we've met a few already. Most such objects are in the northern skies, but many are visible from the southern hemisphere.

M47 lies on the northern edge of the constellation, about 12 degrees east of blue-white Sirius, the brightest star in the night sky. This bright cluster contains some 30 members, about half of which are visible in 7x50 binoculars. The stars appear as jewels against the black velvet background of space and a silver-braid star field in this rich part of the Milky Way. The orange star KQ Puppis lies in the same field of view. Look also to M46, just 1 degree east of M47. Unlike M47, M46 is quite compact and unresolved in binoculars. It contains some 100 stars within its soft white glow.

The star cluster M93 is due south of M46 and M47 near the star xi (ξ) Puppis and right on the plane of the Milky Way. You can see a half-dozen of the cluster's 80 stars. The rest appear as a frosty triangle set in an amazingly rich star field.



Map 20 - The constellation Puppis and associated star clusters

Now to a little observed cluster, Collinder 135. A scattered, coarse cluster, it is sometimes overlooked in the rich star fields of this region. But it's well worth a look in binoculars. The somewhat triangular-shaped group includes the 3rd-magnitude star pi (π) Puppis, along with a double star nu (ν) Puppis. This is a grouping worth lingering over for a time.

NGC 2451 is a striking cluster in the southern regions of the constellation. Like many large open clusters, this one looks better in binoculars. More than 30 stars can be resolved, though the overall effect is a pleasing shimmer caused by unresolved background stars. Most stars in NGC 2451 are blue white, though the cluster's brightest star is unmistakably red-

orange. Look just 1 degree southeast of NGC 2451 for the dim smudge of another cluster, NGC 2477. Binoculars do not resolve this cluster at all, but it's easy to spot next to its brighter neighbor.

NGC 2359 is an easy target with binoculars. Its nearly 50 stars appear as as dim blotch near a 5th-magnitude star 19 Puppis. The combined light of the cluster shines at magnitude 6.5, so it may be visible without optics on a clear night.

For a more involved observing project, look for the variable star L^2 Puppis This is a semi-regular variable with an average period of 140 days. However, the time between peak brightness varies greatly. At peak, this red star reaches magnitude 2.6 before fading to magnitude 6.2. Once you locate the star, follow its changes over the course of many weeks using other stars in your field of view for comparison.

Orion and Lepus; Eridanus

Orion will next command our attention. You will find the layout of the constellation in Map 21. To the unaided eye, to binoculars, and to the telescope, Orion is a gold mine of wonders. This great constellation embraces almost every variety of interesting phenomena that the heavens contain. Here we have the grandest of the nebulae, some of the largest and most beautifully colored stars, star-streams, star-clusters, nebulous stars, variable stars.

In the northern hemisphere, the stars take on the unmistakeable shape of a the hunter of Greek legend. The same shape holds in the south, although the hunter is upside down, so you need to lie on your back to invert your gaze at the constellation. The star Bellatrix marks the left shoulder; a little triangular grouping forms the head; splendid Betelgeuse (α), "the martial star," flashes like a decoration upon the hero's right shoulder. His upraised arm and club are represented by the stars Betelgeuse, Nu (ν), and another, in the knob of the club, Chi (χ) Then look for the equally beautiful Rigel (β) in the hunter's left foot, and the striking row of three bright stars forming the Belt. Below (or above, if you are standing upright!) the Belt hangs another starry pendant marking the famous sword of Orion. The star Saiph marks the right knee. There is no other constellation containing so many bright stars. It has two of the first magnitude, Betelgeuse and Rigel; the three stars in the Belt, and Bellatrix in the left shoulder, are all of the second magnitude; and there are three stars of the third magnitude, more than a dozen of the fourth, and innumerable more of smaller magnitudes, whose scintillations form a celestial illumination of singular splendor.

Betelgeuse is slightly variable. Sometimes it appears brighter than Rigel, and sometimes less brilliant. While it is not as massive as Eta Carinae, Betelgeuse is still a large and cool red supergiant star, possessed of an absorptive envelope or shell, and which will one day end its life in a spectacular supernova explosion that will light the day and nighttime skies of Earth for many weeks. Rigel, on the other hand, is still in its prime of life; it's hotter and younger than Betelgeuse. So, then, we may look upon the two chief stars of this great constellation as representing two stages of stellar existence. Betelgeuse shows us a sun that has almost run its course, that has passed into its decline before the on-coming and inevitable fate of extinction; but in Rigel we see a sun blazing with the fires of youth, splendid in the first glow of its solar energies, and holding the promise of the future yet before it. We may pursue this comparison one step farther back in time and see in the famed Great Nebula of Orion, M42, which glows dimly in the middle of the constellation, between Rigel and Betelgeuse. The nebula represents a still earlier cosmical condition: the birth of stars whose infant rays will illuminate space when Rigel itself is growing dim and Betelgeuse is long passed.

Turn your glass upon the three stars forming the Belt. You will not be likely to undertake to count all the stars that you will see, especially as many of them appear and disappear as you turn your attention to different parts of the field. The stars of the belt are, from east to west, Alnitak, Alnilam, and Mintaka. Though only visible in photographs, Alnitak is embedded in a rich nebulosity overlaid with black dust in the shape of a horse's head, giving the nebula in this region the name "The Horse Head Nebula." As you sweep around the Belt of Orion, notice the sweeping "S-shaped" group of stars that begins just north of Mintaka, sweeps down between Mintaka and Alnilam, ending below the latter.

Sweep all around the Belt and also between the Belt and Gamma (γ) or Bellatrix. According to the old astrologers, women born under the influence of the star Bellatrix were considered lucky.

Above the Belt as seen from the south will be seen a short row of stars hanging towards Orion's feet and representing the sword. In the middle of this row is the Great Orion Nebula, which lies some 1,200 light years from our planet. Just above Iota (ι), you will find the star Theta (θ) embedded in the nebula. This star has two components easily resolved in binoculars. Their position suggests, correctly, that these hot blue stars recently formed out of the diffuse gas and dust of the nebula, and are in fact lighting the nebula and setting it aglow from within. One of the components of Theta is a quadruple star called the Trapezium. A small telescope is required to resolve these four fledgling stars.

Hydrogen is abundant in this regions of space, but the constituent parts of this elemental gas, the proton and neutron, are ripped apart by the energetic blue and ultraviolet light from newly-lit stars. The glow of the Orion Nebula (and all emission nebula such as the Lagoon and eta Carinae) is caused by the recombination of electrons with protons to re-form hydrogen. As the charged particles come together, they release energy as red and green light.

As you look at the nebula, avert your eyes slightly to the expose the most sensitive part of your retina to the light. Even in modest binoculars, you will see the great extent of the nebula as it is seen in photographs, extending over a span of sky twice the diameter of the full moon. You will not, however, see color with binoculars or small telescopes because the light is too feeble to stimulate the color receptors of your eye.

Millions of years hence, this delicate nebula, like all of its kind, will coalesce into an open star cluster that will serve as a fine telescopic object for our distant descendants. As an example of such a star cluster, you will observe just north of M42 (and its nebulous appendage M43) an open star cluster called NGC 1981, a scattering of ten blue-white stars. It makes a pretty contrast adjacent to the nebula of fire-mist within the same field of view.

Other stars are seen scattered in different parts of the Sword. Iota has a lovely silver-blue color, and is one of dozens of blazing hot stars in Orion. Only 8 arcminutes (that's 8/60-th of a degree) south of Iota is a striking double star called Struve 747, named after the famed astronomer who catalogued hundreds of such stars. The comparable brightness and generous separation make this star easily resolved and one of the best in all the sky for binoculars.

Modern measurements reveal the entire region of Orion is embedded in cold dust and gas that will one day yield new stars. The Great Nebula itself is but a tiny transitory blister of star formation. Many more such regions have coalesced in the past, and many more will coalesce over the coming millions of years.

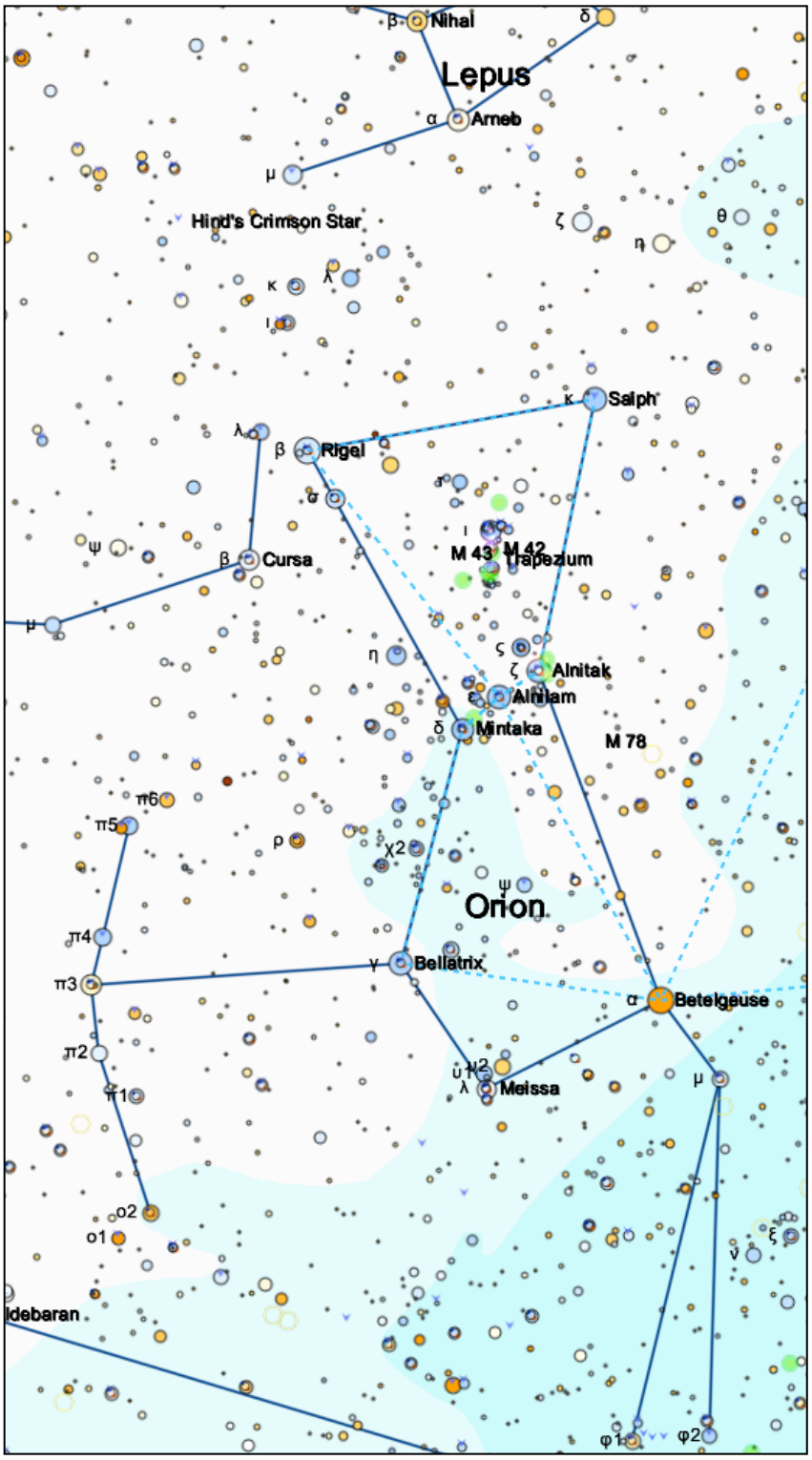
The Great Nebula in Orion

Do not fail to look for two little stars just west of Rigel, which, with modest binoculars, appear to be almost hidden in the flashing rays of its brilliant companion.

With a telescope, Rigel is one of the most beautiful double stars in the sky, having a little blue companion close under its wing.

Run your glass along the line of little stars forming the lion's skin or shield that Orion opposes to the onset of the V-shaped constellation Taurus. Here you will find some interesting combinations, and the star marked on the map π^5 will especially attract your eye, because it is accompanied, about fifteen minutes of arc to the northwest, by a seventh-magnitude star of a rich orange hue.

Look next at the little group of three stars forming the head of Orion. Although there is no nebula here, these stars, as seen with the naked eye, have a remarkably nebulous look, and Ptolemy regarded the group as a nebulous star. The largest star is called Lambda (λ), or Meissa; the others are Phi (ϕ) 1 and 2. Binoculars will show another star above Lambda, and a fifth star below Phi 2, which is the farthest of the two Phis from Lambda. It will also reveal a faint twinkling between Lambda and Phi 2. Binoculars show this twinkling is produced by a pretty little row of three stars of the eighth and ninth magnitude.



Map 21 - The grand constellation Orion (south is up).

In fact, Orion is such a striking object in the sky that more than one attempt has been made to steal away its name and substitute that of some modern hero. The University of Leipsig, in 1807, formally resolved that the stars forming the Belt and Sword of Orion should henceforth be known as the constellation of Napoleon. As if to offset this, an Englishman proposed to rename Orion for the British naval commander Nelson. But *"Orion armed"* has successfully maintained his name and place against all comers. As becomes the splendor of his constellation, Orion is a tremendous hero of antiquity, although it must be confessed that his history is somewhat shadowy and uncertain, even for a mythological story. All accounts agree, however, that he was the mightiest hunter ever known, and the Hebrews claimed that he was no less a person than Nimrod himself.

The little constellations of Lepus and Columba, below Orion, need not detain us long. You will find in them some pretty combinations of stars. In Lepus is the celebrated "Crimson Star," which has been described as resembling a drop of blood in a truly marvelous hue for a sun. You will find it on a line extending from Alpha Lepus (Arneb) through Mu (μ), at an distance west of Mu of just 3 degrees.

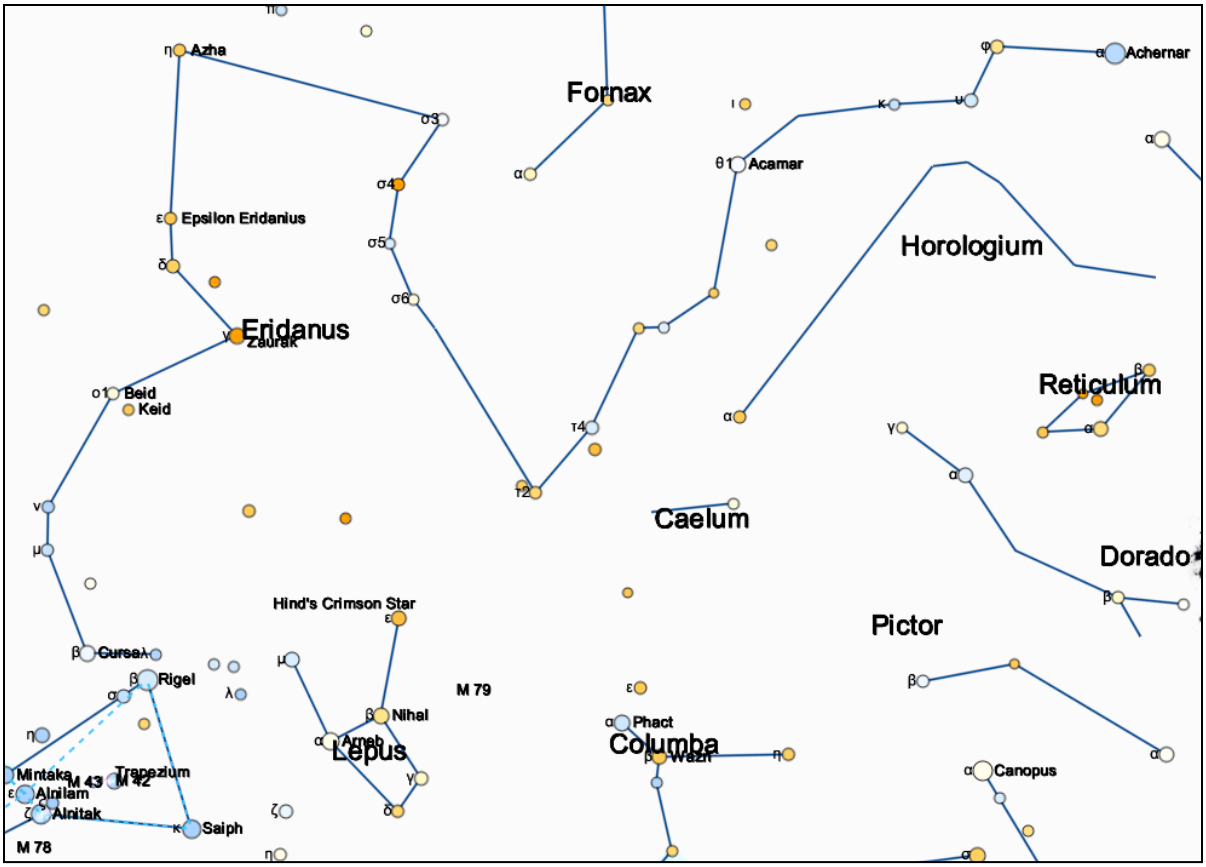
It will take many nights of viewing to take in all the splendors of Orion. But for now, let's turn to the long, winding constellation Eridanus. It is a large though not very conspicuous constellation, which is generally supposed to represent the celebrated river now known as the Po, and at one time, the Nile. It has had different names among different peoples, but the idea of a river, suggested by its long, winding streams of stars, has always been preserved. According to fable, it is the river into which Phaeton fell after his disastrous attempt to drive the chariot of the sun for his father Phoebus, and in which hare-brained adventure he narrowly missed burning the world up.

As Map 22 shows, the imaginary river starts near the brilliant star Rigel, in the left foot of Orion, and flows in a broad upward bend toward the west; then it turns in a southerly direction until it reaches the bright star Gamma (γ), where it bends sharply to the north, and then quickly sweeps off to the west once more, until it meets the group of stars marking the head of Cetus. Then it runs south, gradually turning eastward, until it flows back more than half-way to Orion. Finally it curves south again and reaches nearly overhead at this time of year as seen from the southern hemisphere. Throughout the whole distance of more than 100 degrees, the course of the stream is marked by rows of stars, and can be recognized without difficulty by the casual observer.

The first thing to do with your binoculars, after you have fixed the general outlines of the constellation in your mind by naked-eye observations, is to sweep slowly over the whole course of the stream, beginning at Rigel, and

following its various wanderings. Eridanus ends near the first-magnitude star called Achernar near the constellation Phoenix. Astronomers have determined that Achernar spins so rapidly, it is distorted into a somewhat flattened spheroid, with its equatorial diameter more than 50% greater than its polar diameter. It is one of the least spherical stars yet measured.

Along the stream of Eridanus, you will find many interesting groupings of stars. In the map see the pair of stars below and to the right of Nu (ν). These are the two Omicrons, the upper one being Omicron (o) 1 (also called Beid) and the lower one Omicron 2 (Keid). The latter is of an orange hue, and is remarkable for the speed with which it appears to move across the sky. There are only one or two stars whose proper motion, as it is called, is more rapid than that of Omicron 2 in Eridanus. It changes its place nearly seven minutes of arc in a century. The records of the earliest observations we possess show that near the beginning of the Christian era it was about half-way between Omicron 1 and Nu. Its companion Omicron 1 on the contrary, seems to be almost stationary, so that Omicron 2 will gradually draw away from it, passing on toward the southwest until, in the course of centuries, it will become invisible from our latitudes.



Map 22 - The constellation Eridanus, starting near Rigel in the foot of Orion, to the star Achernar near Phoenix. West is up in this image.

This flying star is accompanied by two faint companions, which in themselves form a close and very delicate double star. These two little stars, of only 9.5 and 10.5 magnitude, respectively, are, of course beyond the sight of the observer with modest binoculars. The system of which they form a part, however, is intensely interesting, since the appearances indicate that they belong, in the manner of satellites, to Omicron 2, and are fellow voyagers of that wonderful star. Omicron 2 is also called 40 Eridani. The system lies just 16.5 light years from Earth.

If you have 50 mm or larger binoculars and dark sky, you may glimpse the oval smudge of the galaxy NGC 1291. Look for it 4 degrees southeast of the star theta (θ) Eridani (Acamar) near a tall triangle of 7th-magnitude stars.

Embraced in the folds of Eridanus lies another Lacaille-named constellation. This is Fornax, the Furnace. It holds a cluster of galaxies, none of which are visible to a modest pair of binoculars.

Taurus; the Hyades and Pleiades

Having admired the star-groups of Eridanus and Orion, let us turn next to Taurus, the Bull, just north of Eridanus. Two remarkable clusters at once attract the eye: the Hyades, which are shaped somewhat like the letter V, with Aldebaran in the upper end of one branch, and the Pleiades, whose silvery glittering has made them celebrated in all ages. The Pleiades are in the shoulder and the Hyades in the face of Taurus, Aldebaran most appropriately representing one of his blazing eyes as he hurls himself against Orion.

The constellation makers did not trouble themselves to make a complete Bull, and only the head and forequarters of the animal are represented. If Taurus had been completed on the scale on which he was begun, there would have been no room in the sky for Aries; one of the Fishes would have had to abandon his celestial swimming place, and even the fair Andromeda and brave Pegasus would have found themselves uncomfortably situated. But, as if to make amends for neglecting to furnish their heavenly Bull with hind-quarters, the ancients gave him a most prodigious and beautiful pair of horns, which make the beholder feel alarm for the safety of Orion.

Starting out of the head above the Hyades, as illustrated in Map 23, the horns curve upward and to the east, each being tipped by a bright star. Along and between the horns runs a scattered and broken stream of minute stars which seem to be gathered into knots just beyond the end of the horns, where they dip into the edge of the Milky-Way.

Below the tips of the horns, and over Orion's head, there are also rich clusters of stars, as if the Bull were flaunting shreds of sparkling raiment

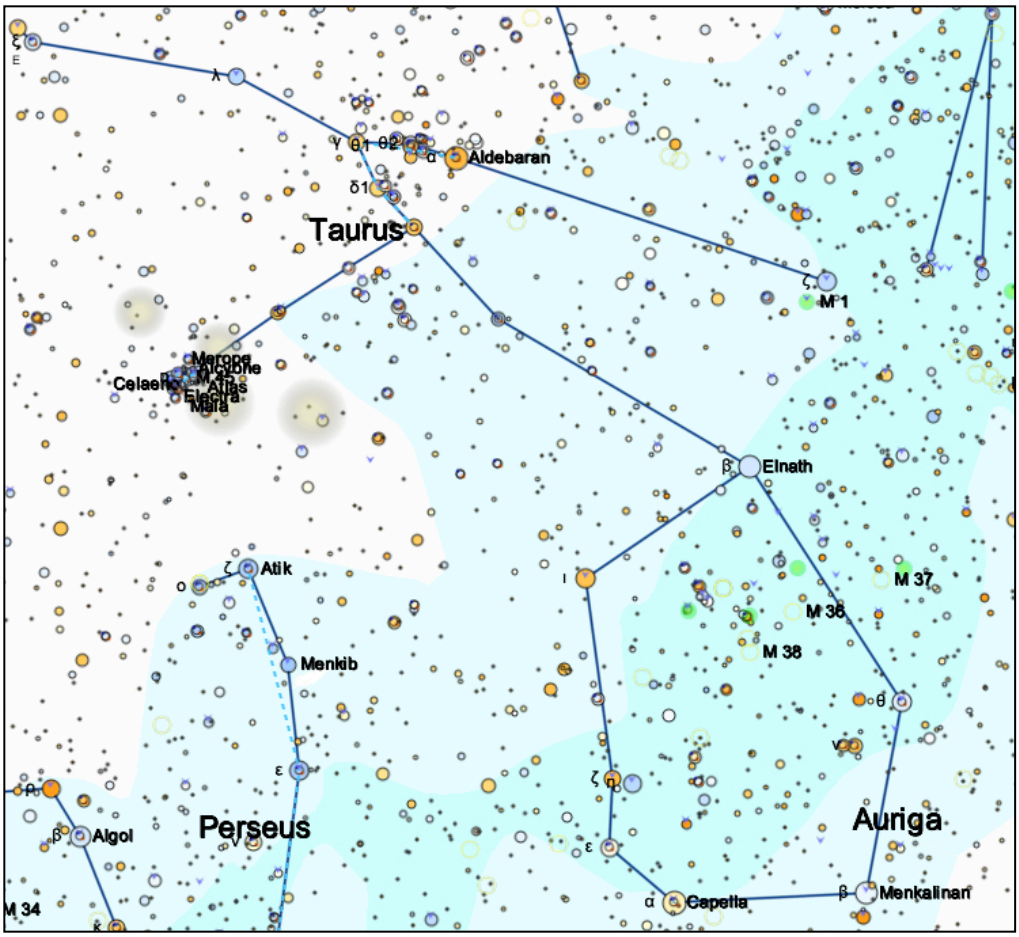
torn from some celestial victim of his fury. With an ordinary glass, however, the observer will not find in this star-sprinkled region around the horns of Taurus as brilliant a spectacle as that presented by the Hyades and the group of stars just above them in the Bull's ear. The two stars in the tips of the horns are both interesting, each in a different way. The upper and brighter one of the two is called Alnath (also called Elnath). It is common to the left horn of Taurus and the right foot of the far-northern constellation, Auriga, just visible above the northern horizon. Alnath is a singularly white star, as you will see in your binoculars. The star in the tip of the right or southern horn, Zeta (ζ), is remarkable, not on its own account, but because it serves as a pointer to a famous nebula, the discovery of which led Messier to form his catalogue of nebulae. This is sometimes called the "Crab Nebula" from the long sprays of nebulous matter which were seen surrounding it with a larger telescope or in detailed images. The nebula is the first in Messier's catalog, and so is also called M1. The map here is simply intended to enable you to locate this strange object. If you wish to study its appearance, you must use a telescope. But with good binoculars in dark sky, you can see it as a speck of light in the position shown in the Map, where the large star is Zeta and the smaller ones are faint stars, the relative position of which will enable you to find the nebula, if you keep in mind that the bottom of the Map is toward the north. This nebula for a time deceived several sky watchers who were on the lookout for the predicted return of Halley's comet in 1835 and again in 1986.

The Crab Nebula is the remnant of a supernova explosion which occurred in 1054 A.D. This star was viewed by ancient astronomers in China and Arabia. It was visible for some months before it faded from view, which is common for this type of dying star.

And now turn to the Hyades, an assemblage of stars not less beautiful than their more celebrated sisters the Pleiades. The leader of the Hyades is Aldebaran, or Alpha Tauri, and his followers are worthy of their leader. The inexperienced observer is certain to be surprised by the display of stars which binoculars bring to view in the Hyades. The illustration below will give some notion of their appearance.

The redness of the light of Aldebaran is a very interesting phenomenon. Careful observation detects a decided difference between its color and that of Betelgeuse, or Alpha Orionis, which is also a red star. It differs, too, from the brilliant red star Antares in Scorpius. Aldebaran has a trace of rose-color in its light, while Betelgeuse is of a very deep orange, and Antares may be described as fire-red. These shades of color can easily be detected by the naked eye after a little practice. First compare Aldebaran and Betelgeuse, and glance from each to the brilliant bluish-white star Rigel in Orion's foot. Upon turning the eye back from Rigel to Aldebaran the peculiar color of the latter is readily perceived. Spectroscopic analysis has revealed the presence

in Aldebaran of hydrogen, sodium, magnesium, calcium, iron, bismuth, tellurium, antimony, and mercury. The star is beyond its middle age and slowing swelling into a red giant, after which it will end its life in by expelling its outer layers as a planetary nebula. And so modern discoveries, while they have pushed back the stars to distances of which the ancients could not conceive, have, at the same time, and equally, widened our understanding of the physical universe and abolished forever the ancient distinction between the heavens and the earth.



Map 23 - The constellation Taurus, including the V-shaped Hyades star cluster and the Pleiades. The constellation Auriga is visible over the northern horizon.

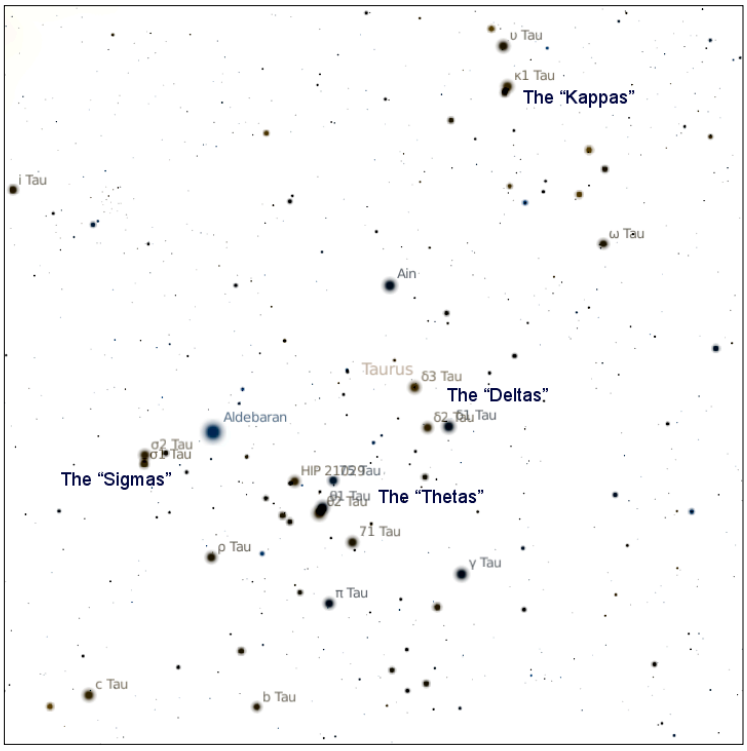
North of Taurus, later in the season, you may spy the hexagonal shape of the constellation Auriga. It is well placed for northern observers, but its star clusters are difficult to see from the southern hemisphere. If you have a clear view of the northern horizon, look for the brilliant white star Capella, the sixth brightest in the heavens.

Keeping in mind that in Map 24 of the Hyades the top is north, the right hand west, and the left hand east. You will be able to identify now the principal stars in the group.

Aldebaran is readily recognized, because it is the largest of all. The bright star near the upper edge of the picture is Epsilon (ε) Tauri, called Ain, and its sister star, forming the point of the V, is Gamma (γ) Tauri. The three brightest stars between Epsilon and Gamma, forming a little group, are the "Deltas" (δ), while the pair of stars surrounded by many smaller ones, half-way between Aldebaran and Gamma, are the Thetas (θ). These stars present a very pretty appearance, viewed with a good glass, the effect being heightened by a contrast of color in the two Thetas.

The little pair southeast of Aldebaran, called the Sigmas, is also a beautiful sight. The distance apart of these stars is about seven minutes of arc, while the distance between the two Thetas is about five and a half minutes of arc. It's an interesting test of eye-sight to try to see these stars as doubles without the aid of a glass. Persons having keen eyes will be able to accomplish this.

North of the star Epsilon will be seen a little group in the ear of the Bull, which presents a brilliant appearance with a small glass. The southernmost pair in the group are the "Kappas" (ϰ), whose distance apart is very nearly the same as that of the Thetas, described above; but I think it improbable that anybody could separate them with the naked eye, as there is a full magnitude between them in brightness, and the smaller star is only of magnitude 6.5, while sixth-magnitude stars are generally reckoned as the smallest that can be seen with the naked eye. Above the Kappas, and in the same group in the ear, are the two Upsilons, forming a wider pair.



Map 24 - An illustration of the Hyades (north is up)

Next we come to the Pleiades:

"Though small their size and pale their light, wide is their fame."

In every age and in every country the Pleiades have been watched, admired, and wondered at, for they are visible from every inhabited land on the globe. To many they are popularly known as the Seven Sisters, although few persons can see more than six stars in the group with the unaided eye. It is a singular fact that many of the earliest writers declare that only six Pleiades can be seen, although they all assert that they are seven in number. These seven were the fabled daughters of Atlas, or the Atlantides, whose names were Merope, Alcyone, Celaeno, Electra, Taygeta, Asterope, and Maia. One of the stories connected with them is that Merope married a mortal, whereupon her star grew dim among her sisters. Another fable assures us that Electra, unable to endure the sight of the burning of Troy, hid her face in her hands, and so blotted her star from the sky. While we may smile at these stories, we can not entirely disregard them, for they are intermingled with some of the richest literary treasures of the world, and they come to us, like some old keepsake, perfumed with the memory of a past age.

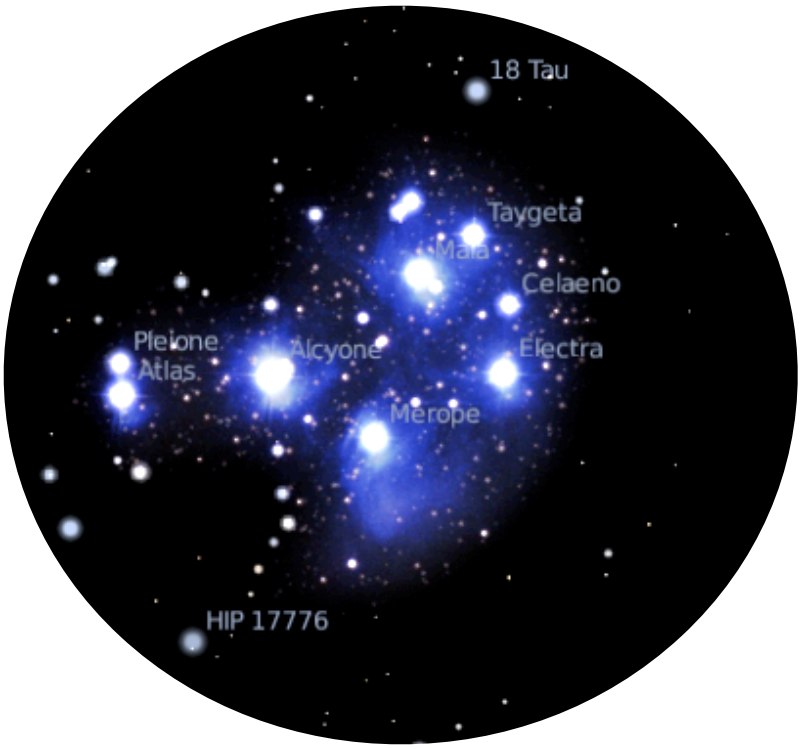
The mythological history of the Pleiades is intensely interesting, too, because it is world-wide. They have impressed their mark, in one way or another, upon the habits, customs, tradition, language, and history of probably every nation. This is true of simple tribes and great empires. The Pleiades furnish one of the principal links that appear to connect the beginnings of human history with that wonderful prehistoric past, where, as through a gulf of mist, we seem to perceive the glow of a golden age beyond. The connection of the Pleiades with traditions of the Flood is most remarkable. In almost every part of the world, and in various ages, the celebration of a feast or festival of the dead, dimly connected by traditions with some great calamity to the human race in the past, has been found to be directly related to the Pleiades. This festival or rite, which has been discovered in various forms among the ancient Hindu, Egyptians, Persians, Peruvians, Mexicans, and Druids, occurs always in the month of November, and is regulated by the culmination of the Pleiades. The Egyptians directly connected this celebration with a deluge, and the Mexicans, at the time of the Spanish conquest, had a tradition that the world had once been destroyed at the time of the midnight culmination of the Pleiades.

Among the original inhabitants of Australia and the Pacific islands a similar rite has been discovered. It has also been suggested that the Japanese, who called the cluster *Subaru*, associated the feast of lanterns with this worldwide observance of the Pleiades, as commemorating some calamitous event in the far past which involved the whole race of man in its effects.

The Pleiades also have a supposed connection with that mystery of mysteries, the great Pyramid of Cheops. It has been found that about the year 2170 B.C., when the beginning of spring coincided with the culmination of the Pleiades at midnight, that wonderful group of stars was visible, just at midnight, through the mysterious southward-pointing passage in the Pyramid. At the same date the pole-star, which in that distant age was not Polaris by Alpha Draconis, was visible through the northward-pointing passage of the Pyramid.

Another curious myth involving the Pleiades as a part of the constellation Taurus is that which represents this constellation as the Bull into which Jupiter (or Zeus) changed himself when he carried the fair Europa away from Phoenicia to the continent that now bears her name. In this story the fact that only the head and fore-quarters of the Bull are visible in the sky is accounted for on the ground that the remainder of his body is beneath the water through which he is swimming. Here, then, is another apparent link with the legends of the Flood, with which the Pleiades have been so strangely connected, as by common consent among many nations, and in the most widely separated parts of the earth.

With binoculars, you may be able to see all of the stars represented in our picture of the Pleiades. The scene is a remarkable one, perhaps the finest for binoculars in the entire heavens. Not only all of the "Seven Sisters," but many other stars, can be seen twinkling among them. The superiority of Alcyone to the others, which is not so clear to the naked eye, becomes very apparent. Alcyone is the large star left of the middle of the picture with a triangle of little stars beside it. To the left or east of Alcyone the two most conspicuous stars are Atlas and Pleione. It requires a sharp eye to see Pleione without a glass, while Atlas is plainly visible to unaided vision, and is always counted among the naked-eye Pleiades,



The Pleiades, with associated nebulosity.

although it does not bear the name of one of the mythological sisters, but that of their father. The bright star below and to the right of Alcyone is Merope; the one near the right-hand edge of the picture, about on a level with Alcyone, is Electra. Above, or to the north of Electra, are two bright stars lying in a line pointing toward Alcyone ; the upper one of these, or the one farthest from Alcyone, is Taygeta, and the other is Maia. Above Taygeta and Maia, and forming a little triangle with them, is a pair of stars which bears the name of Asterope. About half-way between Taygeta and Electra, and directly above the latter, is Celaeno.

You may find it difficult to decide which you can detect the more easily with your unaided eye, Celaeno or Pleione, while you will discover that Asterope, although composed of two stars, as seen with a glass, is so faint as to be much more difficult than either Celaeno or Pleione.

Observations of the proper motions of the Pleiades have shown that there is an actual physical connection between them. They comprise an open star cluster of the type we have met many times already; they are, literally speaking, a flight of suns. Their common motion is toward the southwest. The stars are bound to each other gravitationally, having formed out of a common cloud of gas and dust some 100 million years ago. Like the components of all open star clusters, as they are perturbed by passing stars, the sister stars will eventually disperse into the plane of the galaxy and evolve as lone stars.

In 1859, an extensive blue-white nebula was discovered, of a broad oval form, with the star Merope immersed in one end of it. It was thought the nebula is caused by starlight reflecting off residual gas and dust left over from the formation of the cluster. But modern studies suggest the dust is simply a part of the interstellar medium through which the cluster is passing.

Although the nebulosity is easily seen on time-exposure photographs, you should not expect to be able to see the nebula in the Pleiades with anything other than binoculars of 70-80 mm or more in aperture and pristine dark sky. Still, this star cluster, like the Hyades, is one of few that looks finer in binoculars than a telescope. You are encouraged to return to it again and again. It will provide you, as it did Tennyson, with countless nights of pleasant viewing:

"Many a night I saw the Pleiades, rising through the mellow shade.

Glitter like a swarm of fireflies tangled in a silver braid."

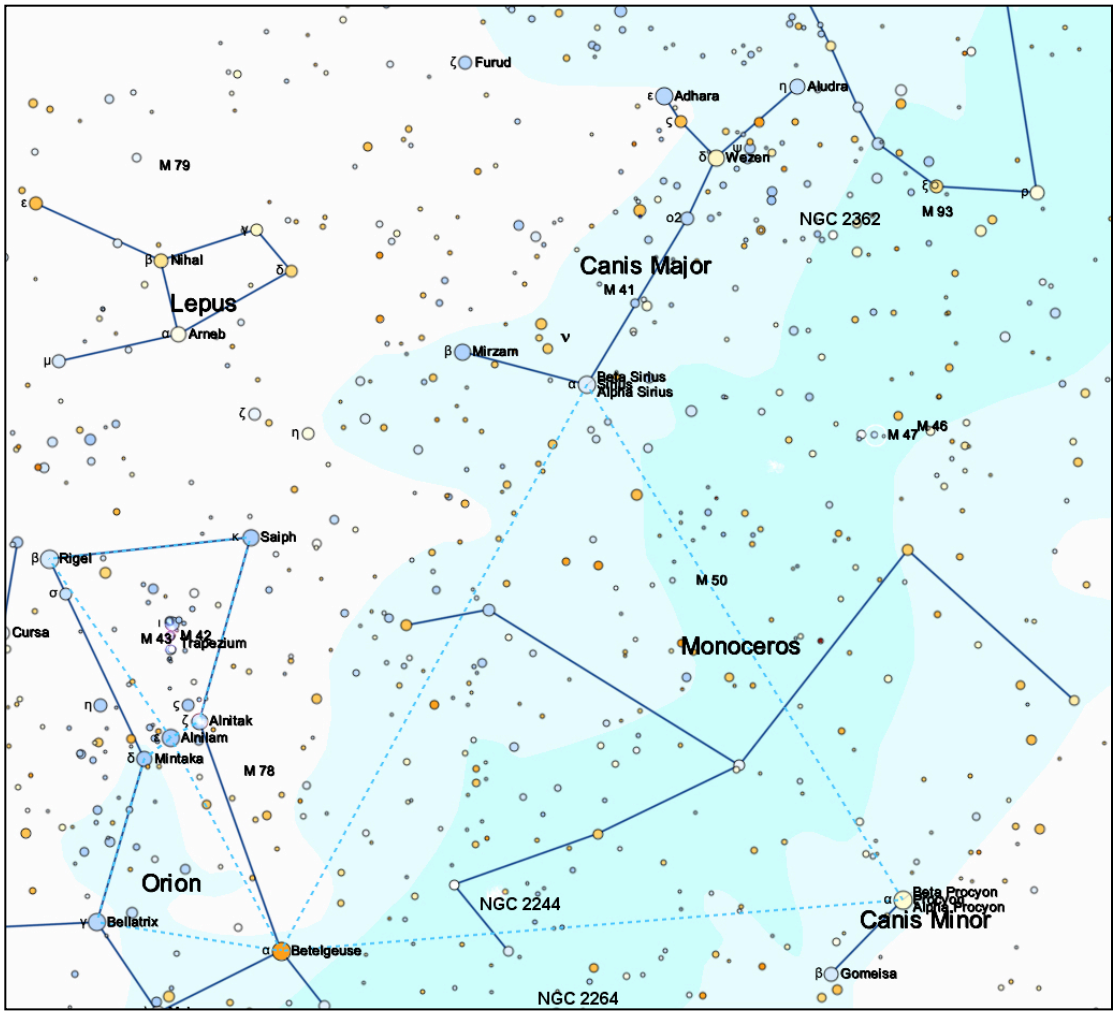
Canis Major; Sirius; Monoceros

We will now turn to the constellation of Canis Major, represented in Map 25. Although, as a constellation, it cannot be compared with brilliant Orion, yet, on account of the unrivaled brightness of its chief star, Canis Major presents almost as attractive a scene as its more extensive rival. Everybody has heard of Sirius, or the Dog Star, and everybody must have seen it flashing and scintillating so splendidly in the southern summer heavens. Sirius, in fact, stands in a class by itself as the brightest star in the sky. Its light is white, with a shade of blue, which requires close watching to be detected. When it is near the horizon, or when the atmosphere is very

unsteady, Sirius flashes prismatic colors like a great diamond. The question has been much discussed, as to whether Sirius was formerly a red star. It is described as red by several ancient authors, but it seems to be pretty well established that most of these descriptions are due to a blunder made by Cicero in his translation of the astronomical poems of Aratus. It is highly improbable that Sirius has changed color.

So intimately was Sirius connected in the minds of the ancient Egyptians with the annual rising of the Nile, that it was called the Nile-star. When it appeared in the morning sky, just before sunrise, the season of the overflowing of the great river was about to begin, and so the appearance of this star was regarded as foretelling the coming of the floods. The “dog days” got their name from Sirius, as they occur in the northern hemisphere at the time when that star rises with the sun.

Your eyes will be fairly dazzled when you turn your binoculars upon this splendid star. By close attention you will perceive a number of faint stars, mere points by comparison, in the immediate neighborhood of Sirius. There are many interesting objects in the constellation. The star marked Nu (v2) in the map, just south and west of Sirius, is really triple, as the smallest glass will show. Look next at the star cluster M41 above and to the east of Sirius. The cloud of minute stars of which it is composed can be very well seen with binoculars, and presents a splendid view in a small telescope.



Map 25 - Canis Major, Canis Minor, and Monoceros

The star Sigma (σ) is of a very ruddy color that contrasts beautifully with the light of Epsilon (ε), Adhara, which can be seen in the same field of view with binoculars. Between the stars Delta (δ), also called Wezen, and Omicron (ο) 1 and Omicron 2 there is a remarkable array of minute stars. The open star cluster NGC 2362 lies just northeast of Wezen and appears in binoculars as a frosty patch of blue-white stars, with the star Tau (τ) set in its midst.

Sirius owes its extraordinary brilliancy to its intrinsic brightness and to its closeness to Earth. It is 8.6 light years away, making it the fifth nearest star to our own sun. It is more massive than our sun by 2 times, and shines some 25 times brighter. While this seems impressive, the intrinsic brightness of Sirius is greatly exceeded by such massive stars as Rigel, Deneb, and Canopus, which are outshone by Sirius only as a consequence of their much greater distance.

Map 25 will also enable you next to find Procyon, or the Little Dog-Star, in the constellation Canis Minor. This star will interest you by its golden-yellow color and its brightness, although it is far inferior in the latter respect to Sirius. About four degrees northwest of Procyon is a third-magnitude star, called Gomeiza, and the glass will show you two small stars which make a right-angled triangle with it, the nearer one being remarkable for its ruddy color.

The mythological history of Canis Major and Minor is somewhat obscure. According to various accounts they represent the goddess Diana's hunting-dogs, Orion's hounds, or the dogs that devoured their master Actseon after Diana had turned him into a stag.

Both Procyon and Sirius are especially interesting because they are each attended by smaller stars which were first perceived by their effect of gravitational attraction upon their brighter companions. Both companion-stars, which, notwithstanding their lack of luminosity, are of great mass.

In the case of both stars, large telescopes bring the mysterious attendants into view. In the 19th century, the famous German scientist Bessel announced his conclusion that both Sirius and Procyon were binary systems, consisting each of a visible and an invisible star. He calculated the probable period of revolution, and found it to be, in each case, approximately fifty years. Sixteen years after Bessel's death, one of Alvan Clark's unrivaled telescopes at last revealed the strange companion of Sirius, a huge body, half as massive as the giant Dog-Star itself, but ten thousand times less brilliant, and more recent observations have shown that its period of revolution is within six or seven months of the fifty years assigned by Bessel. The faint but massive companion stars to Sirius and Procyon are now known to be a type of dense stellar cinder, the remains of a mid-sized star that has settled into its final phase of life as a white dwarf.

The great writer and philosopher Voltaire penned an extraordinary short story called "Micromegas”, in which the hero came from an imaginary planet circling around Sirius. Inasmuch as Voltaire, together with Jonathan Swift who ascribed two moons to Mars many years before they were discovered, it is all the more interesting that Voltaire should have imagined an enormous planet circling around the Dog-Star. But Voltaire went far astray when he ascribed a gigantic stature to his "Sirian." He makes Micromegas, whose world was 21,600,000 times larger in circumference than the earth, more than twenty miles tall, so that when he visited our little planet he was able to wade through the oceans and step over the mountains without inconvenience, and, when he had scooped up some of the inhabitants on his thumb nail, was obliged to use a powerful microscope in order to see them. Voltaire should rather have gone to some of the most minute of the asteroids for his giant, for under the tremendous gravitation of such a world as he

has described Micromegas himself would have been a fit subject for microscopic examination. But, however much we may doubt the stature of Voltaire's visitor from Sirius, we cannot doubt the soundness of the conclusion at which he arrived, after having, by an ingenious arrangement, succeeded in holding a conversation with some earthly philosophers under his microscope, namely, that these infinitely little creatures possessed a pride that was almost infinitely great.

Between Canis Major and Canis Minor lies the constellation Monoceros, the Unicorn. Despite its name, there are no myths associated with this constellation. It is a relatively modern creation, and was first depicted by the Dutch astronomer Petrus Plancius, the son-in-law of the great Johannes Kepler. While it has no stars brighter than 4th magnitude, you will find a few objects worthy of attention here. The star cluster NGC 2232 is an inexplicably obscure star cluster that presents a splendid view in binoculars. It occupies the same area as the full Moon, and it features about 20 stars brighter than magnitude 10, including a single star of 5th magnitude.

The showpiece of Monoceros is the cluster NGC 2244. There are some 40 stars in this open cluster, which lies about 2,400 light years from Earth. Binoculars resolve about 6 stars gathered in a rectangular pattern. In extremely dark sky with good optics, you may see the ghostly circular shape of the Rosette Nebula that is coincident with the star cluster. Look also for the cluster-nebula pair of NGC 2264, the Christmas Tree Cluster, and NGC 2261. While the nebula is hard to spot with binoculars, the cluster is easy to see and takes on a conical shape the resembles an evergreen tree.

And look for the cluster M50, the only Messier object in Monoceros. It’s about 1/3 the distance from Sirius to Procyon. A fuzzy patch with about 6 stars can be seen in most glasses. A single red star sets off nicely against the blue-white suns of this pleasant open cluster.

East and south of Canis Major is the old constellation Argo Navis, where we began our journey this season by exploring Carina and Puppis. We begin our tours of next season with the constellation Vela, the sail of the great ship that carried the Argonauts on their voyage to find the golden fleece.

STARGAZING FOR BEGINNERS

A BINOCULAR TOUR OF THE SOUTHERN NIGHT SKY

Section 5

“The Stars of Southern Autumn”

Vela and Pyxis
Gemini, the Twins
Cancer, The Crab; The Zodiac
Leo, The Lion
Virgo; Corvus and Crater
Hydra, The Serpent

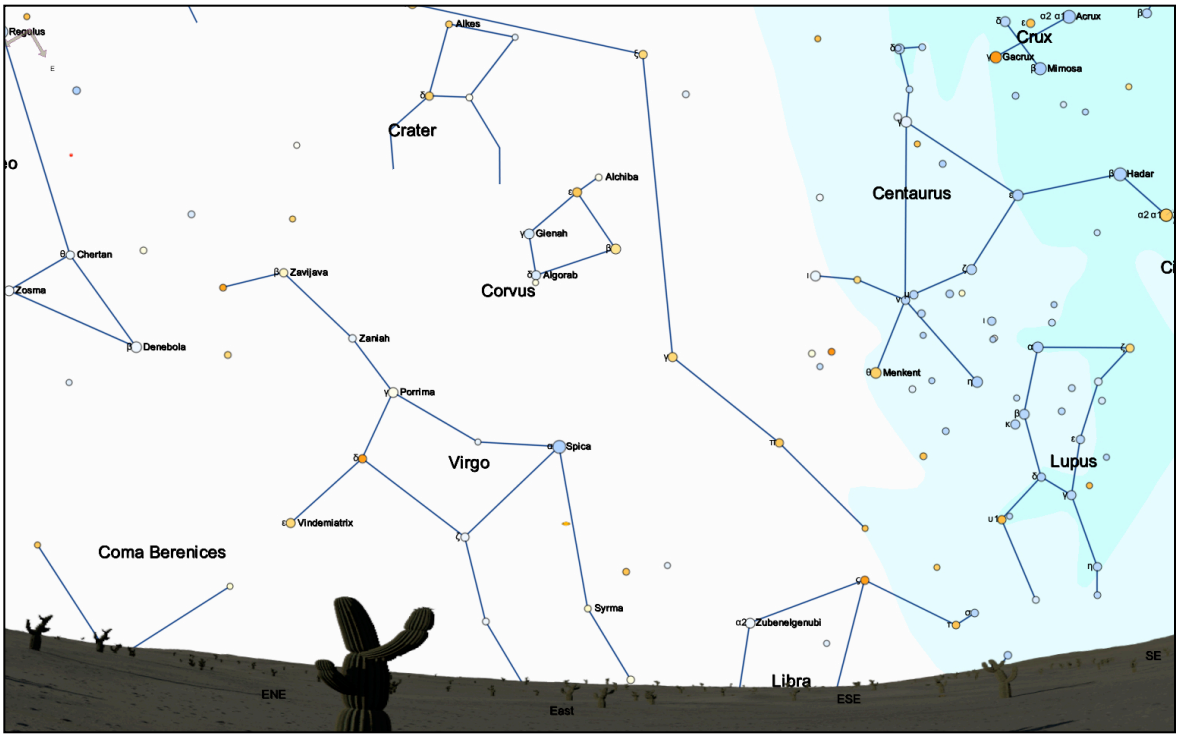
The Stars of Autumn

Summer begins to fade now and the stars of autumn in the southern hemisphere come into view. In the northern hemisphere, the Milky Way has vanished to give way to the star-poor constellations of northern spring. In this part of the sky, covered by the constellations Cancer, Leo, and Virgo, there are few stars because we look out of the plane of the Milky Way galaxy into intergalactic space. A telescope of modest size will show many dozens of distant galaxies in these constellations.

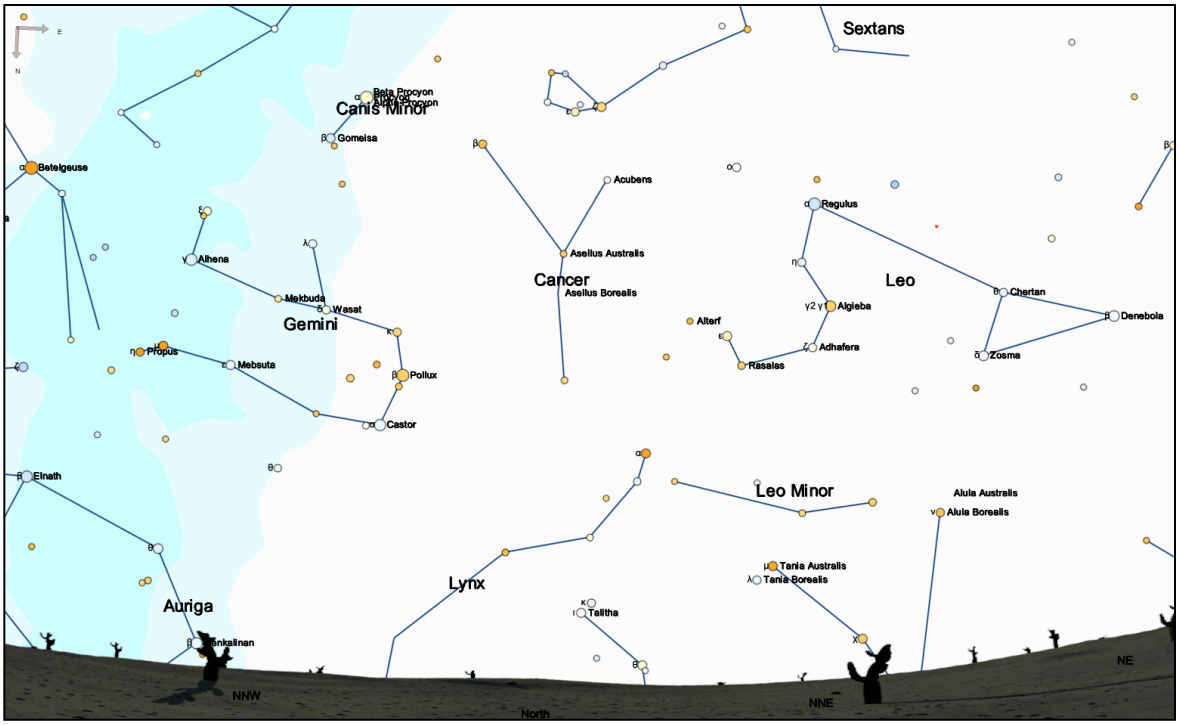
In the southern hemisphere, Cancer, Leo, and Virgo are visible, too, rising in the eastern and northern sky. You will also see the fine constellation Gemini above the northwestern horizon. But more of the Milky Way remains in southern skies. We still see the rich star fields in Carina and Puppis, and in the remaining sections of Argo Navis: Vela, the Sail, and Pyxis, the Mariner's Compass. The winding river Eridanus and Orion still hover above the western horizon, offering a last look at their bright stars. And overhead, along with Argo Navis, lies another winding constellation, Hydra, the largest star group in the sky.

And rising once again in the southeast, you see the constellation Crux, the Southern Cross, where you began your tour of the southern stars.

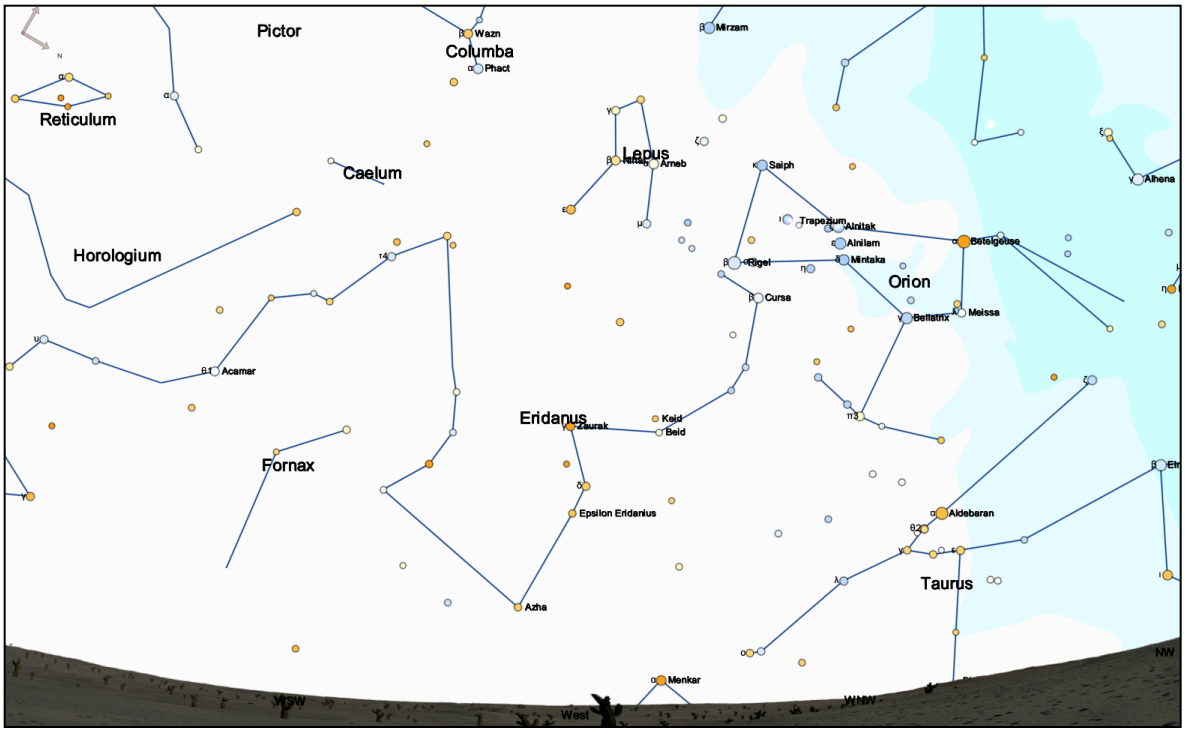
Maps 26(a) through 26(e) show the sky as seen looking south, west, north, east, and directly overhead. The maps are accurate for a latitude of 35 degrees south at 9 p.m. on March 15 local time. As you learned in Section 2, the apparent motion of the sky means the maps are also accurate on March 1 at 10 p.m., on February 15 at 11 p.m, and on March 30 at 8 p.m. You can use the maps at other times, as well. Earlier in the evening on March 15, say at 8 p.m., you will be able to see many of these constellations, but you must look for them farther toward the east than they are represented in the map. And if you are further south than 35 degrees latitude, some stars on the northern horizon will not be visible, while the stars on the southern horizon will be higher.



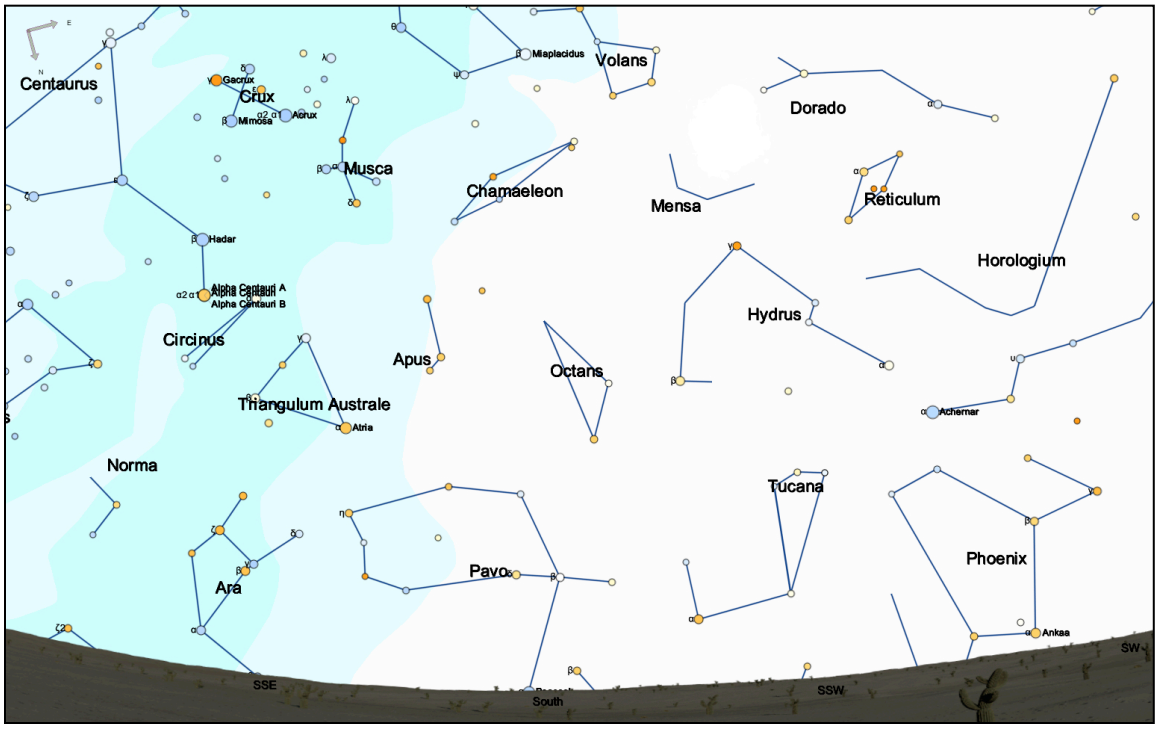
Map 26a - The Autumn Constellations (looking EAST at 35 degrees S latitude, at 9 p.m. on March 15)



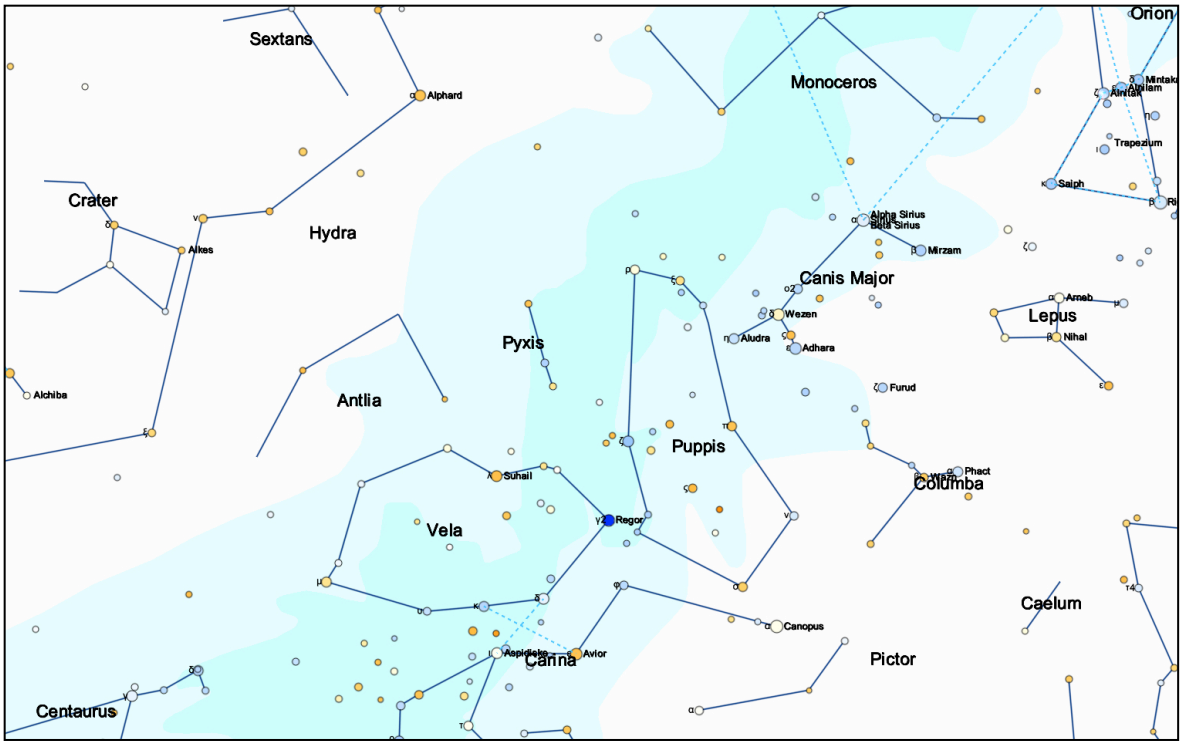
Map 26b - The Autumn Constellations (looking NORTH at 35 degrees S latitude, at 9 p.m. on March 15)



Map 26c - The Autumn Constellations (looking WEST at 35 degrees S latitude, at 9 p.m. on March 15)



Map 26d - The Autumn Constellations (looking SOUTH at 35 degrees S latitude, at 9 p.m. on March 15)



Map 26e - The Autumn Constellations (looking OVERHEAD while facing south at 35 degrees S latitude, at 9 p.m. on March 15)

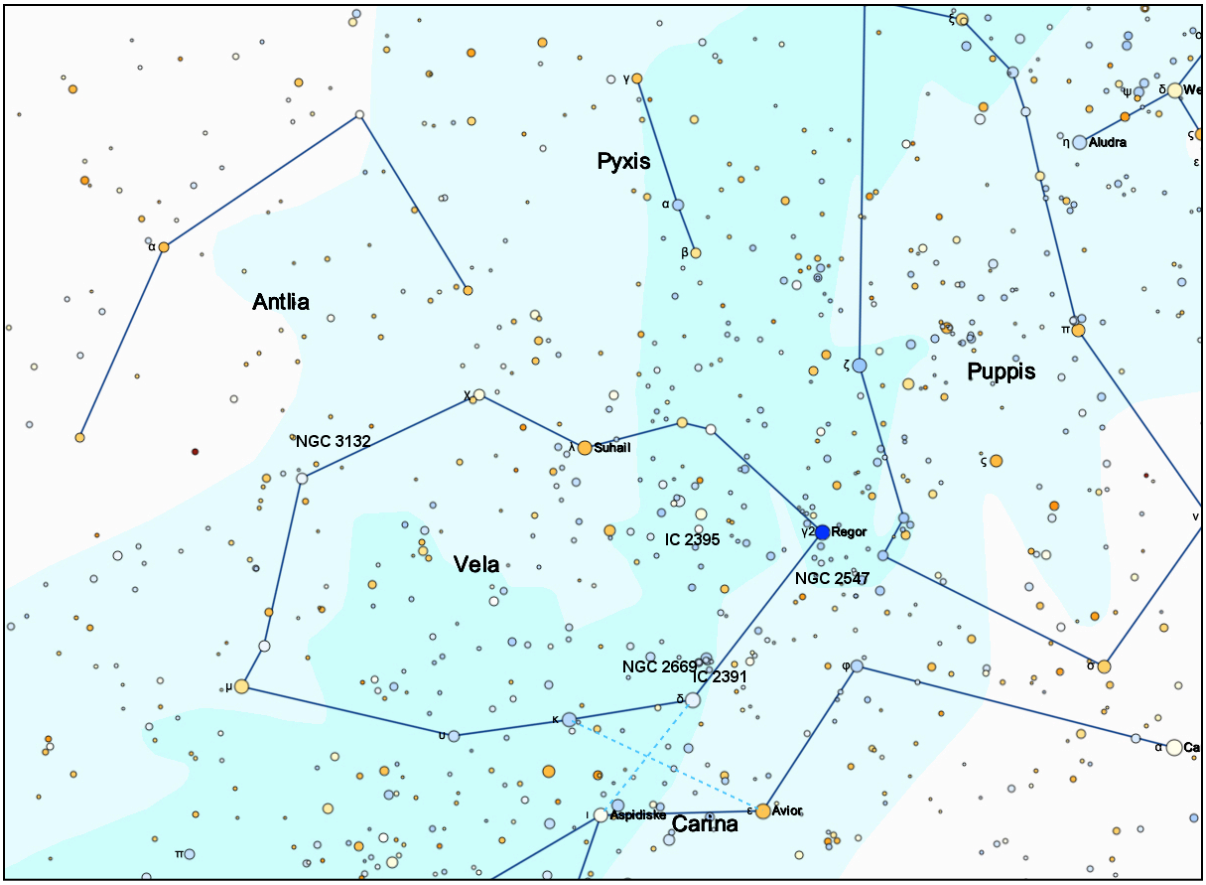
Vela and Pyxis

Vela constitutes the last major section of the defunct constellation Argo Navis. The sail of the mighty ship is a long oval outlined by modestly bright stars mu (μ), upsilon (υ), kappa (ϰ), delta (δ), gamma (γ) (or Regor), lambda (λ), and chi (χ). The whole assembly is wedged between Carina, the keel of the ship, and Puppis, the deck. Tiny Pyxis, the Mariner's compass, lies on the deck itself.

Pyxis holds few sights of interest. But Vela is fine hunting ground for stargazers equipped with binoculars. The whole constellation is peppered with stars, star clusters, and nebulae along the plane of the Milky Way. As you orient yourself, sweep back and forth with your glass within the sail to look for lovely and colorful star groups, especially the section just east of Regor.

Regor (gamma Velorum) is also called Suhail, which is also the name of lambda Velorum. The confusing state of affairs was remedied when the star took on its now-commonly used name in honor of astronaut Roger Chaffee, who died while training for the Apollo 1 mission. "Regor" is simply "Roger" spelled backwards.

First-magnitude Regor is an amazingly complex and interesting star system. There are six stars here, though complex instrumentation is required to discern them all. The brightest is a hot blue star some 180,000 times brighter than our Sun, while its close and unresolved companion is even hotter and shines 100,000 times brighter than the sun. It is preparing to soon explode as a supernova. Regor is fascinating to astronomers, who call the system the "Spectral Gem of the Southern Skies" because of the intriguing spectrum created by hot gases in and around the two brightest stars.



Map 27 - The constellations Vela, Pyxis, and Antlia (north is up)

The two bright blue-white stars of Regor, which are not resolvable directly, have fainter companion stars further out. With your binoculars, look for a white 4th-magnitude star just to the southwest. And look also just to the southeast for two much fainter stars of 8th and 9th magnitude, though these are much harder to find in binoculars.

Just south of Regor, sweep the rich star fields to find the open star cluster NGC 2547. There are some 80 mostly blue-white stars in the cluster, and you can resolve a dozen or so in binoculars. Even in binoculars, the cluster

takes on a curved cross-like shape, and at first glance might remind you of bent miniature version of the constellation Crux.

Now move to the 4th-magnitude star omicron (o) Velorum, the brightest member of the cluster IC 2391. Easily visible to the unaided eye, the cluster was cataloged by the redoubtable Lacaille in1752. The cluster has intrigued and puzzled modern astronomers. It was once thought to be 35 million years old. But extensive measurement and calculation of the abundance of the trace element lithium, which is consumed in the nuclear furnace of each star's core, shows the cluster is closer to 50 million years old. That's still considered quite young for an open cluster.

Binoculars reveal 10-12 stars spread over a full degree of sky. There are two distinct collections of stars in the cluster separated by a mostly black gulf. Can you see any color in the stars? Omicron Velorum, the brightest star in the cluster, may look greenish-blue, while others appear white or yellow-white. Sharpen your observing skills by looking for patterns and shapes among the cluster's stars. IC2391 forms part of a stellar "supercluster", which includes IC 2391 and perhaps 60 other stars scattered across the southern sky. The group likely formed together, and continues to move through space towards the constellation Lepus, the tiny constellation under Orion's feet. IC 2391 is currently about 500 light years from Earth.

Just one degree east of IC 2391, look for the faint trapezoidal glow of NGC 2669. The two clusters make a beautiful pair in the same binocular field of view.

IC 2395 is yet another appealing cluster in Vela. This excellent binocular cluster resolves into half a dozen stars, though there are about 40 in the group. The rest of the stars form a small patch of silver starlight that begins to resolve in larger optics. The cluster is about 4,500 light years away.

Vela's collection of beautiful star clusters is nicely complemented by the planetary nebula NGC 3132. Like all such objects, this planetary is a short-lived nebula created by an old mid-sized star driving off its atmosphere in waves into interstellar space before settling down as a white dwarf star. There are hundreds of planetary nebulae in the night sky, but at 8th magnitude NGC 3132 is the brightest. Look for a tiny grey-white disk just east of chi (χ) Velorum. NGC 3132 is also called the "Eight-Burst Nebula" because of its complex multi-ringed appearance in long-exposure images. Northern observers will notice its resemblance to the famous Ring Nebula in the northern constellation Lyra.

Planetary nebulae like the Ring and the Eight-Burst have nothing directly to do with planets. Their name comes from their disk-like appearance, which William Herschel, the first to discover them in the late 18th century, likened to the small disks that planets present in a telescope.

NGC 3132 is just on the border between Vela and the fainter constellation Antlia, the Air Pump. This group lies off the Milky Way and holds few sights of interest for binocular-equipped stargazers.

Gemini, the Twins

Now let's begin a sweep of four constellations of the zodiac, beginning with Gemini. Turn to the north, and you will see a pair of first-magnitude stars above the north northwestern horizon. These are the celebrated Twins Castor and Pollux from which the constellation Gemini takes its name. The star marked α (Alpha) in the map is Castor, and the star marked β (Beta) is Pollux.

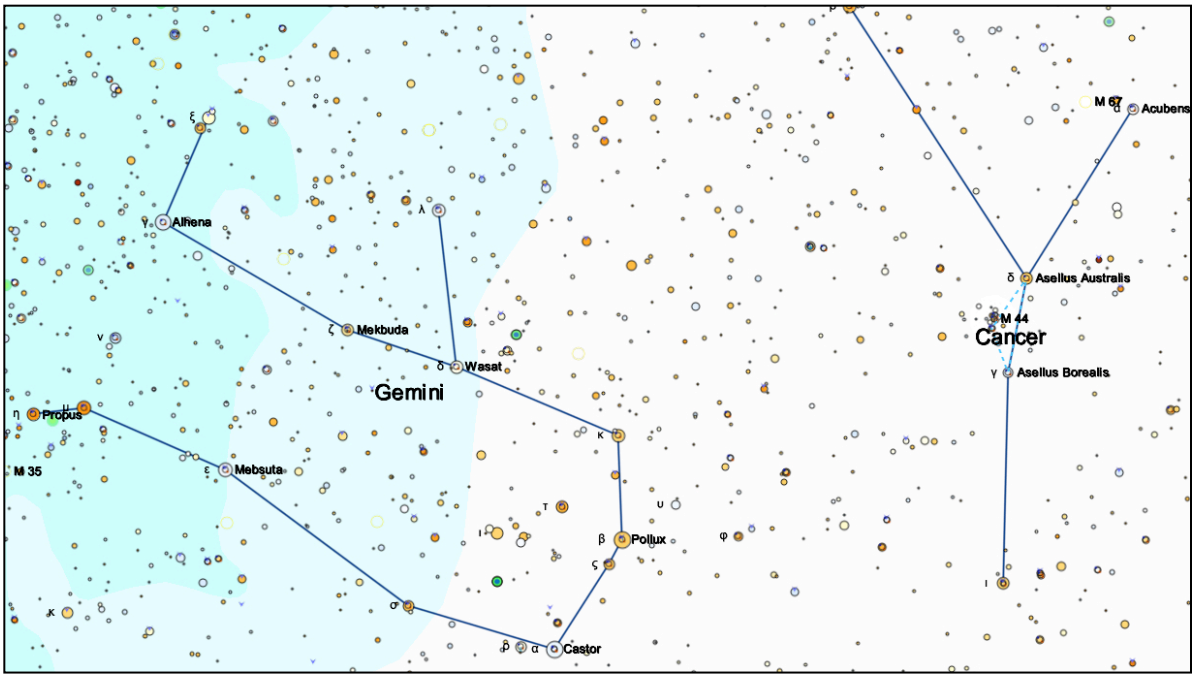
In mythology, Castor and Pollux were sons of Zeus, who together were known as the Dioscuri. Pollux was a boxer, and Castor a horseman and fierce warrior. The brothers proved their courage by joining Jason and his Argonauts on his quest for the Golden Fleece, among other adventures. Upon returning, Castor and Pollux met their fate during more sordid matters, falling into a murderous grievance with another pair of twins, Idas and Lynceus over rustled cattle. Castor was killed by Lynceus, who was in turn slain by Pollux. Pollux grieved for his fallen brother and asked Zeus if the two could share immortality. It pays to have a powerful father: Zeus placed both in the sky as the constellation Gemini. The brightest stars of the constellation take the names of the twins.

Now turn your binoculars towards each of these bright stars. A sharp contrast in the color of Castor and Pollux comes out right away. Castor is white, while Pollux is deep yellow. Castor is a celebrated double star, but its components are far too close to be separated with binoculars. You will be at once interested by the singular cortege of small stars by which both Castor and Pollux are surrounded. These little attendant stars, for such they seem, are arrayed in symmetrical groups pairs, triangles, and other figures which make for pleasant viewing.

Map 28 will show you the position of the principal stars of the constellation. Castor and Pollux are in the heads of the Twins, while the row of stars shown in the map ξ (Xi), γ (Gamma) or *Alhena*, μ(Mu), ν (Nu) Gem, and η (Eta) or *Propus* marks their feet, which are dipped in the edge of the Milky-Way. One can spend a profitable and pleasurable half-hour in exploring the wonders of Gemini. The whole constellation, from head to foot, is gemmed

with stars which escape the naked eye, but it sparkles like a bead-spangled garment when viewed with binoculars.

Owing to the presence of the Milky-Way, the spectacle around the feet of the Twins is particularly magnificent. And here the possessor of binoculars can get a fine view of a celebrated star cluster known in Messier's catalog as M35. It is situated a little distance northwest of the star *Propus*, and is visible to the naked eye, on a clear, moonless night, as a nebulous speck. With a good glass you will see two wonderful streams of little stars starting, one from *Propus* and the other from Nu, and running parallel toward the northwest; M35 is situated between these star-streams.



Map 28- The constellations Gemini and Cancer (south is up)

The stars in the cluster are so closely aggregated that you will be able to clearly separate only the outlying ones. The general aspect is like that of a piece of frosted silver over which a twinkling light is playing. The splendor of this starry congregation, viewed with a powerful telescope, may be guessed at from the picturesque description of a 19th century amateur stargazer, Admiral Smyth: *"It presents a gorgeous field of stars, from the ninth to the sixteenth magnitude, but with the center of the mass less rich than the rest. From the small stars being inclined to form curves of three or four, and often with a large one at the root of the curve, it somewhat reminds one of the bursting of a sky-rocket."*

M35 rivals the finest star clusters in the sky, including those of Carina and Centaurus. No one can gaze upon this marvelous phenomenon, even with the comparatively low powers of binoculars, and reflect that all these swarming dots of light are really suns, without a stunning sense of the immensity of the material universe.

The light from M35 left some 4,000 years ago.

Collinder 89 is another charming star group. Located halfway between M35 and mu (μ) Geminorum. It's a fairly sparse and unconcentrated cluster, with 6-8 stars. It is often passed over for its more famous neighbor.

The June solstice, or the point which the sun occupies when it attains its greatest northerly declination, on the shortest day of the year in the southern hemisphere, is close by this M35 in Gemini. When the sun is in this position, in the glare of the sunshine those swarming stars are then concealed from our sight, but with the mind's eye we can look past and beyond our sun, across the incomprehensible chasm of space, and behold them still shining, their commingled rays making our own sun seem but a lonely wanderer in the expanse of the universe.

It was only a short distance southwest of this cluster that one of the most celebrated discoveries in astronomy was made. There, on the evening of March 13, 1781, William Herschel observed a star whose singular aspect led him to put a higher magnifying power on his telescope. The higher power showed that the object was not a star but a planet, or a comet, as Herschel at first supposed. It was the planet Uranus, whose discovery *"at one stroke doubled the breadth of the sun's dominions."*

Castor and Pollux were regarded by both the Greeks and the Romans as the patrons of navigation, and this fact crops out very curiously in the adventures of St. Paul. After his disastrous shipwreck on the island of Melita he embarked again on a more prosperous voyage in a ship bearing the name of these very brothers. *"And after three months*," writes the celebrated apostle (Acts xxviii, 11) "*we departed in a ship of Alexandria, which had wintered in the isle, whose sign was Castor and Pollux.*" Paul was certainly acquainted with the constellation Gemini, not only because he was skilled in the learning of his times, but because, in his speech on Mars Hill, he quoted a line from the opening stanzas of the poet Aratus' "*Phenomena*", a poem in which the constellations are described.

Cancer, The Crab; The Zodiac

Looking now look eastward from Gemini, you will see a patch of sky with few bright stars (see Map 28). If you have dark and clear sky, your eye will

be caught by a small silvery spot in the sky lying nearly between two rather faint stars. This is the famous Praesepe, or “Manger”, in the center of the constellation Cancer. The two stars on either side of it are called the Aselli, or the Ass's Colts, and the imagination of the ancients pictured them feeding from their silver manger. Turn your glass upon the Manger and you will see that it consists of a crowd of dozens of white stars. This open star cluster has been known since antiquity. Its true nature was a mystery until Galileo aimed the first telescope at this cloudy patch of light. He left a delightful description of his surprise and gratification when he aimed his telescope at this cluster and other similar aggregations of stars and discovered what they really were. Using his best instrument, he was able to count thirty-six stars in the Manger. Your binoculars will reveal nearly as many.

The Manger was a famous weather-sign in olden times, and the Greek poet Aratus, advised his readers to:

" . . . watch the Manger : like a little mist
Far north in Cancer's territory it floats.
Its confines are two faintly glimmering stars ;
These are two asses that a manger parts,
Which suddenly, when all the sky is clear,
Sometimes quite vanishes, and the two stars
Seem to have closer moved their sundered orbs.
No feeble tempest then will soak the lea ;
A murky manger with both stars
Shining unaltered is a sign of rain."

Like other old weather tales, this probably possesses a gleam of sense, for it is only when the atmosphere is perfectly transparent that the Manger can be clearly seen; when the air is thick with mist, the harbinger of coming storm, it fades from sight. Light pollution of the type seen in moderate to large cities renders the Manager difficult or impossible to see with the unaided eye. The manger was also cataloged by the comet hunter Charles Messier. He gave it the 44th position in his famous list; for this reason, the manger is also called M44 (or Messier 44).

The constellation Cancer, or the Crab, was represented by the Egyptians under the figure of a Scarab Beetle. The observer will probably think that it is as easy to see a beetle as a crab there. Cancer, like Gemini, Pisces, and Aquarius, is one of the twelve constellations of the Zodiac, the name applied to the imaginary zone 16 degrees wide and extending completely around the heavens, the center of which is the ecliptic or annual path of the sun and the planets. The names of these zodiacal constellations, in their order, beginning at the west and counting round the circle, are: Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus,

Aquarius, and Pisces. Cancer has given its name to the circle called the Tropic of Cancer, which indicates the greatest northerly declination of the sun in summer, and which he attains on the 21st or 22d of June. But, in consequence of the precession of the equinoxes, all of the zodiacal constellations are continually shifting toward the east, and Cancer has passed away from the place of the summer solstice, which is now to be found in Gemini.

The ecliptic passes through a 13th constellation, Ophiuchus, which we have already met. But this star group was not included by astrologers in the zodiac, as they considered the number 13 to be unlucky.

Cancer holds a second open cluster, M67, which is often overlooked for the more famous Praesepe. The cluster is found just southwest of the star Acubens. It's smaller and dimmer than M44, and not resolved in most binoculars. But its more than 500 stars presents a pleasing image of silver-grey mist. This cluster is 2,500 light years from Earth, about 5 times the distance of M44. It's also one of the oldest known open clusters, with an estimated age of some 3 billion years. Most open clusters are tens or hundreds of millions years old.

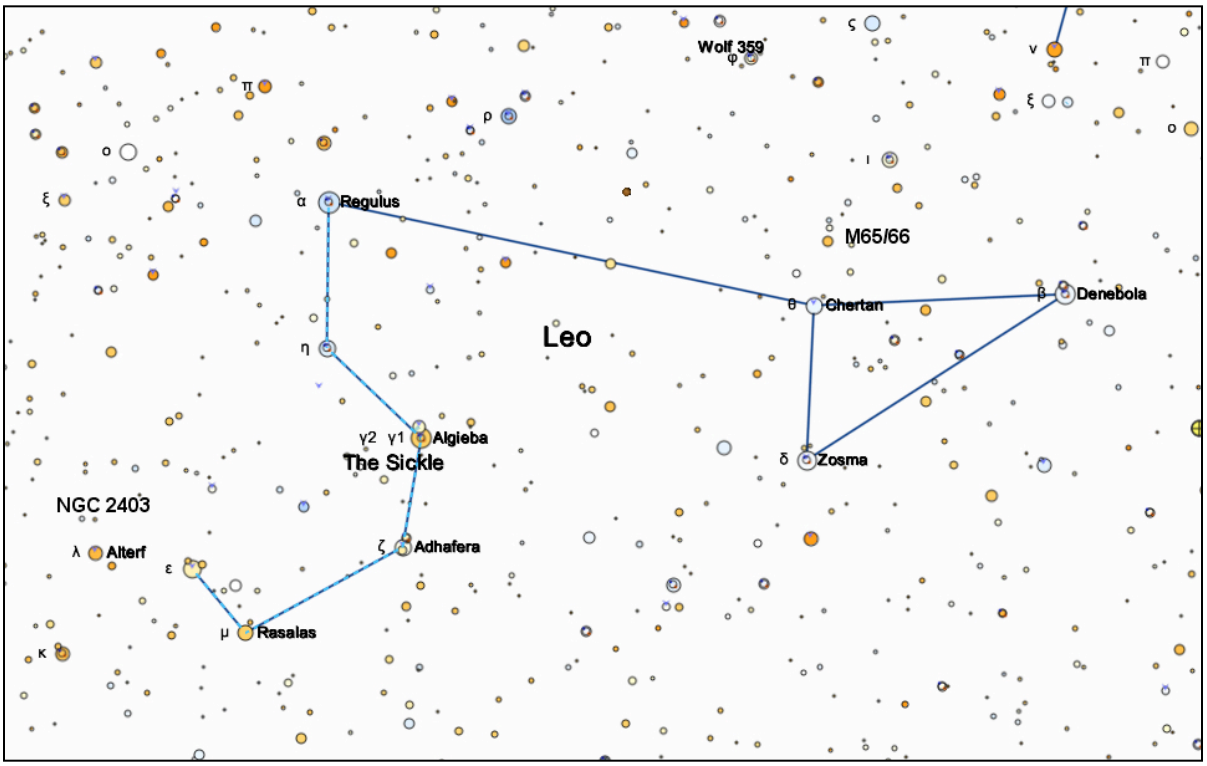
Leo, The Lion

Look eastward once again for another zodiacal constellation, Leo, the Lion. Leo is a bright constellation, and is marked by what appears to be an upside-down "question mark" of stars with a bright star at its base. The question mark is also known as "The Sickle", and it marks the head and mane of the great celestial Lion. From the vantage point of the southern hemisphere, the Lion appears upside down.

The bright star at the base of the Sickle is Regulus, or alpha (α) Leonis. The star's name is Latin for "little king". Many cultures-- Arabian, Greek, Babylonian, and Akkadian-- have associated this star with royalty. Binoculars will reveal a dim 8th-magnitude companion to Regulus. A third companion can be detected with a large telescope. The three stars are gravitationally bound.

By consulting Map 29 you will next be able to find the celebrated star bearing the name of *Algieba*, also called Gamma (ϒ) Leonis. If you had a telescope, you would see this star as a close and beautiful double, of contrasted colors. But in binoculars, it appears as an optical double. You cannot fail to see a small star near it. You will be struck by the surprising change of color in turning from Regulus to Gamma, as the former is white and the latter deeper yellow. It will be well to look first at one and then at the other, several times, for this is a good instance of what you will meet in

your future surveys of the heavens: a striking contrast of color in neighboring stars.



Map 29 - The Constellation Leo, the Lion

Turn next to the star in Leo called *Adhafera*. If your glass is 40 mm or more, and your eye keen, you will easily see three tiny companion stars keeping company with *Adhafera*, two on the southeast, and one, much closer, toward the north. The nearest of the two on the south is faint, being only between the eighth and ninth magnitude, and will probably severely test your powers of vision. Next look at the star ε (Epsilon) Leonis, and you will find near it two seventh-magnitude companions, making a beautiful little triangle.

Away at the eastern end of the constellation, in the tail of the imaginary Lion, upon whose breast shines Regulus, is the star β (Beta) Leonis, also called Denebola. It is almost as bright as its leader, Regulus, and you will probably be able to catch a tinge of blue in its rays. South of Denebola, at a distance of nineteen minutes of arc, or somewhat more than half the apparent diameter of the moon, you will see a little star of the sixth magnitude, which is one of the several "companions" for which Denebola is celebrated. There is another star of the eighth magnitude in the same direction from Denebola, but at a distance of less than 1/10 of a degree, and this you may be able to glimpse with binoculars under favorable conditions. A view requires binoculars of 40 mm aperture or more, and a

magnifying power of seven times. But it requires an experienced eye and steady vision to catch this star.

If you will sweep carefully over the whole extent of Leo, you will be impressed with the power of your optics to bring into sight many faint stars in regions that seem barren to the naked eye. Binoculars of just 30-35 mm aperture will show twenty times as many stars as the naked eye can see.

A word about the "Lion" which this constellation is supposed to represent. It requires a vivid imagination to perceive the outlines of the celestial king of beasts among the stars, and yet somebody taught the people of ancient India and the old Egyptians to see him there, and there he has remained since the dawn of history. The Lion is the most conspicuous figure in the celebrated zodiac; and, indeed, there is evidence that before the story of Hercules and his labors was told this lion was already imagined shining among the stars. It was characteristic of the Greeks that they seized him for their own, and tried to rob him of his real antiquity by pretending that Zeus had placed him among the stars in commemoration of Hercules' victory over the Nemsean lion. In the Hebrew zodiac Leo represented the Lion of Judah. It was thus always a lion that the ancients thought they saw in this constellation.

In the old star maps the Lion is represented as in the act of springing upon his prey. His face is to the west, and the star Regulus is in his heart. The sickle-shaped figure covers his breast and head, Algieba being in the shoulder, Adhafera in the mane of the neck, and Rasalas and Epsilon Leonis in the cheek. The fore-paws are drawn up to the breast and represented by the stars around Subra. Denebola is in the tuft of the tail. The hind-legs are extended downward at full length, in the act of springing. Starting from the star Zosma in the hip, the row consisting of Chertan, Iota (ι), Tau (τ), and Upsilon (υ) Leonis, shows the line of the hind-legs.

Leo had an unsavory reputation among the ancients because of his supposed influence upon the weather. The greatest heat of summer was felt when the sun was in this constellation:

> *"Most scorching is the chariot of the Sun,*
> *And waving spikes no longer hide the furrows*
> *When he begins to travel with the Lion."*

As you look in the direction of Leo, its neighbor Virgo, and other constellations in this part of the sky, you are looking out of the flat plane of the Milky Way and in to intergalactic space towards other galaxies millions of light years away. There are hundreds of galaxies here visible in a small telescope. But a few are bright enough to be visible in binoculars, at least if

you have dark sky. If you have 40-50 mm binoculars, try to find the fuzzy oval shape of the galaxy NGC 2403 just off the "nose" of the Lion (see Map 29). The view in binoculars may be uninspiring, but this galaxy is quite lovely in time-exposure images in larger telescopes.

The same goes for the pair of galaxies M65 and M66, which are just below the triangular hindquarters of the great Lion. In binoculars, the pair look like a faint pair of silver eyes staring back across intergalactic space. This pair interacts gravitationally. If you can see this pair, keep in mind you are seeing light that has traveled for 31 million years across intergalactic space!

Virgo; Corvus and Crater

Now face east and look to the right of Centaurus and a little lower for a single gleaming white star twinkling above the horizon. This is Spica, the brightest star of Virgo, and it is marked on Map 30.

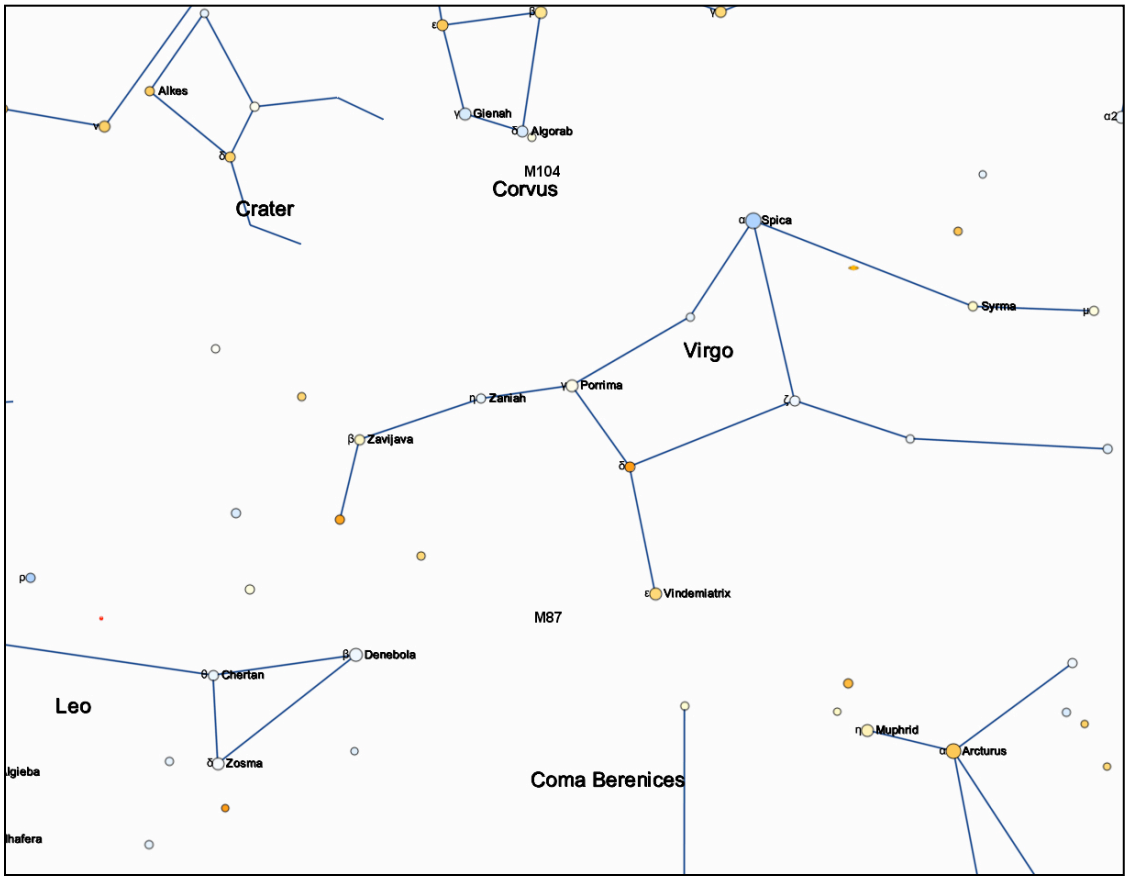
Virgo contains a few interesting foreground stars along with a gaggle of galaxies nestled in her celestial arms. Unlike Orion, Virgo is not a bright constellation. But it's big… the second largest in the sky by area. Only Hydra is larger. The constellation is usually associated with Dike, the Greek goddess of justice, daughter of Zeus and Themis. She lived in the early days of the Olympian gods, when Zeus's father Cronos ruled. It was a golden age of mankind, a time before sickness and war, winter and death.

When Zeus wrested power from Cronos, things turned worse for the world. The seasons grew extreme, and mankind grew restless and warlike and failed to honor the gods. Dike warned mortals that things would get worse– wow, did they ever– and she turned her back on man and became a recluse in the hills of Greece. When she could stand no more of the world's troubles, she cast herself into the sky in the zodiac next to Libra, the Scales (of justice).

Other ancient legends associate Virgo with Persephone, the daughter of Demeter, the goddess of the harvest. Because the stars of Virgo appear before sunrise late in the northern summer, many other cultures, including the Babylonians link Virgo with crops and fertility. In India Virgo was called Kauni, mother of the great god Krishna.

The constellation Virgo lies in the direction of the north galactic pole, far from the starry band of the Milky Way, so there are only a few bright stars here. Alpha (α) Virginis, or Spica, is a blue-white beauty of a star and the brightest in the constellation. Other stars in Virgo include Zavijava (beta Virginis) a white star in the prime of its life, and not much larger than the Sun.

Vindemiatrix, epsilon (ε) Virginis, was known to the ancients as the "grape gatherer because the first appearance of the star before sunrise in August marked the beginning of the vintage. This star may be physically associated with the Hyades star cluster in Taurus.



Map 30 - Virgo, Corvus, and Crater; Coma Berenices, as seen looking north

Porrima – also known as gamma (γ) Virginis-- is a lovely double star just 39 light years away. The pair revolve about each other in 169 years, which means you can see, in a good backyard telescope, the motion of the stars over the course of a decade or so. Until 1995, the stars split easily in a small scope. Since then, they've moved too close together to resolve. And starting in 2010, they've separated once again to become resolvable in a small telescope in steady sky and high magnification.

While Virgo lacks bright stars, it hold no shortage of galaxies. Within the "arms" of the maiden, towards the constellation Leo and between the stars Vindemiatrix and Denebola, in Leo, you can find dozens of galaxies with a small telescope. Most belong to the massive Virgo Cluster, the nearest large galaxy cluster to the Milky Way. While it is difficult to see many galaxies in

Virgo with binoculars, you may be able to spot the brightest and biggest galaxy in Virgo, M87. It appears as a dim circular smudge nearly halfway between Vindemiatrix and Denebola. Don't let the modest appearance of this galaxy disappoint you: you are seeing the combined light of more than one trillion stars! The galaxy is more than 50 million light years away.

The famous Sombero Galaxy, M104, is also quite intriguing in binoculars. You will see an oval disk that brightens much near the center. The core of M104 is much brighter than most spiral galaxies, possibly because of the effects of a super-massive black hole.

Look next just above Virgo at Corvus and Crater, the Crow and the Cup, two smaller constellations with distinctive shapes. You will find that the stars δ (Delta, or *Gienah)* and η (Eta), in the upper left-hand corner of the quadrilateral figure of Corvus, make a striking appearance. The little star Zeta (ζ) is a very pretty double for binoculars. There is a very faint pair of stars close below and to the right of Beta (β). This forms a severe test. Only a good set of binoculars will show both, one being considerably fainter than the other. Crater is worth sweeping over for the pretty combinations of stars to be found in it.

Later in the season, you may see a bright star directly beneath Virgo. It is the star Arcturus in the constellation Boötes. It is the brightest star north of the celestial equator and the fourth-brightest star in the sky (not including the Sun). You may also see the inverted and elongated kite shape of Boötes hanging below Arcturus.

If you have a clear view of the northern horizon, you may see directly left of Arcturus a constellation that, like Taurus, is almost entirely comprised of a star cluster. This is the little constellation called Coma Berenices (Berenice's Hair). Your binoculars will enable you to count twenty or thirty of the largest stars composing this cluster, which are arranged, as so often happens, with a striking appearance of geometrical design. The constellation has a very romantic history. It is related that the young Queen Berenice, when her husband was called away to the wars, vowed to sacrifice her beautiful tresses to Venus if he returned victorious over his enemies. He did return home in triumph, and Berenice, true to her vow, cut off her hair and bore it to the Temple of Venus. But the same night it disappeared. The king was furious, and the queen wept bitterly over the loss. There is no telling what might have happened to the guardians of the temple, had not a celebrated astronomer named Conon led the young king and queen aside in the evening and showed them the missing locks shining transfigured in the sky. He assured them that Venus had placed Berenice's lustrous ringlets among the stars, and, as they were not skilled in celestial lore, they were quite ready to believe that the silvery swarm they saw near Arcturus had

never been there before. And so for centuries the world has recognized the constellation of Berenice's Hair.

Hydra, The Serpent

Directly above the constellations Cancer, Leo, and Virgo, and nearly directly overhead at this time of year lies Hydra, the largest constellation by area in all the heavens. Hydra, the Water Serpent, was one of the original 48 constellations outlined by Ptolemy in the 2nd century A.D. It spans over 1300 square degrees of sky. Though Eridanus is longer, it wraps back upon itself and doesn't span as much sky as Hydra.

The Egyptians saw the long, winding constellation as the celestial representation of the life-giving river Nile. According to the ancient Greeks, Hydra was a fearsome swamp creature with a long, dragon-like body and nine heads. The beast terrorized the village of Lerna in the northeast Peloponnesian Peninsula, killing livestock and threatening to cut off access to the village's water supply. But the brave Hercules (or Heracles, in Greek) came to the rescue along with his nephew Iolaus. Hercules clubbed and hacked at the monster's heads, but when he knocked one off, two grew back in its place. So Hercules schemed to have Iolaus cauterize the monster's wounds with a torch each time the hero knocked off a head. It worked. The beast was defeated, and Hercules buried the monster in the swamp.

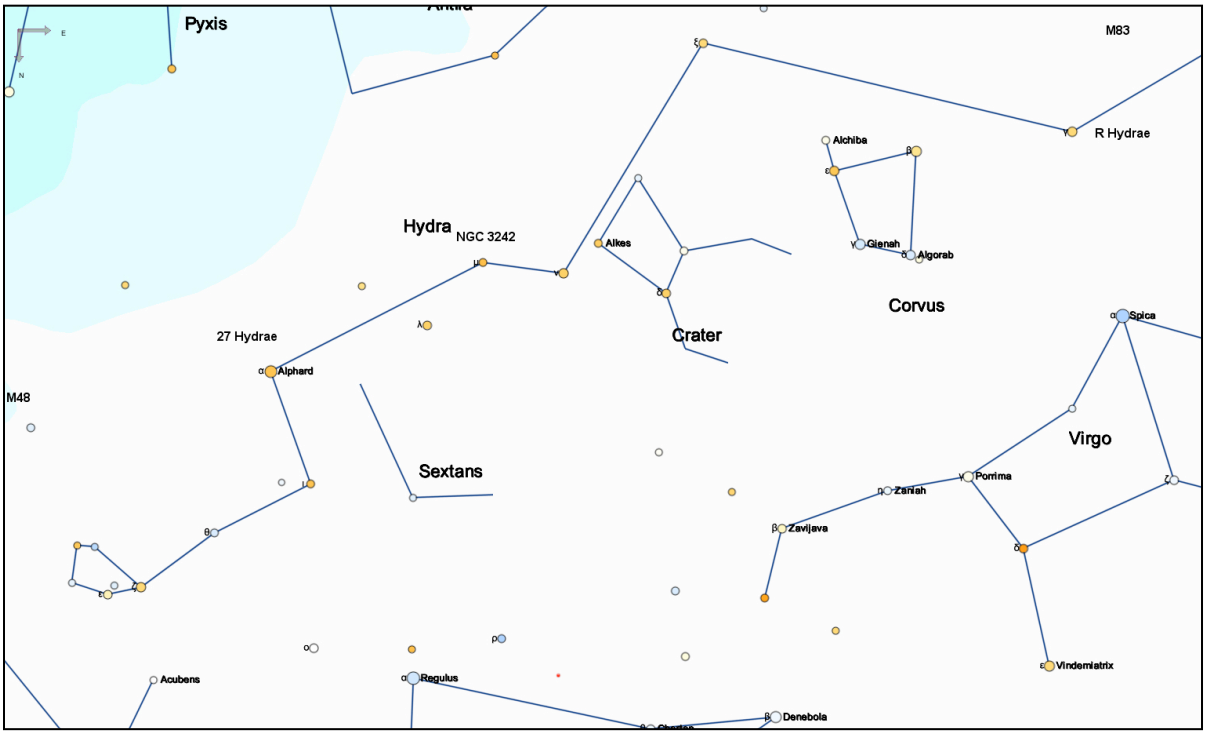
While its stars are not bright, Hydra is easy to find because of its long zig-zag line of some 17 stars. It immediately jumps out in darker sky; city dwellers may need to use binoculars to trace its shape. Find the circular head of Hydra about halfway between Regulus and Procyon in Canis Minor. The head is a delight in binoculars and fits nicely in a 5-degree field of view. (The constellation has but one head, not nine). Then follow the rest of the constellation to zeta (ζ), alpha(α), lamba(λ), nu(ν), xi(ξ), and finally gamma (γ) Hydrae, about 15 degrees below Spica. It takes the entire constellation about three months to work its way across the sky as the Earth revolves about the Sun.

At 2nd magnitude, the brightest star in Hydra is the rich-orange giant Alphard, which is Arabic for "the Solitary One", an appropriate name because of its lonely place in this part of the sky.

Physically, Alphard is fascinating. The star has an unusually high abundance of the element barium, a situation caused by a long-dead companion star that irradiated Alphard with neutrons, creating barium and other heavy trace elements in its atmosphere. Alphard itself is on the way to doom; it has long exhausted the hydrogen fuel in its core and has swelled

to burn cooler and some 400 times brighter than our sun. Alphard lies 175 light year away.

Just two degrees southwest of Alphard, look for the easily-split double star 27 Hydra. The pair consists of a yellow-white primary star of 5th magnitude and a second white star of 7th magnitude.



Map 31 - Hydra, the largest constellation in the night sky

About 14 degrees southeast of Procyon, look for Messier's "lost cluster" M48. A catalog error by Messier puzzled astronomers for some time, since he recorded the incorrect position for the cluster. But Messier's description of the cluster corresponds to nearby NGC 2548. This is a fine cluster for binoculars as it spreads over a full degree of sky. A dozen stars are visible in most optics. Look in particular for a small triangular asterism near the center of the cluster.

Hydra hosts NGC 3242, one of the most famous of planetary nebulae. Look for it just 2 degrees southwest of mu (μ) Hydrae. Like many such nebulae, NGC 3242 looks in passing like the disk of a planet. Upon his discovery of this nebula in 1785, Herschel wrote, *"Beautiful, brilliant, planetary disk ill defined, but uniformly bright, the light of the colour Jupiter… 1′ in diameter".* A telescope is required to reveal any detail or structure in the nebula, but even a small pair of binoculars will show an 8th-magnitude blue-green disk.

Long-period variable R Hydrae is one of the easiest such stars to observe, perhaps just as easy as the more famous Mira in the constellation Cetus. This red star peaks at magnitude 4, visible even without optical aid, then drops to magnitude 11, which is hard to see in binoculars. The period of the star is irregular, but averages about 390 days.

Perhaps the finest deep-sky sight in Hydra is the so-called “Southern Pinwheel Galaxy” M83. A difficult sight from the northern hemisphere, this face-on spiral galaxy is high in the sky in the south and easily seen in binoculars. You will not see spiral arms, as in photographs of the galaxy, but a careful gaze will reveal the soft glow of the arms and a star-like bright nucleus. M83 is 15 million light years away, and ranks as one of the 25 brightest galaxies in the night sky.

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And with these constellations we finish our review of the celestial wonders that lie within the reach of so humble and inexpensive an instrument as binoculars. We have made the circuit of the southern sky, and the stars that illuminate the winter skies of the southern hemisphere will soon be seen advancing from the east, and pressing close upon the autumn constellations. The familiar figures of the Southern Cross and Centaurus and the other constellations of the winter sky will come to resemble the faces of old friends whom we are glad to welcome. These starry acquaintances never grow wearisome. Their interest for us is as fathomless as the deeps of space in which they shine. As we watch them in their courses, the true music of the spheres comes to our listening ears, the chorus of creation faint with distance, for it is by slow approaches that man draws near to it chanting the grandest of epics, the Poem of the Universe; and the theme that runs through it all is the reign of physical law.

Do not be afraid to become a star-gazer. The human mind can find no higher exercise. He who studies the stars will discover

"An endless fountain of immortal drink
Pouring unto us from heaven's brink."