THE PANORAMA OF THE NIGHT SKY

When the night sky is dark and clear, it presents a dazzling spectacle. Myriads of stars, glowing patches of gas, a planet or two, the Moon in its phases, perhaps a meteor shower, an eclipse of the Moon or even a comet, all such sights are there for the taking by anyone who cares to look up.

Even when dimmed by city lights and smog, the night sky is worth a long look. The panorama is constantly changing, with the view never quite the same, even on successive nights. There is always something of interest, some sight to appreciate, whether you are viewing with binoculars, a small telescope, or just with your unaided eyes.

Astronomy, the science of the stars, is perhaps the most ancient form of methodical human knowledge. To track the paths of the celestial lights today is to retrace the steps of the first observers many thousands of years ago.

Starting with the stars

Most of the things we see in the night sky are **stars**, vast balls of glowing gas similar to our Sun but so far away from us that they are reduced to mere points of light, scattered mostly at random across the heavens. The unaided human eye can detect about 6000 stars under dark, clear conditions, but less than half of those are visible at any one time.

For thousands of years, skywatchers in various cultures have been grouping the stars together into unchanging patterns know as **constellations** or **asterisms** (both expressions come from Greek or Latin words for 'star'). These change their positions and orientations in the sky throughout the night and the year, but their shapes do not vary noticeably. You can always pick them out and together they (and the brighter stars in them) form a grid of familiar reference points across the night sky.

Nowadays, 88 constellations are officially recognised. Many other constellations have been devised over the centuries but have now fallen into disuse. All constellations have names, and the older and more spectacular ones have myths and legends associated with them in many cultures. The best known of these stories are drawn from the mythology of ancient Greece and Rome, tales of gods, monsters, heroes and great deeds.

Star stories

For example, the story of Andromeda, the maiden chained to the rock, is recounted in no less than six constellations. Among the stars we find Andromeda herself, the monster Cetus sent to devour her, her rescuer Perseus, her parents Cepheus and Cassiopeia, and the wonderful winged horse Pegasus (even though it was only peripheral to the Andromeda story).

The legendary quest of the Argonauts for the Golden Fleece has many memorials in the sky. In addition to their ship, the mighty Argo itself, now broken into its Keel (Carina), Sail (Vela), Poop (Puppis) and Compass (Pyxis), we also find the wonderful ram that provided the fleece (Aries), some of the Argonauts (Gemini the Twins, Hercules and Orpheus the Musician, through his harp Lyra), and even the centaur Chiron (Centuarus) who tutored the expedition leader Jason.

There are still more, if you take the figure of Ophiuchus, the man holding a serpent, to be Aescalepius, the ship's doctor on the Argo, or the northern figure of Draco to be the serpent that guarded the sacred grove where the Fleece hung, or Taurus to be one of the firebreathing bulls with horns of brass that Jason had to tame. Strangely, Jason himself is not on show.

There are some vivid scenes. Orion the Hunter, accompanied by his two dogs (Canis Major and Canis Minor), is in trouble with a charging bull (Taurus), and is unknowingly trampling on a hare (Lepus). Ophiuchus has his hands full with the serpent. The two centaurs are preoccupied; Centaurus is fighting a wolf (Lupus) and Sagittarius the Archer has an arrow aimed at the fearsome Scorpion. Leo recalls the Nemean Lion slain by the mighty Hercules as one of his 12 labours, and Cancer the Crab that bit his heel while he was battling with the many headed Hydra (and was crushed as a result). In the sky, Hercules has his foot on the head of a Dragon. So the struggle goes on.

The positions of some of the star groups are significant. Crater the Cup, Corvus the Crow and Hydra the Water Snake lie close together because of the story they share (see text to Sky Chart 8). Orion, so the legend goes, met his end when stung by the Scorpion. As a result, they are on opposite sides of the sky, one rising while the other sets.

Libra the Scales, lying between Virgo the Young Maiden and Scorpius, has links to both. As the Goddess of Justice, Virgo weighed the evidence on the scales near at hand. But in some old lists, Libra was not its own constellation but the greatly enlarged claws on the Scorpion coming close behind. In one region of the sky, all the star groups have to do with water. Most likely, this served as a calendar, indicating when the rains would come.

Not all the constellations are so exciting. Many are quite dull, especially those more recently named in southern skies which could not be seen from the Middle East in ancient times. Among these we find many scientific instruments!

Constellations vary greatly in size and many are surprisingly

Cambridge University Press
978-0-521-71405-1 - The Southern Sky Guide, Third Edition
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large, though this is perhaps not so surprising when we realise only 88 cover the whole sky. The largest of all (though not otherwise spectacular) is Hydra at more than 1300 square degrees, six or seven times bigger than your hand at arm's length. Virgo is not far behind, and half a dozen are 1000 square degrees or more. At the other end of the scale, the Southern Cross is less than 70 square degrees in size, and half a dozen thumbs will hide it.

Table 1. The 88 constellations

Proper name	*Meaning*	*Size (square degrees)*	*25 brightest stars*	*Month when highest at 8 p.m.*	*Go to Chart*
Andromeda	The Chained Maiden	722		November	13
Antlia	The Air Pump	239		April	8
Apus	The Bird of Paradise	206		July	3
Aquarius	The Water-Carrier	980		October	12
Aquila	The Eagle	652	Altair	August	19
Ara	The Altar	237		July	3
Aries	The Ram	441		December	13
Auriga	The Charioteer	657	Capella	February	15
Bootes	The Herdsman (or Waggoner or Ploughman)	907	Arcturus	June	17
Caelum	The Engraving Tool	125		January	1
Camelopardalis	The Giraffe	757			
Cancer	The Crab	506		March	15
Canes Venatici	The Hunting Dogs	465		June	17
Canis Major	The Big Dog	380	Sirius, Adhara	February	7
Canis Minor	The Little Dog	183	Procyon	February	7, 15
Carpricornus	The Sea-Goat	414		September	11
Carina	The Keel (of Argo)	494	Canopus	March	2
Cassiopeia	(mother of Andromeda)	598			
Centaurus	The Centaur	1060	Rigil Kentaurus (Alpha Centauri), Hadar (Beta Centauri)	May	3, 9
Cepheus	(father of Andromeda)	588			
Cetus	The Sea Monster (or Whale)	1231		November	5
Chamaeleon	The Chamaeleon	132		April	2
Circinius	The Pair of Compasses	93		May	3
Columba	The Dove	270		February	6
Coma Berenices	Berenice's Hair	386		May	17
Corona Australis	The Southern Crown	128		July	4, 11
Corona Borealis	The Northern Crown	179		June	18
Corvus	The Crow	184		May	9
Crater	The Cup	282		April	8
Crux	The (Southern) Cross	68	Acrux, Mimosa, Gacrux	May	3
Cygnus	The Swan	804	Deneb	September	19
Delphinus	The Dolphin	189		September	19
Dorado	The Gold-Fish	179		February	1
Draco	The Dragon	1083			
Equuleus	The Colt	72		September	19, 20
Eridanus	The River	1138	Achernar	December	1, 6
Fornax	The Furnace	398		December	1, 5
Gemini	The Twins	514	Pollux, Castor	February	15
Grus	The Crane	366		October	4
Hercules		1225		July	18
Horologium	The Clock	249		December	1
Hydra	The Female Water-Snake	1303		April	8, 9
Hydrus	The Male Water-Snake	243		December	1

Cambridge University Press
978-0-521-71405-1 - The Southern Sky Guide, Third Edition
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A full list of the 88 constellations, the meanings of their names, their brightest stars, their sizes, their positions in the sky and on the maps in this book is given in Table 1. Pages 4–5 provide a first look at the better-known and more spectacular star groups in the form of diagrams marking their shapes and more notable stars. More details on these (and more on the stories associated with them) can be found alongside the Sky Charts later in this book (pages 48–87).

Table 1. *(cont.)*

Proper name	*Meaning*	*Size (square degrees)*	*25 brightest stars*	*Month when highest at 8 p.m.*	*Go to Chart*
Indus	The Indian	294		September	4
Lacerta	The Lizard	201		September	20
Leo	The Lion	947	Regulus	April	16
Leo Minor	The Lesser Lion	232		April	16
Lepus	The Hare	290		January	6
Libra	The Scales	538		June	9, 10
Lupus	The Wolf	334		June	3
Lynx	The Lynx	545		March	15
Lyra	The Harp	286	Vega	August	19
(Mons) Mensa	The Table Mountain	153		February	1, 2
Microscopium	The Microscope	210		September	4
Monoceros	The Unicorn	482		February	7
Musca	The Fly	138		May	3
Norma (et Regula)	The Level (and Square)	165		July	3
Octans	The Octant	291		All months	3, 4
Ophiuchus	The Man with the Serpent	948		July	10
Orion	The Hunter	594	Rigel, Betelgeuse	January	6
Pavo	The Peacock	378		October	4
Pegasus	The Winged Horse	1121		October	20
Perseus	(rescuer of Andromeda)	615		December	14
Phoenix	The Phoenix	469		November	1
Pictor	The Painter's Easel	247		February	1
Pisces	The Fish	889		November	4, 13
Piscis Austrinus	The Southern Fish	245	Fomalhaut	October	12
Puppis	The Poop (of Argo)	673		February	2, 7
Pyxis	The Compass (of Argo)	221		March	2
Reticulum	The Reticule	114		December	1
Sagitta	The Arrow	80		August	19
Sagittarius	The Archer	867		August	11
Scorpius	The Scorpion	497	Antares, Shaula	July	10
Sculptor	The Sculptor's Chisel	475		November	5
Scutum	The Shield	109		July	12
Serpens	The Serpent	637		July	10, 11
Sextans	The Sextant	314		April	8
Taurus	The Bull	797	Aldebaran	January	6, 14
Telescopium	The Telescope	252		August	4
Triangulum	The Triangle	132		December	13
Triangulum Australe	The Southern Triangle	110		July	3
Tucana	The Toucan	295		November	1, 4
Ursa Major	The Great Bear	1280		April	16
Ursa Minor	The Little Bear	256			
Vela	The Sail (of Argo)	500		March	2
Virgo	The Young Maiden	1294	Spica	May	9
Volans	The Flying Fish	141		February	2
Vulpecula	The Fox	268		September	19

Cambridge University Press
978-0-521-71405-1 - The Southern Sky Guide, Third Edition
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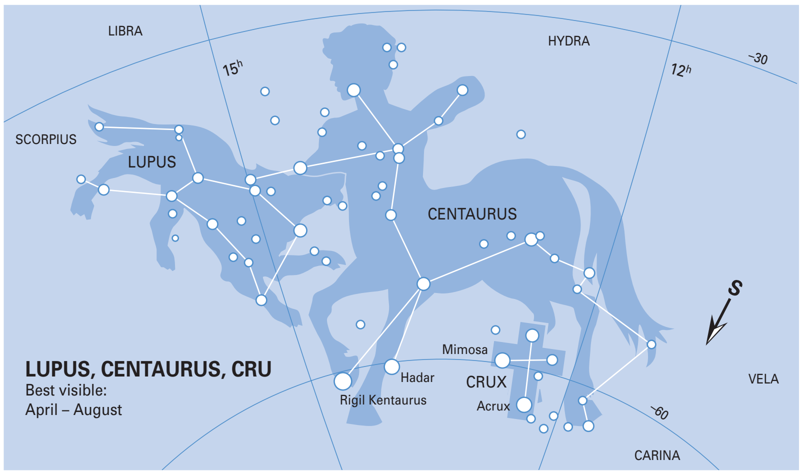

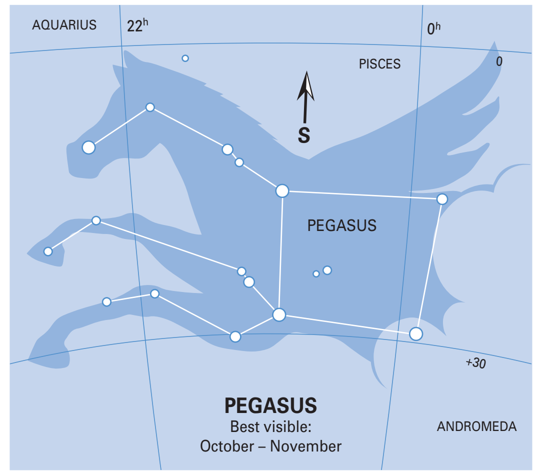

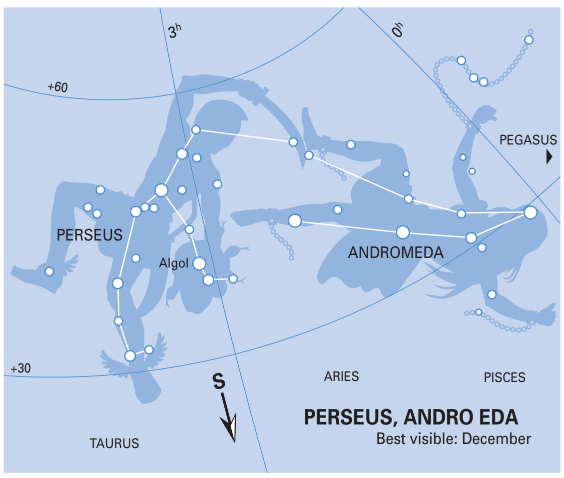

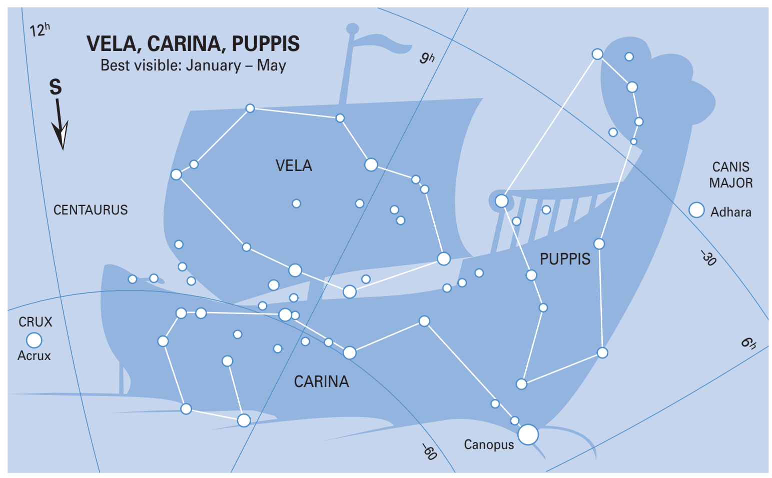

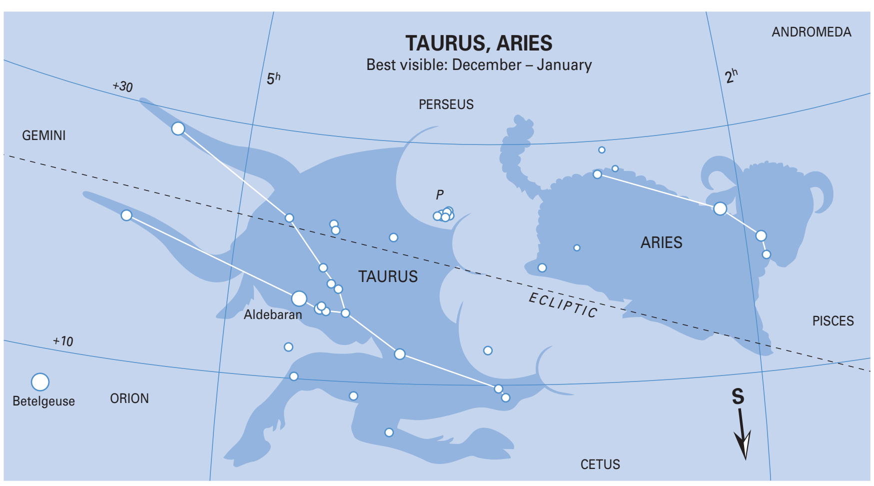

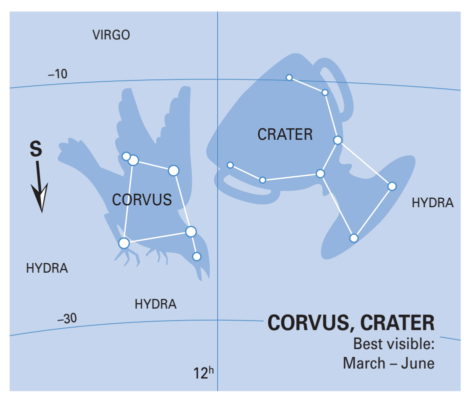

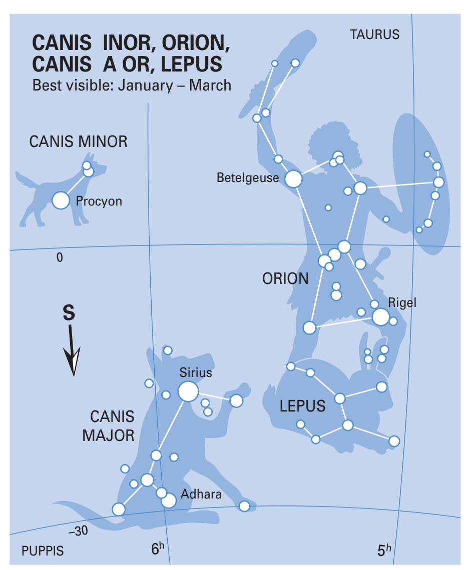

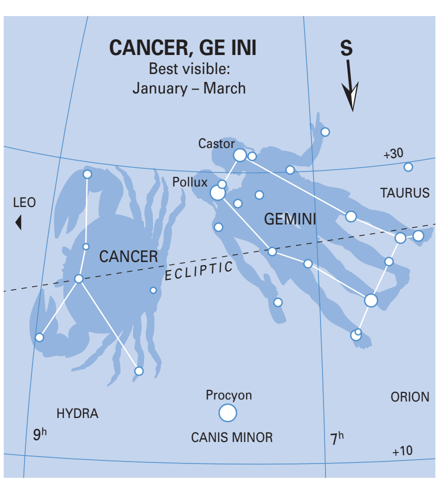

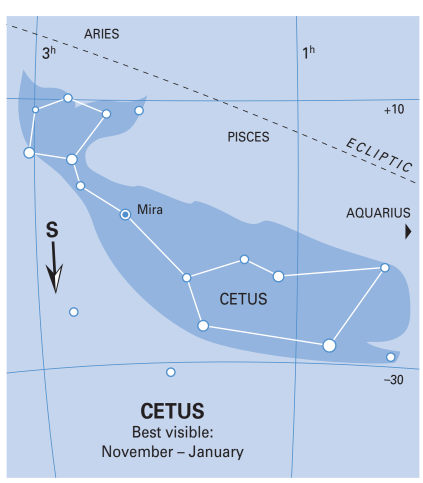

Cambridge University Press
978-0-521-71405-1 - The Southern Sky Guide, Third Edition
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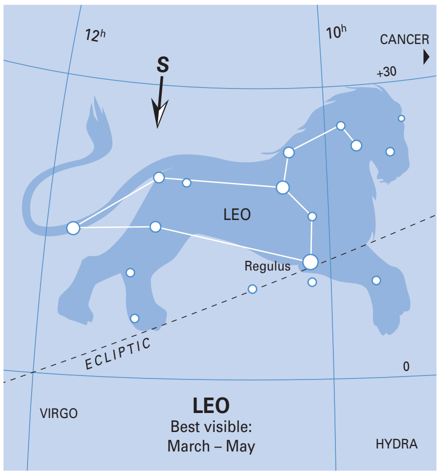

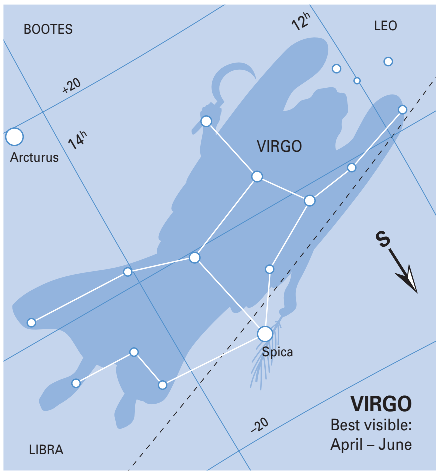

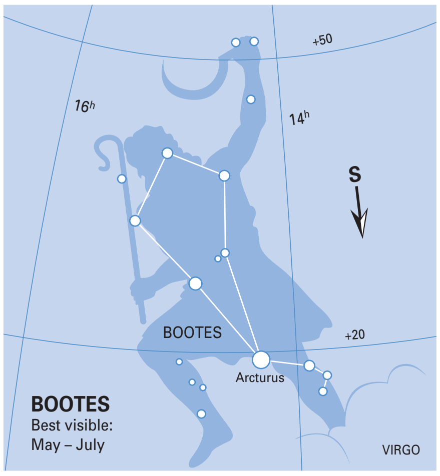

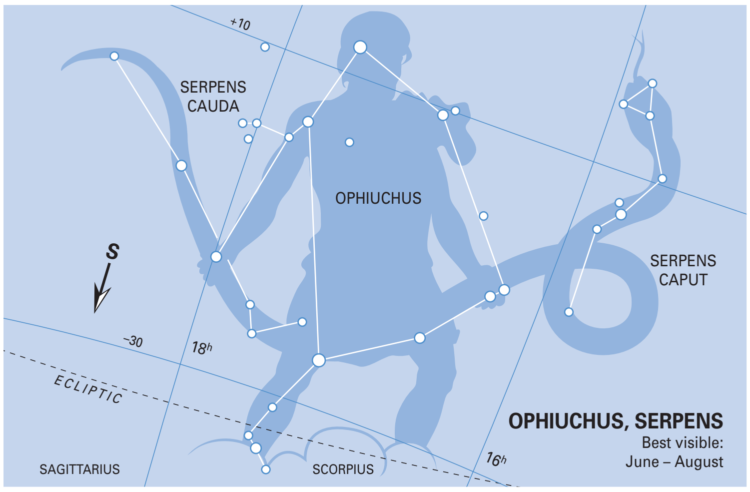

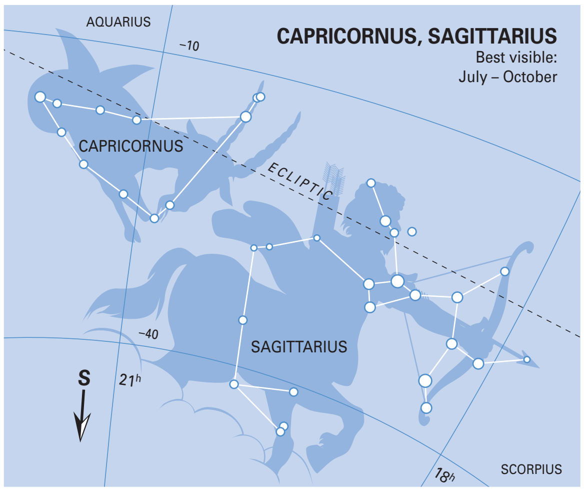

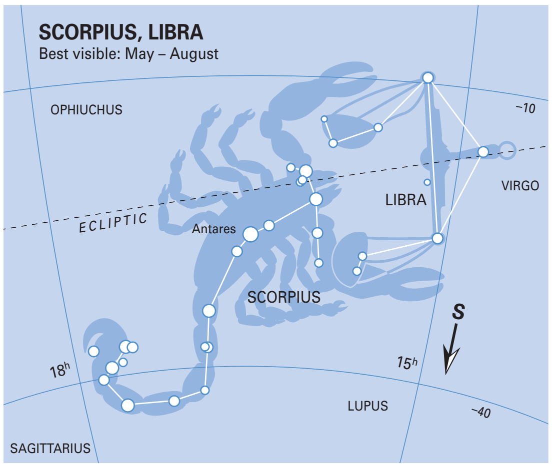

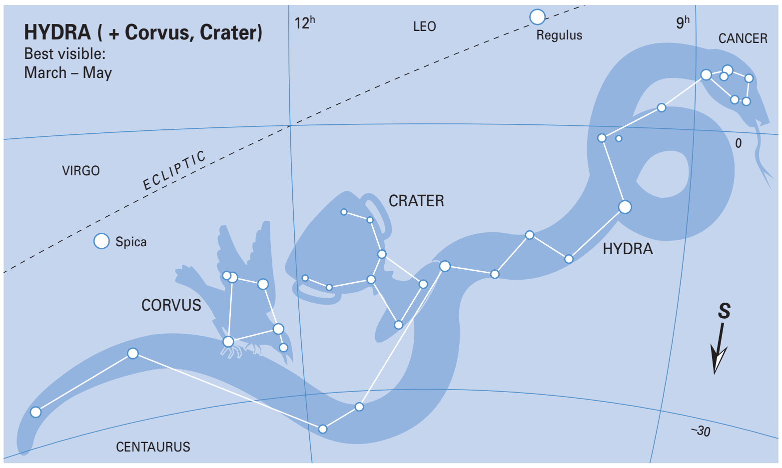

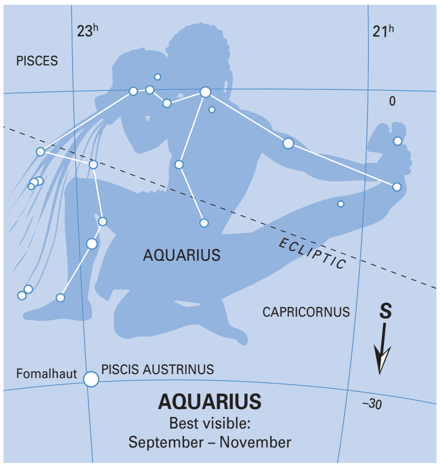

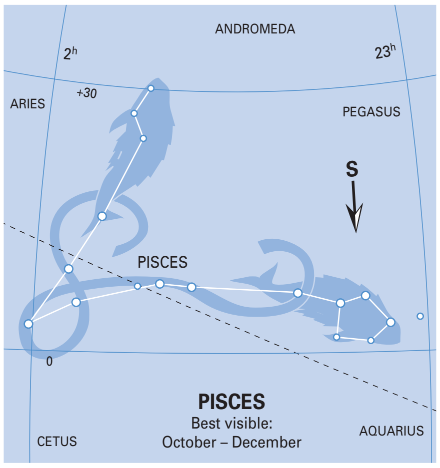

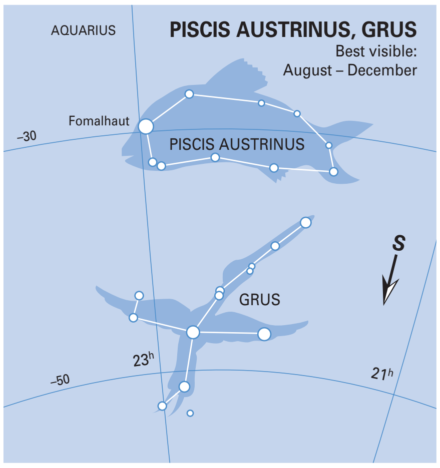

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The stars by name

The night sky is a friendly place. You can greet many of the stars by name. At least 100 of the brighter stars have proper names, mostly Greek, Latin or (particularly) Arabic in origin. For example, Fomalhaut means 'the mouth of the fish', and Rigel means 'the foot' (of Orion). Antares means 'the rival of Ares', because its red colour is similar to that of the planet Ares (now called Mars). Regulus in Leo the Lion means 'little king' and Deneb is 'the tail' of Cygnus the Swan. It is fitting that Sirius, the brightest of the night-sky stars, has a name meaning 'the sparkling one'. Many of these names have become very garbled over the centuries and their origins are hard to find.

Astronomers do not use these names much, especially as only the brighter stars have them. Instead they follow a practice popularised in the early seventeenth century by the German astronomer Johann Bayer, though the system dates back to Ptolemy. They attach the letters of the Greek alphabet (alpha, beta, gamma, delta, epsilon, and so on) to the stars in a constellation in general order of brightness. After the letter comes the name of the constellation in the possessive (or genitive) form. When the Greek letters run out (which does not take long in most constellations) ordinary Roman letters are used.

For example, Antares (which marks the heart in the striking constellation of Scorpius the Scorpion) is officially Alpha Scorpii. Rigel, Betelgeuse and Bellatrix in Orion the Hunter are respectively Alpha, Beta and Gamma Orionis. Regulus is Alpha Leonis and so on. The brightest star in a constellation is usually called alpha, but this is not always the case. For example, Pollux in Gemini the Twins is brighter than his brother Castor but is ranked as Beta Geminorum. The discrepancy is sometimes due to stars varying in brightness over the years, as with Betelgeuse in Orion, which is now noticeably fainter than Rigel.

The two 'pointers' that indicate the way to the Southern Cross are known both as Rigil Kentaurus ('the foot of the Centaur') and Hadar (for 'ground') and as Alpha and Beta Centauri, being the brightest stars in the constellation of Centaurus the Centaur. The Southern Cross itself is known as Crux Australis. Its five main stars in order clockwise, beginning at the bottom, are Alpha Crucis (also called Acrux), Beta Crucis (Mimosa), Gamma Crucis (at the top), Delta Crucis and Epsilon Crucis.

The Greek alphabet

Α	α	alpha	Ν	ν	nū
Β	β	bēta	Ξ	ξ	xī
Γ	γ	gamma	Ο	ο	omicron
Δ	δ	delta	Π	π	pī
Ε	ϵ	epsīlon	Ρ	ρ	rhō
Ζ	ζ	zēta	Σ	σ ς	sigma
Η	η	ēta	Τ	τ	tau
Θ	θ	thēta	Υ	υ	upsīlon
Ι	ι	iōta	Φ	ϕ	phī
Κ	κ	kappa	Χ	χ	chī
Λ	λ	lambda	Ψ	ψ	psī
Μ	μ	mū	Ω	ω	ōmega

Another naming system was begun by English Astronomer Royal John Flamsteed in 1725. This numbers the stars in a constellation by position, usually by increasing right ascension (see page 12), for example, 61 Cygni. Brighter stars will have several names. Betelgeuse is 58 Orionis as well as Alpha Orionis. There are other naming systems for variable stars and for double stars, usually based on various catalogues.

Brighter and fainter stars

Not all the stars look the same. They differ, not only in their positions in the sky, but also in their colours and brightnesses. The brightness of a star is indicated by its **magnitude**, making use of a system going back nearly 2000 years to the Greek astronomer Ptolemy. He divided the brightnesses of the naked-eye stars into six levels, with the brightest stars being of the **first magnitude**. Those stars are roughly two and a half times brighter than the more numerous second magnitude stars, which are in turn two and a half times brighter than the even more plentiful third magnitude stars. This means that a first magnitude star is six times brighter than a third magnitude star, and 100 times brighter than a sixth magnitude star, the faintest visible without aid.

Nowadays this system had been extended. Magnitudes can be subdivided, so that 2.3 is just fainter than 2.2, and just brighter than 2.4. First magnitude stars are those brighter than 1.5 (there are 21 of these), second magnitude objects are brighter than 2.5, and so on. Originally, the brightness of stars was judged by the experienced eye; modern instruments assess brightness to one hundredth of a magnitude.

Very bright objects have negative magnitudes, such as the Sun (minus 27), the Moon (minus 12), some planets (for example, Venus can reach minus 4) and even some of the brightest stars (for example, Sirius is now officially listed as magnitude minus 1.5). The system works for fainter stars as well, with the faintest stars detectable with the largest telescopes being of magnitude 27. (That makes them more than 10 billion times fainter than Alpha Centauri, the brighter of the two pointers to the Southern Cross!)

How far away are the stars?

To be precise, what we have discussed so far is a star's **apparent magnitude**, that is, how bright it seems to be from Earth. That depends not only on how bright a star actually is but also on how far away it is. For example, the two Pointers (Alpha and Beta Centauri) look to be about equal in brightness. But Beta is in fact 10,000 times brighter than Alpha and 100 times further away.

The common measure of distance in deep space is the **light year**. This is the distance travelled by a ray of light (covering 300,000 km every second) in a year, and is equal to roughly 10 trillion (10 million million) kilometres. The nearest bright star to us (other than the Sun) is Alpha Centauri, the brighter of the two Pointers to the Southern Cross. This is a little over 4 light years away. Sirius is 9 light years distant, Canopus 74 light years, Spica 220 light years,

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978-0-521-71405-1 - The Southern Sky Guide, Third Edition
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Table 2. The 25 brightest stars

Name	*Constellation*	*Apparent mag.*	*Distance (l.y.)*	*Absolute mag.*
Sirius	Canis Major	−1.46	8.6	1.4
Canopus	Carina	−0.72	74	−2.5
Rigil Kentaurus	Centaurus	−0.27	4.3	4.1
Arcturus	Bootes	−0.04	34	0.2
Vega	Lyra	0.03	25	0.6
Capella	Auriga	0.08	41	0.4
Rigel	Orion	0.12	1400	−8.1
Procyon	Canis Minor	0.38	11.4	2.6
Achernar	Eridanus	0.46	69	−1.3
Betelgeuse	Orion	0.50 (var)	1400	−7.2
Hadar	Centaurus	0.61 (var)	320	−4.4
Acrux	Crux	0.76	510	−4.6
Altair	Aquila	0.77	16	2.3
Aldebaran	Taurus	0.85 (var)	60	−0.3
Antares	Scorpius	0.96 (var)	520	−5.2
Spica	Virgo	0.98 (var)	220	−3.2
Pollux	Gemini	1.14	40	0.7
Fomalhaut	Piscis Austrinus	1.16	22	2.0
Becrux (Mimosa)	Crux	1.25 (var)	460	−4.7
Deneb	Cygnus	1.25	1500	−7.2
Regulus	Leo	1.35	69	−0.3
Adhara	Canis Major	1.50	570	−4.8
Castor	Gemini	1.57	49	0.5
Gacrux	Crux	1.63 (var)	120	−1.2
Shaula	Scorpius	1.63 (var)	320	−3.5

Note: var = variable.

Antares 520 light years. About 25 stars lie within 12 light years of the Sun.

The most distant first magnitude stars, such as Rigel in the constellation of Orion the Hunter or Deneb in Cygnus the Swan, are 1400 or 1500 light years away. To be seen so clearly at such a distance they must be immensely bright, much brighter in reality than our Sun. The measure of intrinsic brightness is **absolute magnitude**, which means how bright the star would appear to be if it was 33 light years away. Our Sun has an absolute magnitude of 4.8, while Rigel rates at −8.1. The difference of 13 magnitudes makes Rigel 60,000 times brighter than the Sun in reality. If Rigel were as close as Alpha Centauri, it would outshine the Moon.

The varying distances to the stars have another implication. It means that the various star patterns as we see them from Earth are often purely a matter of chance and depend on our viewing point. From elsewhere in our stellar neighbourhood, the Southern Cross may not look like a cross at all. Nor are the patterns eternally enduring. The seemingly ‘fixed’ stars are actually hurrying through space at many kilometres per second. Even their great distances from us will not hide that movement if we are willing to wait a few thousand years.

Stars of many colours

Across the sky, we find stars of many **colours**. Green and purple stars may be rare but many stars have a red, orange or yellow tinge, or a hint or more of blue. Nowadays, we understand that colour indicates how hot the surface of the star is. Stars cooler than our Sun are redder in colour (for example, Aldebaran in Taurus the Bull, or Gamma Crucis), and stars hotter than our Sun are bluer in colour (for example, Sirius or Beta Centauri).

We also now know the link between a star’s colour and its intrinsic brightness. For at least 90 per cent of stars, the brighter they are, the hotter (and therefore bluer) they are. Such stars are also bigger and heavier than the dimmer, cooler, redder stars. They also have shorter lives. Our Sun has been shining for over 5 billion years and has some billions of years of life left yet. In contrast, very large, hot, blue stars exhaust their fuel in only a few million years. Most of the stars redder than the Sun (and therefore smaller than it) are too dim to be seen with the unaided eye.

There are exceptions. A class of stars known as **giants** are both brighter and redder (or at least yellower) than our Sun. This is even truer for the **supergiants**. Both Betelgeuse and

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Antares are cool and red (at 3000 degrees their surface temperatures are half that of the Sun) but they are vast in size and brightness, 10,000 times or more the brightness of the Sun and perhaps 500 times its diameter. Placed where the Sun is they would engulf the inner planets, including Mars. These behemoths are stars in old age.

Another group of stars, the **white dwarfs**, are both hot and dim. They are also small and represent the remains of once much brighter and bigger stars. Their inner fires have gone out.

Sizes and distances in the sky

It is useful early on to find a simple way to indicate the apparent distances between stars in the sky and the sizes of the constellations. The usual measure is in **degrees** with 90 degrees from the horizon to the **zenith** (the highest point in the sky, directly overhead) and 90 degrees between the four main points in the compass (say from north to east).

Your hands are a good rough guide to distances. The hand spread out at arm's length measures about 20 degrees from the tip of the thumb to the tip of the little finger. Across the clenched fist (including the thumb) totals about 10 degrees at arm's length. A fist plus a span makes up 30 degrees, the size of many a large constellation, such as Leo or Orion or Scorpius. For smaller separations, use the thumb (about 2 degrees) or the little finger (about 1 degree), again at arm's length.

It is easy to overestimate the sizes of objects in the night sky. The Moon, for example, is only half a degree across, and is easily covered by the little finger at arm's length. Its apparently larger size near the horizon is an illusion, as use of the little finger will quickly show.

For small distances, we break down each degree into 60 minutes (of arc) and each minute into 60 seconds. The Moon is therefore about 30 minutes or 1800 seconds of arc across. We need these small measures to describe, for example, the separations of double stars (page 8), which are usually measured in seconds of arc, or the sizes of nebulae (pages 18–19), which usually amount to some tens of minutes of arc. Minutes of arc are denoted by the symbol ′, seconds by ″.

More than one at a time

Most stars have some additional point of interest. For instance many are multiple stars, two or more stars revolving about a common centre. Of the 25 stars within 12 light years of our Sun, 17 belong to double or even triple star systems. Our Sun, having no companion, is in the minority.

Alpha Centauri, the nearest star to the Sun, is a triple. Two of its component stars are close and similar, being both Sun-like. The third, a dim red star called Proxima Centauri, is sufficiently far away from the other two to be noticeably closer to us. The most spectacular multiple stars are those in which the component stars are about equal in brightness but different in colour.

To the naked eye, nearly all these multiples appear to be single stars, but in many cases binoculars or a small telescope can distinguish the separate stars. The closer together the stars are the larger the telescope needed to separate them.

Under ideal conditions, a pair of good binoculars with 50 mm lenses will be able to separate a pair of sixth magnitude stars only two and a half seconds of arc apart (a second of arc is about 2000th of the apparent angular diameter of the Moon). A telescope of 120 mm aperture will separate a pair only 1 arc second apart. The stars are harder to split if they are unequal in brightness, or if they are much fainter or brighter than the sixth magnitude.

There are some notable naked-eye doubles, such as Theta Tauri and Epsilon Lyrae. The latter is a good test of keen sight, while each component is itself double, with a small telescope needed to resolve them.

Various astronomers have assembled catalogues of multiple stars. Three drawn on in this book are those of Dunlop (signified by a Greek delta), Struve (Sigma) and Herschel (h). The Dunlop list contains many southern stars.

Stars that change

Other stars provide fascination by varying in brightness, by a little or a lot, regularly or unpredictably. About 3 per cent of all naked-eye stars are variables. You can tell a variable star from its name. The letters R to Z are put in front of the name of the constellation, and if more names are needed, the system uses the prefixes RR to RZ, SS to SZ and so on. For example, RR Lyrae is a variable star (and a famous type of variable star at that).

These variable stars are of several types.

About 20 per cent of variable stars are **eclipsing variables**. These are double stars so aligned that one of the pair passes first in front of and then behind the other. The way the brightness of the combined light of the two stars varies depends on their relative brightnesses. If one is very much brighter than the other, there will be one deep minimum in the 'light curve' (when the dim star hides the bright one) and one shallow maximum (when the bright star is in front).

This is the case with the most famous such star, the 'demon star' Algol (Beta Persei). This varies in magnitude from 2.2 to 3.5 every three days. In the case of Beta Lyrae, the stars are more even in brightness and the light varies more gradually over the whole period.

Far more common (more than 60 per cent of all variables) are single stars that pulsate in some way, mostly in and out. For such pulsating variables, the amount of change and the time taken cover a wide range and have a range of causes.

For **Mira-type** stars (of which Omicron Ceti, the 'wonderful star' is the prototype), a typical range of magnitudes is 4 to 11 (that is, from a naked-eye object to one invisible even in binoculars), with the variations taking anything from 80 to 1000 days. Mira-type stars are red giants or supergiants and make up one fifth of all variables.

For **Cepheids** (of which Delta Cephei is the prototype), brightness will swing by two magnitudes in between one and 135 days. Though quite rare (less than 1 per cent of all variables) Cepheids are of particular interest, since the time taken for the swing is directly related to the star's absolute brightness. This has let astronomers use them as 'standard candles' to plot distances in the universe. Cepheids are supergiant blue and white stars, which appear to inflate and deflate in size by about 10 per cent. **RR Lyrae** stars are similar to Cepheids, but the variations take two days at most.

Flare stars or novae suddenly increase in brightness by a factor of a thousand or more, and then fade away once more into obscurity. Many other stars are irregular variables or semi-regular at best. Betelgeuse is an example. That makes their swings hard if not impossible to predict and therefore more important to track. Amateur astronomers can play a significant role here.

The heavens in motion

The heavens do not stand still. Throughout the night, the positions of the stars change relative to the horizon and the zenith, though not relative to each other (that is, the constellations hold their shapes). Generally speaking, stars first appear somewhere along the eastern horizon and slowly move westwards across the sky. They are highest in the sky when **crossing the median**, that is, the line north and south passing right overhead (through the zenith). Some hours later, the stars in question will set at some point on the western horizon.

Even 10 minutes of observing, using your hands to mark the position of a bright star relative to some nearby object such as a tree or building, will show that the stars are on the move. Since the heavens turn over roughly once a day, the stars shift by some 15 degrees every hour. That is about one and a half fist widths at arm's length. This grand motion, like so many in the night sky, is only apparent, since it is actually the Earth that is turning from west to east.

For stars high in the southern sky, the turning of the earth shows as a steady clockwise movement of the stars around a fixed point known as the **south celestial pole** ('south pole' for short). This point lies due south and at an angle above the horizon equal to the observer's latitude. For an observer at 35 degrees south latitude, the pole lies 35 degrees above the southern horizon. For observers further north, it is lower in the sky, for those further south, it is higher.

The southern stars appear to circle the pole at the same 15 degrees per hour rate, amounting to a 90 degree or right angle shift every six hours. This means that, if a star such as Achernar lies due east of the pole at six in the evening, it would be above the pole at midnight and due west of it at six in the morning.

The north celestial pole, visible to people in Europe, North America and North Asia but below the horizon for us, is marked by a brightish star called **Polaris** (or the **Pole Star**), which marks the end of the tail of the constellation of the **Little Bear** (**Ursa Minor**). There is no southern 'pole star'. The nearest star to the South Pole (**Sigma Octantis**) is quite faint (as its name would suggest), but the pole is quite easy to find using some of the nearby bright stars.

A line extended through the long bar of the Southern Cross passes very close to the Pole, which lies some four cross-lengths (about 27 degrees) from Acrux. A line passing at right angles between the Pointers also finds the Pole. So the Pole lies where the two lines (through the Cross, between the Pointers) intersect. A point on the horizon directly below the Pole marks due south. Skywatchers have no excuse for being lost if the southern stars are visible.

Mapping the sky

To help us get to know the night sky better, skywatchers have been making maps and charts of the heavens for thousands of years, just as explorers and geographers have done with the surface of the Earth we live on. The map on pages 10–11 is an example. It shows the whole sky in four pieces, with the brighter stars (down to magnitude 3) and the boundaries of the 88 constellations marked. The numbers in boxes refer to Sky Charts 1 to 20 in the third part of this book, which show the night sky in much greater detail.

The Earth is a sphere (more or less) and the continents and seas lie on its surface (more or less). The stars are very different. They lie at vastly varying distances from us, and we can map them only by imagining that they are attached to the inside of a vast 'celestial sphere' (size unknown) centred on the Earth (Indeed, until a few hundred years ago, most people thought that really was the case!).

Trying to make maps on flat-plane paper of the inside of this celestial sphere meets the problem faced by cartographers on Earth. The job cannot be done without distorting the picture, especially away from the equator. Some maps show Greenland bigger than Australia, which is not the case. We have kept the distortion down by drawing separate maps for the regions of sky around the north and south celestial poles.

One aspect of the maps is puzzling. With north at the bottom of the map, and south at the top, the right-hand end should mark the west. On a map of the Earth that would certainly be true. Instead, the right-hand end indicates the east. The difference arises from the fact a map of the surface of the Earth is drawn from the outside looking in. Sky maps are drawn from the inside of the celestial sphere looking out. This reverses some of the directions.

The line around the middle

If Map A were a map of the Earth, the line across the middle of the rectangular chart (marked 0 degrees) would be the **equator**. On this map it marks the **celestial equator**, an imaginary line across the night sky, 90 degrees from each of the **celestial poles** (that is, running around the widest part of the celestial sphere).

Where the celestial equator lies in the sky depends on where you are. For observers on the Earth's equator, it passes right overhead from east to west. If you were at the south (geographic) pole, it would lie along the horizon, with the south celestial pole right overhead.

Throughout the southern hemisphere, the celestial equator still cuts the horizon due east and west, but passes across the northern sky, missing the zenith by an amount equal to the observer's latitude. Thus for an observer at 35 degrees south

Cambridge University Press
978-0-521-71405-1 - The Southern Sky Guide, Third Edition
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Excerpt
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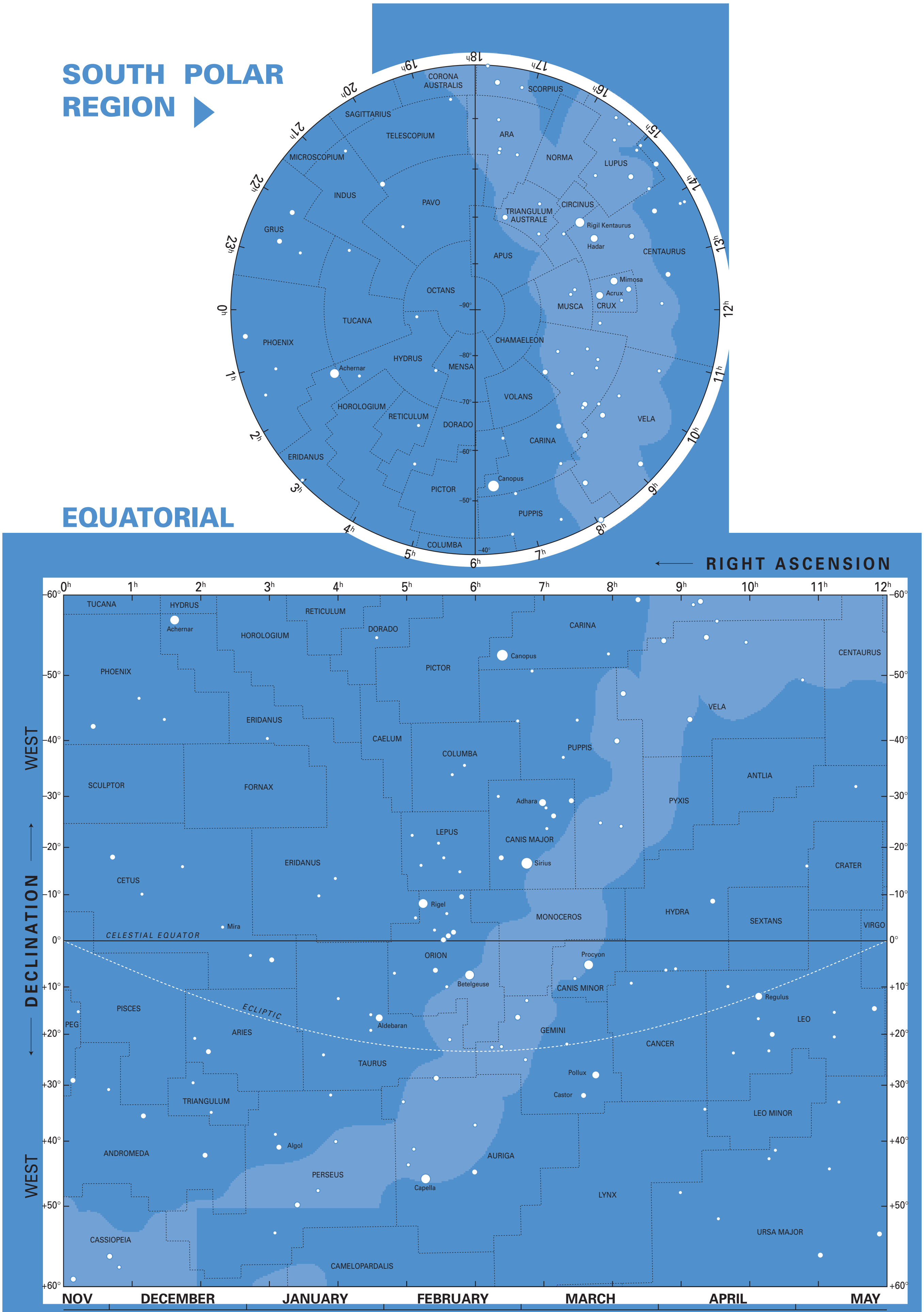

Map A. Whole-sky map