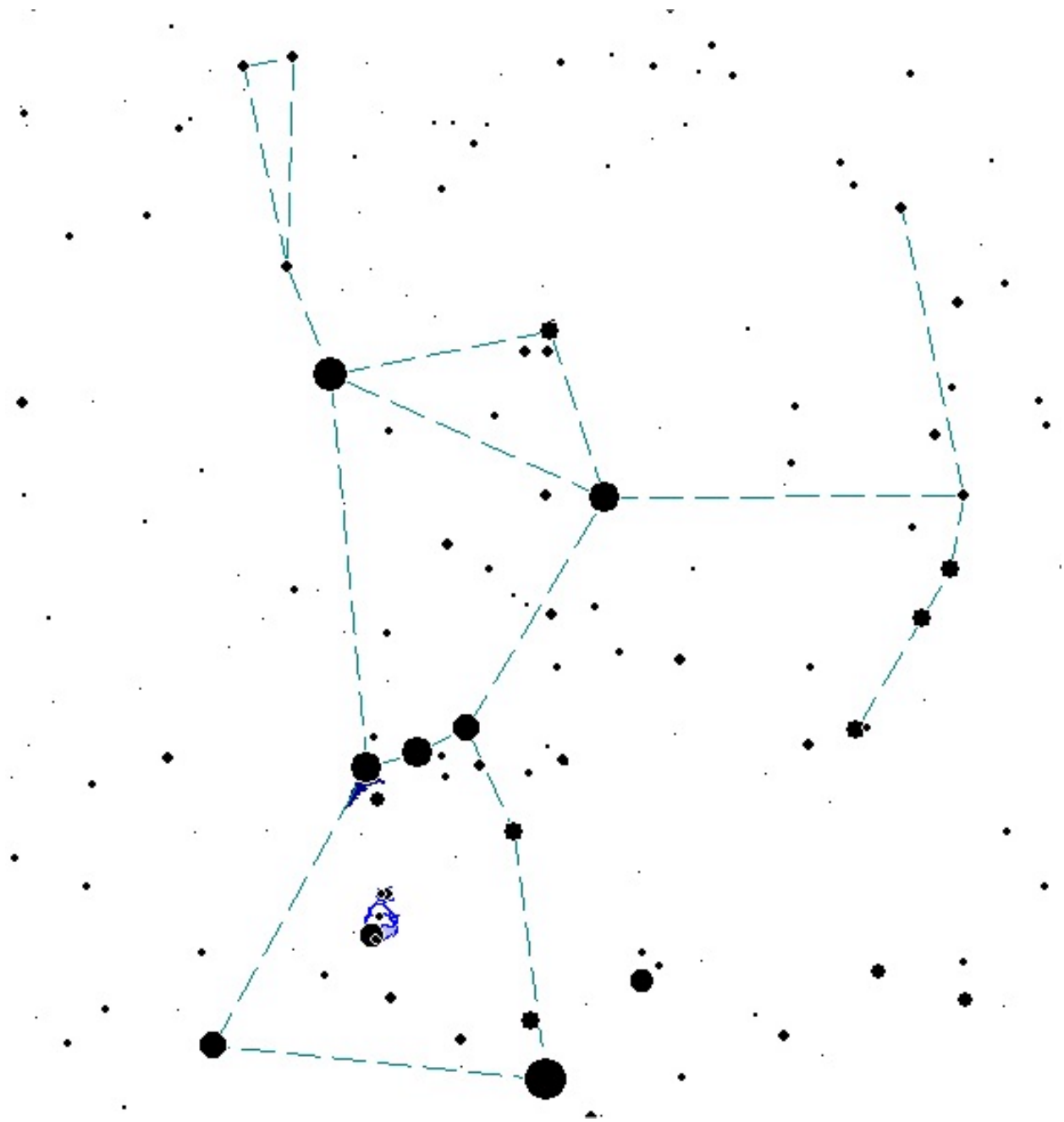




# OAS Constellations Program



## Observing Log





# OAS Constellations Program

The purpose of this program is to teach "naked eye" astronomy and map reading so binoculars and telescopes are unnecessary. Electronic devices, "go to" telescope drives and computer software should not be used. Participants will need a good planisphere, star chart or guidebook. Recommended references include the Wil Tirion's Bright Star Atlas 2, Antonin Rukl's Constellation Guidebook and The National Audubon Society Field Guide to the Night Sky (see list at the end of this guide).

The program was adapted with permission from the Kalamazoo Astronomical Society's *Constellation Observing Club*.

## Rules

- (1) Observe 20 prominent constellations.
- (2) Observe 20 minor or faint constellations.
- (3) Observe 10 prominent asterisms and star clusters.
- (4) Sketch the brighter marker stars of each of the constellations and asterisms.
- (5) Any notable features should be drawn and labeled (i.e., bright stars, star color, fuzzy patches, etc.).
- (6) Drawings should be annotated with the name, date, time, observing location, sky conditions (Calm? Windy? Hazy? Clouds?), and an estimate of azimuth & elevation. More than one constellation or asterism may be in a single sketch as long as each is clearly identified.

## Prominent Constellations

Observe and sketch at least 20 of these prominent constellations:

<u>Observed</u>	<u>Major</u>	<u>Date/Time</u>	<u>Observed</u>	<u>Major</u>	<u>Date/Time</u>
<input type="checkbox"/>	Aquila	_____	<input type="checkbox"/>	Leo	_____
<input type="checkbox"/>	Auriga	_____	<input type="checkbox"/>	Lyra	_____
<input type="checkbox"/>	Bootes	_____	<input type="checkbox"/>	Ophiuchus	_____
<input type="checkbox"/>	Cancer	_____	<input type="checkbox"/>	Orion	_____
<input type="checkbox"/>	Canis Major	_____	<input type="checkbox"/>	Pegasus	_____
<input type="checkbox"/>	Capricornus	_____	<input type="checkbox"/>	Perseus	_____
<input type="checkbox"/>	Cassiopeia	_____	<input type="checkbox"/>	Sagittarius	_____
<input type="checkbox"/>	Cepheus	_____	<input type="checkbox"/>	Scorpius	_____
<input type="checkbox"/>	Coma Berenices	_____	<input type="checkbox"/>	Serpens (both halves)	_____
<input type="checkbox"/>	Corvus	_____	<input type="checkbox"/>	Taurus	_____
<input type="checkbox"/>	Cygnus	_____	<input type="checkbox"/>	Ursa Majoris	_____
<input type="checkbox"/>	Gemini	_____	<input type="checkbox"/>	Virgo	_____
<input type="checkbox"/>	Hercules	_____			

## Asterisms

Observe and sketch 10 of these famous asterisms or star clusters:

<u>Observed</u>	<u>Asterism</u>	<u>Date/Time</u>	<u>Observed</u>	<u>Asterism</u>	<u>Date/Time</u>
<input type="checkbox"/>	Big Dipper	_____	<input type="checkbox"/>	Northern Cross	_____
<input type="checkbox"/>	Circlet	_____	<input type="checkbox"/>	Pleiades	_____
<input type="checkbox"/>	Great Square	_____	<input type="checkbox"/>	Sickle	_____
<input type="checkbox"/>	Hyades	_____	<input type="checkbox"/>	Summer Triangle	_____
<input type="checkbox"/>	Keystone	_____	<input type="checkbox"/>	Teapot	_____
<input type="checkbox"/>	Kids	_____	<input type="checkbox"/>	Winter Hexagon	_____
<input type="checkbox"/>	Little Dipper	_____			



**Minor Constellations**

Observe and sketch 20 of these minor or faint constellations:

<u>Observed</u>	<u>Minor</u>	<u>Date/Time</u>	<u>Observed</u>	<u>Minor</u>	<u>Date/Time</u>
<input type="checkbox"/>	Andromeda	_____	<input type="checkbox"/>	Lacerta	_____
<input type="checkbox"/>	Antlia	_____	<input type="checkbox"/>	Leo Minor	_____
<input type="checkbox"/>	Aquarius	_____	<input type="checkbox"/>	Lepus	_____
<input type="checkbox"/>	Aries	_____	<input type="checkbox"/>	Libra	_____
<input type="checkbox"/>	Caelum	_____	<input type="checkbox"/>	Lupus	_____
<input type="checkbox"/>	Camelopardalis	_____	<input type="checkbox"/>	Lynx	_____
<input type="checkbox"/>	Canes Venatici	_____	<input type="checkbox"/>	Microscopium	_____
<input type="checkbox"/>	Canis Minor	_____	<input type="checkbox"/>	Monoceros	_____
<input type="checkbox"/>	Centaurus	_____	<input type="checkbox"/>	Phoenix	_____
<input type="checkbox"/>	Cetus	_____	<input type="checkbox"/>	Pisces	_____
<input type="checkbox"/>	Columba	_____	<input type="checkbox"/>	Piscis Austrinus	_____
<input type="checkbox"/>	Corona Australis	_____	<input type="checkbox"/>	Puppis	_____
<input type="checkbox"/>	Corona Borealis	_____	<input type="checkbox"/>	Pyxis	_____
<input type="checkbox"/>	Crater	_____	<input type="checkbox"/>	Sagitta	_____
<input type="checkbox"/>	Delphinus	_____	<input type="checkbox"/>	Sculptor	_____
<input type="checkbox"/>	Draco	_____	<input type="checkbox"/>	Scutum	_____
<input type="checkbox"/>	Equuleus	_____	<input type="checkbox"/>	Triangulum	_____
<input type="checkbox"/>	Eridanus	_____	<input type="checkbox"/>	Ursa Minor	_____
<input type="checkbox"/>	Fornax	_____	<input type="checkbox"/>	Volans	_____
<input type="checkbox"/>	Grus	_____	<input type="checkbox"/>	Vulpecula	_____
<input type="checkbox"/>	Horogolium	_____			
<input type="checkbox"/>	Hydra	_____			

Other constellations may be used. (Only constellations that are visible from Nebraska and Iowa are listed.)



Date: \_\_\_\_\_ Time: \_\_\_\_\_  
Obs. Location: \_\_\_\_\_

Name: \_\_\_\_\_  
 Major  Minor  Asterism

Azimuth: \_\_\_\_\_

Elevation: \_\_\_\_\_

Conditions:

Calm  Windy

Hazy  P. Cloudy  Clear

Description (shape, Mythology, etc.):

Note direction of North.

Date: \_\_\_\_\_ Time: \_\_\_\_\_  
Obs. Location: \_\_\_\_\_

Name: \_\_\_\_\_  
 Major  Minor  Asterism

Azimuth: \_\_\_\_\_

Elevation: \_\_\_\_\_

Conditions:

Calm  Windy

Hazy  P. Cloudy  Clear

Description:

Note direction of North.



## Frequently Asked Questions

### Who may earn a Constellations Certificate?

The Omaha Astronomical Society will award a certificate to anyone who completes the project requirements. (A pin or cloth patch may also be awarded if you are an OAS member.)

1. Study the rules.
2. Go out at night and observe the stars.
3. Make sketches and take notes.
4. Submit your notebook for review.

### What is a *constellation*?

A constellation is an internationally recognized group of stars. The sky has been divided into 88 areas, each containing a distinctive pattern of “marker stars”. The famous *Leo* is fairly easy to spot because it has bright marker stars, but this area of the sky also includes faint stars, nebulae, galaxies, and occasionally the Sun, Moon, and/or planets. Constellations such as *Lacerta*, however, do not have bright marker stars and are not recognized quite as easily.

### What is an *asterism*?

An asterism is an easily recognizable pattern of stars. Asterisms such as the *Big Dipper* are within a single constellation, while others such as the *Great Square* are in two or more constellations. The *Summer Triangle* and *Winter Hexagon* each encompass several constellations.

### What is a *star cluster*?

For the purposes of this project, a star cluster is a group of brighter stars that appear close to each other in the sky.

### How accurate do drawings have to be?

Each of your drawings should show enough bright “marker stars” to outline the pattern of the figure or object depicted in the constellation. Include the Moon, planets, star clusters, bright nebulae, etc. if they are visible. Weather conditions and your observing location will affect the view. For example, on a clear night far away from city lights, you will probably be able to see hundreds of stars in *Orion* – we don’t expect you to draw all of them, just the prominent stars. If you wish to use the same drawing to depict several constellations, or any of the asterisms, the same logic applies.

### May someone else help?

Yes, but don’t forget the purpose is to help YOU to learn the night sky! You’ll learn the most when you are doing the work. We encourage you to show your notebook to an experienced observer early in your project, to make sure you are on track.

### Who reviews completed notebooks?

When you finish all required observations, submit your notebook to Deb Cheney or Clark Cheney, or to one of the other OAS officers. They will review your work, and prepare your certificate or contact you with their questions.



## Visible Constellations

Three-fourths of the 88 modern astronomical constellations may be viewed from Eastern Nebraska and Western Iowa. However, several of these may be unfamiliar even to very experienced observers! Some constellations are small, have faint marker stars, contain no distinctive deep-sky objects, or are partially obscured by the Southern horizon at our latitude.

Proper Name	Pronunciation	Common Name	Possessive Form	IAU Abbr.
Andromeda	And-DROM-eh-dah	(Chained) Princess	Andromedae	And
Antlia	Ant-lee-ah	Air Pump	Antliae	Ant
Aquarius	AK-WARE-ee-us	Water Carrier	Aquarii	Aqr
Aquila	AK-will-ah	Eagle	Aquilae	Aql
Aries	AY-reez	Ram	Arietis	Ari
Auriga	Aw-RYE-gah	Charioteer	Aurigae	Aur
Bootes	Bo-OH-teez	Herdsmen	Bootis	Boo
Caelum	SEE-lum	Carving Chisel	Caeli	Cae
Camelopardalis	Ka-MEL-oh-pard-al-iss	Giraffe	Camelopardalis	Cam
Cancer	KAN-ser	Crab	Cancri	Cnc
Canes Venatici	KAY-neeZ Ve-NAT-i-sy	Hunting Dogs	Canum Venaticorum	CVn
Canis Major	KAY-nis MAY-ger	Big Dog	Canis Majoris	CMa
Canis Minor	KAY-nis MY-ner	Small Dog	Canis Minoris	Cmi
Capricornus	KAP-ri-kor-nus	Sea Goat	Capricorni	Cap
Cassiopeia	Kass-ee-oh-PEE-ah	Queen	Cassiopeiae	Cas
Centaurus	Sen-TORE-us	Centaur	Centauri	Cen
Cepheus	SEE-fuse (or SEE-fuss)	King	Cephei	Cep
Cetus	SEE-tus	Sea Monster (or Whale)	Ceti	Cet
Columnba	Kol-LUM-ba	Dove	Columbae	Col
Coma Berenices	KO-ma Bare-en-EYE-seez	Berenice's Hair	Comae Bernenices	Com
Corona Australis	Kor.OH-na Os-TRAL-iss	Southern Crown	Coronae Australis	CrA
Corona Borealis	Kor-OH-na Bor-ee-AL-is	Northern Crown	Coronae Borealis	CrB
Corvus	KOR-vus	Crow	Corvi	Cor
Crater	KRAY-ter	Cup	Crateris	Crt
Cygnus	SIG-nus	Swan	Cygni	Cyg
Delphinus	Del-FYE-nus	Dolphin	Delphini	Del
Draco	DRAK-oh (or DRAY-ko)	Dragon	Draconis	Dra
Equuleus	Ee-KWOO-lee-us	Colt	Equulei	Equ
Eridanus	Eh-RID-an-us	River	Eridarti	Eri
Fomax	FOR-naks	Furnace	Fornacis	For
Gemini	JEM-in-eye	Twins	Geminorum	Gem
Grus	Gruss	Crane	Grucis	Gru
Hercules	HER-cue-leez	Strong Man	Herculis	Her
Horologium	Hor-oh-LOW-jee-um	Clock	Horologii	Hor
Hydra	HIGH-drah	Female Water Snake	Hydrae	Hya
Lacerta	La-SIR-tah	Lizard	Lacertae	Lac
Leo	LEE-oh	Lion	Leonis	Leo
Leo Minor	LEE-oh MY-ner	Small Lion	Leonis Minoris	LMi
Lepus	LEE-pus	Hare	Leporis	Lep
Libra	LEE-brah (or LIE-brah)	Scales	Librae	Lib



Lupus	LEW-puss	Wolf	Lupi	Lup
Lynx	Links	Lynx (Wild Cat)	Lyncis	Lyn
Lyra	LYE-rah	Lyre (Harp)	Lyrae	Lyr
Microscopium	My-crow-SCOPE-ee-um	Microscope	Microscopii	Mic
Monoceros	Mo-NOS-er-os	Unicorn	Moncerotis	Mon
Ophiuchus	Oh-fee-YOU-kuss	Snake Handler	Ophiuchi	Oph
Orion	Oh-RYE-an	Hunter (or Giant)	Orionis	Ori
Pegasus	PEG-ah-sus	Flying Horse	Pegasi	Peg
Perseus	PUR-see-us	Hero	Persei	Per
Phoenix	FEE-nicks	Phoenix	Phoenicis	Phe
Pisces	PIE-seez	Fishes	Piscium	Psc
Piscis Austrinus	PIE-sis Os-TRY-nus	Southern Fish	Piscis Austttni	PsA
Puppis	PUP-is	Ship's Stern	Puppis	Pup
Pyxis	PIK-sis	Mariner's Compass	Pyxidis	Pyx
Sagitta	Se-JIH-tah	Arrow	Sagittae	Sge
Sagittarius	Sa-jih-TARE-ee-us	Archer	Sagittarii	Sgr
Scorpius	SCORE- pee-us	Scorpion	Scorpii	Sco
Sculptor	SKULP-tor	Sculptor's Tools	Sculptoris	Scl
Scutum	SKYOO-tum	Shield	Scuti	Sct
Serpens *	SIR-pens	Snake (Serpent)	Serpentis	Ser
Sextans	SEX-tans	Sextant	Sextantis	Sex
Taurus	TORE-us	Bull	Tauri	Tau
Triangulum	Tri-ANG-you-lum	Triangle	Traianguli	Tri
Ursa Major	ER-sa MAY-jor-is	Big Bear	Ursae Majoris	UMa
Ursa Minor	ER-sa MY-nor-is	Little Bear	Ursae Minoris	UMi
Vela	VEE-lah	Ship's Sail	Velorum	Vel
Virgo	VER-go	Virgin	Viginis	Vir
Volans	VO-lanz	Flying Fish	Volantis	Vol
Vulpecula	Vull-PECK-you-lah	Fox	Vulpeculae	Vul

\* NOTE: Serpens is divided by the constellation Ophiuchus, the Snake Handler. The western half is commonly called the Snake's Head or *Serpens Caput* (SIR-pens Kap-utt), while the eastern half is called the Snake's Tail or *Serpens Cauda* (SIR-pens Kay-oo-dah).

## Asterisms

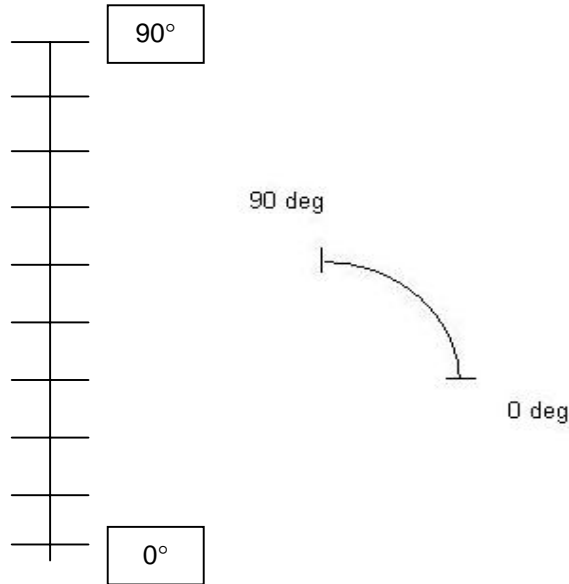
Asterism	Constellation(s)	Hints
Big Dipper	UMa	
Circlet	Psc	
Great Square	And, Peg	
Hyades	Tau	
Keystone	Her	Four-sided wedge, with two sides nearly equal
Kids	Aur	
Little Dipper	UMi	
Northern Cross	Cyg	
Pleiades	Tau	
Sickle	Leo	
Summer Triangle	Aql, Cyg, Lyr, & others	
Teapot	Sgr	
Winter Hexagon	Aur, Gem, Ori, Tau, & others	



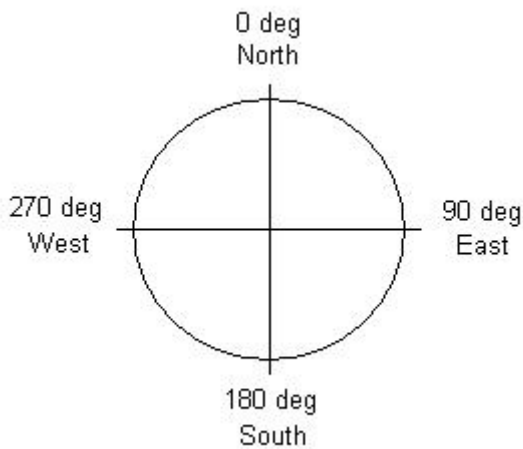
## Estimating Azimuth & Elevation

You can estimate the azimuth and elevation of any celestial object if you are familiar with a few basic guidelines. First, you can estimate angles using your outstretched hands (fists, fingers, etc.) Your hand is about  $25^\circ$  from little fingertip to thumb, fingers spread wide. Your closed fist is about  $10^\circ$  wide, your three middle fingers are about  $5^\circ$  wide when pressed together, and the tip of your little finger is about  $\frac{1}{2}^\circ$  wide. Start at the horizon and measure upwards.

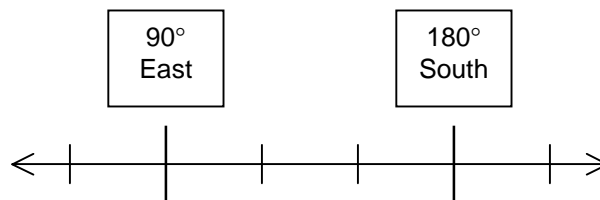
Elevation is measured with a vertical scale, with  $0^\circ$  on the horizon and  $90^\circ$  straight up over the top of your head.



Second, locate North then estimate the azimuth along the horizon. You may find it is easiest to stand so that North is at your front, your back, or directly off either your left or right shoulder.



Azimuth is measured with a horizontal scale, with  $0^\circ$  at North,  $90^\circ$  to the East, etc. The compass circle is completed at  $360^\circ$  where it strikes North again





## Planisphere

The planisphere is an analog computer for calculating the positions of the stars. The name refers to the representation of the celestial *sphere* on the flat *plane* of the page. Because of the motion of the earth, the appearance of the sky changes both with the hour of the day and the time of the year, as well as your location on the earth. A single printed star chart cannot capture all these combinations; for completeness, you need a book of them. On the other hand, at the twist of a dial a planisphere can show the positions of the stars at any time, on any day, for a particular latitude, so it is as good as a whole book of star charts.

Included are planispheres for use at 40° N, 45° N or 50° N latitude, that you can print and assemble yourself.

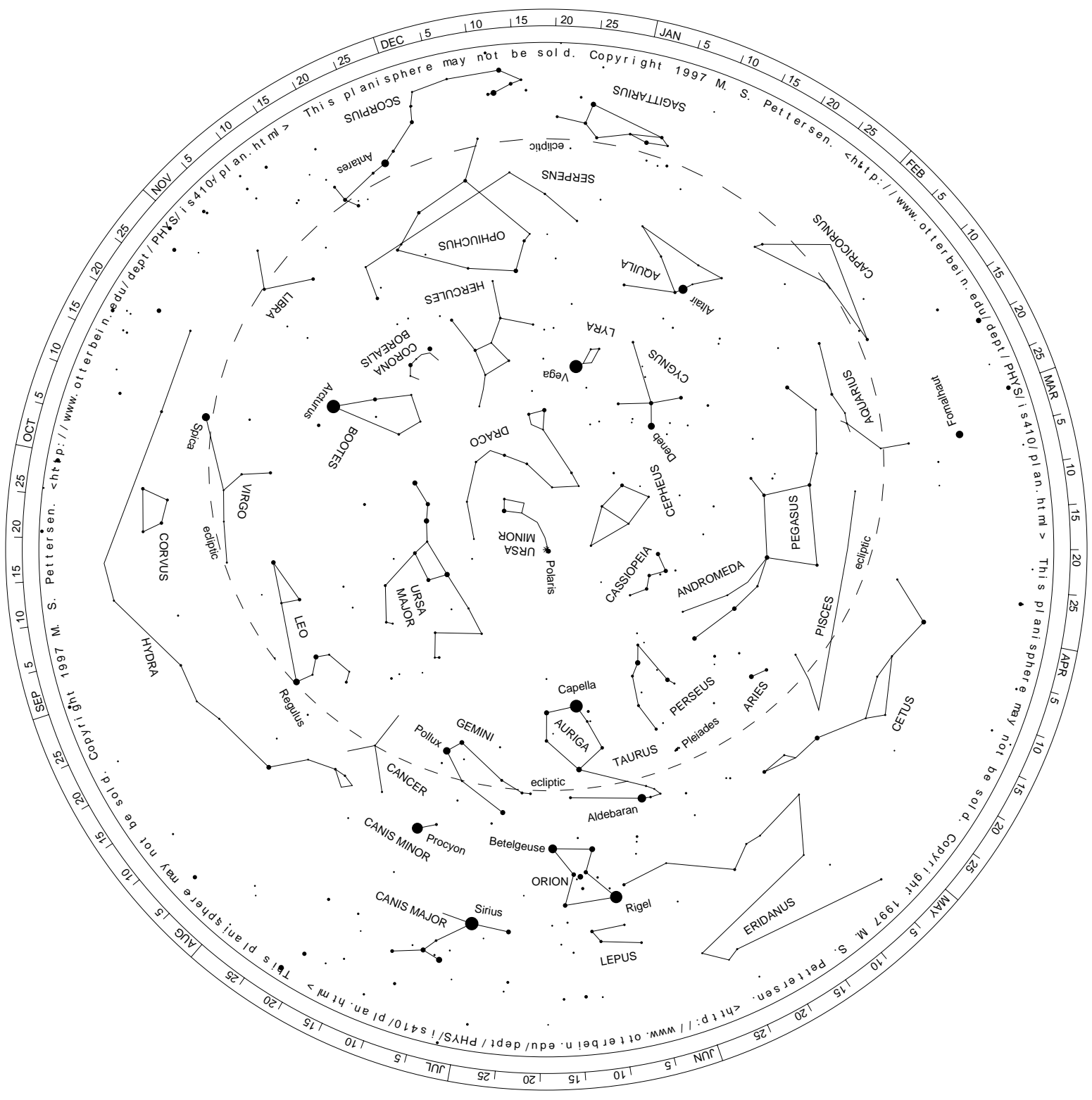
You can also buy a planisphere or a book of star charts, starting at \$8, at most bookstores. If you want to buy a book, refer to the next section for list of suggested books.

### INSTRUCTIONS FOR ASSEMBLY

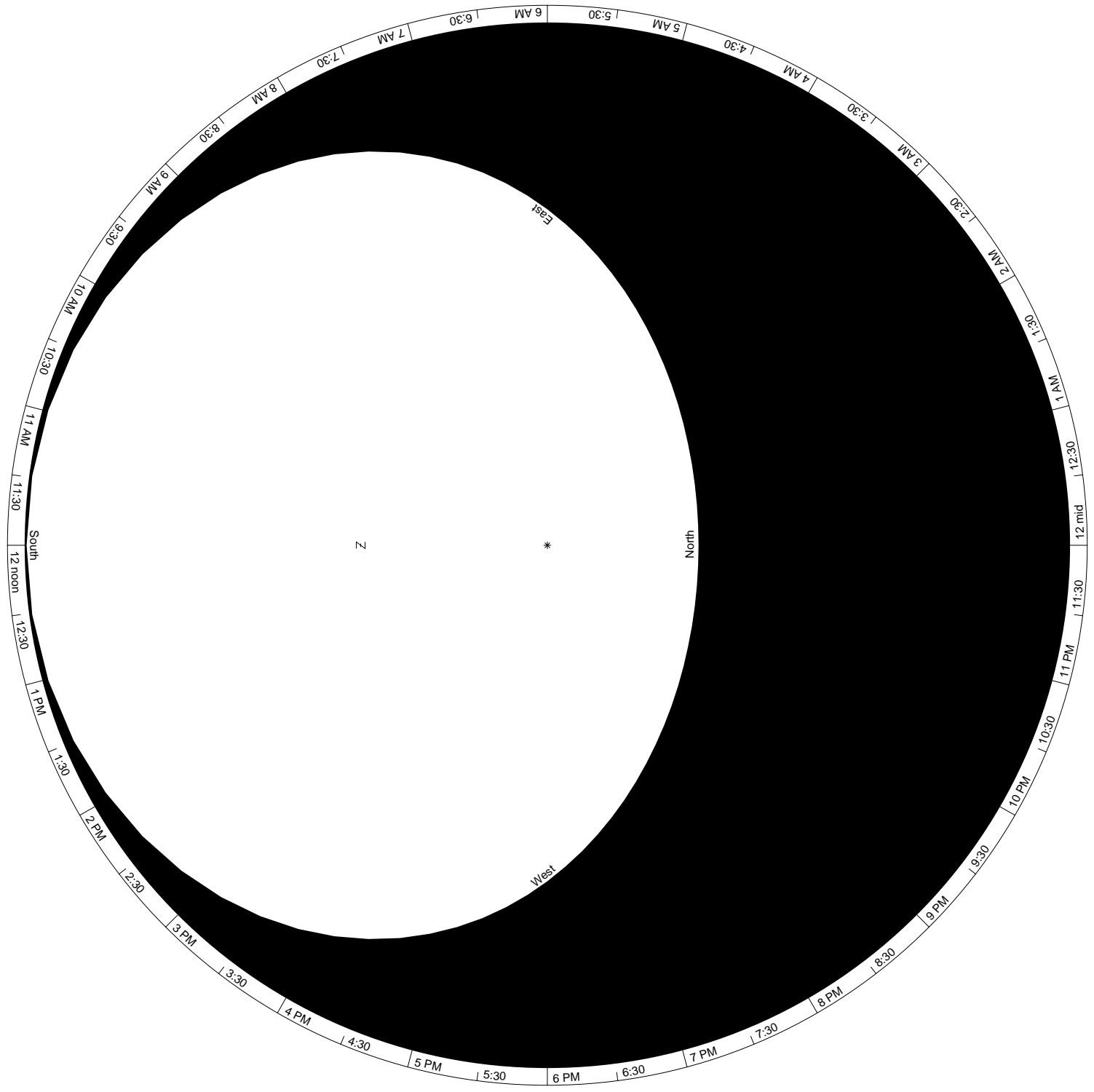
Photocopy the top plate onto a transparency (or print directly on a transparency, if you can). The photocopy may not be *exactly* the same size as the original; if not, make a plain paper copy of the bottom plate so that it is reduced or enlarged by the same amount. Glue the bottom plate onto a sheet of cardboard. Cut off everything outside the outermost circle on both plates. Attach the plates with a pin through the center (marked by an asterisk) so they are centered and can rotate freely. (The mark at the center of the bottom plate may be hard to spot: it is almost on top of the North Star, Polaris.) Bend the pin so the point lies flat against the back of the bottom plate, and tape it there. Your assembled planisphere should resemble the figure at the top of this page.

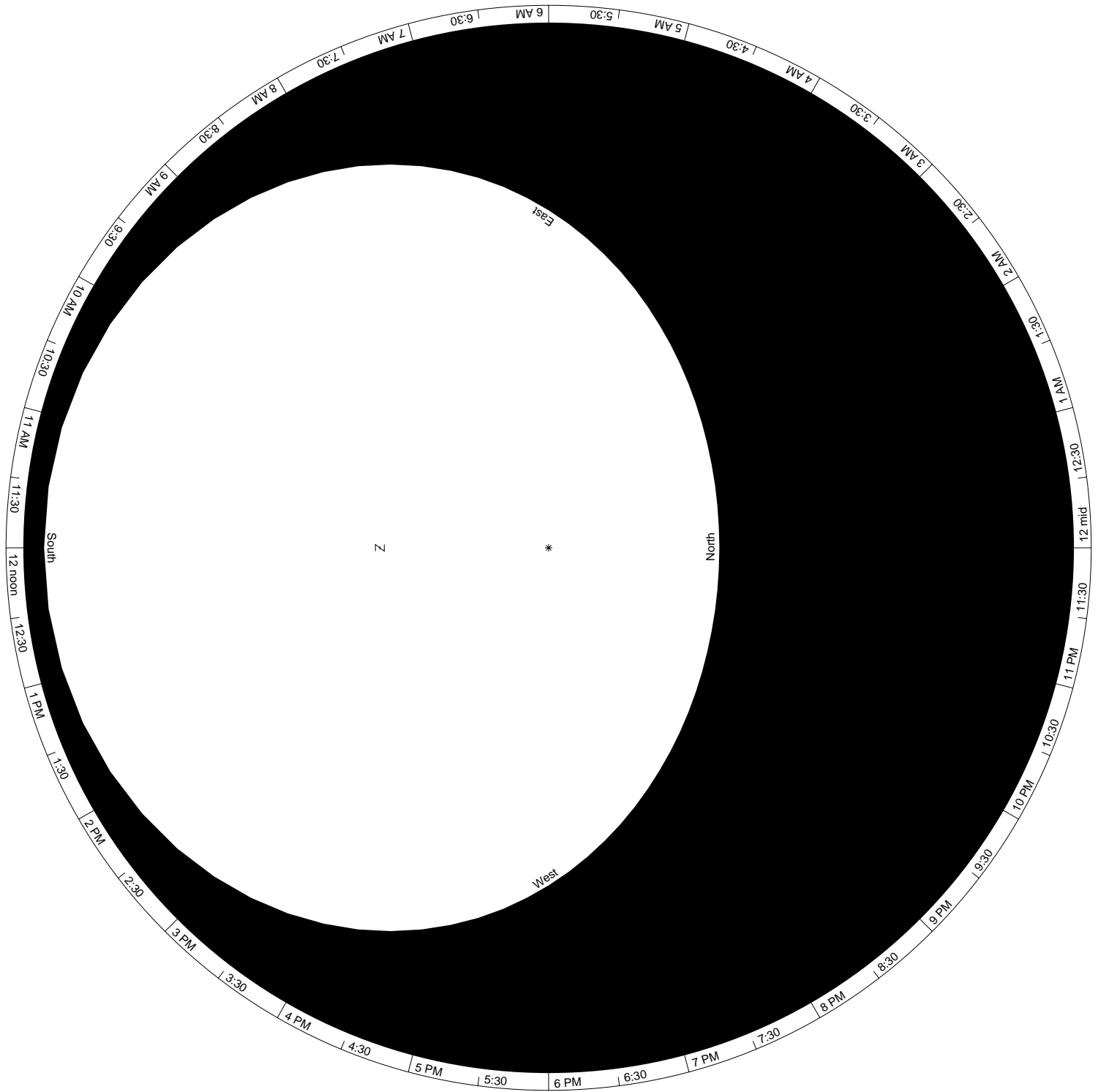
### INSTRUCTIONS FOR USE

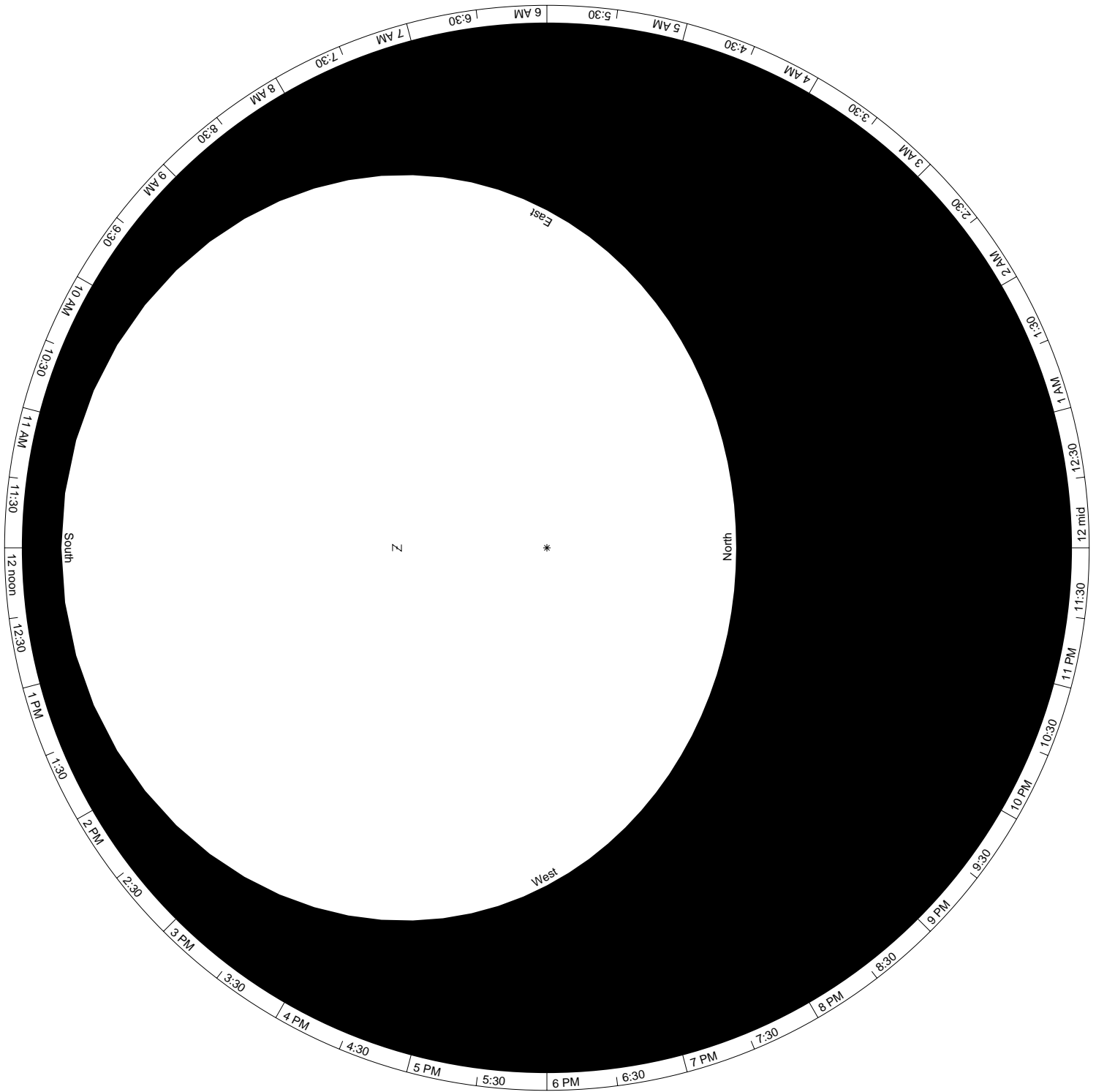
1. To see what the stars look like at a particular time on a particular day, dial the planisphere so that the time on the inner ring lines up with the date on the outer ring. (The times marked are Standard Time; during Daylight Savings Time, the clock reads one hour later than the planisphere.) The entire portion of sky visible at that time on that day will appear through the window.
2. Bigger dots represent brighter stars. (Don't look for big dots in the sky. All stars appear as points of light in all but the very most advanced telescopes.)
3. If you hold the planisphere over your head, it will show you basically what you see in the sky. The oval represents the horizon. Stars further away from the edge appear higher in the sky. The zenith, the point directly overhead, is marked with a "Z". Thus, those stars between the part of the oval marked "East" and the point marked "Z" will appear in the eastern sky between the horizon and the zenith.
4. The planisphere only shows stars brighter than magnitude 4. If you are far from city lights, you will be able to see many, many more stars than are shown on the planisphere! To orient yourself, try to concentrate on the brighter stars and the constellations that are easiest to identify, such as the Summer Triangle (the stars Vega, Deneb and Altair), the Square of Pegasus in fall, Orion in winter, the Big Dipper in spring, or any other constellations you know. Then you can try to identify dimmer stars and constellations by their relation to the stars you already know.
5. Due to the limitations inherent in making a flat map of the celestial sphere, constellations near the southern horizon are stretched along the horizon in the representation of the planisphere.
6. The Sun, Moon and planets are not shown on the planisphere, because they do not always appear in the same part of the sky. However, they always stay near the dashed line indicating the circle of the ecliptic. If you see a relatively bright object near the ecliptic that isn't moving, doesn't twinkle and is not marked on the planisphere, it is probably a planet.



PLANISPHERE--BOTTOM PLATE  
 Copyright (C) 1997 M. S. Pettersen  
 Department of Physics and Astronomy  
 Otterbein College, Westerville, Ohio







PLANISPHERE--TOP PLATE--for use at 50 degrees N  
 Copyright (C) 1997 M. S. Pettersen  
 Department of Physics and Astronomy  
 Otterbein College, Westerville, Ohio



## Resources for Learning about Constellations

Novice astronomers often ask Omaha Astronomical Society members where to find good, inexpensive astronomy study resources. Here are several suggestions:

(1) Use your local public libraries! In addition to the astronomy books and magazines in their collections, most libraries can borrow books from other area libraries and then check them out to you. Many libraries also have detailed astronomy books in their reference section, reserved for on-site reading. Don't forget to look in an encyclopedia for details on specific aspects of astronomy or related sciences.

(2) Basic sky maps, charts, and tutorials are available for free on the Internet. The 'Net is not regulated, so you'll encounter a lot of fictitious and unproved information – be sure to check with an experienced astronomer to verify chosen sites have scientifically accurate content. Here are a few credible websites with star charts that you can download free:

<http://skyandtelescope.com>

<http://www.astronomy.com>

<http://www.heavensabove.com>

<http://www.skymaps.com>

(3) If you would rather purchase a book or map, there are many discount booksellers who take orders via the Internet, by e-mail, by telephone, and/or by mail order. (Make sure to ask about their "return" policy, in case you get something damaged or otherwise not to your liking.)

(4) Several stores in the Omaha area, including the large bookstores *Barnes & Noble* and *Borders*, sell great astronomy books at retail prices. Most local stores allow you to leisurely browse their selections, and they sell gift cards or gift certificates.

(5) Astronomy software can also be obtained in many of the same places you find astronomy books. Some "freeware" is available, and several good programs are sold retail. Look for "planetarium" programs that feature charts of the stars, especially those that allow you to customize and print observing charts.

(6) Don't forget to look through old science textbooks, especially college-level books on astronomy and earth science.

(7) The OAS occasionally gives away information packets at public astronomy events.

Here are a few other places to try:

Library sales

Flea markets

Garage sales and estate sales/auctions

Used book stores

Internet booksellers and auction sites



## Books Recommended for Novice Astronomers

In April 2003, Omaha-area stores had many fine astronomy books for sale. This alphabetical list is by no means comprehensive, but all listed books have been reviewed for basic information content of use to beginners:

- ❑ “A Walk through the Heavens: A guide to stars and constellations and their legends” by Milton Heifetz and Wil Tirion (\$10 paperback). Well-illustrated maps for beginners; includes mythology for several prominent constellations.
- ❑ “Bright Star Atlas” by Wil Tirion and Brian Skiff (\$10 paperback) Large sector star charts for basic & intermediate observing; data tables for locating popular targets.
- ❑ “Cambridge Star Atlas” by Wil Tirion (\$25 hardback). Colored star charts; data tables for observing stars, planets, and deep-sky targets.
- ❑ “Cambridge Starfinder: The complete astronomy map and guide pack” by Cambridge University Press (\$25 packet). “No frills” – an envelope containing two large, folding maps of the night sky and the Moon, and a planesphere.
- ❑ “Constellation Guidebook” by Antonin Rukl. (\$15 softcover) Easily digested, well-illustrated guide to all 88 modern constellations; includes observing information on more advanced targets.
- ❑ “Discover the Stars: Starwatching using the naked eye, binoculars, or a telescope” by Richard Berry (\$14 paperback). A fine, basic hobby guide suitable for families.
- ❑ “Night Sky: A guide to field identification” by Mark Chartrand (\$15 paperback). A compact “Golden Field Guide”; good general reference. B/W maps.
- ❑ “NightWatch: A practical guide to viewing the universe” by Terence Dickenson (\$30 spiral-bound hardback). Good beginner’s guide and general reference; easy to understand with information for growth.
- ❑ “New Astronomer: The practical guide to the skills and techniques of skywatching” by Carole Stott (\$25 hardback). Many, many maps! Has charts of monthly planet positions and includes a kit to assemble a small planesphere.
- ❑ “The Great Atlas of the Stars” by Serge Brunier (\$50 spiral-bound softcover). Almost a “coffee table” book – large format, full-color photographs of the night sky with clear overlays to outline constellations, asterisms, and prominent celestial features.
- ❑ “The Sky at Night: Your guide to the heavens” by Robin Kerrod (\$30 boxed set). A beginner’s kit containing two compact, spiral-bound map and theory books, a 9-inch planesphere, and a small red observing flashlight.
- ❑ “The Star Guide: Learn how to read the night sky star by star” by Robin Kerrod (\$28 hardback). Well illustrated; easy-to-read maps of prominent constellations. Includes a 9-inch planesphere.
- ❑ “365 Starry Nights: An introduction to astronomy for every night of the year” by Chet Raymo (\$16 paperback). Profusely illustrated in B&W; observing is broken down into daily lessons. (*Although this particular book doesn’t contain star charts, it can be used with charts available for free from the Internet.*)
- ❑ “Touring the Universe: A practical guide to exploring the cosmos thru 2017” by Ken Graun (\$28 spiral-bound softcover). A beginner’s guide to the hobby; richly illustrated. Covers equipment choices and scientific theory, as well as star charts.

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