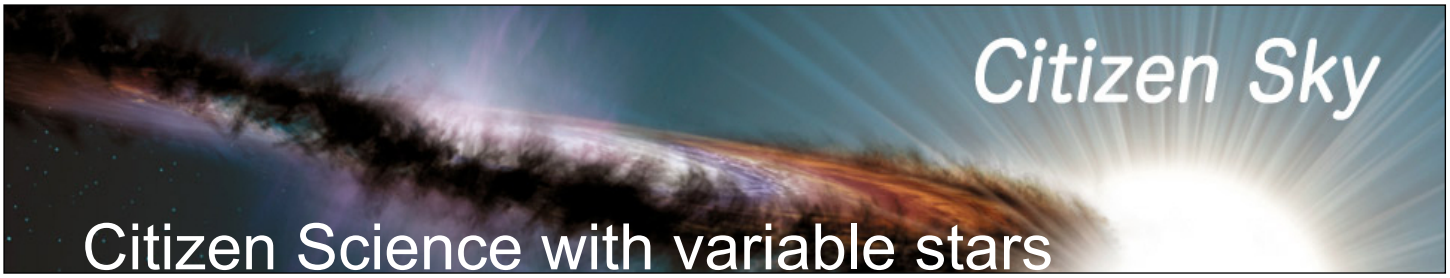


Brought to you by the AAVSO, the National Science Foundation and Your Universe

Astronomers need your help!

Variable stars are stars that change in brightness over time.

There are too many for professional astronomers to monitor alone. So, we need *your help* to monitor these stars over days, weeks and years.

This guide will help you find some bright variable stars, measure their brightness and then submit the measurements to assist professional astronomers.

Participate in one of the oldest citizen science projects in history! Thousands of people just like you are also helping out. Astronomers need large numbers of people to get the amount of precision they need to do their research.

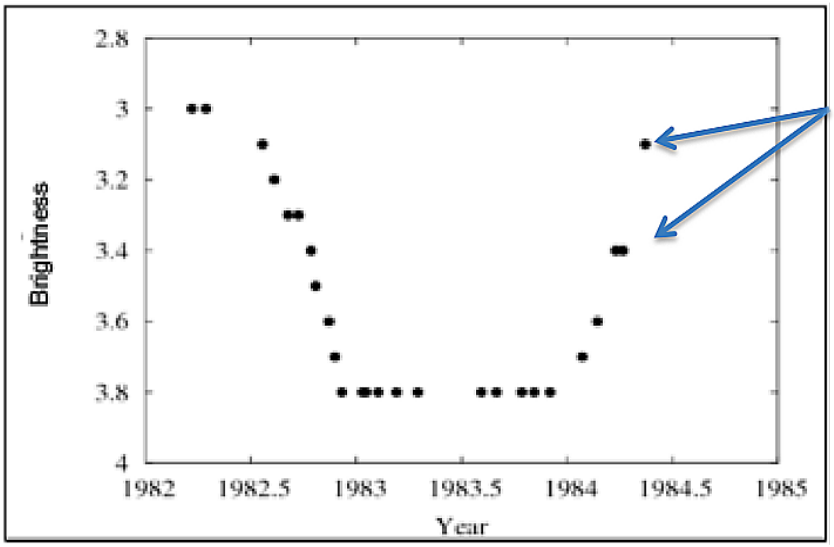
You are the key.

CitizenSky is a collaboration of the American Association of Variable Star Observers (**AAVSO**), the University of Denver, the Adler Planetarium, the Johns Hopkins University and the California Academies of Science with support from the National Science Foundation.

Header artwork is reproduced with permission from Sky & Telescope magazine (www.skyandtelescope.com)

This is a *Light Curve*

It shows how a star's brightness changes over time. Light curves are a fundamental tool for variable star astronomy. They are relatively simple and easy to grasp. They are simply a graph of brightness (Y axis) vs. time (X axis). Brightness increases as you go up the graph and time advances as you move to the right.



Each of these data points is a single brightness estimate of the star made by an amateur astronomer

The brightness of a star is measured in units of "magnitude". Notice that the magnitude scale on the graph above shows smaller numbers as the star gets brighter and larger numbers as the star gets fainter.

This light curve shows that the star began at magnitude 3.0 in 1982. Around mid-year it began to dim rapidly until it reached magnitude 3.8 by the end of the year. It remained there until the beginning of 1984 when it began a slower climb back to normal brightness. By the middle of 1984, it was almost back to normal brightness.

Light curves are a fundamental tool used by astronomers to look at behavior of variable stars over time.

Using a Star Chart

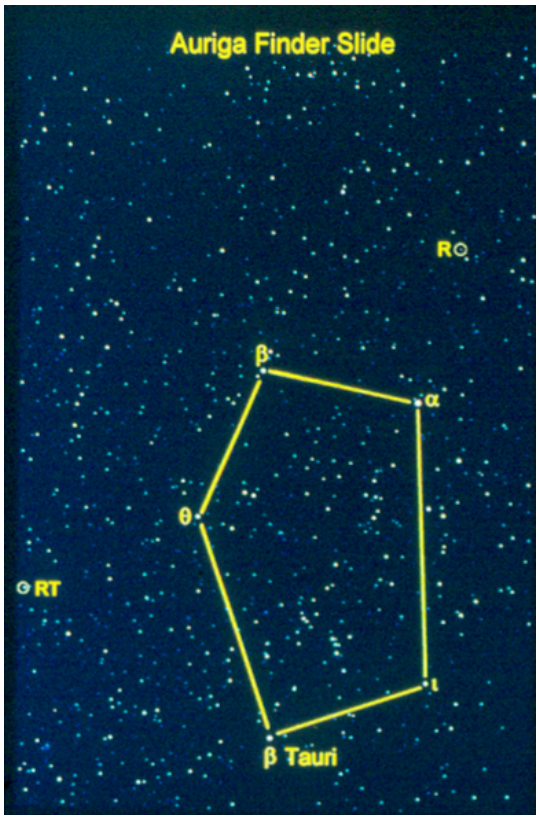
It's easier than it looks!

A star chart is just a map of the sky. You use it to match a pattern of stars in the sky with a pattern of stars on the chart, just like you'd match a pattern of streets with those on a street atlas.

1. First, find the constellation that the variable star is in.
2. On the next page is a map of constellations in the northern sky.
3. Face North and rotate the chart so the current season is at the bottom.
4. Hold the map up against the sky and look for the constellations.
5. For epsilon Aurigae: We suggest starting with Cassiopeia, which is usually easy to find because it looks like a "W" hanging in the sky.
6. Once you have found that, look for Capella. It is a **very** bright star near it but lower in the sky. Once you have Capella, you have found Auriga!
7. Go to page 5 to learn how to make your observation.

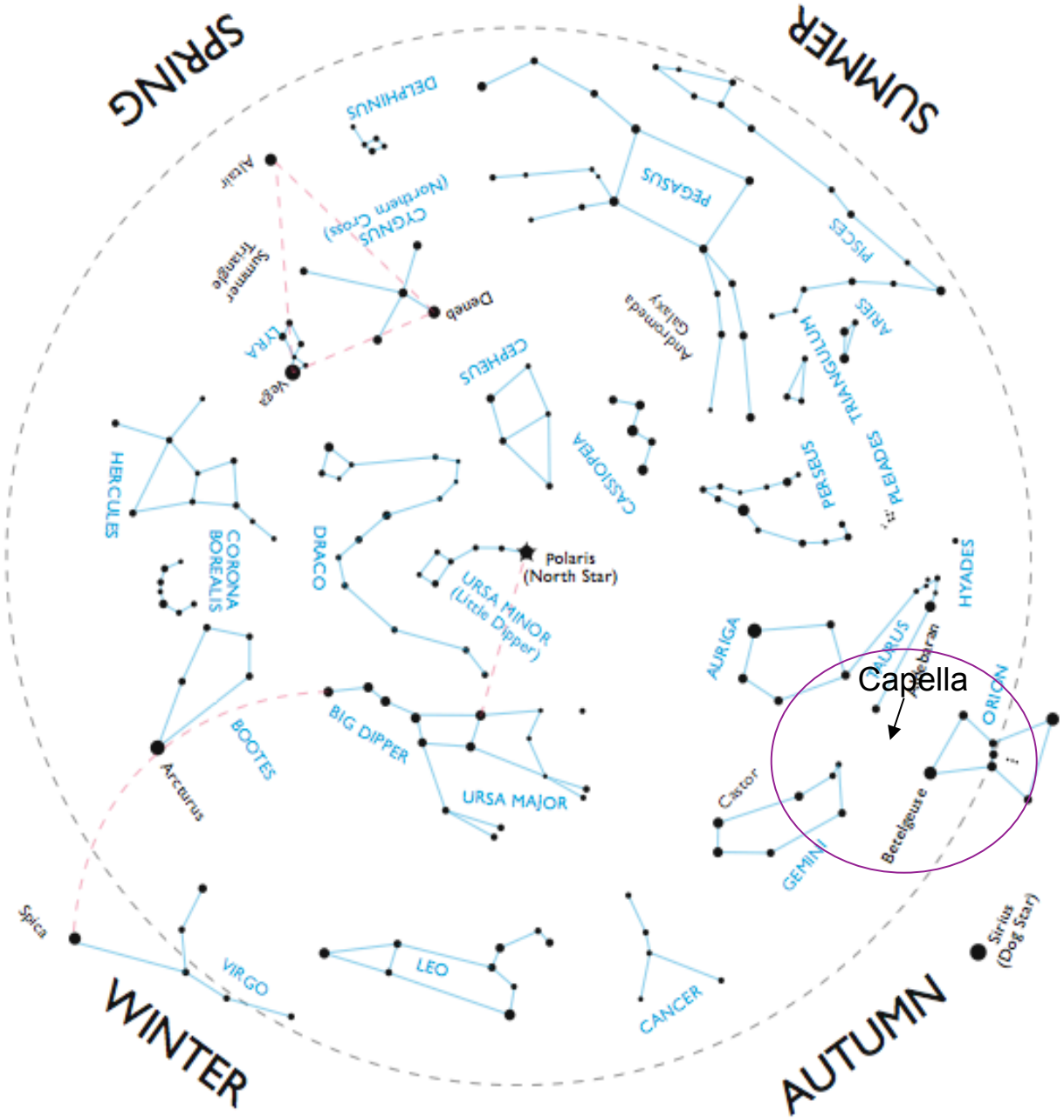
This is a photograph of an area of the sky around Aurigae

N



This is the same photograph, with Aurigae outlined in yellow

Star Chart for the Northern Horizon



To orient yourself with the stars, face north and rotate the chart until the current season shows at the bottom. The constellations at the bottom of the chart will be in the northern sky, while the stars at the top of the chart will be to the south. This is based on midnight stargazing. As the night progresses, the stars will appear to rotate counter-clockwise due to the rotation of the earth.

 www.AuroraHunter.com

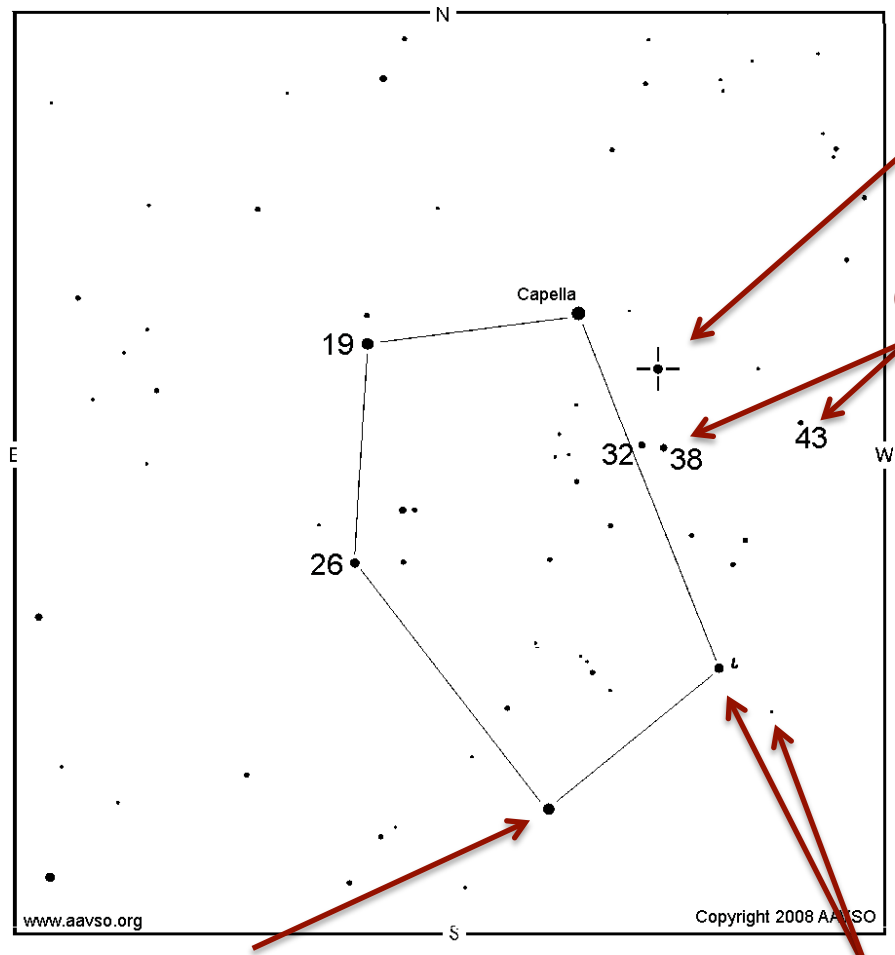
This sky chart is reprinted with permission from Sky & Telescope magazine.
Visit www.skyandtelescope.com to customize the chart for your location and time. Purchase a copy of the magazine at your local newsstand for an easy-to-use, fold-out sky chart in each issue.

Using a Variable Star Chart

This is also known as "star hopping".

You found the constellation, now find the variable star. This star chart is a little different from the last one. It is "zoomed in" on the constellation Aurigae. It also has some information you'll need to make a brightness estimate of a star.

1. Find the stars in the constellation that look like the ones on the chart. Be patient, the first time you do this it may take a long time. It will be much easier after the first time.
2. Find the variable star by locating the star at the cross hairs on the chart.
3. Next, find the comparison stars – the stars with numbers on them.
4. That's it! Now turn to the next page to make an estimate of the variable star's brightness.



The variable star

Comparison stars

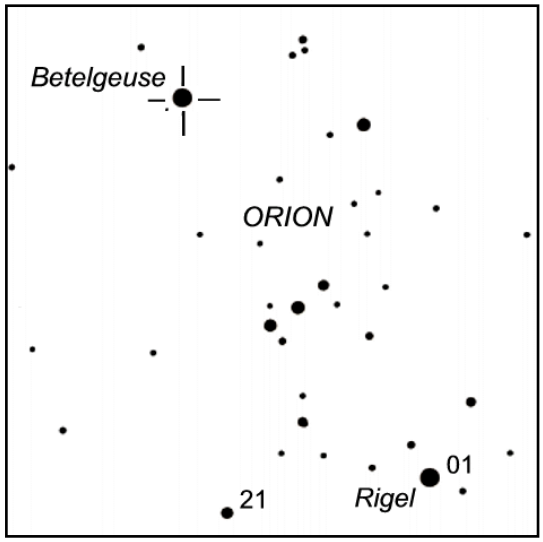
Brighter stars in the sky will have bigger dots on the chart, like this one

Other stars in the sky

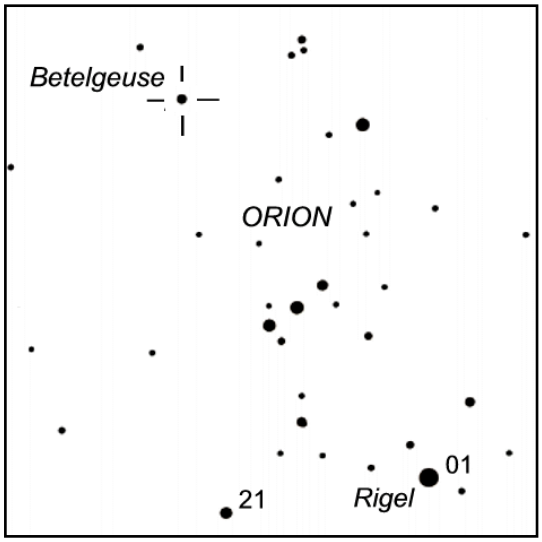
Measuring a Star's Brightness

a.k.a. making an "observation"

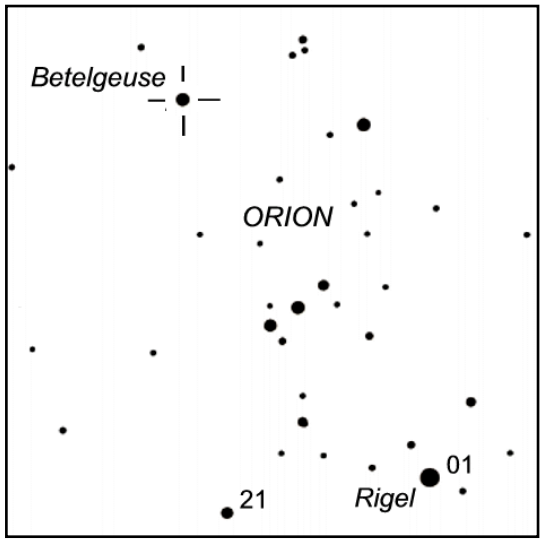
To measure a star's brightness, you simply compare it to other stars in the sky. Those other stars are called "comparison stars" because you use them to make the comparison. Astronomers have carefully measured the brightness of the stars and assigned them a magnitude according to the brightness. **The smaller the magnitude number, the brighter the star.**



In this example, Betelgeuse will be close to the same brightness as Rigel, which has a magnitude of 0.1. So one may estimate Betelgeuse at magnitude 0.1.



In this example, Betelgeuse will be close to the same brightness as the star labeled 21. So one may estimate it at magnitude 2.1.



In this example, Betelgeuse is somewhere in the middle between the 0.1 and the 2.1 comparison stars. So one may estimate it somewhere in between the two numbers, say, magnitude 1.1.

It is important to note that the decimal point has been left off of the magnitude labels on star charts. When you report your observations, you should definitely include the decimal!

Reporting Your Observations

Once you have made an estimate, write it down in a journal. Record the day, the time and the magnitude estimate. Don't try to memorize and recall it later. This is scientific data so we need it to be as accurate as possible.

There are two ways to report your data to professional astronomers: via postal mail or the Internet.

- **Internet:** We *highly* recommend submitting your observations via the Internet. By doing so, your observations get sent to astronomers very quickly. Also, you can compare your observations to other observers immediately after you have submitted them. To submit online, log on to the AAVSO website then go to:

https://www.aavso.org/webobs/individual

Select "Visual" from the drop-down box next to "What type of Observations are you submitting?", fill out the form and click the "Submit Observation" button at the bottom of the page. If you have a question about anything, try clicking one of the "More help…" links.

It will take about 10 minutes to submit your data for the first time. Once your data is submitted, you can request a plot of your star from the Light Curve Generator (https://www.aavso.org/lcg) and see your observation plotted on the light curve. This way you can see how you compare with others and with any other data you had previously turned in. *Never look at the light curve **before** you submit your observations, as it could bias your report!*

- **Postal Mail:** If you prefer to submit your estimates via postal mail, fill out the form on the next page and mail it to the AAVSO. If you would like more forms, just ask and we will mail you new copies.

AAVSO Report Form

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
49 Bay State Road, Cambridge, MA 02138, USA

VARIABLE STAR OBSERVATIONS

Sheet ________ of __________ Report No. __________

For Month of ____________________ Year ____________

Observer ______________________________________

Street ____

City ________________________ State ____________

Country ____________________ Zip Code ___________

Time Used, GMAT or ______________________________

Instrument(s) ___________________________________

AAVSO Observer Initials

____

For AAVSO HQ Use Only

Received _______________

Entered _______________

Verified _______________

Variable	Date	Mag.	Key* &	Remarks	Comp. Stars	Chart ID
Alpha Ori	*Jan. 1, 2013 9:15pm*	*2.2*		*Sample observation*	*20, 25*	*10-star tutorial*

Total Number Observations Reported

* KEY field contains AAVSO-selected one-letter abbreviations for REMARKS. Obtain list from AAVSO Headquarters or web site.

Ten Star Training Program

Observing a variable star takes practice. We have designed a training program that begins with stars that are easy to find and observe. Slowly the stars become more challenging as you go down the list. By the time you reach Epsilon Aurigae at the bottom of the list, you'll be an expert variable star observer contributing real data to professional scientists!

Begin by observing the stars at the top of the list and then move your way down. Charts for finding these stars are available at the back of this packet.

Some of these stars can only be seen during certain seasons of the year. If a star is currently "out of season" for you, just skip it and come back to it later when the time is right.

	Star Name	Season	Notes
1	alpha Orionis	Fall, Winter	a.k.a. Betelgeuse, a red star in the "armpit" of Orion
2	eta Geminorum	Fall, Winter	
3	gamma Cassiopeia	All Year	Cassiopeia is an easy constellation to find - it looks like a giant "W" written on the sky.
4	beta Persei	Winter	This star has an entire eclipse in one night! See chart for more info.
5	beta Lyrae	Summer	Very easy to find in the summer – it's next to the bright star straight overhead!
6	R Lyrae	Summer	
7	miu Cephei	All Year	Note the spelling of "miu". This is intentional- to replace the greek character "mu".
8	delta Cephei	All Year	
9	eta Aquilae	Summer	
10	epsilon Aurigae	Winter, Spring	Our VIP star!

Note: The seasons listed are when the star's constellations are easily seen in the evening northern hemisphere sky. If you stay out later, or get up very early, then the *next* season's constellations are viewable. For example, after midnight in the spring you can see many of the summer constellations.

Last Steps

Keep observing!

Please make an observation of these stars at least once per month and submit your data as soon as you can.

Itching for a Bigger Challenge?

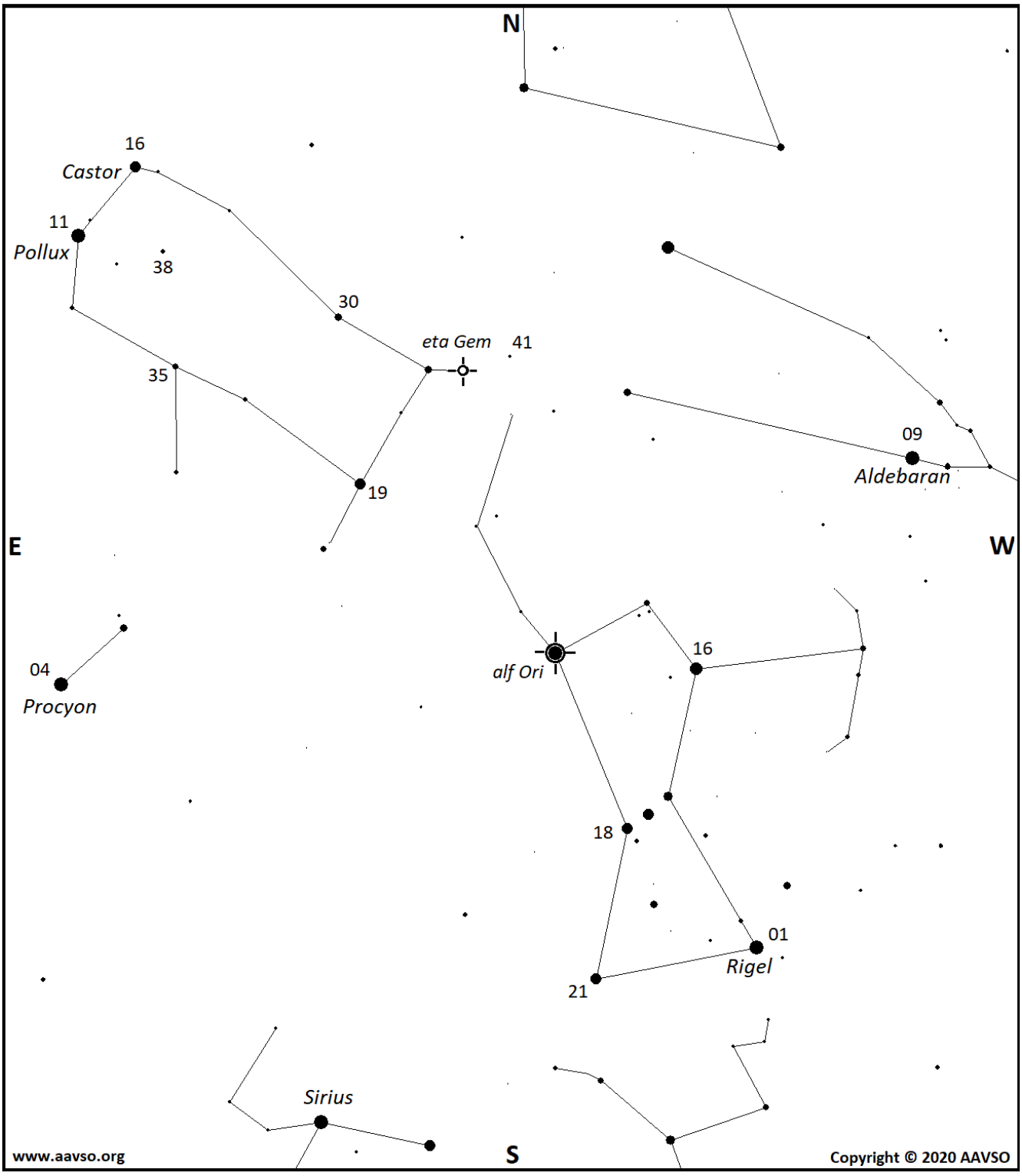
The AAVSO has many citizen science projects that range the gamut from introductory to advanced. Participants in the more advanced projects can even get their names published in professional journals. Our projects don't always involve making observations. Some involve programming, education & public outreach, data mining, data analysis and more. Contact us if you would like more information on these projects.

For More Information…

Visit www.aavso.org for more information on variable stars and how you can contribute to more citizen science projects. We also have a complete manual and curriculum about variable stars called *Variable Star Astronomy (VSA).* It is available at: https://www.aavso.org/education/vsa

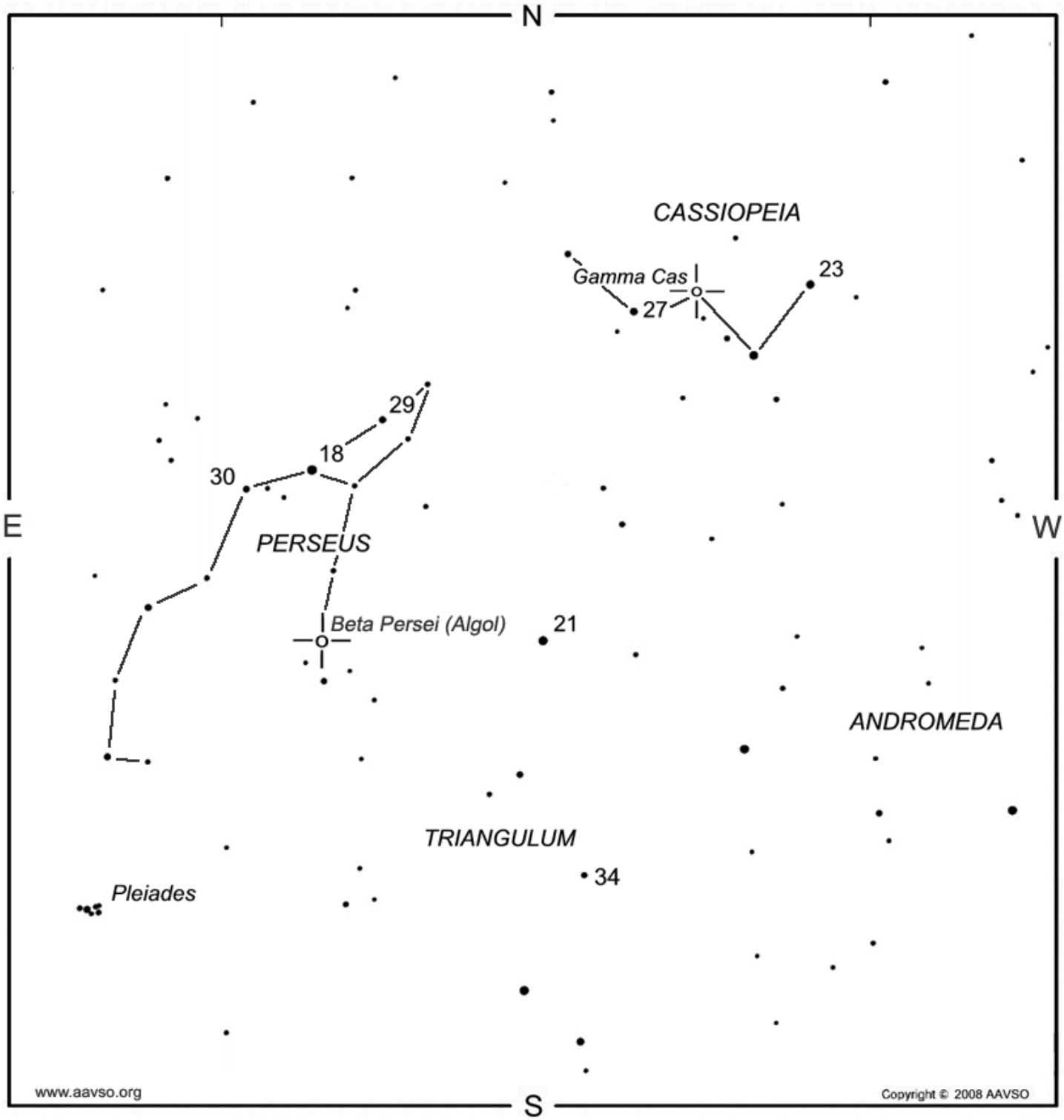
Illustration by Citizen Sky participant Brian Thieme

Star Chart for alpha Orionis and eta Geminorum



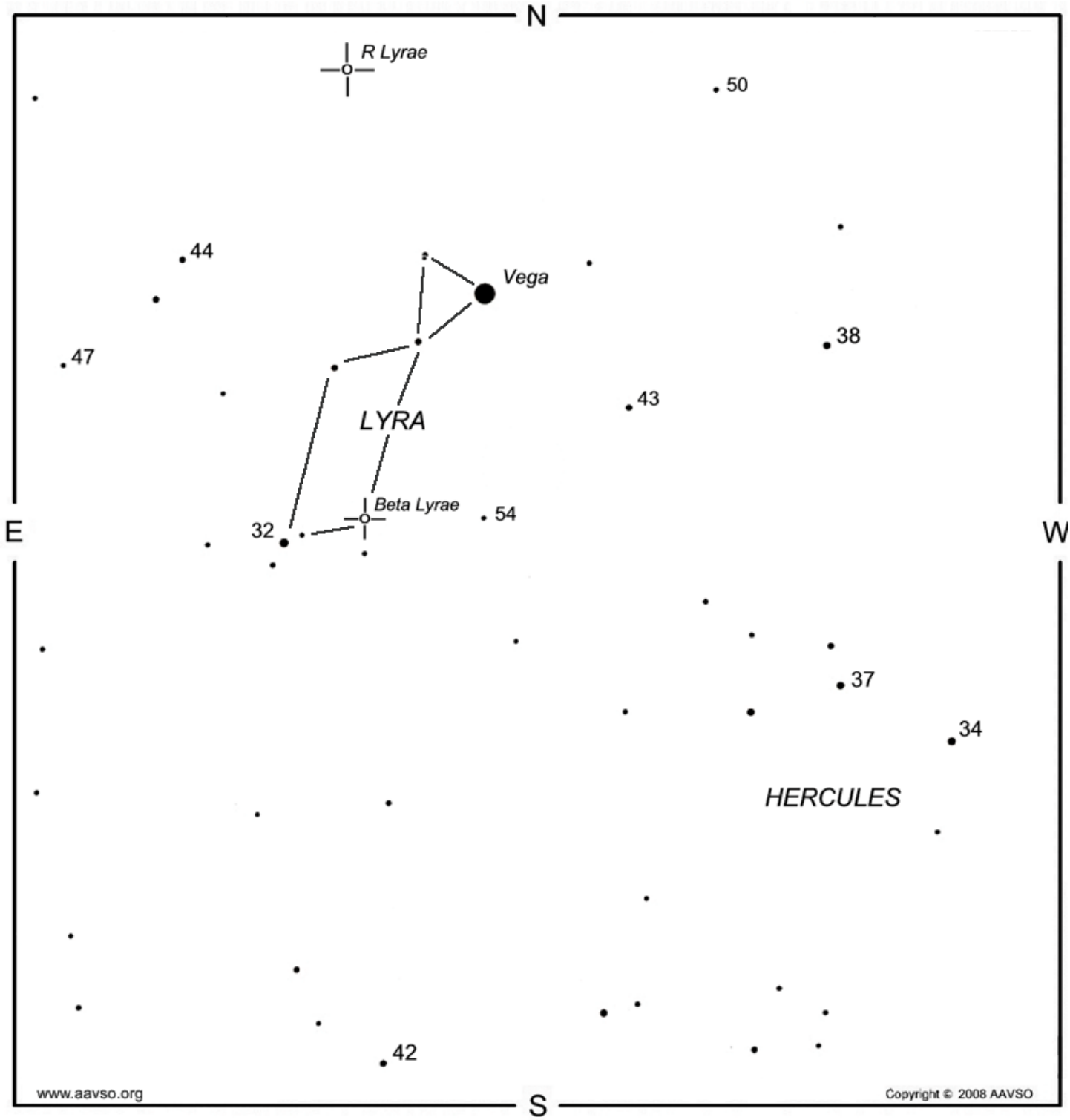
Notes: alpha Orionis (Betelgeuse) is very easy to find. Orion's belt consists of three very bright stars that can be seen from almost any city. Once you find the belt, the rest of the constellation is easy to recognize. Alpha Orionis is a very red star, but sometimes it is hard to see the color form city locations. It is also a very large star. If it was placed in the center of our solar system, it would engulf all planets out to Jupiter —including Earth! Alf Ori varies in brightness by several tens of a magnitude over the course of a few months. At first it can be hard to notice the change, be patient and you will see it!

Star Chart for gamma Cassiopeia and beta Persei



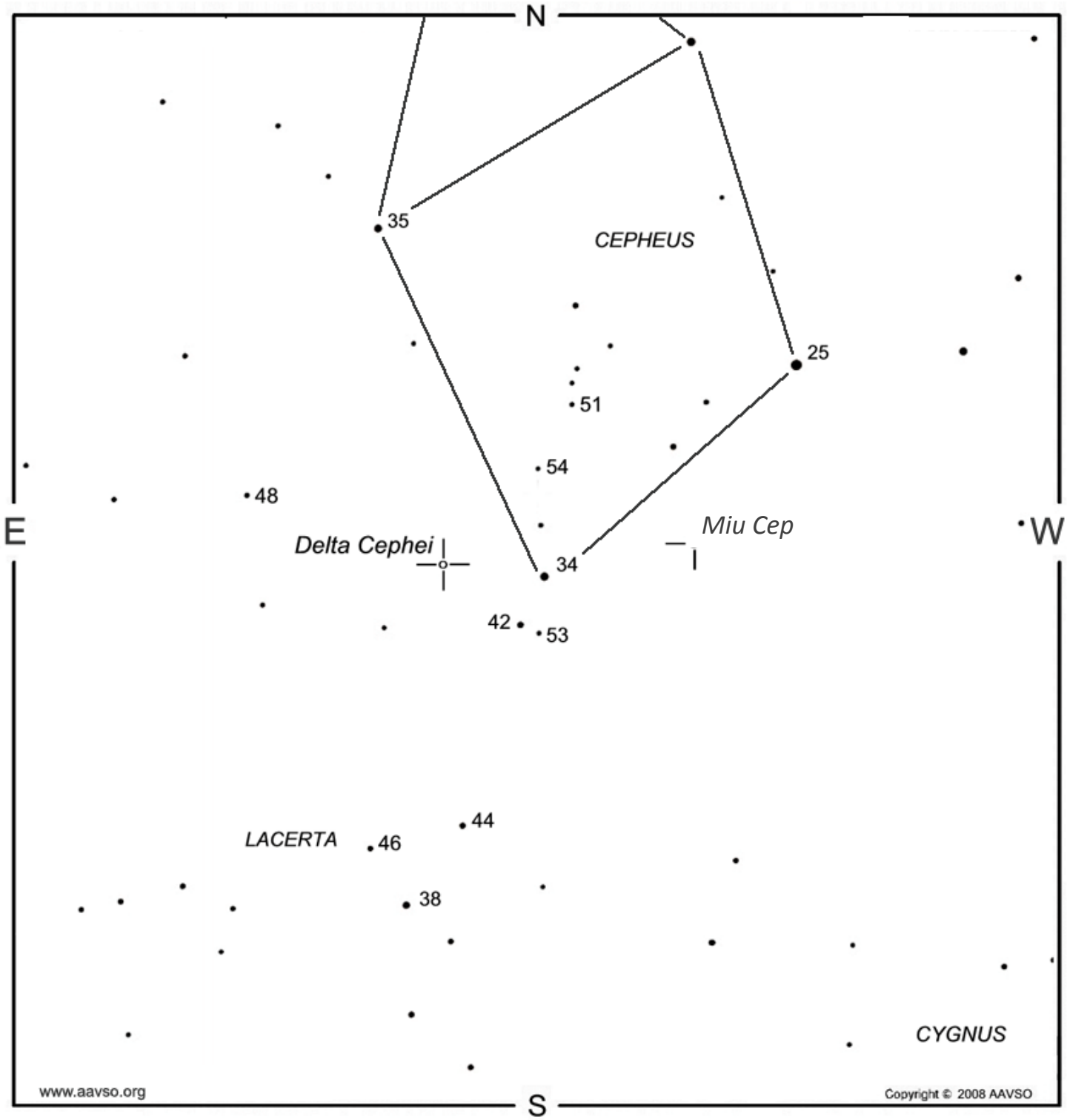
Notes: Beta Persei (Algol – the Demon Star) is an interesting star. Around every 3 days it goes into an eclipse that lasts around 8 hours. This means if you can sometimes see the star get dim and then bright again in a single evening! It happens very quickly, so for this star we recommend making one observation every 30 minutes. After only a few observations, you'll see it noticeably dimmer than when you started. Predictions of when the eclipses should occur can be found at:
https://sites.google.com/site/aavsoebsection/legacy-stars

Star Chart for beta Lyrae and R Lyrae



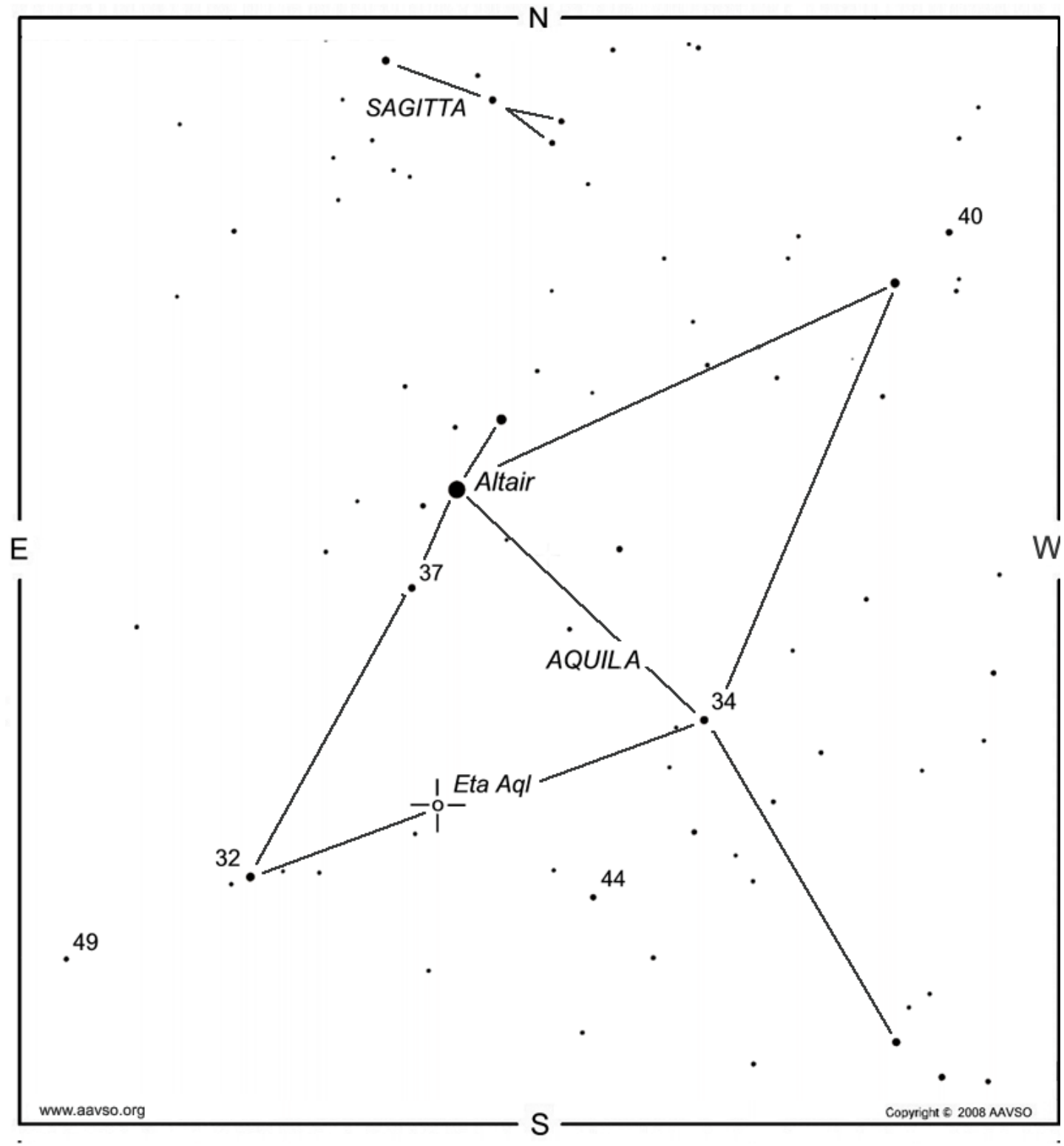
Notes: Lyrae is a very easy constellation to recognize in the summer. Vega is the brightest star in the summer sky and is usually near the top of the sky in the early to mid evening hours. The constellation looks somewhat like an hourglass and is relatively small compared to most of the other constellations in these charts. Beta Lyrae usually varies from 3.4 to 4.4 magnitude and it takes about 13 days to see a complete cycle.

Star Chart for miu Cephei and delta Cephei



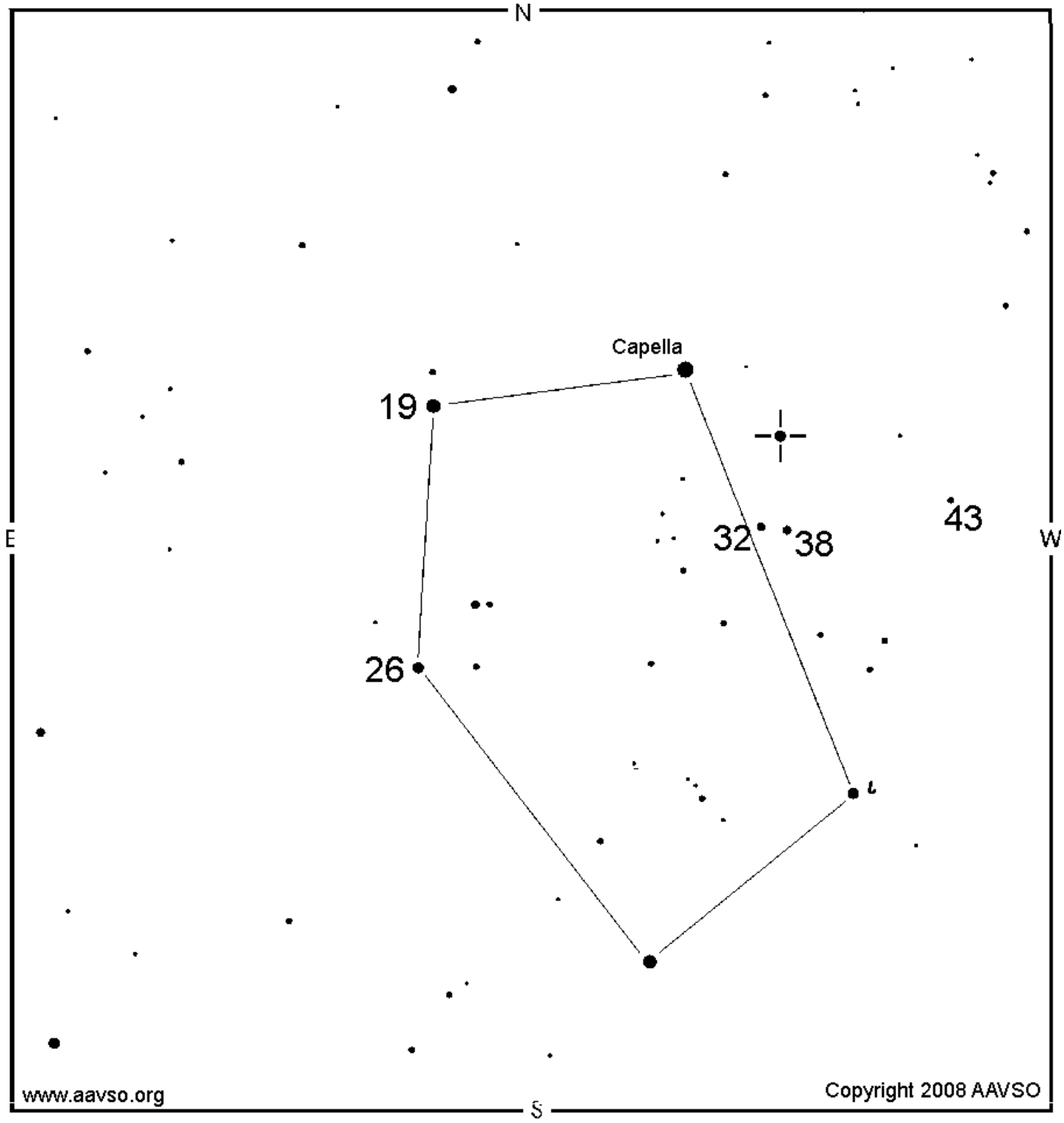
Notes: On our brightness scale, Delta Cephei changes from magnitude 3.3 to a 4.5 and back again over the course of a little over 5 days. Observe this star every night for a week and you can watch a complete cycle. A star of magnitude 3.3 can be seen from most urban locations. However, a 4.5 star may be a challenge due to light pollution washing it out. Therefore, if you are living in an area with bright nighttime skies it may look like Delta Cep disappears when it dims down to 4.5 and then it may seem to reappear when the star returns to 3.3!

Star Chart for eta Aquilae



Notes: Eta Aquilae is similar to Delta Cephei. It varies in brightness from magnitude 3.5 to 4.4 over the course of about a week.

Star Chart for epsilon Aurigae



Notes: Epsilon Aurigae is part of an unusual system featuring a star which every 27 years is eclipsed by a giant disk of particles possibly containing another star. The last eclipse in 2009-10 was the subject of many studies and a massive international citizen science project. You can read the results of the Citizen Sky project in the *Journal of the AAVSO* (https://www.aavso.org/jaavso-v40n2). It is important to keep watching this star because no one really knows what could happen next!