



# Citizen Sky

## Citizen Science with variable stars

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.*

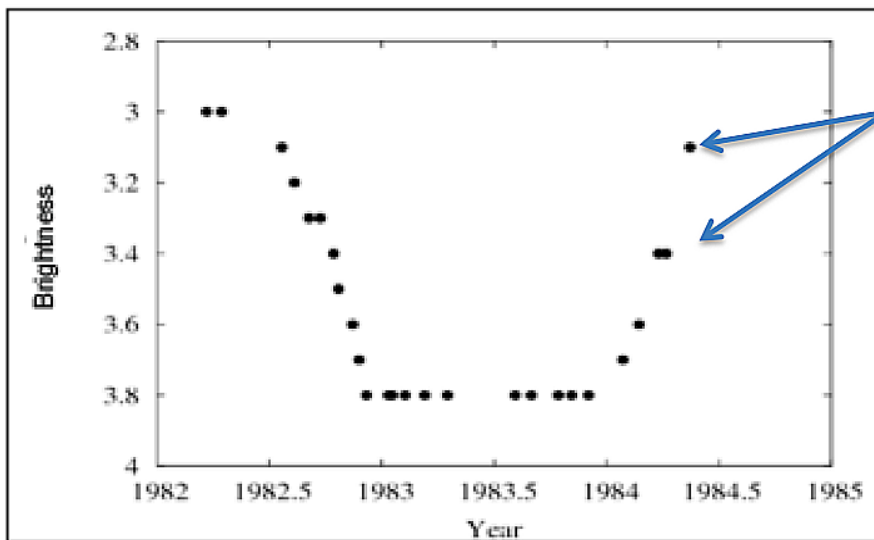


**CitizenSky** is a collaboration of the American Association of Variable Star Observers (**AAVSO**), the University of Denver, the Adler Planetarium, the Johns Hopkins University and the California Academies of Science with support from the National Science Foundation.



# 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

This light curve shows that the star began at a brightness of magnitude 3 in 1982. Around mid-year it began to rapidly dim until it reached brightness of 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!*

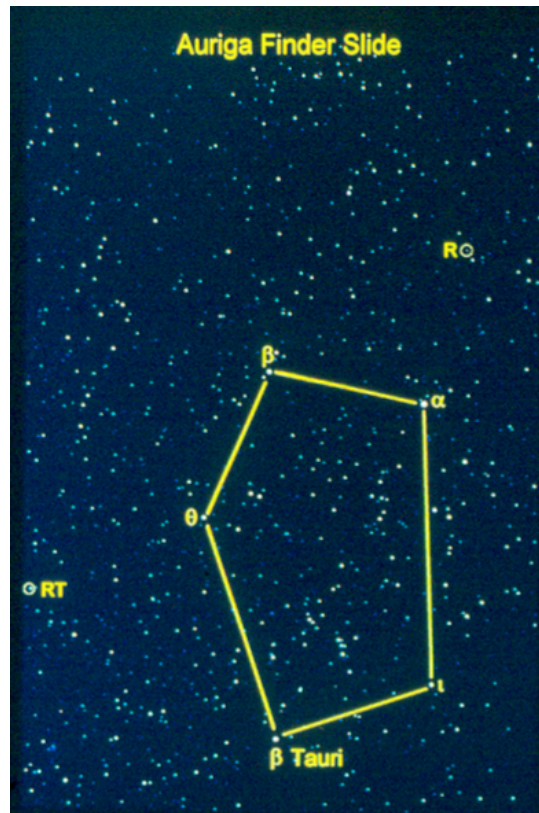
A star chart is just a map of the sky. You use it to match a pattern of stars in the sky with a pattern of stars on the chart, just like you'd match a pattern of streets with those on a street atlas.

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 Aurigae!
7. Go to page 5 to learn how to make your observation.



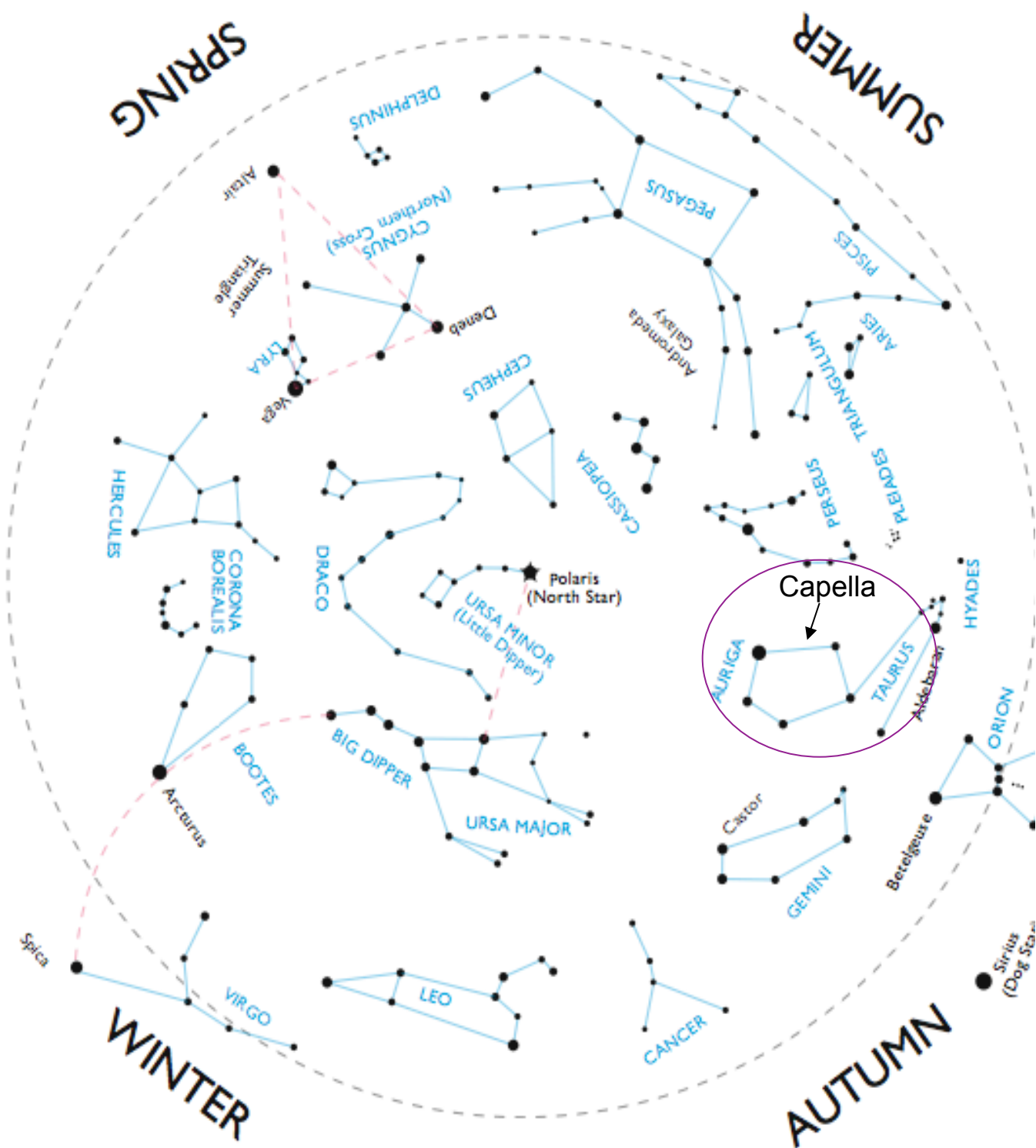
This is a photograph of an area of the sky around Aurigae

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.

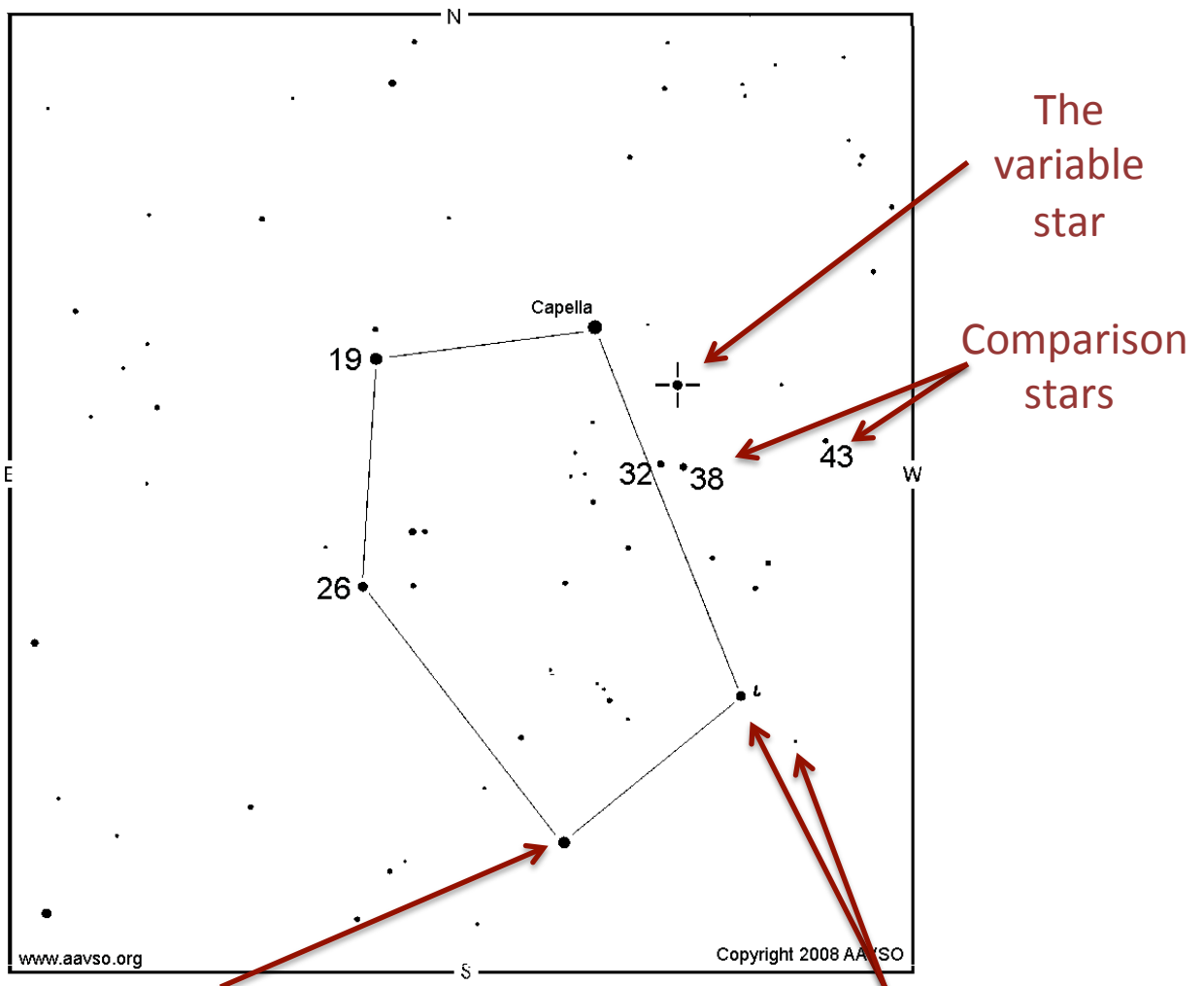
Reprinted by CitizenSky.org with permission from Todd Salati.

# 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. By the fourth or fifth observation, you won’t even need the chart!
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.



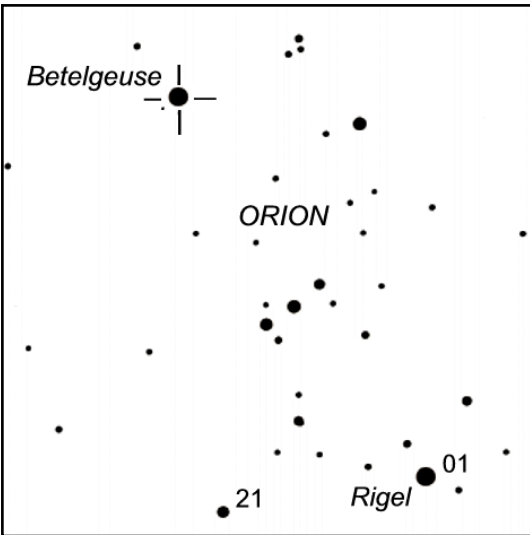
Brighter stars in the sky will have bigger dots on the chart, like this one

Other stars in the sky

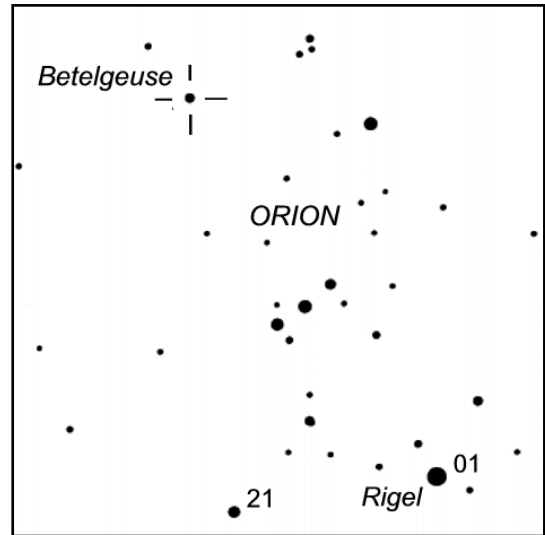
# Measuring a Star's Brightness

*a.k.a. making an "observation"*

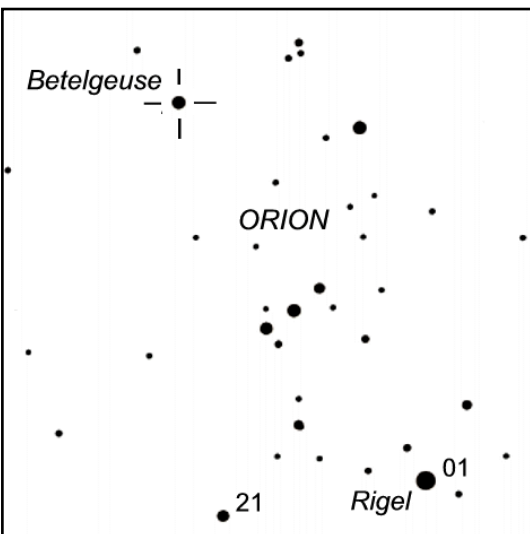
To measure a star's brightness, you simply compare it to other stars in the sky. Those other stars are called "comparison stars" because you use them to make the comparison. Astronomers have carefully measured the brightness of the stars and assigned them a number according to the brightness. **The smaller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



In this example, Betelgeuse will be close to the same brightness as Rigel, which has a 01 brightness. So one may estimate Betelgeuse at brightness 01.



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



In this example, Betelgeuse is somewhere in the middle between the 01 and the 21 comparison stars. So one may estimate it somewhere in between the two numbers, say, brightness 11.

# Reporting Your Observations

Once you have made an estimate, write it down in a journal. Record the day, the time and the brightness 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.

## 1. Go to <http://www.citizensky.org/submitdata>

It will take about 10 minutes to submit your data for the first time. Once your data is submitted, the web site will show you other data submitted by other observers, with your data highlighted. This way you can see how you compare with others and with any other data you had previously turned in. After that it should take no more than five minutes to submit your data.

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

Your Full Name: \_\_\_\_\_

Your Address (if you want confirmation): \_\_\_\_\_

E-Mail Address (optional): \_\_\_\_\_

### Sample Observation

Name of Star: Alpha Ori Date & Time of Observation: January 1, 2009 9:15pm  
Estimated Brightness: 22 Comparison Stars Used: 20, 25

### Observation #1

Name of Star: \_\_\_\_\_ Date & Time of Observation: \_\_\_\_\_  
Estimated Brightness: \_\_\_\_\_ Comparison Stars Used: \_\_\_\_\_

### Observation #2

Name of Star: \_\_\_\_\_ Date & Time of Observation: \_\_\_\_\_  
Estimated Brightness: \_\_\_\_\_ Comparison Stars Used: \_\_\_\_\_

### Observation #3

Name of Star: \_\_\_\_\_ Date & Time of Observation: \_\_\_\_\_  
Estimated Brightness: \_\_\_\_\_ Comparison Stars Used: \_\_\_\_\_

### Observation #4

Name of Star: \_\_\_\_\_ Date & Time of Observation: \_\_\_\_\_  
Estimated Brightness: \_\_\_\_\_ Comparison Stars Used: \_\_\_\_\_

### Observation #5

Name of Star: \_\_\_\_\_ Date & Time of Observation: \_\_\_\_\_  
Estimated Brightness: \_\_\_\_\_ Comparison Stars Used: \_\_\_\_\_

You can mail this report at any time. All five observations do not need to be filled out. Please mail this report to: AAVSO 49 Bay State Road Cambridge MA 02138.

# 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. This project will continue until 2012. Please continue to make observations until then.

*Get a Certificate!*

When you have made and submitted ten observations to the AAVSO, a certificate will be mailed to you certifying your contribution to real science.

*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.

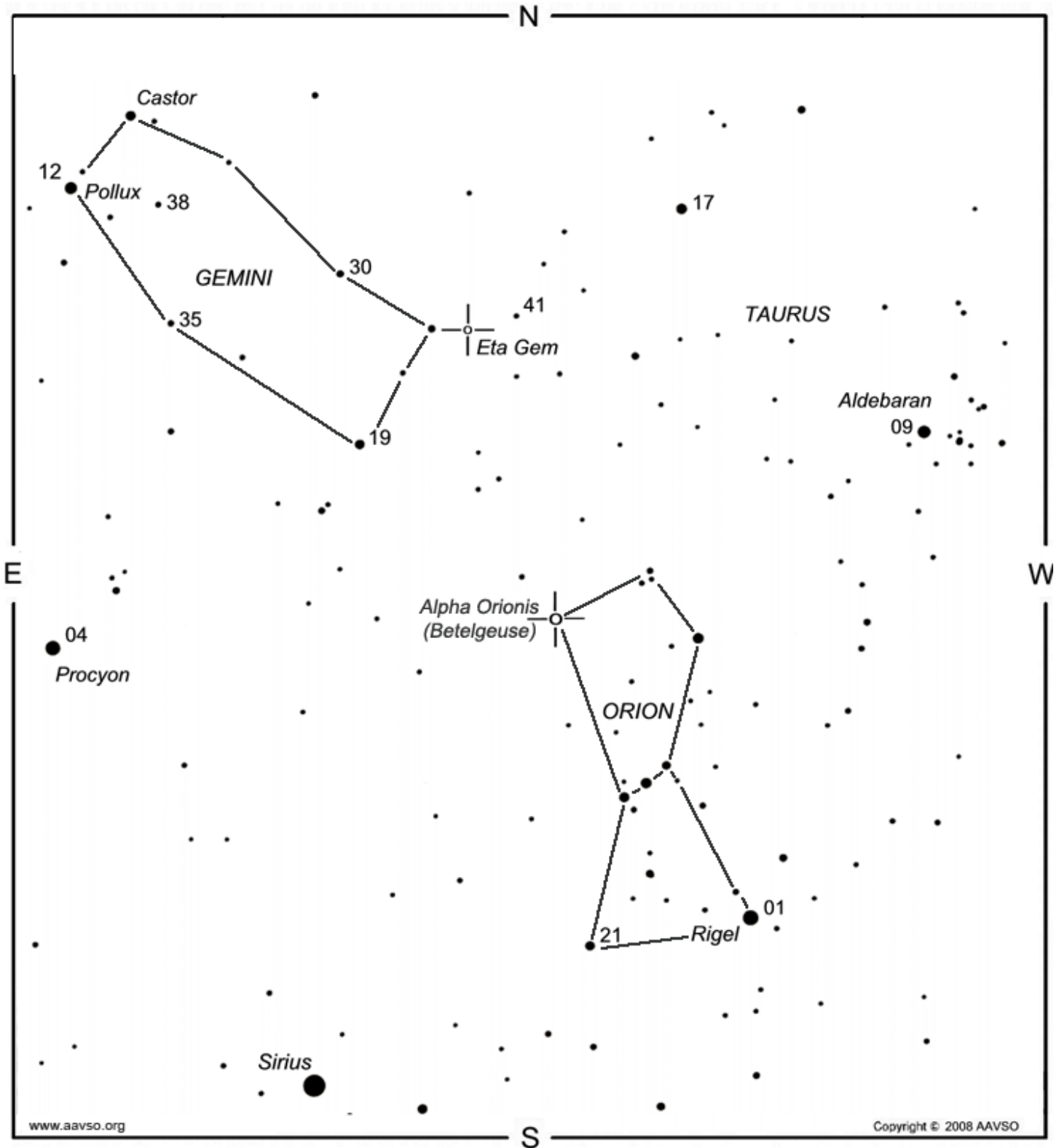
*For More Information...*

Visit [www.citizensky.org](http://www.citizensky.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: <http://www.aavso.org/education/vsa/>



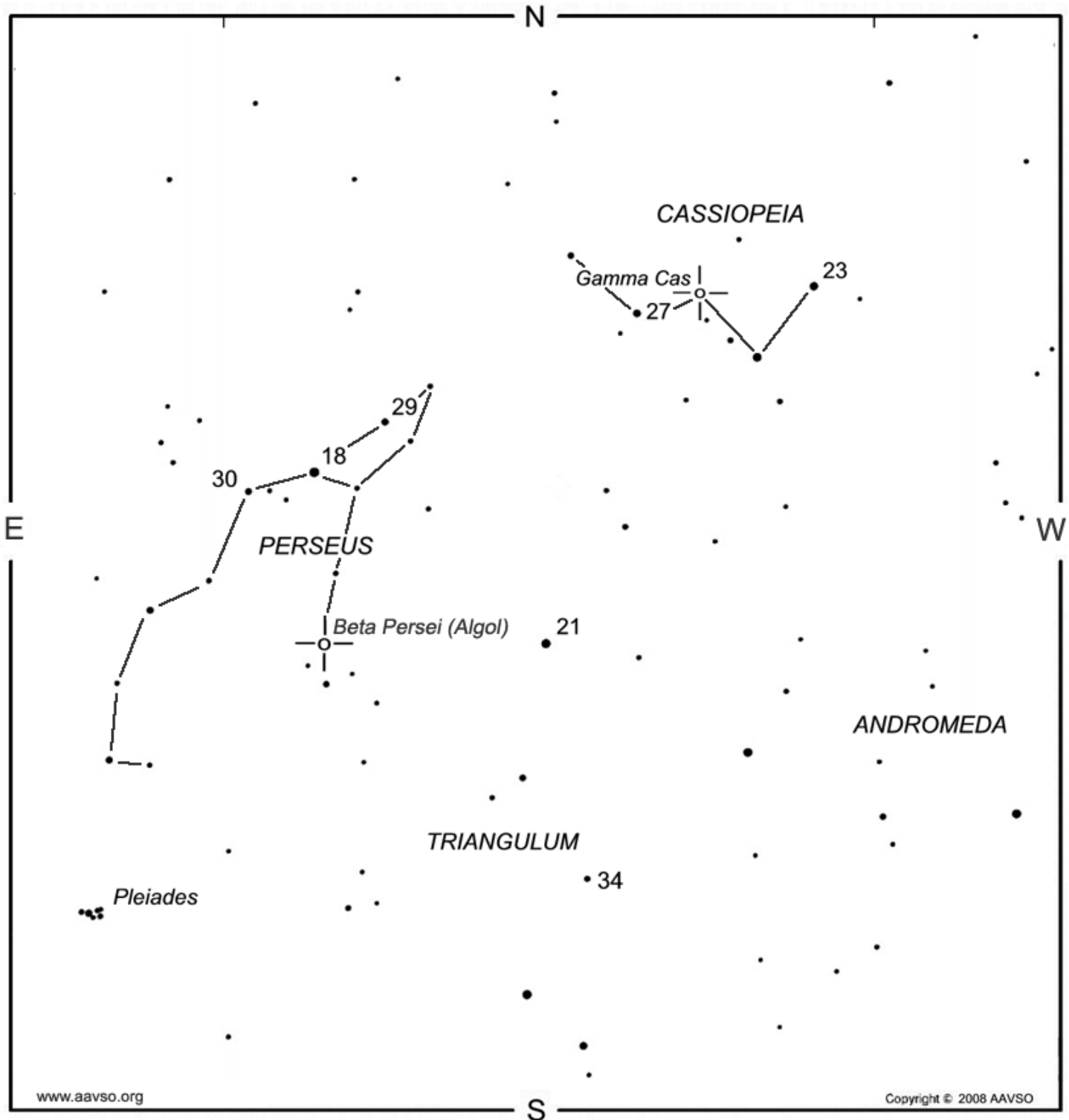
Illustration by Citizen Sky participant Brian Thieme

# Star Chart for alpha Orionis and eta Geminorum



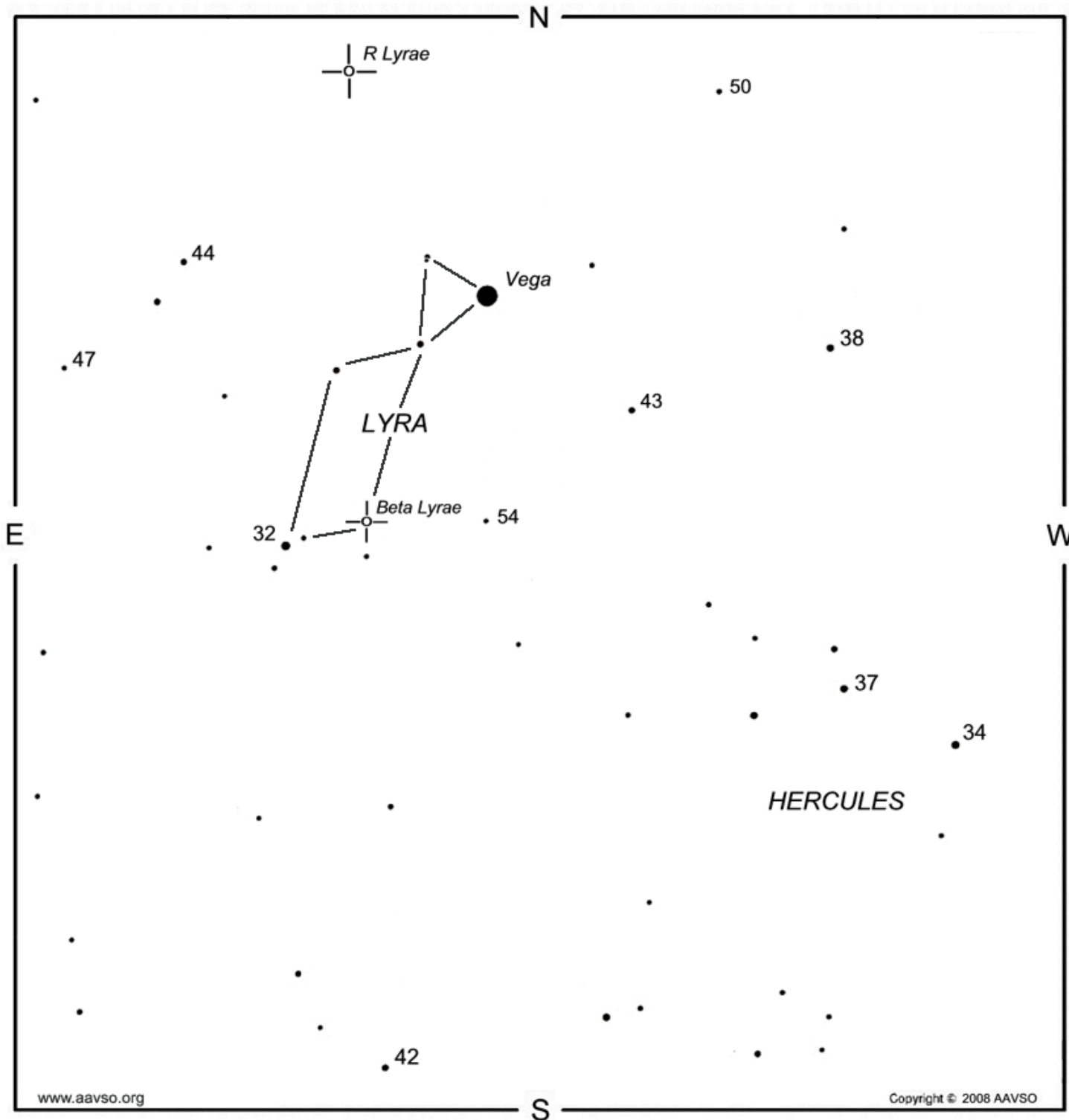
**Notes:** Alpha Orionis (Betelgeuse) is very easy to find. Orion's belt consists of three very bright stars that can be seen from almost any city. Once you find the belt, the rest of the constellation is easy to recognize. Alpha Orionis is a very red star, but sometimes it is hard to see the color from 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! Alpha Orionis varies in brightness from 05 to 15 on our brightness scale over a course of a few weeks. At first it can be hard to notice the change, be patient and you'll see it.

# Star Chart for gamma Cassiopeia and beta Persei



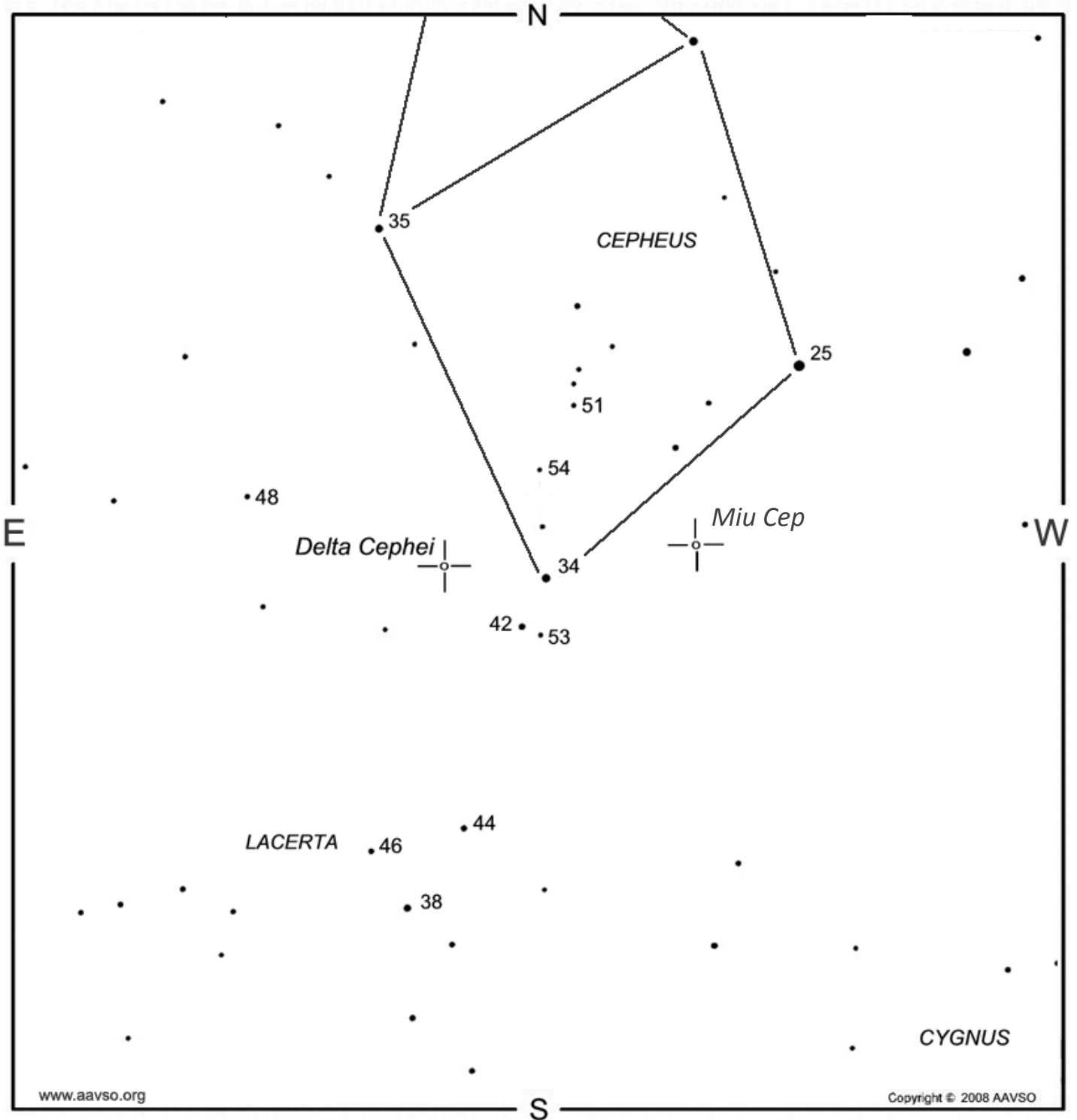
**Notes:** Beta Persei (Algol – the Demon Star) is an interesting star. Around every 3 days it goes into an eclipse that lasts around 8 hours. This means if you can sometimes see the star get dim and then bright again in a single evening! It happens very quickly, so for this star we recommend making one observation every 30 minutes. After only a few observations, you'll see it noticeably dimmer than when you started. Here are some upcoming dates and midpoint times (EDT) for 2009 eclipses: *Dec. 3 at 10:30pm, Dec. 6 at 7pm, Dec. 23-24 at midnight, Dec. 27 at 9pm. Start observing about 43 hours before midpoint. More predictions are at <http://www.aavso.org/observing/programs/eclipses/ebephem.shtml>*

# Star Chart for beta Lyrae and R Lyrae



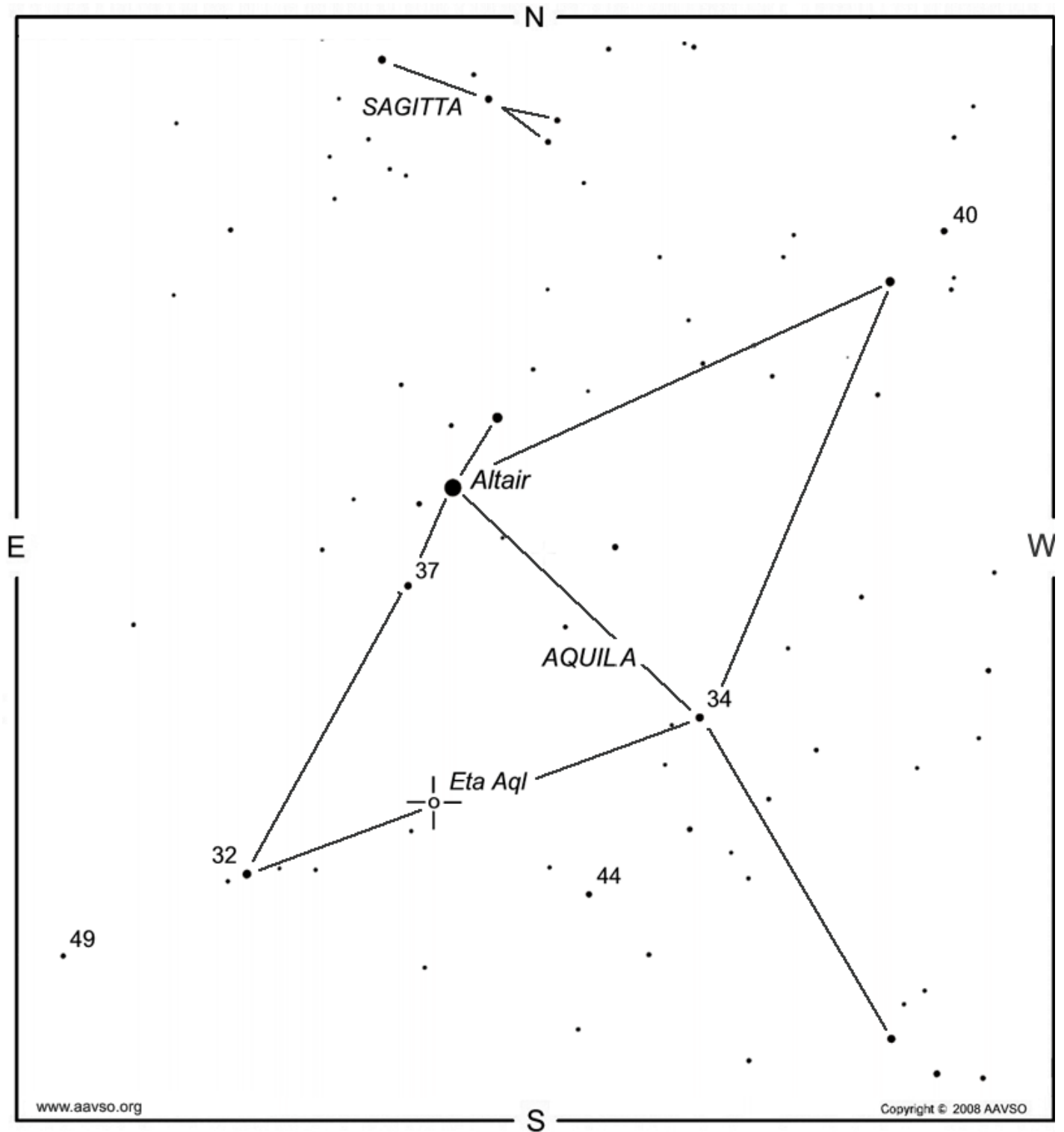
**Notes:** Lyrae is a very easy constellation to recognize in the summer. Vega is the brightest star in the summer sky and is usually near the top of the sky in the early to mid evening hours. The constellation looks somewhat like an hourglass and is relatively small compared to most of the other constellations in these charts. Beta Lyrae usually varies from 34 to 44 on our brightness scale. 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 a 33 to a 45 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 33 brightness can be seen from most urban locations. However, a 45 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 45 and then it may seem to reappear when the star returns to 33!

# Star Chart for eta Aquilae



**Notes:** Eta Aquilae is similar to Delta Cephei. It varies in brightness from 35 to 44 over the course of about a week.

# Star Chart for epsilon Aurigae

