Astronomy of the Northern Sky - A Sky Quest on Star Lives

- Larry Krumenaker

There is no topic so vital to an astronomy course as the life of a star like our Sun. It ties in to so many questions: How old is our planet? Where do we come from? What is the future of the solar system? Why do all the stars look different in brightness and/or color? We have looked at parts of this story in issues past, in this column and in some other *TCA* articles. Here we begin to put all the previous columns of information together into the full story of what we are, where we came from, where we are, and where are we going. This is going to be somewhat like a Sky Quest, a search for objects in the northern sky (see Figure 1), instead of a Web Quest, with the story and sky info (the latter in this blue color) moving along together. Non-stellar objects are labeled with catalog abbreviations and numbers: M=Messier's Catalog, NGC is the New General Catalog, and IC means Index Catalog, a follow-up to the NGC. We've covered star names and spectral classes in earlier *TCA* issues, except for HD, the Henry Draper catalog. In this Sky Quest, we shall talk about stellar evolution, the birth, life and death of a star like our Sun, and finding the representative stages up in the northern sky.

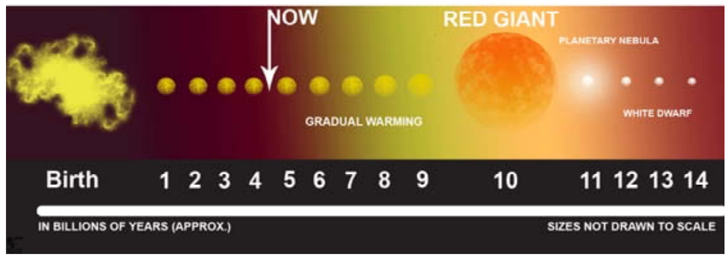

Figure 2. The stages in the life cycle of the Sun.

Our Past

The basics of stellar evolution are the universe is the ultimate in recycling. Stars are born from clouds of gas and dust in space, some dark, some bright because they are either reflecting starlight or glowing on their own from the energy from hot stars within or near them. Once a nebula begins to collapse

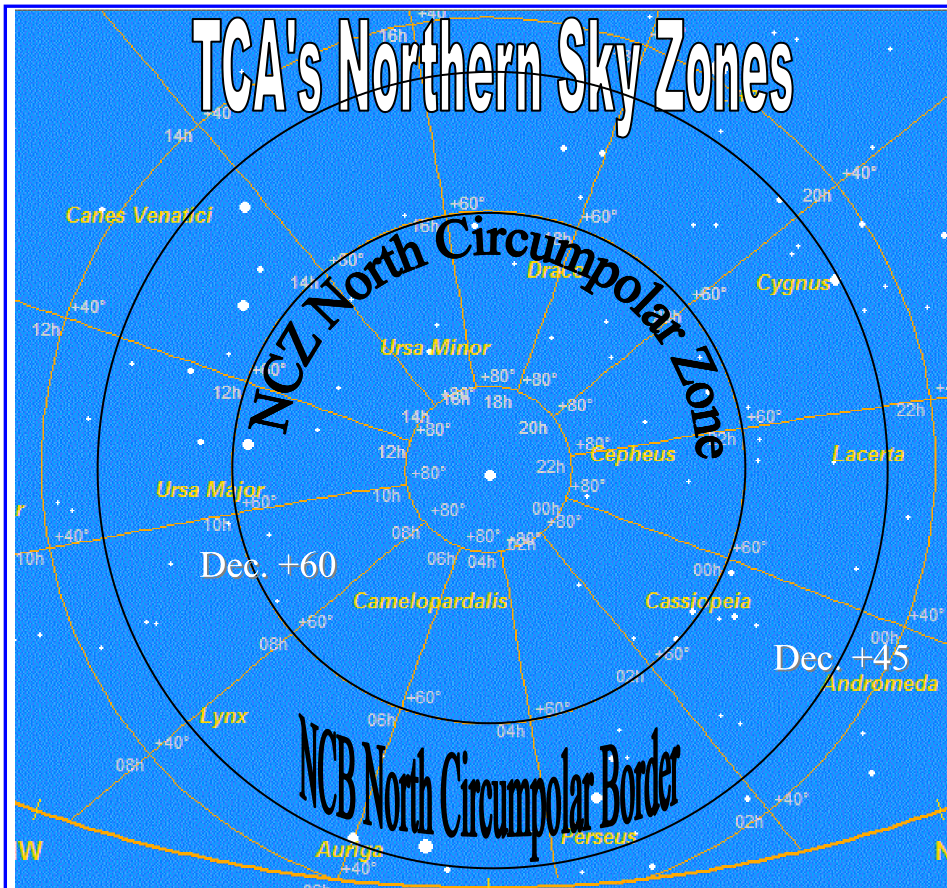

Figure 1. *TCA*'s definition of Northern Sky areas.

This article continues *TCA*'s series "Astronomy of The Northern Sky," where we will point out a number of objects to teach certain astronomy concepts year round. This issue we look at stars and their stages of formation, existence and death.

The North Circumpolar Zone (NCZ) is all objects found between declinations +60° to +90°. The outlying area of declinations +45° to +60° we call the North Circumpolar Border (NCB). The inner limit comes from what stars are always circumpolar, whether you are in northern Europe or on the US-Mexico border. The outer limit is set by the northern limit of our readers' locations and these stars are circumpolar for them; the other limit is set at no more than half a sky, but not circumpolar for the more southerly observers.

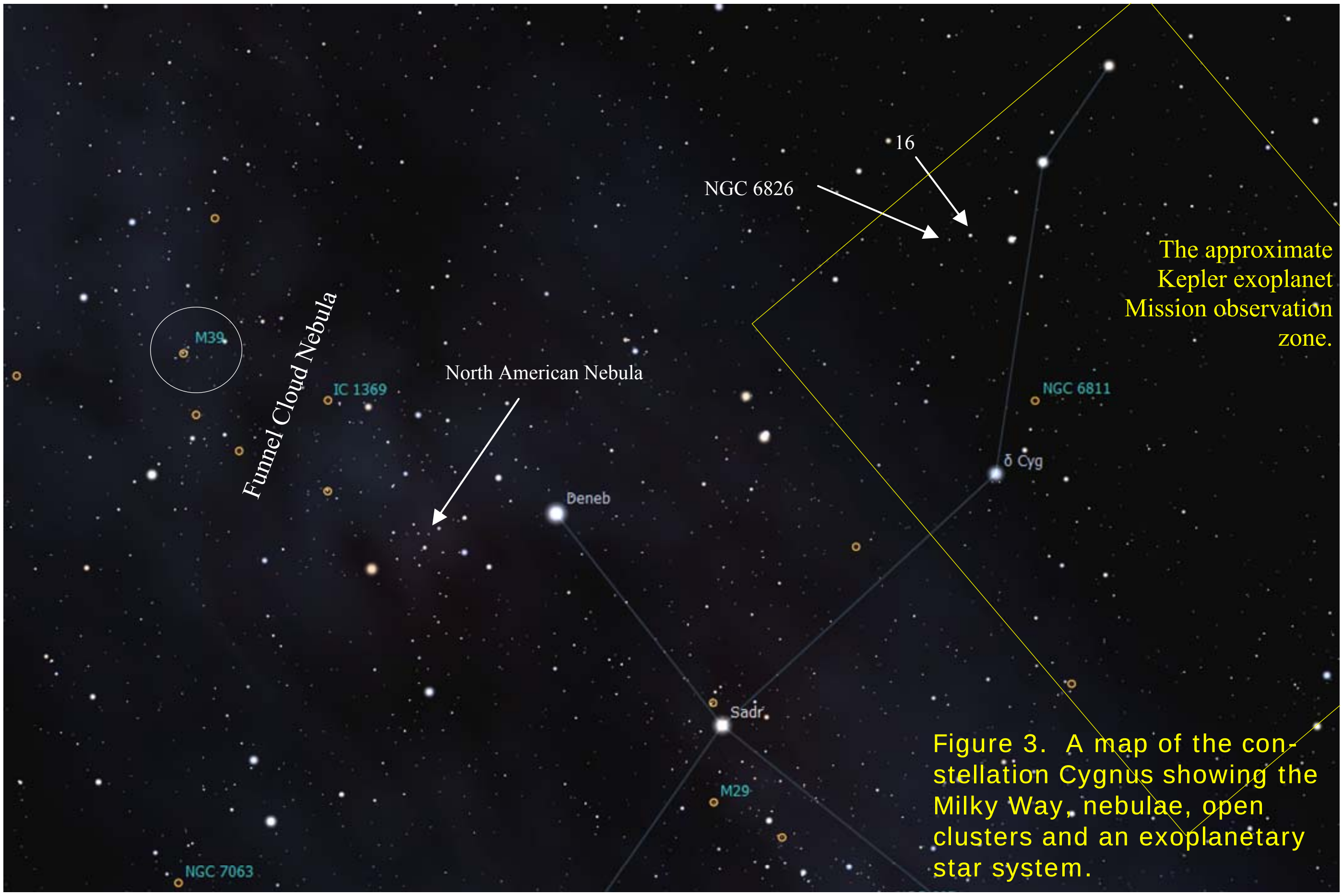

Figure 3. A map of the constellation Cygnus showing the Milky Way, nebulae, open clusters and an exoplanetary star system.

from its own gravity, and starts to spin, it contracts and forms a disk with a thicker center where the star itself forms. The disk likely forms smaller, non-energy producing, non-glowing bodies—planets—with moons, comets and other small bodies around them. What kind of star? All depends on the mass available. More mass—> bigger star, hotter, more bluish, shorter living.

The Northern Sky faces mostly away from the Milky Way center. Much of the easy-to-find nebulosity is not in this part of the sky, but there are a few we can detect with naked eye, binoculars or small telescopes, preferably the wide-field or rich-field type. All we can use in the northern sky are in Cygnus.

The brightest emission nebulae just barely makes it into our northern sky zone. The North American nebula is centered at RA 20:59 Dec. +44º 30' but it has roughly a 3º diameter so at least part of it qualifies for being in the North Circumpolar Border. From dark sites it is a clearly visible glow to the northwest of Deneb. I find averted vision brings the "Southeast Coastline" into focus for me. Surrounding the area, both inside our Border and outside of it, the Milky Way itself is not smooth but corrugated with dark zones. These are relatively near-to-Earth dark nebulae. Indeed, the easiest for us might be the so-called Funnel Cloud Nebula, a 12º-long slash across the Milky Way just above the North American nebula, centered on 21:00 +53º. It looks like someone almost sliced the Milky Way into two pieces here, and if even a hint of Cygnus' Milky Way is visible in light-polluted regions, this dark slice is likely to be seen. (It is a funnel cloud in that it resembles the sinuous trunk of a tornado, not a kitchen or chemistry funnel.)

Stars don't seem to form alone. They start out in groups. Larger nebulae (sometimes also called molecular clouds) form lots of stars, which we see as open or galactic star clusters. Looser groups are called associations (or OB associations, as most of the stars visible are on the hot, blue end of star types). None of these are permanent features; as the group ages and travels around the galaxy, it gradually disperses. Some of the stars formed as binaries or triple stars, even multiple stars, and these retain their little families even as the cluster vanishes. To locate binaries in the northern sky, see the article in *TCA* #13, Fall 2012.

Just a bit north of the Funnel Cloud is a star cluster of some interest, M39 (21:32 +48º 26'). Cygnus, despite its rich Milky Way clouds, is not so rich in star clusters, and as we fly northward from Deneb there are fewer and fewer to see, until we reach the other side of the sky where we find Cassiopeia and then Perseus. The former is rich, with a capital R, in star clusters. Take a wandering look in binoculars all around and through the M or W of Cassiopeia and see how many star cluster candidates you can detect! I'll wait….

Now, check against our map (Figure 4). These are the more interesting candidates to examine again, and look upon with a telescope:

M52 A line from α to β and extended the same distance leads to this rich, dense star cluster (23:24 +61º 35'). Just off its western edge is a planetary nebula, NGC 7635, which needs a telescope to be seen. Further West you cross a star-poor field caused by a dark nebula, and then you come to a very dim emission nebula, IC 1470.

M103 Easy to find, a bit hard to view, because it is just East of δ Cas and thus in its glare when viewed in binoculars (1:33 +60º 42'). Three other lesser clusters lie to its East.

NGC 188 Perhaps the oldest (i.e. longest living) known galactic cluster. It is actually much closer to Polaris than to the W of Cassiopeia. If you go up the handle of Ursa Minor to Polaris and then make a left turn, you'll come to 2 UMi (old name, lives in Cassiopeia's turf) and NGC 188 is near there. If you ever need a star cluster any time of year, this is the one to choose, as it is ALWAYS up in the sky! See Figure 5a, Ursa Minor's map (0:44 +85º 21').

NGC 457 The E.T. cluster, so named because some see an outline, with two bright star eyes, of the Hollywood extraterrestrial. Look South and a little West of δ for the star ϕ (Phi). If you consider M103 at a clock's hour hand between the 9 and 10 o'clock positions from δ, NGC 457 is the minute hand on the 5, and about 3 times farther away from δ (1:19 +58º 20').

NGC 7789 One of the richest, if not the brightest, cluster. A faint cloud until you get enough magnification or bigger optics, then it is a cloud of stars fairly uniformly sprinkled in a circular zone. Get to it by drawing a line from κ Cas (the front edge of her 'chair') through β and only go half the distance away from β (23:57 +56º 44').

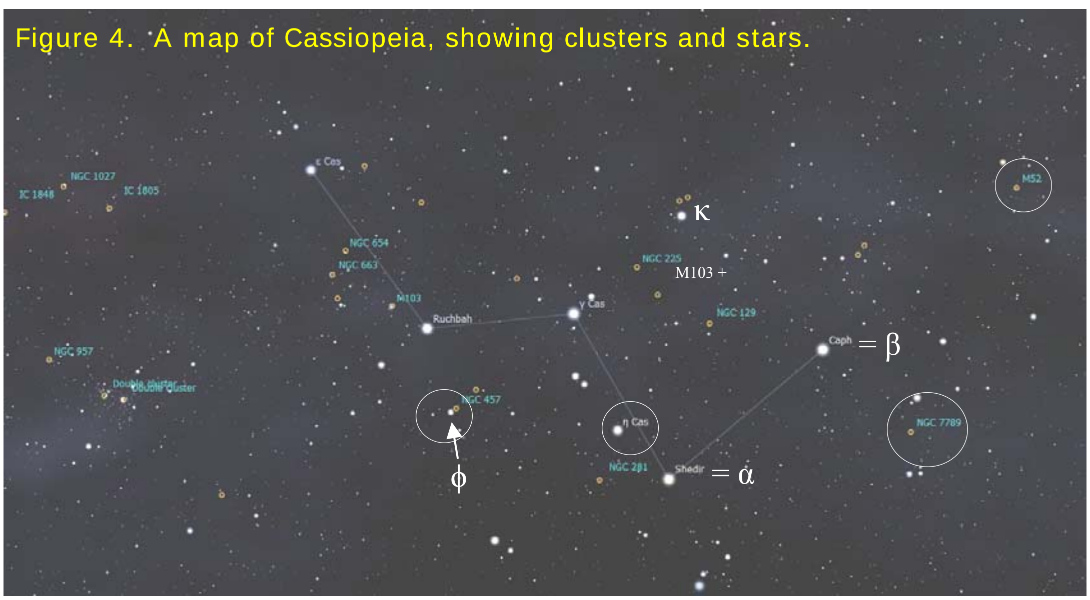

Figure 4. A map of Cassiopeia, showing clusters and stars.

It's Greek to You?

Bayer designation is one of the oldest ways of naming stars. It uses a Greek letter plus the constellation's genitive form, e.g. α Ursa Majoris. Thus the brightest one should be Alpha, the second brightest Beta, and so on. The system isn't perfect; sometimes the names are out of order and sometimes you can have a bunch of stars with the same letter, distinguished by numbers, i.e. ζ^1, ζ^2, etc. and actually listed in positional order.

Below are the Greek letters we'll be using in the article:

- Alpha α
- Beta β
- Gamma γ
- Delta δ
- Epsilon ε
- Zeta ζ
- Eta η
- Omicron ο
- Psi ψ

These are the abbreviations for the constellations mentioned:

- UMa Ursa Major
- UMi Ursa Minor
- Cyg Cygnus
- Aur Auriga
- Per Perseus
- Dra Draco
- Cas Cassiopeia
- Cep Cepheus

Perseus has two cool sets of star groups. Visible as a bright knot in the Milky Way between Perseus and Cassiopeia, binoculars and small telescopes reveal a pair of star clusters, known as h and Chi (χ) Persei, or NGC 869/884, the Double Cluster (2:21 +57º 8'). Few star clusters are this beautiful and you should make this a target for a night-time stellar-evolution lesson any time it is visible.

The top part of the π-shaped constellation, centered on its brightest star, α, is in fact an OB association, a group of hot, young stars traveling in space together but not gravitationally bound enough to maintain itself. It is too loose to be a cluster (3:27 +49º 7').

Present

Stars like our yellowish, G2 spectral type, dwarf star Sun are expected to live stable lives for 10-12 billion years. We're halfway through this stage. It is fusing atoms of hydrogen into helium and generating energy in the process. We should next head to a star that represents our Sun. Solo, yellow, dwarf.

The closest bright star in the northern sky to this model is η Cas, between α and γ (0:50 +57º 53'). It is a G0 V star, slightly hotter than the Sun but likewise a dwarf star. It is about 19 light years away, and our Sun would look pretty much the same if we were to view it from any planets around η.

Exoplanetary System Star Name	RA (h:m)	Dec. (+º ')	Distance (ly)	Magnitude
11 UMi	15:17	+71 49	391	5
16B Cyg	19:42	+50 31	68	6.3
4 (π^2) UMa	8:40	+64 20	254	4.6
42 Dra	18:25	+65 33	316	4.8
γ Cep	23:29	+77 38	46	3.2
o UMa	8:30	+60 43	183	3.4
HD 120084	13:42	+78 04	319	5.9
HD 32518	5:09	+69 38	394	6.4
HD 139357	15:35	+53 55	153	6

Evidence indicates that most stars like our Sun form solar systems There is some evidence that binaries can have planets, too, but most of the exoplanets we have detected so far are around single stars.

Speaking of exoplanets, are there any stars we can point to that have exoplanets? Yes, around 9 such stars that are also bright enough to be seen with the naked eye in good locations, in binoculars everywhere else (a magnitude limit of 6.5). Of course, their planets can't be seen with binoculars or telescopes.

All the stars in the table on the right have one known planet, all found by the radial velocity technique, that is, seeing lines in the spectrum of the star shift redwards/bluewards in a periodic fashion due to the influence of the planet on the star as they orbit around a common center of mass. The nearest system is γ Cephei, about 46 light years away from the Sun. It is also the brightest and easiest to find of these nine stars, magnitude 3.2 and the point of the roof in the traditional five-sided 'house' shape of Cepheus. Oh, and the Kepler mission exoplanets are centered on Cygnus' western wing, near 16 Cygni! You will find the table's stars marked on each of our various maps, coordinates are in the table above.

Future

Once the Hydrogen in the core (not the whole star!) gets used up, the core will contract under the weight of the rest of the star until the pressure increases the temperature high enough to fuse Helium into Carbon. This pushes the star's atmosphere outwards, enlarging the star to Earth's orbit size, give or take, and cools that atmosphere turning it into a red giant star. This stage lasts about a billion years. Locate red giant stars by using this column from *TCA* #14, Winter 2012.

For a star like our Sun, once the Helium runs out, there isn't enough mass to burn heavier elements. The star gently lets go of its outer atmosphere, being the brief beautiful object called a planetary nebula. The rest of the star collapses into a white dwarf, glowing hot and bright but oh so small, Earth-sized, living on residuals (energy, not Hollywood cash). Some planetary nebulae in the northern sky are easy to view and locate. You'll need a telescope to find these, though.

The Cat's Eye Nebulae, NGC 6543, in Draco is among the brightest anywhere, magnitude 8.1 (17:59 +66º 38'). On the way from β to γ Ursa Majoris (and slightly outside this line which makes the bottom of the Big Dipper's Bowl), near the point of a thin north-pointing triangle, is the Owl Nebula, M97, a pale ghostly disk (11:15 +55º 1'). A last one, NGC 6826 (19:45 +50º 31'), lies less than a degree East of double star 16 Cyg. Called the Blinking Planetary, it has the distinction of being easier to see with averted vision, that is, looking NOT directly at it but using the more sensitive retina cells to the side of the eye!

More massive stars may run through several stages like this, until Iron is produced. This element takes more energy to burn than you get (rather like having credit card payments higher than your monthly paycheck). A supernova explosion occurs with most everything blasted back into space. For a time we might see a supernova remnant of glowing gas but eventually most of the star ends up feeding itself back into the nebulae around it, enriching them and possibly squeezing the existing dust and gas into starting the cycle all over again. The core just squeezes down into either a neutron star or a black hole.

Here is where the lesson ends. There are no easily viewable white dwarf stars in the Northern sky although with large telescopes they can be seen in some of the planetary nebulae. While supernovae do occur in this part of the Milky Way, their remnants are all too faint. Neutron stars and black holes (or black hole candidates) require large scopes, if they can be seen at all. TCA

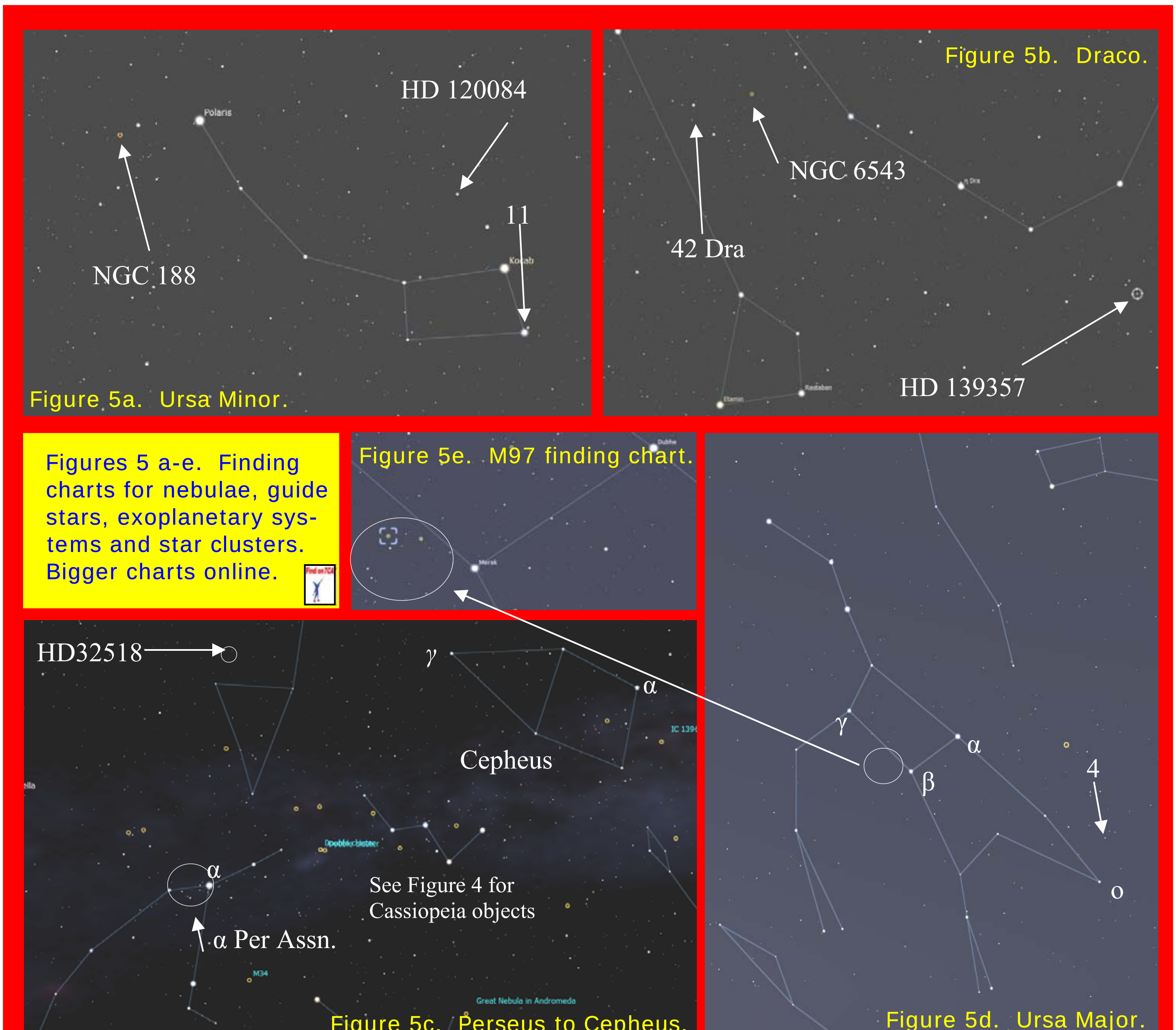

Figure 5a. Ursa Minor.
Figure 5b. Draco.
Figure 5c. Perseus to Cepheus.
Figure 5d. Ursa Major.
Figure 5e. M97 finding chart.

Figures 5 a-e. Finding charts for nebulae, guide stars, exoplanetary systems and star clusters. Bigger charts online.

All charts/screenshots made with the program *Stellarium*. Star/deep sky object data from the RASC *Observer's Handbook*.