Science Olympiad Coaches Clinic 2002 – C Division

1. The types of objects important to stellar evolution.
2. Students should become VERY FAMILIAR with the objects they are responsible for knowing. They should construct a 3-ring binder and have a page(s) for each object. They should find several different images for each object – remember they need to be familiar with what the objects look like in different wavelengths. They should mark them as radio, optical, x-ray – etc… They should also group the objects together that are similar, such as stellar nurseries, supernovae remnants, etc… and don't forget that some, like 30 Doradus, have a common name (Tarantula Nebula)
3. This is an example of some different images of the Cone Nebula.
4. This is also a stellar nursery. N44C is located in the LMC (Large Magellanic Cloud) – a neighboring galaxy. Remember, students need to know the location of the deep sky objects.
5. The Cygnus Region contains many different objects, including stellar nurseries, supernovae remnants, a nebula, and some quasars.
6. Students need to be familiar with where the objects are located, and they are need to be able to recognize images of where they are located, whether it is a galaxy or a constellation. The Cygnus Region is located in the constellation Cygnus. The constellation could be shown with or without lines, so students need to be familiar with what the more obvious constellations look like without lines. Anything obscure or in the southern hemisphere would have the lines included.
7. Proto-stars are located above the Main Sequence on the HR Diagram. Just as they are ready to drop onto the Main Sequence they are T-Tauri stars, thermonuclear fusion is starting but not yet steady. When the fusion process begins the stars become Zero Age Main Sequence stars (ZAMS.) Some objects never achieve fusion and these failed stars are called brown dwarfs – they are not planets and not stars. Brown dwarfs would be located below the HR Diagram between the K and M stellar classifications.
8. Students should know that stars come as single (the Sun) or in binary or multiple star systems. An open cluster is a group born together (Pleiades) that slowly drift apart over time. All these stars exist in the plane of the galaxy where there is enough gas and dust for stars to be born. Globular clusters are not in the plane of the galaxy; they are above and below the plane and contain hundreds and thousands of very old stars. M15 is a globular cluster.
9. This slide of M15 shows an interesting object that is actually two binary systems, each one containing a neutron star.
10. Planetary nebular are atmospheres shrugged off by Sun-sized stars on their way to the red giant stage. They come in many different shapes. Note the very different images of the Helix nebula (planetary nebula) from optical, to IR to an optical close-up of the inner edge taken by Hubble. In the top image you can see the future white dwarf core of this dying star.
11. Students need to know the main difference between the two types of supernovae explosions, Type II and Type Ia. Type II have a progenitor that is a single massive star and leaves a neutron star, pulsar (spinning neutron star), or black hole. The

Type Ia supernova results from a white dwarf (which is already the end product of a dying Sun-sized star) in orbit around a star which is in the giant stage. The gravity from the white dwarf pulls material off the loosely held outer atmospheric layers of the giant. If a huge amount of the material falls onto the white dwarf it can trigger a supernova explosion that literally blows the white dwarf to pieces and nothing is left of the star. This event is much brighter than the Type II event – note the light curves of these two events on the chart.

12. These are all objects the students are responsible for knowing, including what they are and where they are located. The two objects on the right side may involve a new state of matter – and are called "strange quark stars". The Chandra website has a thorough description of these two interesting objects.
13. Remember that binary stars orbit each other. That means the light they emit changes in brightness if one orbits in front of the other (this would be a regular or periodic change in the light) or if one is a white dwarf pulling material off a red dwarf companion. In this case, the in-falling material onto the white dwarf may cause little explosions (novae) or a supernova Type Ia explosion.
14. The galactic radio arc image contains the black hole located at the center of our galaxy. All active galaxies contain black holes at their centers it is thought. Quasars are the earliest galaxies (furthest away) and have extremely massive and active black holes.
15. Remember – the most important thing about spectra is that hot stars do not have very many emission lines (too hot for electrons to be held to the nuclei so not many electrons to jump up and fall back down in their energy levels to emit photons) and the coolest stars have a lot of emission lines because they are so cool that even compounds can exist.
16. This is a sample of how spectra are related to Main Sequence stars – few lines for the hottest and brightest stars at the upper left of the HR Diagram, and many lines for the coolest and dimmest stars at the lower right of the HR Diagram.
17. Students must be familiar with the Hertzsprung-Russell Diagram (HR Diagram). The vertical axis can be labeled either Absolute Magnitude (how bright the stars actually are if they were all at the same distance from Earth), and the horizontal axis can be labeled with temperature, color, or the spectral classification of OBAFGKM (they all mean the same thing). Remember, this is very similar to the Periodic Table of the Elements – and the location of a star on the HR Diagram tells you how bright it is, it's temperature, age, mass, composition, and evolutionary stage (living stars on Main Sequence, dying stars on Red Giant and Super Red Giant branches, and end product of Sun-sized stars on White Dwarf branch.) The stars in individual globular clusters and open clusters can also be diagrammed on an HR Diagram. The more stars that have evolved from the Main Sequence to the giant or supergiant branches the older the group of stars is. If there are white dwarfs plotted, the group of stars is even older.
18. Students should be able to locate the stars and deep sky objects they are responsible for knowing on the HR Diagram. They should know where hot bright stars like the Pleiades belong, the Sun, red giants such as Betelgeuse, and white dwarfs. Objects such as galaxies, black holes, and neutron stars are not placed on

the HR Diagram, however objects such as planetary nebulae (above white dwarf branch) and supernovae remnants (red supergiant branch) are.

19. Students should be familiar with the different types of light curves from red giants and supergiants (Mira stars – periodic with ~300 day periods), and the Type II and Type Ia supernovae events.
20. REMEMBER that many images of each object should all be located and placed together – objects can look very very different in different wavelengths. Note the Vela remnant. The first two are optical, the third one is from the old Rosat satellite, and the last one is a close-up of the pulsar at the center taken by the Chandra X-ray Observatory.
21. Write down all important equations. Then for each equation have students rearrange the equation. It is much easier to find a variable if that variable is set to the left side of the equation and equal to everything else. Just this small preparation will dramatically reduce mathematical errors. Have students rearrange every equation listed here. Also write out relationships associated with a sphere (nebulae, stars, and remnants can be roughly thought of as a sphere.)
22. The Chandra website contains multiwavelength images of all the images they have taken with easy to understand text about each object.
23. Use the Space CD-ROM I constructed (the 2002 section) on multiwavelength missions to easily access sites and images. The Cosmic Evolution icon on the Wright Center homepage is a course in stellar evolution. The textbook shown is also very readable.
24. These are the ONLY URL'S YOUR STUDENTS NEED…. Astronomy Picture of the Day is an absolute treasure of images and information, simply stated.
25. – 28. These images can be used to study stellar evolution for both mid-sized and massive stars. Complete instructions and answer keys are on the Chandra education website under classroom-ready materials. Click on Stellar Cycles.

29. The Chandra URL
30. The Wright Center URL

REMEMBER – loading laptops with a lot of material is no more productive than bringing a box of books to rummage through. This takes TOO MUCH TIME. Have your students prepare a very organized and cross-indexed 3-ring binder. That activity will allow them to become very knowledgeable about the material and they will be much more successful in this event.