



Constellation Classification Cards*

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Background:

The Constellation Classification Cards are meant to be used within the context of a stars and/or constellations unit. It is assumed that the students are receiving instruction in the properties of stars and in recognition of constellations. The cards can be used to reinforce factual knowledge and to assist in classifying stars in a variety of ways. While there are 88 official constellations, we have chosen stars representing 11 of the most prominent constellations that are visible from the Northern Hemisphere.

The Next Generation Science Standards will soon be implemented in many states. The activities presented below are an ideal way for educators to introduce many of the concepts that are contained in the Performance Expectations and Disciplinary Core Ideas for grades 5 to 8.

Objectives:

The students will learn the names and shapes of 11 constellations and the properties of 29 stars within these constellations, plus the Sun. They will classify these stars by group (constellation), brightness, distance from Earth, temperature, and color. Students will learn that even though constellations look like close groups of stars from our viewpoint on Earth, the stars within constellations vary in brightness, distance, temperature, and color. There are two versions of the Constellation Classification Cards, labeled A and B. The first set, A, is designed for students just learning about the constellations and the basic characteristics of stars. In this set, the term brightness is used. In the second set, B, more advanced students are introduced to the additional term, magnitude. In addition, several stars are what are called binaries (a star system with two stars orbiting around their center of mass). In Set B both stars are shown, along with their combined brightness. This set also contains additional information on the stars—their absolute magnitude, their type (size), and their spectral class. This set also lists the temperature as Kelvin instead of degrees Centigrade (see #8 below).

Making the Cards:

We have created this activity so that it can be used as a kit with the cards pre-made. Therefore we have included the instructions for making the cards at the end of the activity. We have designed these activities assuming that most groups will be 20 to 30 girls/students and so include 30 cards in the handout that goes with these instructions. However, we have 23 additional cards with two additional constellations. If you would like copies of these cards please contact Larry Lebofsky at: lebofsky@lpl.arizona.edu or go to the NIRCam website: <http://zeus.as.arizona.edu/~dmccarthy/GSUSA/index.htm>.

Procedure:

1. Using the original card set, make an enlarged copy of any constellation card to share with the class. Copies of the cards are available directly from Larry Lebofsky at

lebofsky@lpl.arizona.edu so that images can be downloaded or displayed for the students from his Dropbox site.

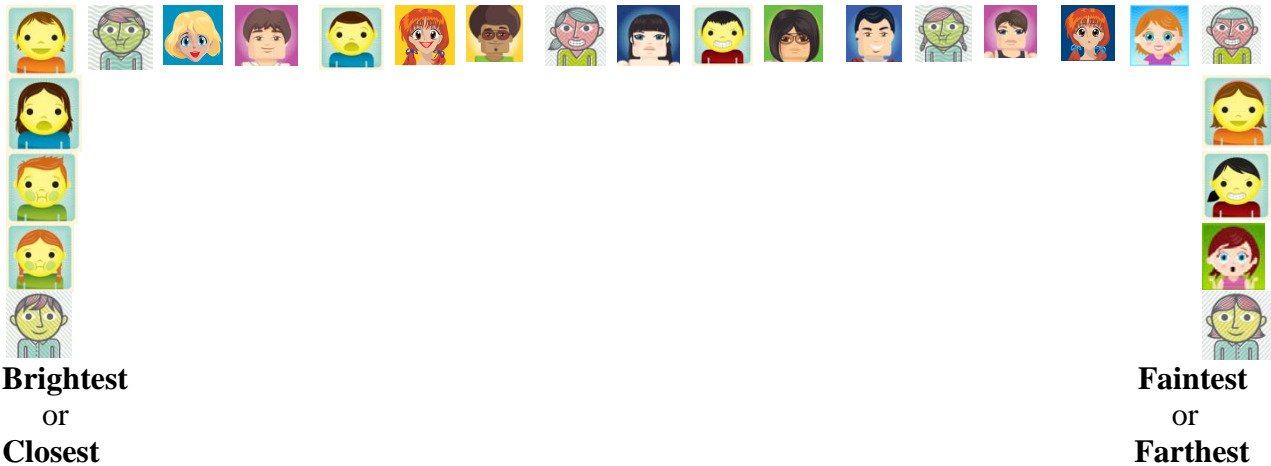
2. Show the class the sample constellation card. Discuss the information included on the card: name of the constellation, name of a star in the constellation, its brightness, its distance from Earth, its temperature, and its color. If the second set is used, discuss the additional information. **Note: The brightness/magnitude scale is designed so that the brightest stars have negative numbers and the fainter stars have larger, positive numbers. Similar to the earthquake Richter magnitude scale, the magnitude scale is non-linear (logarithmic). Each magnitude represents a factor of about 2.5 in brightness, so that 5 magnitudes is exactly a factor of 100 in brightness. Note: you may need to explain absolute magnitude to your students. Absolute magnitude is used so that star brightnesses can be compared. While brightness (magnitude or apparent magnitude) is what we see when we look up at the stars in our sky, absolute magnitude is the brightness of a star as seen from exactly 32.6 light-years (10 parsecs) away.**
3. OPTION: Show a second card and discuss differences and similarities.

Activity Option #1: Make a human linear model using the cards according to group, distance, temperature, and color.

1. Distribute the laminated cards, one per student. At the end of this activity, we give recommended stars for groups of 20 and 30 girls/students. The sets are designed to assure that there are at least two stars per constellation (except Procyon in Canis Minor) and that the extremes (e.g., hottest/coldest and nearest/farthest) are represented.
2. Using the Star Classification Information Sheet, the teacher will ask students to arrange themselves in a variety of ways. The stars represented on their cards can be classified according to constellation (11 constellations), brightness or magnitude (6 groupings) distance in light-years (8 groupings), temperature (6 groupings), and color (8 groupings). Using Set B, girls/student can also classify by absolute magnitude (7 groupings), type or size (5 groupings), and spectral class (7 groupings).
3. Begin by telling the students that stars are like people in several ways. Stars are found in “families” which we call constellations. Ask the students to form groups with the other members of their constellation family. Ask them to make note of the other students in their families. Remember, there is only one star card for Canis Minor. Also, our Sun will not have a family. Because the Sun is so close to the Earth, its distance from the Earth is given in light-minutes
4. Next, tell the students that family members are not all together all day long. Now we are going to move around into different groups. Ask the students to consult their cards and find their brightness.
5. This model requires the students to stand and move around the room. Forming a large U-shaped line works well; it allows the students to see the cards other students are holding. For example, if the open end of the U is facing the teacher, brighter stars begin at the left-hand point of the U (from the perspective of the teacher) with the other stars in brightness order so that the faintest stars end at the right-hand point of the U. Ask the girls/students with brightnesses less than zero (brightest) to start the line on the left. There will be two less than zero: the Sun and Sirius. Then have the students with brightnesses between 0.0 and 0.99 line up next to the first two students in order of their brightness. If 20 or 30

cards are used, there will be five students in this group. Continue with brightnesses between 1.0 and 1.99, etc., until all of the students are in line. The student on the right end will be the one with the star Zosma in constellation Leo (if 20 cards are used) or Thuban in the constellation Draco (if 30 cards are used.)

6. Ask the students from each constellation family in turn to identify themselves. Family members will no longer be grouped together because some stars in a constellation are bright, while others are fainter.



7. Family members can live nearby or farther away. Again, begin the U-shape in the front left corner of the room, starting with the closest stars. Ask the students with distances less than 25 light-years to start the line. If 20 cards are used, there should be one student representing 8.3 light-minutes (the Sun), one at 8.6 light-years, and one at 11.4 light-years. Consult the Star Classification Information Sheet for other groupings (e.g., 25–49.9 light-years, 50–99.9 light-years, etc.). Have the students for each grouping arrange themselves in the line in order. If you are making a U-shape around the perimeter of the room, the U should again start with the Sun and Sirius, but end with Aludra in Canis Major. **Note: 1 light-year = 63,000 AU (astronomical units). 1 AU = 93 million miles or 150 million kilometers (the mean distance of the Earth from the Sun).**
8. Ask the students from each constellation family in turn to identify themselves. Students should notice that, while constellations may look like stars grouped closely together from our perspective on Earth, these stars may actually be very distant from each other. Two-dimensional drawings of constellations can be very misleading; remind the students that the stars are in a three-dimensional universe. The stars Sirius and Aludra in Canis Major are a good example; one is the closest and one is the farthest in this distance model.
9. Ask the students to consult their cards and find the temperature of their stars. Remind the students that people have different temperaments; some are really cool, while others are very hot-tempered. Ask them to re-group their stars from coolest to hottest. Begin the U-shape at the front left again (as viewed by the teacher), beginning with stars that are less than 4,000°C (4,000 K if using Set B). If 20 cards are used, there will be four in this category (only two if using Kelvin), with Antares and Betelgeuse representing the coolest stars. Consult the Star Classification Information Sheet for other groupings to complete

the U-shape, ending with Alnitak and Mintaka at 30,000°C (30,000 K). **Note: If you look up information on stars, you will see that astronomers always use Kelvin (temperature from absolute zero), not degrees Centigrade (0°C where water freezes). This is a difference of 273 degrees. However, because star temperatures are usually only approximations, we have rounded when going from Kelvin to degrees Centigrade as in the cases of Alnitak and Mintaka.**



10. Ask the students from the original constellation family groups to identify themselves one group at a time. Notice that both the coolest and hottest stars are from Orion, but that most of the Orion family represents hot temperatures.
11. Ask the students to remain in temperature order. Ask them to turn over their cards so that the side with the color-coded construction paper is facing out. The students should notice the colors form a pattern, from the coolest stars (red) to the hottest stars (blue). This pattern represents the spectrum of light.





Group of Girl Scout Leaders with Constellation Cards

12. NOTE: If you use the cards from the prepared kit or have mounted the two-color star cards as described below in the *Procedure*, and if you form the U-shape with the opening facing front and the cooler stars beginning at the left point, flipping the cards from top-to-bottom should form a perfect spectrum, with the orange half of the yellow-orange cards nearest the orange stars and the yellow half nearest to the yellow stars. The same will be true for the yellow-white and blue-white cards. When the colored sides of the cards are facing away from the students, the constellations and the star information should be upside down. If some students turn the cards from right-to-left instead of flipping them, the two-color cards may need to be adjusted to show the correct order.

Three or four stars may *appear* to be out of place. This reflects the approximations that go into classifying stars and determining their colors and temperatures.

Activity Option #2: Make a 3D human graph representing distance from Earth, brightness, and temperature. For this activity, we are assuming there will be 30 girls/students. If there are not enough students for all 30 cards, eliminate some of the white and blue stars.

1. This activity requires a large open area and two chairs. The final graph will have three “axes” representing brightness, distance, and temperature.
2. Begin the activity as described in Activity #1. Distribute the cards, one per student.
3. As in Activity #1, begin by having the students group themselves according to constellation groups.
4. Ask the students to consult their cards to find their distance from Earth. Beginning at the front of the room, have the students representing the closest stars (8.3 light-minutes, 8.6 light-years, and 11.4 light-years) start the baseline parallel to a wall but not against the wall, facing the opposite wall. Using the Star Classification Information Sheet, ask the next group in distance (25–49 light years) to join the line in distance order. Do the same for the rest of the distance groups.

5. Ask the students from each constellation to identify themselves. As in the U-shaped model in Activity #1, the model should begin with the Sun and Sirius and end with Aludra from the constellation Canis Major.
6. Ask the students to consult their cards to find their brightness. A “0” on the brightness scale is equal to the brightness of Alpha Lyrae, the brightest star in the constellation Lyra. Negative numbers, e.g., Sirius = -1.46, are the brightest stars; the highest positive numbers, e.g., Thuban = 3.65, are the dimmest stars. For Set B, there are six cards with three numbers. Stars with three numbers and a slash, e.g., Mintaka = 2.23 (3.2/3.3), are binary stars. Use the first number given for the combined brightness of the two stars when forming the graph. Stars with three numbers and a dash e.g., Rigel = 0.18 (0.03–0.3) are variable stars. Use the first number given for variable stars, their mean brightness, when forming the graph. One star, Albireo, has only two numbers (3.18/5.09) and appears that way in both sets. Use the first number for Albireo when forming the graph. Albireo is a beautiful double star (the stars are close to each other in the sky, but may not be orbiting each other, i.e., not a binary).
7. Students with stars less than 0 on the brightness scale should take one giant step *backward*. These students represent the brightest stars, Sirius and the Sun. Students with stars between 0 and 1.1 on the brightness scale should remain on the baseline. There will be one binary star and two variable stars in this group.
8. Students with stars between 1.1 and 1.7 should take one giant step *forward*. Students with stars between 1.75 and 2.0 should take two giant steps forward from the baseline. There will one binary in this group.
9. Students with stars between 2.05 and 2.9 should take three giant steps forward from the baseline. There will be one binary star in this group. Students fainter than 3.0 should take four giant steps forward from the baseline. There will be one double star in this group.
10. Have the original constellation families identify themselves. Allow the variable stars to move from their brightest position (lower number on the card) to their dimmest position (higher number on the card).
11. Have the students consult the temperature category on their cards. Have the students with stars between 3,000–4,000°C sit on the floor. These represent the coolest stars (red). Have the students with stars between 4,000–5,000°C kneel on the floor. These represent cool stars (orange, orange-yellow). These numbers may need to be adjusted when using the second set which gives the temperature in Kelvin.
12. Have the students with stars between 5,000°C–7,000°C sit on chairs. These represent the medium stars (yellow, yellow-white). Have the students with stars between 7,000°–31,000°C remain standing. These represent the hot stars (white, blue-white, and blue).
13. Have the original constellation families identify themselves. Notice that the stars within the constellations differ in distance, brightness, and temperature from each other.

Activity Option #3: Classification

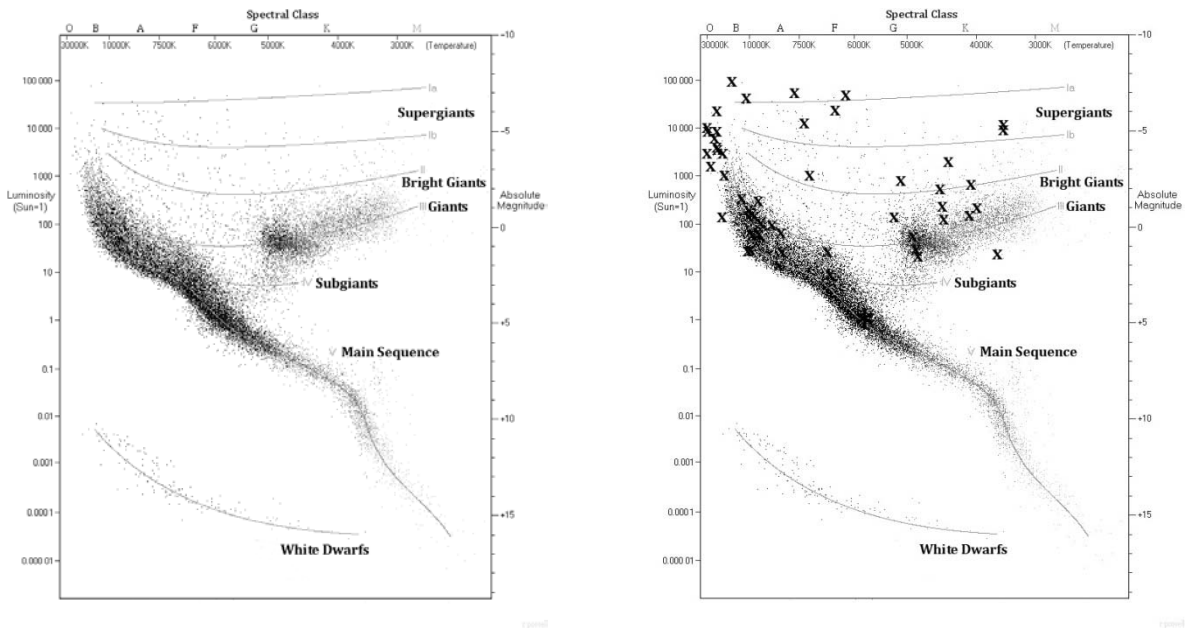
1. Distribute the cards among small groups of students. Allow the students to study the categories and brainstorm ways to sort the cards. For example, they may be interested in finding all of the blue and blue-white stars in Orion. Record their findings on butcher paper or the white board.
2. Discuss patterns, similarities, and differences. For example, the constellations look like they are made up of closely grouped stars from our viewpoint on Earth. Yet the closest

and farthest stars represented in the cards are both in Canis Major. Likewise, the coolest and hottest stars represented in the cards are both from Orion.

3. Allow the students to graph or chart their chosen characteristics of the stars on paper or as described in Activities #1 and #2 above. This can be done on paper or as a computer graphing activity.

Activity Option #4: Hertzsprung-Russell (H-R Diagram) for Card Set B.

1. This activity can only be done with the Card Set B which has the stars' absolute magnitudes. Around 1910, E. Hertzsprung and H. Russell first plotted the spectral types (or temperatures) of stars vs. their absolute magnitudes. This plot was the key to our understanding of stellar evolution and the life cycles of stars.
2. Have the students line up in a straight line (not in a U-shape) by temperature as in Activity #1.
3. Have them step forward according to their absolute magnitudes. First, have the faintest star, the Sun, at absolute magnitude +4.8 take 1 step forward. Next, have the stars between +4.0 and +2.1 take 2 steps forward (one star). Next, have all the stars between +2.0 and 1.1 take 3 steps forward (three stars if 20 to 30 cards are used). Continue until the last group, -6.0 to -7.9, takes 12 steps forward. The students have recreated the H-R Diagram!
4. An H-R Diagram is shown on the left, below. On the right is the same diagram with all 53 of the Constellation Card stars plotted. As you can see, the majority of the stars that we see are among the brightest of all the stars. The Sun is, by far, the faintest.



Extensions:

1. On the Constellation Classification Cards, as well as on star charts and planispheres, brighter stars appear as larger circles. Learn how to use these aids to find stars.

2. After completing the activities, discuss the origins of the star and constellation names. Read or research the myths associated with the constellation names, or find other skylore interpretations from other cultures.
3. If the students did Activity Option #4, have them research the brightest stars and the nearest stars. Wikipedia has lists that include nearly 100 of each. Have them plot these stars on an H-R Diagram. They will find that only a few stars are common to both lists. This reinforces the concept that the stars that we see in the sky are generally not the nearest stars to us. In terms of absolute magnitude, the Sun is, by far, the faintest star we can see. However, most of the nearest stars are fainter than the Sun and too faint for us to see without a telescope.

Star Classification:

When girls/students line up to classify the stars by brightness, distance, etc., you may want them to form groups/families: 1,000 light-years or greater from the Earth, for example. The number in each group will depend on how many cards you use, so we have listed below suggested groups, but not the number of stars in each group.

Brightness (Magnitude): Brighter than 0.0, 0.0–0.99, 1.00–1.99, 2.00–2.99, 3.00–4.00

Distance (Light-years): less than 1, 1–24, 25–49, 50–99.9, 100–199, 200–499, 500–999, 1000 or greater

Temperature (Centigrade or Kelvin): less than 4,000, 4,000–5,999, 6,000–7,999, 8,000–9,999, 10,000–29,999, 30,000 or greater

Color: Blue, Blue-White, White, Yellow-White, Yellow, Yellow-Orange, Orange, Red

Absolute Magnitude: Brighter than -6.0, -6.00 to -4.01, -4.00 to -2.01, -2.00 to -0.01, 0.00 to 1.99, 2.00 to 3.99, 4.00 or greater

Type (Size): Supergiant, Bright Giant, Giant, Subgiant, Main Sequence (Dwarf)

Spectral Class: O, B, A, F, G, K, M

Recommended Constellation Cards:

Below are our recommended groups of stars. The files that contain these stars are labeled.

Base Set —Twenty Cards:

Star	Constellation	Characteristic		Star	Constellation	Characteristic
Sun	None	our star		Alnitak	Orion	hot
Procyon	Canis Minor	close & bright		Betelgeuse	Orion	cool
Capella	Auriga	bright		Mintaka	Orion	hot
Menkalinan	Auriga			Rigel	Orion	
Aludra	Canis Major	far		Antares	Scorpius	cool
Sirius	Canis Major	close & bright		Shaula	Scorpius	
Altais	Draco			Aldebaran	Taurus	
Eltanin	Draco			El Nath	Taurus	
Regulus	Leo			Dubhe	Ursa Major	
Denebula	Leo			Merak	Ursa Major	

Extended Set—Twenty-one to Thirty Cards:

Add: Albireo and Deneb (Cygnus), Algieba (Leo), Arneb and Nihal (Lepus), Thuban and Rastaban (Draco), Zosma (Leo), and Alkaid and Mizar (Ursa Major).

Directions for Making the Cards:

The materials below will make one set of 30 cards, either Set A or Set B.

Materials:

- Constellation Classification Card Set
- 12x9 construction paper as follows:
 - 6 sheets white
 - 3 sheets blue
 - 3 sheets yellow
 - 4 sheets orange
 - 1 sheet red
- Paper cutter, X-ACTO knife, or scissors
- Tape or glue
- Laminating supplies

Procedure:

1. Make copies of the original card set. Cut each sheet in half so that there is one star per card.
2. Cut each sheet of construction paper in half. Locate the cards for stars that are *only one color*. For example, the star Antares in the constellation Scorpius is a red star.
3. Center and glue each single color star card on 1/2 sheet of the matching color construction paper. There are 2 blue stars, 7 white stars, 2 yellow stars, 5 orange stars, and 2 red stars. **Note: In the case of binary stars in Set B, we have only used the first (brightest) star for classifying purposes in these activities.**
4. Cut the remaining half sheets of construction paper in half again. These will be used with the stars designated with two colors.
5. Combine the colors for the two-color stars by slightly overlapping the center seam and taping to secure them. Center and glue the matching star cards over the taped colors. There are 6 blue-white stars, 3 yellow-white stars, and 3 yellow-orange stars. **Note: In order to have the correct sequence of star colors when aligned by temperature, it is important to glue the two colors on consistently. In Activity Option #1, Step 9, we assume the temperature is aligned with coolest temperature to the left when looking at the students (see the graphics in 8 and 10 below). In order for this activity to work properly, the following sequence is important: for blue-white stars, the blue should be behind the constellation figure and the white behind the text; for yellow-white stars, white should be behind the constellation figure and yellow should be behind the text; and for yellow-orange stars, yellow should be behind the constellation figure and the orange should be behind the text.**

*Loosely derived from a presentation by Vivian Hoette at an NSTA conference in 1995 and subsequently published in “Adler Planetarium Stars Cards Lesson Plan: Among the Winter Stars,” 1995.