

## EXHIBIT DESCRIPTIONS, GOAL & OBJECTIVES

### *Big Dipper*

**Objectives:** Students will learn that the perceived two-dimensionality of the sky is just an illusion, and that the sky has depth.

**How To use:** Look at the grouping of stars from different angles. Then look at through the view hole, and notice that the stars resemble the famous pattern of the Big Dipper. Look again at the stars from other angles, and notice that the Big Dipper pattern is gone.

**Explanation:** The stars in the night sky are so far away that they all seem to be mere points of light, making it impossible to judge depth. Two stars that seem to be close together could actually be very far apart. While some of the stars in the Big Dipper are relatively close together, the two stars at the ends are much farther away, which is impossible to tell just by looking at the night sky. Because of the three-dimensionality of constellations, you will not see the same patterns if you make significant changes in your position in space.

**Concepts:** constellations, space, distance



**Watch the video titled “Big Dipper” (2:42) with Dr. Steve Lord of NASA’s Infrared Processing and Analysis Center at the California Institute of Technology. This video describes how our understanding of star motion has evolved and how that motion affects the constellations.**

# Big Dipper

## Illinois Assessment Framework Grade 4

- 12.4.47** Identify the order of planets from the sun, and know that the further planets take longer to go around the sun. Understand that all planets in our solar system revolve around the sun. Because Earth revolves around the sun, objects (e.g., stars, planets, constellations) in the sky appear to change positions throughout the year. Know that it takes Earth  $365 \frac{1}{4}$  days to revolve around the sun.
- 12.4.49** Define a **constellation** as a group of stars that form a pattern in the sky. Understand that constellations are useful in the study of space because they help create a map of the sky. Know that locations in the sky are often described using the names of constellations.

**Mission:** Determine the true shape of the Big Dipper.

**Instructions:** Look through the eyepiece to see the Big Dipper as it looks from Earth.

**Information:** Stars that look close together from Earth may really be far apart. This model shows how stars in the Big Dipper are aligned.

<b>Light-years:</b>	Alkaid	101 light-years
	Mizar	78 light-years
	Aloith	81 light-years
	Megrez	81 light years
	Phecda	84 light-years
	Merak	79 light-years
	Dubhe	124 light-years

# Big Dipper

## Illinois Assessment Framework Grade 7

**12.7.101** Define **light year**, how many kilometers it is, and know that galactic distances may be measured in millions and billions of light years.

**11.7.02** Distinguish among and answer questions about performing the following: observing, drawing a conclusion based on observation, forming a hypothesis, conducting an experiment, organizing data, constructing and reading charts and graphs, and comparing data. Recognize the **common units of the metric system**.

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## **AMONG THE STARS OF WINTER**

Star Cards and Lesson Plan by Vivian Hoette

**LEVEL** Third through tenth grade students.

**INSTRUCTIONAL ARRANGEMENT** There should be open space (a hallway or an open area in the classroom, etc.) for students to form groups or lines.

**RATIONALE** Personalizing star information allows students to understand physical characteristics of stars in a familiar way, association individual stars with members of the student group and sorting stars while sorting the people who have information about those stars on cards.

**LENGTH** Twenty minutes or more depending on the teacher's objectives and the students' interests. Star cards may be used on several occasions or with different grade levels depending on lesson objective.

### ***OBJECTIVES***

- Students will learn that stars vary in: color, brightness, true size and luminosity, distance from Earth, temperature, etc. Stars are identified by their place within a constellation pattern.
- Students will learn that the peak color in a star's light is related to the star's surface temperature.
- Students will learn that most of the stars we see in the night sky are bigger and brighter than the Sun.
- Using star data as a source of comparison and classification, students will practise classification, ordering, and application of numerical skills involving positive and negative numbers, the number line, decimals to the hundredth place, and number names up to hundreds of thousands.
- Students will become familiar with star and constellation names and historic constellation figures.

### ***MATERIALS and PREPARATION***

1. Cut apart the star cards of the forty or so named stars belonging to constellations of the Winter Circle (Orion, Lepus, Canis Major, Canis Minor, Gemini, Auriga, Taurus).
2. Mount the cards on red, orange, yellow, white, blue-white or blue construction paper to match the peak color of each star's spectrum. Laminate the cards.

Use a marker to write the name of the star and its constellation in large letters on the back of the card. Use uppercase for the first letter and lowercase for the remaining letters of the star's name. Use all uppercase for the name of the constellation.

## **PROCEDURE**

### **Engage student interest.**

- Ask students to observe the night sky on a clear evening or view constellation slides in class. Invite the students to sketch, share, and discuss their observations.
- Randomly drop stars of different sizes and colors onto dark construction paper. Ask students to glue down the stars, create drawings around them, and tell or write stories about the drawings.

### **Allow Students to Explore and Classify Stars.**

1. Let students select a particular star card, or pass out cards randomly. (Some teachers use the cards as a basis for cooperative group arrangements.)
2. Ask students to study the information on the cards. Give them time to look over the cards and compare the information on their card with information on the cards of their classmates.
3. Ask the group if anyone has an idea about how these stars could be organized. (As we look at the stars in the night sky they seem “stuck” in their constellations. In this activity, students are able to arrange and rearrange stars according to their apparent and physical properties.)
4. As different ideas are suggested, encourage the person who suggested the idea to organize people in the class (each representing a different star) to form groups or lines illustrating the plan suggested. Encourage student leadership.

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**AMONG THE STARS OF WINTER DATABASE II**

Star Name	Greek Letter	Star Luminosity Class	Temperature in Kelvins (K)	Diameter in Suns	Lumin. in Suns	Apparent Magnitude	Absolute Magnitude	Spectral Type
Capella	α	giant	5,100	11	72	0.08	0.09	G8 III
Menkalinan	β	subgiant	9,000	2	45	1.9 var.	0.6	A2 IV
Almaaz	ε	supergiant	7,200	365	200,000	2.99 var.	-8.5	F0 Ia
Hoedus II	η	main sequence	21,000	3	377	3.17	-1.7	B3 V
Hassaleh	ι	bright giant	4,200	73	655	2.69	-2.3	K3 II
Theta Auriga	θ	peculiar	10,000	2	146	2.62 var.	-0.7	A0 pec
Hoedus I	ζ	bright giant	4,300	53	655	3.75 var.	-2.3	K4 II
Sirius	α	main sequence	9,700	2	21	-1.46	1.42	A1 V
Mirzam	β	bright giant	26,000	4	6,500	1.98 var.	-4.8	B1 II
Wezen	δ	supergiant	6,000	365	125,000	1.86	-8	F8 Ia
Adhara	ε	bright giant	20,000	5	4,500	1.5	-4.4	B2 II
Muliphen	γ	bright giant	14,000	5	1,803	4.11	-3.4	B8 II
Aludra	η	supergiant	14,500	37	50,000	2.44	-7	B5 Ia
Furud	ζ	main sequence	18,000	2	377	3.02	-1.7	B2.5 V
Procyon	α	subgiant	6,700	2	7	0.38	2.64	F5 IV
Gomaisa	β	main sequence	13,000	2	95	2.90 var.	-0.2	B8 Ve
Castor	α	main sequence	9,300	2	28	1.58	1.14	A1 V
Pollux	β	giant	4,900	9	32	1.14	0.98	K0 IIIb
Wasat	δ	subgiant	7,000	2	8	3.53	2.46	F2 IV
Mebstuta	ε	supergiant	5,000	33	175	2.98	-0.9	G8 Ib
Alhena	γ	subgiant	9,800	3	79	1.93	0	A0 IV
Propus	η	giant	3,100	34	125	3.28 var.	-0.5	M3 III
Tejat Post.	μ	giant	2,900	35	125	2.88 var.	-0.5	M3 IIIa
Alzirr	ξ	giant	6,600	2	11	3.36	2.1	F5 III
Mekbuda	ζ	supergiant	5,700	86	5,000	3.79 var.	-4.5	G0 Ib
Amed	α	supergiant	7,400	32	6,000	2.58	-4.7	F0 Ib
Nihal	β	bright giant	5,600	30	545	2.84	-2.1	G5 II
Betelgeuse	α	supergiant	3,400	265	5,000	0.50 var.	-4.5	M1 Iab
Rigel	β	supergiant	13,000	58	55,000	0.12	-7.1	B8 Iac
Mintaka	δ	giant	24,000	13	50,000	2.23 var.	-7	B0 III
Alnilam	ε	supergiant	23,000	16	25,000	1.70 var.	-6.2	B0 Iae
Bellatrix	γ	giant	23,000	3	2,168	1.64	-3.6	B2 III
Algiebba	η	main sequence	19,000	8	1,977	3.36 var.	-3.5	B1 V
Nair al Saif	ι	giant	28,000	6	20,000	2.77	-6	O9 III
Saiph	κ	supergiant	22,000	4	525	2.06	-2.1	B0.5 Ia
Meissa	λ	not identified	35,000	3	552	3.66	-2.2	O8 e
Alnitak	ζ	supergiant	28,000	80	34,000	2.05	-6.6	O9.5 Ib
Aldebaran	α	giant	4,000	34	137	0.85 var.	-0.6	K5 III
El Nath	β	giant	14,000	2	344	1.65	-1.6	B7 III
Ain	ε	giant	5,000	13	65	3.53	0.2	G9.5 III
Al Hecka	ζ	giant	18,000	4	1247	3	-3	B4 III
Alcyone	η	giant	15,000	3	344	2.87	-1.6	B7 III
Sun		main sequence	5,800	1	1	-26.72	4.74	G2 V

### AMONG THE STARS OF WINTER DATABASE III

Star Name	Significance of star name
Capella	little she-goat; goat star; rainy goat star
Menkalinan	shoulder of the rein holder
Almaaz	he-goat; western goat star; signal for close of navigation; also called Al Anz
Hoedus II	one of the kid goats; rising before Sun marks stormy season
Hassaleh	marks back of charioteer's knee
Theta Auriga	marks wrist of charioteer
Hoedus I	one off the kid goats; rising before Sun marks stormy season
Sirius	sparkling; dog star; scorching one, rising before Sun on hottest days of summer
Mirzam	roarer, or announcer of Sirius
Wezen	weight; also called Wesen
Adhara	maiden; attendant of Suhail who married Orion
Muliphen	marks the top of the dog's head
Aludra	maiden; attendant of Suhail who married Orion
Furud	male ape; also called Phurud
Procyon	before the dog (rising before Sirius); water dog (near Milky Way)
Gomaisa	watery eyed (near Milky Way); also called Mirzam
Castor	horseman; mortal twin
Pollux	boxer; immortal twin
Wasat	middle of the sky (near the ecliptic)
Mebuta	outstretched paw of the lion
Alhena	brand mark
Propus	the projecting foot; also called Tehat Prior
Tejat Post.	heel
Alzirr	button
Mekbuda	folded paw of the lion
Amed	the hare
Nihal	camels quenching their thirst
Betelgeuse	arm of central one; armpit of white belted sheep
Rigel	left leg of giant; Orion's left foot
Mintaka	belt
Alnilam	string of pearls
Bellatrix	Amazon female warrior
Algiebba	handle of the sword
Nair al Saif	bright one of the sword
Saiph	sword of powerful one
Meissa	glittering star
Alnitak	girdle
Aldebaran	follower (of the Pleiades); eye of the bull
El Nath	the one butting with horns
Ain	eye
Al Hecka	white one
Alcyone	brightest one of the Pleiades (Seven Sisters)

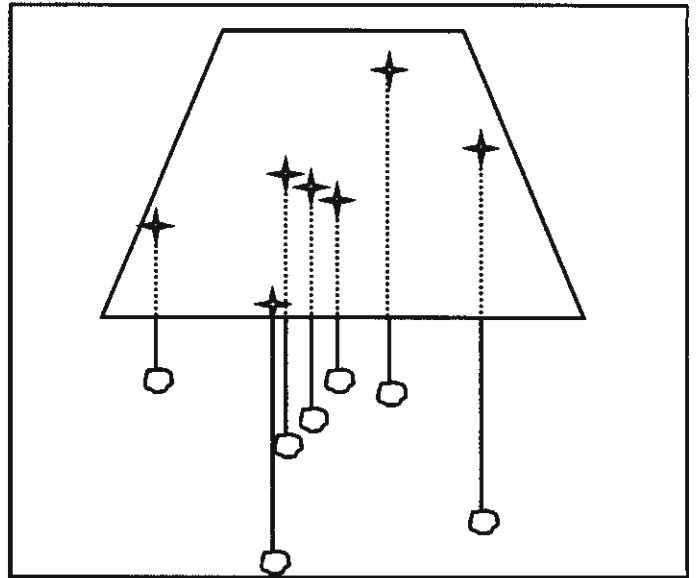
## Orion-in-the Round

### Creating the constellation Orion In-the-Round

Orion, the Hunter, is one of the few constellations that looks like what it is supposed to be. The stars that make up Orion lie at very different distances from the Sun, but their resemblance to a human figure can only be seen from one angle. Viewed from another angle, they would not look anything like the hunter. Make this model of Orion and find out!

#### Materials needed:

Large piece of cardboard (15" by 12")  
Ruler  
7 cotton balls  
String  
Glue or tape  
Pin or scissors (to make holes)



#### Instructions:

Tie string around each cotton ball (which represents a star), leaving at least 20 inches of string trailing off from the cotton ball. Place cardboard so that the long side is facing you. That side will be called the "front". For each star, measure as far along the front edge from the right hand corner as indicated by the number in the column marked "Measurement from Right". Then, measure back along a line perpendicular to that edge, a distance equal to that in the column marked "Measurement from Front", and make a hole in the cardboard with a pin or the tip of a scissors at that point. Thread one string through the hole so that the cotton ball hangs down under the cardboard the same distance as in the column marked "Length of String". Tape or glue the string to the top of the cardboard so that the "star" will not move. When all the stars have been put in their place in space, hold the cardboard up so that the "front" is again facing you. You will see the stars of Orion in their familiar pattern. Turning the cardboard will show the positions of the stars in space relative to one another. Also, note that the stars only look like a hunter when viewed from certain perspectives.

Orion In-the-Round continued...

Name of Star	Measurement from Right	Measurement from Front	Length of String
Betelgeuse - the right shoulder	13 3/4"	1 7/16"	1 15/16"
Rigel - the left foot	3 3/4"	4 7/16"	13 5/8"
Bellatrix - the left shoulder	6 1/4"	1 5/8"	2 3/4"
Mintaka - westernmost in the belt	8"	10 13/16"	7 3/4"
Alnilam - center of belt	9"	5 9/16"	8 3/8"
Alnitak - easternmost of the belt	10 1/4"	5 1/8"	8 15/16"
Saiph - the right foot	12"	5/16"	14 3/4"

## **EXPLAIN ASTRONOMY CONCEPTS**

(follow-up to AMONG THE STARS OF WINTER)

Discuss the astronomy concepts and content of the various data fields presented on the cards as students suggest ways to organize the stars.

**Star names:** The names of stars are very old. Meanings that do not make sense when looking at the constellation drawings may give clues to the origination of names from earlier cultures who have imagined different pictures in the stars and told different stories. Often star names refer to significant rising and setting times, seasonal and meteorological events, as well as to imaginary figures.

**Identification:** On constellation drawings, brighter stars are identified by Greek letters assigned by Johann Bayer in 1601. These stars are identified by the Greek letter and the constellation name in the Latin genitive case. This identification is given in its abbreviated and entire form.

**Distance:** Distance in space is measured in light-years. One light-year is the distance light travels in a year, about 9.5 trillion kilometers or about 6 trillion miles.

**Peak Color:** Starlight is studied by spectroscopy (using diffraction to break light into its component colors). Depending on how hot a star is, the light emitted from the star shines brightest in certain wavelengths. Stars whose spectra peak in the red are cooler than stars whose spectra peak in the blue.

**Temperature in Kelvins:** This is the surface temperature of the star. When one organizes the stars by surface temperature, one also sees the relationship of peak color to temperature.

Astronomers use the Kelvin scale. Scale changes in Kelvin (K) are equivalent to those in Celsius; the difference is the placement of zero. Absolute zero in Kelvin is 0 K; absolute zero in Celsius is -273.150 degrees. Freezing in Kelvin is 273.150 K; freezing in Celsius is 0 degrees. Boiling in Kelvin is 373.150 K; boiling in Celsius is 100 degrees. One reads the temperature in the Kelvin scale as so many Kelvins rather than using the word degrees as with the Celsius or Fahrenheit scales.

**Star's Class (called Luminosity by astronomers):** The stage of the star's "life" cycle. Most stars spend most of their existence in the main

sequence phase. Later, stars enlarge dramatically to become giant or supergiant stars. Finally, most stars shrink to become white, red, or black dwarfs. Some stars explode to become supernovae while their cores collapse to become extremely dense neutron stars or black holes.

**Diameter:** Width of the star, as compared to the Sun.

**Luminosity:** Total light energy emitted by the star, as compared to the Sun.

**Magnitude Scales:** A measure of the brightness of a star. The magnitude scale is logarithmic (2.5 times the brightness between consecutive numbers). Our eyes see light logarithmically. Magnitudes describe brightness inversely so that smaller numbers indicate brighter stars; zero and negative numbers indicate still greater brightness.



**Apparent Magnitude:** How bright the star appears or seems to be as we observe it from Earth. The system was first set up ages ago with a scale of one to six. One was for the brightest stars and six was for the faintest stars people could see. Since that time we have been able to measure the brightness of stars more accurately. The apparent magnitude scale now extends to zero and negative numbers for the very brightest stars.

**Absolute Magnitude:** True or intrinsic brightness of a star; this scale measures the stars as if they were all the same distance away (about 32.6 light years).

**Spectral Type:** Spectral classifications are O, B, A, F, G, K, and M. O stars are the hottest and M stars are the coolest. Luminosity class is indicated by Roman numerals. I is supergiant; II is bright giant; III is giant; IV is subgiant; and V is main sequence. Spectral and luminosity classes are further subdivided with numbers and letters.

**Constellation Drawings:** The drawings of Auriga, Canis Major, Canis Minor, Gemini, and Orion are adapted from Johann Bode, 1801. The drawing of Taurus is adapted from John Bevis (based on Bayer), 1750. The drawing of Lepus is adapted from Pardies.

### Enhance Student Interest

- Plan a field trip for your students to a planetarium near your school.
- Arrange to bring a portable planetarium to your school.

- Plan a star party inviting an amateur astronomer to bring a telescope to your school in the evening.
- Use diffraction gratings or prisms to analyze various sources of light.
- Visit the library to find books on astronomy and constellations. Research constellations stories.

### **Evaluate Students' Understanding**

- Give individuals or small groups of students a subset of star cards and ask them to organize and group the stars by various criteria. Ask students to explain their classification systems.
- Ask individuals or groups to brainstorm all the ways stars are different from each other and the ways stars are alike. Do this as both a pre- and post-evaluation of students' ideas about stars.
- Use the KWL (Know? Want to know? Learned?) method. What do you already know about stars? What do you want to know about stars? Pose these questions to students before the activity. After the activity ask students to write or discuss what they have learned about stars.

### **ABOUT THE DATABASE**

*The physical star data used for this set of cards was drawn from StarList 2000 by Richard Dibon-Smith who also provided updated data regarding Alnitak, Betelgeuse, Mebsuta, and Saiph. The temperature values were determined by the author using a variety of methods. Star data varies widely depending on the reference work one is using. Conflicting data results as astronomers learn more about stars, refer to different data sets or use different methods of analyzing data. The author accepts full responsibility for errors not accounted for by the range of values found in the available astronomical reference works.*

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## LIGHT TRAVELS AS A GAME

### Performance Standard 11A.D, 12C, 13A

Students will apply the processes of technological design to compare the properties of various kinds of energy:

- *Knowledge:* Identify the ways that light can travel because it is a form of energy.
- *Application:* Design ways to demonstrate how light travels.
- *Communication:* Explain how the ways that light travels can apply to other kinds of energy.

### Procedures

1. In order to know and apply concepts that describe properties of force, matter and energy and the interactions between them (12C), and the concepts, principles and processes of scientific inquiry (11A) and technological design (11C), students should experience sufficient learning opportunities to develop the following:
  - Identifying technological design dilemma associated with testing how light travels by brainstorming possible ways to observe light using mirrors, prisms, clear and clouded materials.
  - Determine procedural sequence, success criteria and design options to 'construct' a light pathway game board prototype with obstacles to investigate how light energy is affected.
  - Display and analyze data from investigation.
  - Communicate the findings to explain how light travels.
  - Generate possible alternative designs for testing light again.
  - Generalize how other forms of energy are similar to light.

*Note to teacher:* This activity relates to knowledge associated with the Illinois standard 12C, while addressing the performance descriptors for stage D within standard 11B. Applying scientific habits of mind and principles of safety noted in standard 13A are foundational. (**Safety note:** If penlight pointers are used; students should be advised of the danger of looking directly into the beam of light or pointing them at other student's eyes. Precautions for the safe use of mirrors and glass squares should be discussed.)
2. Have students review and discuss the assessment task and how the rubric will be used to evaluate their work.
3. For Patterns in Energy Using Light investigation ask students to describe their current understanding about how a mirror works, what a prism does, how light starts and stops, what reflecting means, how lasers work, where light goes. Then, ask where students learned what they already know about light.
4. Small groups of students should initially practice with different materials to see how light is affected: Allow them to use prisms and see how they refract regular (white) light (from a focused flashlight, etc.) into a rainbow of colors;

test mirrors for their capabilities to reflect light; experiment with various materials such as colored filters, waxed paper, clear glass, translucent (clouded) glass, to see how they allow light to travel through. Encourage multiple combinations of materials.

5. The technological design component of this activity needs to focus on the design of a light pathway game board so that light (from a penlight pointer) can travel through a determined number of obstacles to get to the end of the path along a predetermined length or space. Students will need to develop their rules and success criteria for a light pathway game board prototype which can use prisms, mirrors, transparent and translucent materials, colored filters, etc. Ideas for their success criteria could be:
  - How many light obstacles are used? (at least 3)
  - Does the path make a full circle or square?
  - Is the display the most colorful or have the longest path?
  - Does it display options of reflection, refraction and absorption or combinations of these options, etc.?
6. Students will need to sketch out the game board's projected light pathway and predict what will happen at each obstacle. They should test their game board with a penlight pointer to adjust locations of their obstacles, through which their final pathway must follow. Adjustments to design are allowed.
7. Students must display their final light pathway game board and determine the success of the design based on the class-determined criteria. Require students to generate one or more proposals for how to improve their prototype. They may suggest adjustments to success criteria for more testing.
8. Ask students to propose their generalizations about how energy travels based on what they have learned about light. Do other forms of energy heat, sound, electrical, mechanical energy travel in the same ways as light? They should submit a written conclusion about their design, its success according to class criteria, improvement possibilities and energy generalizations.
9. Evaluate each student's work using the Science Rubric as follows and add the scores to determine the performance level:
  - *Knowledge*: Identifications of reflection, refraction, absorption and transmission were complete and correct.
  - *Application*: Demonstrations of light travel through and around different obstacles were complete and correct.
  - *Communication*: Explanations of light energy travel were thorough and accurate; generalizations to other forms of energy were logical and promoted additional interest in investigations.

### **Time Requirements**

- 20-30 minutes for introductory group demonstrations of light energy possibilities; 20-40 minutes to design and test prototype; 20-30 minutes to discuss tests and conclusions.

**Resources**

- Game board paper to trace light pathway and placement of obstacles
- Obstacles such as prisms, mirrors (1-inch-square safety mirrors), waxed paper, colored gel filters, clear and frosted glass (1 inch squares of safety glass), etc.
- Penlights for individual group use
- Science rubric

## WHERE ARE THE STARS?

### Performance Standard 12F/11A/13A.H

Students will apply the processes of scientific inquiry to compare the view from the Earth to the galaxies accordingly:

- *Knowledge:* Understand the categories of comparisons between stars.
- *Application:* Formulate strategies for classification of stars through various physical and graphic displays.
- *Communication:* Explain the basis for classification of stars within and between various constellations.

### Procedures:

1. In order to know and apply the concepts that explain the composition and structure of the universe and Earth's place in it (12F), the concepts, principles and processes of scientific inquiry (11A), and know and apply the accepted practices of science (13A), students should experience sufficient learning opportunities to develop the following
  - Generate inquiry questions and eventual hypotheses which address the classification variations of stars in constellations.
  - Differentiate qualitative and quantitative astronomical data and their applicability.
  - Use conceptual, mathematical and physical models of stars within and between selected constellations.
  - Distinguish relationships of scientific models and hypotheses.
  - Interpret and represent analysis of astronomical data about constellation members.
  - Analyze research and data for supporting or refuting the selected hypotheses.
  - Report, display and defend the data analysis of constellation members and other star groupings.
  - Generate further questions for star classifications.

*Note to teacher:* This activity relates to knowledge associated with standard 12F, while addressing the performance descriptors for stage H within standard 11A. Applying scientific habits of mind noted in standard 13A are applicable. The teacher and classroom resources provided for this activity are supplied with permission from Vivian Hoette, University of Chicago, Yerkes Observatory. It is suggested that each constellation's star cards should be printed onto colored stock paper according to the noted star's peak color. The cards could be laminated for reuse.

2. Have students review and discuss the assessment task and how the rubric will be used to evaluate their work.
3. This activity can introduce or reinforce information about the characteristics of Stars of Winter (for the Northern Hemisphere). Randomly distribute the star cards among the students. Ask students to assemble

themselves by the constellations in which their selected star is found. Ask students to focus on the individual star on their card. Ask students to propose additional arrangements for the stars they represent (other than by constellation). Color is among the most obvious of the properties, so when it is suggested, ask the students to group themselves accordingly. Constellation groups will now disperse, demonstrating that all stars in a constellation are not the same color. This may precipitate questions or reinforce an understanding of the colors of stars. Record all student-generated questions for further individual research. Ask for another criterion for arranging the stars. As it is also an early entry on each of the cards, students may suggest temperature. When brought up, ask students to line up in temperature order, specifying a location for the coolest and hottest stars. Students should find they have stayed within their color group, organizing by delineations of temperature. Ask students what they observe the peak color of a star is determined by its surface temperature. As students suggest other ways of arranging, have students do so, always specifying a position for the maximal and minimal values of each property. It is recommended that a couple of students who suggested the physical characteristic - distance from Earth, diameter, luminosity, apparent and absolute magnitudes be responsible for seeing the order is correct.

4. Ask students to observe the arrangements and make a hypothesis as to what the arrangements reveals about the nature of stars. Teachers can add technical information to supplement student concepts of the properties. Inquire whether the posed hypotheses match previous understanding of stars or produce somewhat contradictory ideas. This can introduce or reinforce the understanding of the relationships of scientific theories, models, hypotheses, experiments and methodologies used by scientists (accepted practices of science). Students should graphically represent their hypotheses, using models, bar/line graphs, etc., and present the analysis of their findings. Following class presentations, students should generalize their understandings about the locations and properties of the stars in the winter constellations.
5. Evaluate each student's work using the Science Rubric as follows and determine the performance level.
  - *Knowledge:* The categories and bases for comparisons between stars are explained correctly and thoroughly.
  - *Application:* The physical and graphic displays of selected star characteristic are portrayed accurately and comply with appropriate mathematical requirements.
  - *Communication:* The basis for students' classification of stars within and between various constellations is explained thoroughly and appropriately, using the correct terms and modeling strategies.

**Time requirements:** 1 class period for initial star card activity; 1-2 class period(s) for preparation of graphic display for star data groupings; 1 class period for class presentation.

**Resources:**

- Star cards printed on stock or construction paper (yellow, orange, white, red, light and dark blue).
- Appropriate graphing or modeling resources.
- Science rubric.

**Teacher notes:**

Possible hypotheses:

- ★ that stars within a constellation can be far different than or similar to others stars in that grouping,
- ★ that stars that appear close in the sky can actually be huge (astronomical) distances from each other and from Earth,
- ★ that apparent magnitude is a function of distance from Earth - the greater the distance, the lesser the magnitude and vice versa, so the sun has a large apparent magnitude,
- ★ that absolute magnitude is a function of luminosity, so the sun is, by comparison, a star of low luminosity (it can be explained that absolute magnitude is based on placing all stars an imaginary 33 light years from Earth), that levels of magnitude are like golf scores; the smaller the value (or larger the absolute value of a negative integer) the greater the magnitude of that star; conversely, the larger the value of a positive integer, the lesser the intensity), and
- ★ that size of star is a function of luminosity.

**Possible extension activities:**


- ★ Study summer constellations not included in the star cards. Students can produce star cards of similar format to those used in class, including attaching to appropriately-colored paper. Pre-investigation of internet or library resources by teacher will minimize a lack of information available to some students. Constellation groups present their findings with a diagram of the star formation (holes punched in dark paper for display on an overhead projector). Individual presenters should compare their star to sun or other well-known star such as Polaris to demonstrate understanding of the physical properties of stars. For example, a presenter can say the star has an apparent magnitude about four times that of the sun or 1/4 that of Polaris, or that their star is about half the distance from the Earth as another star.
- ★ Create a personal, albeit imaginary, constellation and apply knowledge to that grouping. Start by using a grid of graphing paper, with letters in alphabetical order along one axis, letters of their name in spelling order


along the other. Students poke through grid squares where each name letter matches the alphabetical letter. Students then transfer this template of holes to marks on a piece of construction paper and appropriately-sized sticker stars are placed on these marks. Students then create a figure or shape that encompasses the pattern of stars, but is not a “connect-the-dots” puzzle. They then name their constellation, based on their name or the shape they have chosen. The presenting student then chooses a star in the design and creates imaginary data for this star. Their presentation, however, must reflect an understanding of the physical properties of stars. For example, if the chosen star has a Kelvin temperature of 10,000, acquired knowledge should lead the student to say it is probably a blue-white body; distant stars should have high value apparent magnitude (meaning “being less visible in the sky”); greatly luminous stars should have a low value (or even negative value) absolute magnitude.


# MISSION 3:

# Star Viewer

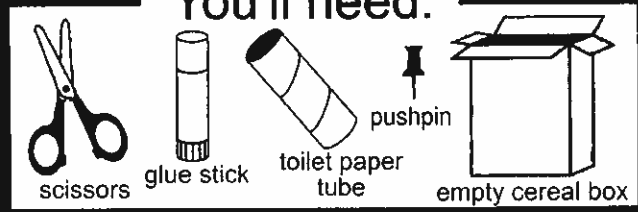
**BUILD IT!**

**1**  Cut out the star cards below on the dotted lines.


**2**  Glue the page to a piece of cardboard from a cereal box.


**3**  Carefully cut out the cards.

You'll need:

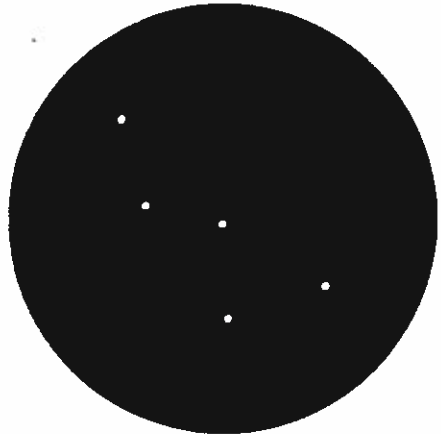


scissors glue stick toilet paper tube pushpin empty cereal box

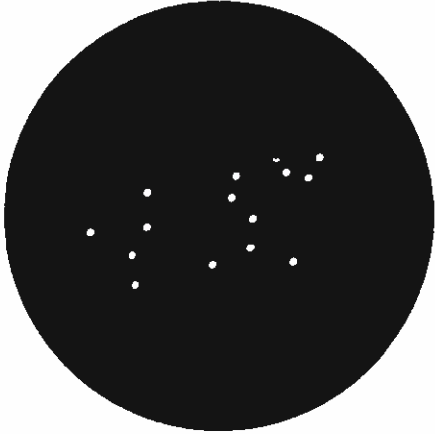
**4**  carefully poke a hole through every white dot on the cards.

**5**  Hold a card against the end of a toilet paper tube and look through.

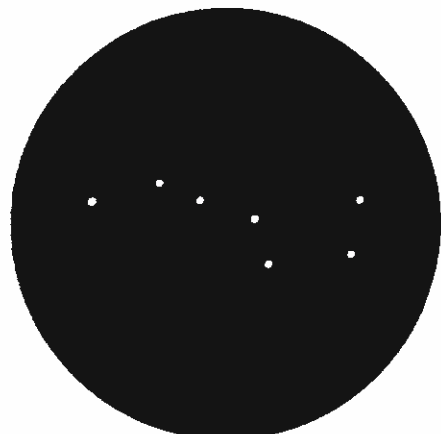
## Cassiopeia



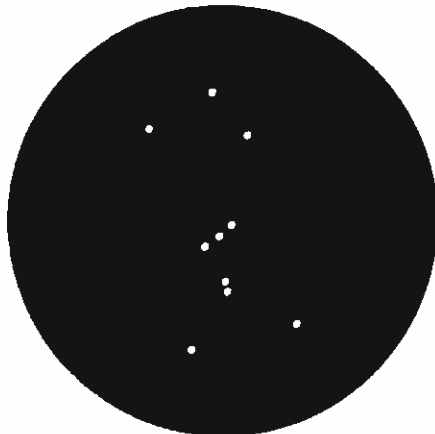
## Leo (the Lion)



## Big Dipper



## Orion (the Hunter)



CUT ALONG THE DOTTED LINES

