Emera Astronomy Center
and M. F. Jordan Planetarium

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Cosmic Classroom Guide

STARS!

COMPILED & EDITED BY LEISA PREBLE

THE UNIVERSITY OF MAINE

A Member of the University of Maine System

Emera Astronomy Center
and M. F. Jordan Planetarium

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Mission Statement:
The mission of the Maynard F. Jordan Planetarium of the University of Maine is to provide the University and the public with educational multi-media programs and observational activities in astronomy and related subjects.

Cosmic Classroom

Looking for fun and interesting space activities? The planetarium staff has prepared a collection of materials we call the Cosmic Classroom for you to use before and/or after your visit. These materials are entirely for use at your own discretion and are not intended to be required curricula or a prerequisite to any planetarium visit. The Cosmic Classroom is one more way that the Jordan Planetarium extends its resources to help the front line teacher and support the teaching of astronomy and space science in Maine schools.

The lessons in this Cosmic Classroom have been edited and selected for the range of ages/grades that might attend a showing of this program at the Jordan Planetarium. Those activities that are not focused at your students may be adapted up or down in level. Our staff has invested the time to key these materials to the State of Maine Learning Results in order to save you time.

The State of Maine Learning Results performance indicators have been identified and listed for the program, the Cosmic Classroom as a package, and each individual activity within the package. The guide also includes related vocabulary and a list of other available resources including links to the virtual universe. We intend to support educators, so if there are additions or changes that you think would improve, PLEASE let us know.

Thank you, and may the stars light your way.

The Maynard F. Jordan Planetarium Staff

The Program – *STARS!*

Every star has a story. Some are as old as time, faint and almost forgotten. Others burn bright and end their lives in powerful explosions. New stars are created every day, born of vast clouds of gas and dust. Through every phase of their existence, stars release the energy that lights the Universe. Journey to the furthest reaches of our galaxy and experience both the awesome beauty and the destructive power of stars.

We are very glad that you have chosen to visit our planetarium with your group. We hope that this guide either will help you prepare your group or help you review their experience at the University of Maine's sky theater.

State of Maine Learning Results Guiding Principles

The lessons in this guide, in combination with *Stars*, will help students to work towards some of the Guiding Principles set forth by the State of Maine Learning Results. By the simple act of visiting the planetarium, students of all ages open an avenue for self-directed lifelong learning. A field trip encourages students to think about learning from all environments including those beyond the schoolyard. A Jordan Planetarium visit also introduces visitors to the campus of the largest post-secondary school in Maine and encourages them to think of this as a place which holds opportunities for their future education, enjoyment and success.

Other sites on the University campus, including three museums, explore a variety of subjects, and the Visitors Center is always willing to arrange tours of the campus. A field trip can contribute to many different disciplines of the school curriculum and demonstrate that science is not separate from art, from mathematics, from history, etc. The world is not segregated into neat little boxes with labels such as social studies and science. A field trip is an opportunity for learning in an interdisciplinary setting, to bring it all together and to start the process of thinking. For a more complete discussion of field trips, please visit the Jordan Planetarium web site at http://astro.umaine.edu/

If used in its entirety and accompanied by the Planetarium visit this guide will help students to:

Become **a clear and effective communicator** through

A. oral expression such as class discussions, and written presentations
B. listening to classmates while doing group work, cooperation, and record keeping.

Become **a self-directed and lifelong learner** by

A. introducing students to career and educational opportunities at the University of Maine and the Maynard F. Jordan Planetarium.
B. encouraging students to go further into the study of the subject at hand, and explore the question of "what if?"
C. giving students a chance to use a variety of resources for gathering information

Become **a creative and practical problem solver** by

A. asking students to observe phenomena and problems, and present solutions
B. urging students to ask extending questions and find answers to those questions
C. developing and applying problem solving techniques
D. encouraging alternative outcomes and solutions to presented problems

Become **a collaborative and quality worker** through

A. an understanding of the teamwork necessary to complete tasks
B. applying that understanding and working effectively in assigned groups
C. demonstrating a concern for the quality and accuracy needed to complete an activity

Become **an integrative and informed thinker** by

A. applying concepts learned in one subject area to solve problems and answer questions in another
B. participating in class discussion

State of Maine Learning Results Performance Indicators

In conjunction with the Maynard F. Jordan Planetarium show *STARS!,* this guide will help you meet the following State of Maine Learning Results Performance Indicators in your classroom.

Grades 3-5

Science and Technology –

B1. Skills and Traits of Scientific Inquiry

a. Pose investigable questions and seek answers from reliable sources of scientific information and from their own investigation.
e. Communicate scientific procedures and explanations.

D1. Universe and Solar System

c. Recognize that the sun is a star and is similar to other stars in the universe.

D3. Matter and Energy

d. Describe what happens to the temperatures of objects when a warmer object is near a cooler object

Grades 6-8

Science and Technology -

B1. Skills and Traits of Scientific Inquiry

c. Use appropriate tools, metric units, and techniques to gather, analyze and interpret data.

D1. Universe and Solar System

a. Describe the different kinds of objects in the solar system including planets, sun, moons, asteroids and comets.

c. Describe the location of our solar system in its galaxy and explain that other galaxies exist and that they include stars and planets.

D3. Matter and Energy

i. Use examples of energy transformations from one form to another to explain that energy cannot be created or destroyed.

k. Describe the properties of solar radiation and its interaction with objects on Earth.

NGSS

5-ESS1-1. Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from earth.

5-ESS1.A The Universe and its Stars.
The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth.

5-PS1.2 Make observations and measurements to identify materials based on their properties.

MS-ESS1.A The Universe and the Stars. Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.

Performance Indicators Snapshot

The Show

MLRs – Science and Technology

Grades 3-5.
B1.a, e; D1.c; D3.d

Grades 6-8.
B1.c; D1. a, e; D3. i, k

NGSS
5-ESS1-1, 1.A
5-PS1.2
MS-ESS1.A

The Guide

Grades 3-5.	**Grades 6-8.**
B1.a, e	B1.c
D1.c	D1.a,e
D3.d	D3.i, k

NGSS
5-ESS1-1, 1.A
5-PS1.2
MS-ESS1.A

Colors of Stars

Mary Kay Hemenway
The University of Texas at Austin Department of Astronomy
The University of Texas McDonald Observatory
Adapted for **UT**OPIA by Brad Armosky

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to analyze the effects of heating and cooling processes in systems. (3-5. Science & Technology. D3.c.)
2. Learners will be able to use appropriate tools, metric units and techniques to gather, analyze, and interpret data. (6-8. Science & Technology. B1.c.)

The General Idea:

Students observe colors in the flame of a burning candle to explore connections between matter, light, color, and temperature — basic concepts of matter and energy. They elaborate on these basic concepts in a new context of astronomy and stars. When matter gets hot enough, it emits visible light. When heated to the same temperature, light bulb filaments, horseshoes, and stars will emit the same characteristic blend of color (or wavelengths) of light. Stars are different colors — white, blue, yellow, orange, and red. The color indicates the star's temperature in its photosphere, the layer where the star emits most of its visible light.

Getting Ready:

- Choose one of the following StarDate radio program scripts for students to read, or you may read it aloud to them: "Spring Triangle" or "Denebola."
- Optional: You may wish to check the StarDate Online web site (http://stardate.org) for interesting radio scripts that will help students find stars of different colors in the night sky. See the "Elaborate" section of this activity.
- Distribute to each group of students: white paper, crayons or colored pencils (lots of different colors), and one candle in a candle holder. Remind students of your classroom's safety rules before beginning.

What You Need:

- StarDate radio script ("Denebola" or "Spring Triangle"); included.
- Candles and candle holders (e.g., cupcakes)
- Matches
- White paper
- Crayons or colored pencils. Offer students a wide variety of colors.
- Construction paper
- Colored chalk
- String
- Spherical balloons (yellow and white)
- Ruler or meter stick

What To Do:

Light the candles. Ask the students to draw what they see in the flame, and to pay special attention to the colors they select. Ask students to record the colors they selected to draw the flame. Some students will use a wide variety of blue, yellow, orange, and red to capture the subtle hues in the flame.
Optional: If you have a digital camera, ask each group to take a picture (flash off) of their candle flame. Use the camera *after* students have completed their candle flame drawings.

What To Discuss:

When everyone is finished drawing, ask each group to describe what they saw and respond to the following questions:

1. Which part of the flame do you think is the hottest?
   The blue part is the hottest. Many think that "red" is always the hotter color, so that's what they expect.
2. As you watch the candle flame, what things or events in everyday life come to mind?
   Colors of the flame on a gas stove, camp fire, outdoor charcoal grill fire, rocket engine during liftoff, blowtorch, jet engine…

The answers will usually make the students want to look at their candle flame again, so don't extinguish the flames until all students have reported (unless it becomes a safety issue). Most will notice that the color of the flame is different close to the wick.

Optional: Load the digital images onto a computer to display on a video projector. Each group may refer to these images, as well as their drawings, to describe their flame. In stars, just as in Earth-bound fires, blue is hotter than yellow, and yellow is hotter than red. The Sun is much hotter than a candle flame. Unlike a candle, the Sun uses nuclear fusion as its energy source, not a chemical reaction like burning oil or wood. Stars are different colors because they are different temperatures. They are all "hot" compared to most things on Earth; they range in surface temperature from less then 3000 K to over 50,000 K. Explain to students that when we heat things that don't easily melt (like metal), they first look normal, then begin glowing "red-hot," and later become "white-hot."

Continuations/Extensions:

Draw scale models of stars

Because it is difficult to make three-dimensional models that preserve scale, some of the representations of stars in this activity will be flat. On a sidewalk or parking lot, try drawing colored circles in chalk for the larger stars. You can make the smaller ones out of colored construction paper. To begin, students blow up a yellow balloon to represent the Sun, then a white one that is 2.7 times larger (in diameter and circumference) to represent Vega (guide students through solving this problem):

• Measure the circumference of the yellow balloon (Cy) using string.
• Calculate the circumference of the white balloon: Cw = 2.7 ¥ Cy
• Cut a new string to the length of Cw
• Blow up the white balloon until its circumference is Cw.

Students make paper disks the same diameter and color as these two balloons. Now, they compute how large the disk would be for the larger stars. Making a disk to represent a star is like using a flat picture to represent a person. Stars are spheres of hot gas, round like balloons. Students draw the largest diameters outside (using chalk or tracing the outline with string).
To make a circle:

- Measure a piece of string equal to the calculated diameter.
- Fold the string in half and hold at the center
- Place a piece of chalk where the ends of the string meet and trace a circle.

Use the table provided to scale the star diameters. For example, if you begin with a one centimeter Sun, then Betelgeuse will be 8.3 meters! So, this activity takes a lot of space.

Star	Diameter (Sun's diameter = 1)	Color
Sun	1	Yellow
Betelgeuse in Orion	830	Red
Antares in Scorpius	775	Red
Vega in Lyra	2.7	White
Rigel in Orion	50	Blue
Proxima Centauri C (closest star to the Sun)	0.03	Red
Dubhe (brightest star in the Big Dipper)	14	Orange

Although stars range in mass from less than one-tenth the mass of the Sun to 100 solar masses, the most massive stars are not the largest. Stars like Betelgeuse and Antares have "puffed up" into red giants hundreds of times the Sun's diameter, yet Betelgeuse is about 20 times more massive than the Sun. There is a lot of empty space inside Betelgeuse. If Betelgeuse is 830 times the Sun's diameter, air at sea level is almost 25,000 times the average density of Betelgeuse.

Evaluate:

Explore (20 points)
(20 points) Candle flame drawing: Students represent the flame with a variety of colors, and accurately proportion parts of the flame. Some may include the wick and candle.

Explain (40 points)
1. Which part of the candle flame do you think is the hottest? Why?
(20 points) Students draw on prior knowledge / everyday experience and their understanding of science concepts in their explanations.
2. As you watch the candle flame, what things or events in everyday life come to mind?
(20 points) Students list a variety of things and/or events:
For instance: jet engine, blowtorch, hot oven, bread toaster coils, camp fire, Space Shuttle launch, the Sun, sunset colors…

Elaborate: Make and draw models of stars (40 points)
Parts 1 and 2: (10 points) Students inflate the yellow balloon to represent the Sun and inflate the white balloon so that its circumference is 2.4 times larger than the Sun balloon.
Parts 3 and 4: (10 points) Students accurately measure and cut out the paper disks, then correctly calculate the scale diameters for the four large stars in the table.
Part 5: (20 points)
Students accurately calculate the model star radii using the table. The radii depend on the scale size they choose for the Sun.
Students use the string and chalk to draw big circles that represent the large stars:
• Measure a piece of string equal to the calculated diameter.
• Fold the string in half and hold at the center.
• Place a piece of chalk where the ends of the string meet and trace a circle.

STARDATE CLASSROOM RESOURCES
StarDate: March 7, 2004

Denebola

Leo, the lion, prowls through our evening sky this month, and stands high overhead around midnight. Its two brightest stars mark opposite ends of the constellation. Regulus, the heart of the lion, is at Leo's western edge. And the second-brightest star, Denebola, marks Leo's tail at the constellation's eastern end. Look for it above and to the left of the full Moon this evening, and to the lower left of the brilliant planet Jupiter.

The name Denebola evolved from the ancient Arabic name Al Dhanab al Asad – the lion's tail.

Like the Sun, Denebola is a main-sequence star -- a sedate, comfortable star in the prime of life. But Denebola is a blue-white star, which means that its surface temperature is several thousand degrees hotter than the Sun's. And if you placed the two stars side by side, Denebola would appear about 15 times brighter than the Sun.

This means that Denebola's consuming its nuclear fuel at a faster rate, so it'll live a shorter life.

Denebola is about 40 light-years from Earth. In other words, a beam of light -- speeding along at almost six TRILLION miles every year -- takes 40 years to travel from Denebola to Earth. The light we see from Denebola tonight left the star not long after the first humans were launched into space.

If intelligent beings live on planets in orbit around Denebola, they should just now be receiving the television broadcasts of those early missions.

We'll talk about another prominent star tomorrow.

STARDATE CLASSROOM RESOURCES
StarDate: March 15, 2004

Spring Triangle

Summer and winter offer two of the most prominent geometric shapes in the night sky – the Summer Triangle and the Winter Circle. These patterns of bright stars dominate the evening sky during their respective seasons – and the Winter Circle is STILL in view in the west as darkness falls.

There's no well-recognized shape for spring, but perhaps there should be. Three bright stars form a tall triangle in the east beginning around 9 p.m. The stars are spread pretty far apart, but they still stand out – especially from cities, where bright lights overpower most of the fainter stars.

The most prominent member of this triangle is Arcturus, the third-brightest star in the night sky. It's in the constellation Bootes, the herdsman. This brilliant yellow-orange star is low in the east in mid-evening, and wheels high across the sky during the night.

It's a type of star known as a giant, which means it's old and bloated – a preview of what our own Sun will look like in several billion years.

Well to the right of Arcturus, just a little lower in the sky, you'll see Spica, the brightest star of Virgo. And well above Spica and a little to its right is Regulus, in the constellation Leo. These stars are quite similar. Like the Sun, they're both in the prime of life. But they're hotter than the Sun, so they shine brighter and bluer.

Look for the bright but wide-spread "Spring Triangle" in the east beginning around 9 o'clock.

Name________________________________

Date_________________________________

The Color of Stars

Student Worksheet

Explore

Draw the candle flame

Explain

1. Which part of the flame do you think is the hottest? Why?

2. As you watch the candle flame, what things or events in everyday life come to mind?

Elaborate: Make and draw scale models of stars

1. Inflate a yellow balloon to represent the Sun.
2. Inflate a white balloon 2.7 times larger than the Sun balloon. The white balloon represents nearby star called Vega. How do you know if the white balloon is 2.7 times bigger?
3. Make paper disks the same diameter and color as the Sun and Vega balloons.
4. Calculate how large the paper disk would be for the larger stars

Star	**Model diameter**
Betelgeuse	
Antares	
Rigel	
Dubhe	

5. Draw the largest circles outside to represent the four large stars. How do you think you could make the circles using string and chalk?

Scale Size and Colors of Stars

Star	**Diameter** (Sun's diameter = 1)	**Color**
Sun	1	Yellow
Betelgeuse in Orion	830	Red
Antares in Scorpius	775	Red
Vega in Lyra	2.7	White
Rigel in Orion	50	Blue
Proxima Centauri C (closest star to the Sun)	0.03	Red
Dubhe (brightest star in the Big Dipper)	14	Orange

Use the table to calculate the model star diameters. For example, if you begin with a one centimeter Sun, then Betelgeuse will be 8.3 meters!

Making Your Own Spectrometer

http://coolcosmos.ipac.caltech.edu/cosmic_games/spectra/makeGrating.htm

Objectives and State of Maine Learning Results Performance Indicators:

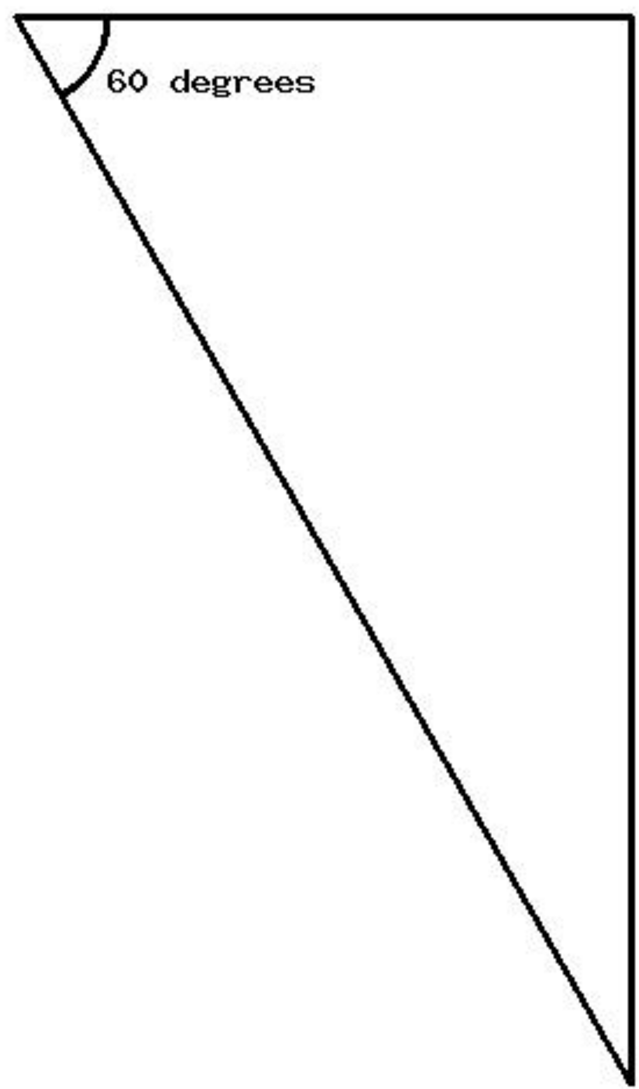
1. Learners will be able to build their own spectrometer. (3-5. Science and Technology. B2.c)
2. Learners will be able to use simple equipment and appropriate units of measurement to observe and collect data. (3-5. Science and Technology. B1.a)

NGSS

1. Learners will be able to define the design problem to ensure a successful solution.

The General Idea:

Simple spectroscopes, like the one described here, are easy to make and offer users a quick look at the color components of visible light. Different light sources (incandescent, fluorescent, etc.) may look the same to the naked eye but will appear differently in the spectroscope. The colors are arranged in the same order but some may be missing and their intensity will vary. The appearance of the spectrum displayed is distinctive and can tell the observer what the light source is.

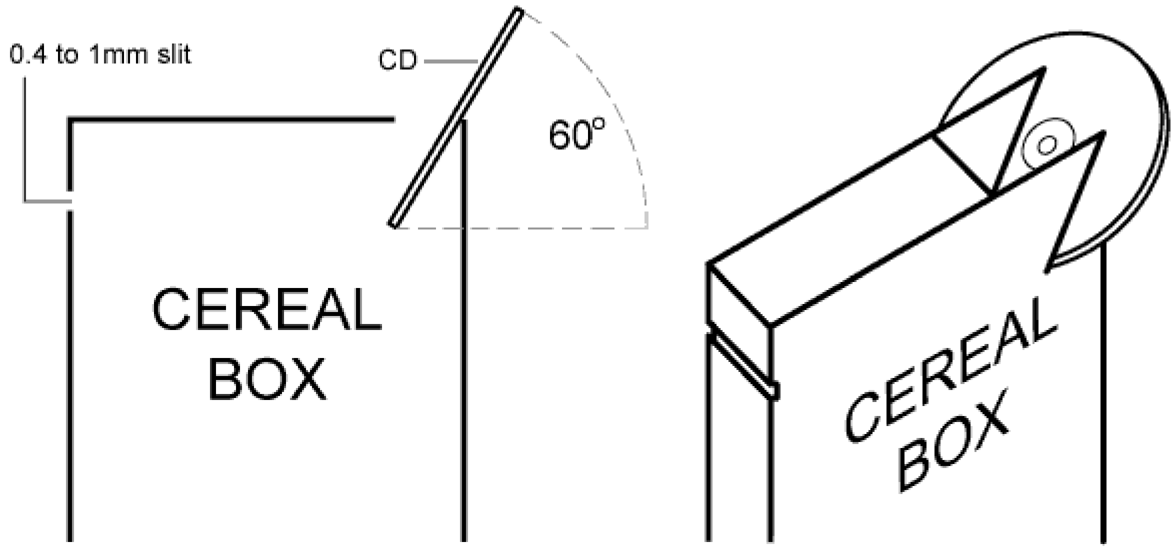


What You Need:

- CD
- Cereal Box (any Size)
- Ruler
- Scotch tape
- Scissors
- Aluminum foil
- 60° angle template (cut out of heavy paper or a manila folder)

What To Do:

1. Divide class into groups of 2 or 3. You will need enough of the above materials so that you have one CD, one cereal box, and one template for each group (or, just build one spectroscope for demonstration for the entire class).
2. On top of the box, measure in 1.5 inches and make a mark.
3. Using the 90 degree edge of the triangle, draw a guideline across the width of the box.
4. Cut along the guideline, then unfold the flaps you just made and cut them off.



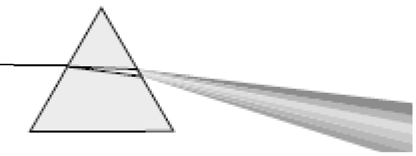
5. Place the short edge of the triangle along the top edge of the box and draw a 3 inch line towards the center of the box; using these lines as guides, cut two 3" slits on both sides of the cereal box as shown.
6. Flip the box over and do the same thing on the other side.
7. Slide the cd into the slits as shown.
8. Now, cut a rectangle out on the opposite long side of the box. The rectangle should be the width of the box and one inch high. The top of the rectangle should be about half an inch from the top of the box. To cut it, first poke a hole towards the top of the box with a pen. Then, cut a rectangle using the hole as a starting point.
9. Take enough aluminum foil to cover the hole and fold it in half; place the creased side towards the middle of the hole and tape it in place.
10. Take a second piece of foil and cover the bottom half of the hole. You want to leave a gap between the two pieces of foil, between .4 and 1 mm. Too wide and the spectra gets blurry. Too narrow, and not enough light gets in.
11. Tape the top of the box closed.

What To Discuss:

- How do astronomers measure the spectra of objects in space? What do those spectra tell us about these objects?
- Investigate other applications for the electromagnetic spectrum.
- Compare student drawn spectra from different light sources. Possible light sources could include:
  The Sun
  A Candle
  Fluorescent Light Bulb
  Mercury Vapor Lamp
  Sodium Lamp

Student Sheet - Simple Spectroscope

Name_______________________________________



Use your spectroscope to analyze the colors of light given off by different sources. Reproduce the spectra you observe with crayons or colored markers in the spaces below. Identify the light sources. (**When using the Sun as a light source, do not look at it directly with your spectroscope. You can harm your eye. Instead, look at sunlight reflected from a white cloud or a sheet of white paper.**)

Light Source: ______________________

Light Source: ______________________

Light Source: ______________________

1. Describe how the spectra of the three light sources you studied differed from each other. How were they similar?

2. Would you be able to identify the light sources if you only saw their visible spectra?

The Maynard F. Jordan Planetarium - Cosmic Classroom Activity

Are All Stars Like the Sun?

This activity was adapted from *Northern Lights, Solar Sprites* produced by IMAGE Education and Public Outreach Team, NASA Goddard Space Flight Center. http://teachspacescience.org/graphics/pdf/10000151.pdf

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to conduct a simple investigation. (3-5. Science & Technology. B1.a)
2. Learners will be able to ask and answer questions about the Sun. (3-5. Science & Technology. D1.c)
3. Learners will be able to use data to construct a reasonable explanation. (3-5. Science & Technology. B1.e)

NGSS:

1. Learners will be able to support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth. (5-ESS1-1. Earth's Place in the Universe.)
2. The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1.A. The Universe and its Stars)

The General Idea:

The Sun is a star like the others stars in the sky, only much closer to Earth. Students think about the Sun as one of many stars rather than as our unique source of light and energy. Stars come in different colors and sizes, but all are sources of energy. We make estimates of the numbers of stars in a segment of the sky, and classify the stars according to their brightness. We then observe colored images of stars, and record our ideas on whether or not all stars are like the Sun, and discuss the importance of studying our nearest star.

What You Need:

- "Star Image handout, one copy in black and white, one copy in color for each group of 2-3 participants
- 1 science journal for each participant

What To Do:

1. Share prior knowledge about stars. Ask participants to share what they already know about stars. Use some of these prompts:
   What do you know about stars?
   How are the stars like our Sun?
   Have you noticed that you can seem more stars in the sky when you are in the country than when you are in the city? Why do you think that is so?
   Have you ever looked at stars through a telescope?
2. Divide participants into groups of 2 or 3 and distribute a black and white image of stars to each group. Ask them to develop a plan for estimating the number of stars in the whole image without counting every star.
3. As the groups work, ask them about their strategies. They may come up with plans such as:
   a) Divide the image into squares. Count the stars in one square, and multiply by the number of squares.
   b) Divide the image into squares, and count the number of stars in a full square and an emptier one. Find the average, and multiply by the number of squares.
   Give each group an opportunity to share their strategies and their estimates. How many

stars do they estimate are in their image?

4. Ask participants what differences they observed in the brightness of the individual stars. Then ask them to pick one or two sections of their star image and classify the stars in that section as faint, medium, or bright. In their star journals, have them record their data on a bar graph with the number of stars along the vertical axis, and the three categories of brightness along the horizontal axis. If necessary, model a bar graph for the group.
5. Invite groups to share their results. Ask them what brightness of star is the most common? Are there more bright stars or more faint stars? Ask the participants to think about what causes the differences in brightness: Are the brightest stars really brighter than other stars, or do they only seem brighter because they are closer to us? Explain that differences in star brightness can be due both to the actual brightness of the star and how far away it is from us. The actual brightness depends on the size (the larger a star is, the brighter it tends to be) and temperature (hot stars are brighter, cooler ones are dimmer). However, how bright a star appears to be also depends on how far away from us it is. A dim star that is very close to us can appear to be brighter than a bright star further away. The Sun, a medium-sized star, is much closer to us than any other star in the sky, and consequently appears to be much brighter.
6. Distribute the colored images of stars and ask participants to describe the stars they see. Ask them what colors they observe? Do you notice any patterns in star color and brightness?

<u>What To Discuss:</u>

- Explain that, even to the naked eye, stars vary slightly in color. Star color is connected to the star's temperature. The hotter stars are bluer in color, the smaller, cooler stars are reddish. Scientists also use spectroscopes to study the light from stars – we can tell what stars are made of by looking at their spectral patterns.
- Explain that the Sun is the only star that is close enough for us to see well. All the others are very far away, and appear just as points of light, even in big telescopes. As we learn more about our own star, we learn more about other stars in the galaxy.
- Ask participants to summarize their thoughts on why it is important to study the Sun. Ask what can we learn by studying the Sun? Why might it be important to find out more about the Sun?

STAR IMAGE

NASA/HST

Life Cycle of Stars

Adler Planetarium & Astronomy Museum
Astronomy Connections: Gravity and Black Holes

Objectives:

1. Learners will understand how stars are formed and produce energy. (6-8. Science and Technology. D3.i.)
2. Learners will be able to demonstrate the motions of stars and other objects. (6-8. Science and Technology. D1.a.)

NGSS:

1. MS-ESS1.A

Purpose:

This activity enables students to enact the lifecycles of different types of stars, thereby illustrating the rarity of black hole-producing stars.

Materials

- 12 Red, 12 Yellow, 4White, and 2 Blue Balloons (1 balloon/student for a class of 30)
- Wooden beads
- Marbles
- Ball bearings
- Pin (to pop balloons)
- Red, yellow, and black markers for writing on balloons

Preparation**:**

Place 1 wooden bead inside each red and yellow balloons.
Place 1 marble inside each white balloon.
Place 1 ball bearing inside each blue balloon.

What to Do:

1. Begin by introducing the ways in which stars come into being and produce energy: through gravity's force and nuclear fusion. Nuclear fusion is the bringing together of atoms to form heavier atoms with a release of energy. This can best be done, perhaps, by asking students to state their ideas of what makes the stars shine.
2. Ask if all stars are the same, and ask students to help make a list of things that might vary between stars: mass, color, heat. Make sure to include "life cycle."
3. Ask if students know how black holes form (answer: they form when certain kinds of stars die). Ask how often students think that black holes form, and if they believe our Sun will form a black hole. Don't forget to ask them to explain the reasons behind their ideas! This information will be helpful to you in determining how best to structure your questions through the rest of the lesson.
4. State that the class will do an activity that illustrates how all of these differences in stars' characteristics are related, and will show when, and how often, black holes form.
5. Pass out balloons, distributing different colors, one balloon per student. You should have significantly more red and yellow balloons than blue and white, roughly 80% red and yellow, 15% white, and 5% blue. Explain that the property that causes the main differences between stars is mass. As you pass out balloons, tell students the approximate mass of their star.
6. Ask students which balloons they think represent the hottest stars. Point out that actually red stars are the coolest, and blue stars are the hottest. Ask what color our Sun is (yellow).

7. Ask which color star students believe will live longest, and why. Write prediction on board. Record differing opinions, too.
8. Guide students through the following series of steps (see next page). For each stage, tell students what to do for their color of balloon. To help students follow the progression, you might write different stages on a board or overhead as you move on, and note important events. Also, ask students to make predictions as you work.

EVALUATION:
Discuss as a class what they saw at different stages of each type of stars' life. Which stars became black holes? Why did only those stars become black holes? Which stars deflated and which exploded? What is the main difference between those stars?

ASSESSMENT:
Compare activity to predictions made at beginning of class. Record conclusions drawn from activity next to predictions, pointing out that changing your ideas is part of being a good scientist.

Life Cycle of Stars Information Chart

	Red Balloons	**Yellow Balloons**	**White Balloons**	**Blue Balloons**
Age of Star	0.4 Solar Mass (2/5 the mass of our Sun): Red stars	1 Solar Mass (the mass of our Sun): Yellow Stars	3 Solar Masses (3 times the mass of our Sun): White	9 Solar Masses (9 times the mass of our Sun): Blue
(start)	Blow up the star to about 3" diameter	Blow up the star to about 3" diameter	Blow up the star to about 3" diameter	Blow up the star to about 3" diameter
5 Million Years	Wait. Do not change diameter of balloon.	Wait. Do not change diameter of balloon.	Wait. Do not change diameter of balloon.	Blow slightly more air into balloon.
10 Million Years	Wait	Wait.	Blow up a little more	Blow up star as fast and as much as you can. When star is fully inflated, teacher pops balloon—a supernova.
500 Million Years	Wait.	Wait (note that planets are forming)	Continue to slowly inflate star. As it gets bigger, star cools, so color it yellow and red (make squiggles on surface with markers).	This popped star has become a black hole; all of the super nova remnants can be thrown out into space.
1 Billion Years	Wait	Blow up a little bit.	Quickly blow up star until fully inflated; pop balloon. Make sure to catch marble	Still black hole!

	Red Balloons	Yellow Balloons	Blue Balloons	White Balloons
8 Billion Years	Wait.	Blow up more. The star is getting cooler, so color it red with marker. It is now a supergiant.	This star has exploded. Holding on to neutron star (marble), throw supernova remnants into space.	Still black hole
10 Billion	Wait	Blow up a little more. Outer envelope dissolves, so cut up balloon. The inside ball becomes a white dwarf, and the bits of balloon represent the planetary nebula.	Neutron star	Black hole
50 billion years	Blow up a little more	Move "planetary nebula" farther away.	Neutron star	Black hole
200 Billion years.	Deflate; star has shrunk and died. Color black. Wooden bead inside is a white dwarf.	Nebula is gone. Discuss that the white wooden bead turns black to show that it has burned out.	Neutron star	Black hole.

A Star Is Born

DiscoverySchool.com
http://www.discoveryschool.com

CREDIT:
Lee Ann Hennig, astronomy teacher, Thomas Jefferson High School for Science and Technology, Alexandria, Virginia.

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to understand that the sun is the principle energy source for phenomena on the Earth's surface. (6-8. Science & Technology. D3.k)
2. Learners will be able to understand characteristics and movement patterns of the various objects in our solar system. (6-8. Science & Technology. D1.a)
3. Learners will be able to understand common characteristics of stars in the universe (6-8. Science & Technology. D1.c)

NGSS:

1. 5-ESS1-2
2. 5-ESS1.A

The General Idea:

Since we cannot watch a star evolve through its entire lifetime, astronomers use their knowledge of a star's behavior at various stages of its life to piece together a picture of the star's entire life.

The most important factor in how a star evolves and eventually dies is its initial mass. (It is assumed that the students already possess background information concerning how stars of different masses evolve—solar mass stars, such as the sun; low-mass stars 0.8 or less than the sun's mass; and higher-mass stars.)

What You Need:

- Only research materials are required for this activity. You might want to have a selection of sources on hand in the classroom, but students should go to the library or the Internet for additional research.
- Reference materials on stellar evolution, including, if possible, examples of images taken by the Hubble space telescope of stars in different stages of development.
- A computer with Internet access

What To Do:

1. Ask your students how they think astronomers can make inferences about the life of a particular star, from its birth to its death, taking into consideration that it is impossible to observe a star's evolution through its entire lifetime.
2. Make sure students understand that because a star's initial mass largely determines how the star will behave at various stages of its life, observing a star at any of those stages can give astronomers information about the star's initial mass and, therefore, about how the star was born, will evolve, and will die.
3. Tell the class that they will be dividing into teams to do research on a star's life. Each team will focus on one aspect of the stellar evolution of a particular star.
4. Assign each of seven teams a star at a particular stage of stellar evolution: proto-star (example: the Eagle Nebula, a stellar nursery), proto-planetary disk and stellar system in formation (example: Orion Nebula), cluster of young stars (example: the Pleiades), middle-aged, normal star (example: the sun), cluster of older stars—red giant (example: Betelgeuse), dying stage—supernova, planetary nebula, white dwarf (example: Supernova 1987A), end state of a star—black dwarf, black hole, neutron star (example: Cygnus X-1).
5. Tell students to keep track of the sources for their facts so that they or other interested classmates can go back to those sources for further information.

6. Encourage students to include visuals in their reports.
7. Have teams report their findings to the class through a poster session, sharing of photographic or printed sources, PowerPoint presentation, or some other format of the students' own choosing.
8. After each team's report, have team members lead a whole-class discussion on what could be inferred about earlier and later stages of the star's development based on information about the star at the stage of stellar evolution the team has researched. What can they infer about the star's initial mass? (For example, our sun will never become a black hole because it has too little mass, and therefore too little gravity. Rather, it will expel a ring of gas rich in heavier elements as a planetary nebula and then contract to become a white dwarf.)

ADAPTATIONS:

Instead of having team members act as discussion leaders, at the end of each report, ask the class specific questions they can answer by making inferences about earlier and later stages of the star's evolution based on information they have learned from the report.

What To Discuss:

1. Explain how the Hubble space telescope's discoveries have improved our understanding of stellar evolution.
2. Debate whether manned space missions should be scheduled during times of increased solar activity. Is space exploration worth the risk of exposing humans to harmful radiation?
3. Discuss what you would expect to see if you were observing a newly forming planetary system. How would the material be distributed? What events would you expect to see on the forming protoplanets?
4. Discuss the two possible explanations of why Venus rotates retrograde and hypothesize and debate alternative explanations.
5. Analyze how astronomers came to the conclusion that Neptune's great dark spot didn't just shift from the southern hemisphere to the northern hemisphere.
6. Our sun is like a giant thermonuclear reactor, generating an incredible amount of energy each second. Fortunately, this violent maelstrom is well contained. Explain how Einstein's famous equation, $E = mc^2$, relates to the sun's energy production. Describe what you think would happen if all the sun's mass were instantly converted to energy.

EVALUATION:

You can evaluate your students on their reports using the following three-point rubric:

- **Three points:** report well researched; information clearly and logically organized; presentation interesting and lively; discussion session well organized
- **Two points:** report adequately researched; information sufficiently organized; presentation dull; discussion session disorganized
- **One point:** report insufficiently researched; information inadequately organized; presentation poorly prepared; discussion session disorganized

You can ask your students to contribute to the assessment rubric by determining a minimum number of facts to be presented in a report and setting up criteria for an interesting and lively presentation.

Continuations/Extensions:

Inner Circle

The three largest terrestrial planets, Earth, Venus, and Mars, share a common heritage in terms of their location in the solar system, composition, and age; however, the path each of these planets took on its evolutionary track is very different. Divide the class into three teams with the assignment to research and present their findings on how their individual planet evolved to its current state. The teams' combined research should make it apparent that many factors played a role in the appearance of each of the three planets and the conditions surrounding each one. Be sure students address the following factors:

1. The planet's orbital characteristics
2. Development and composition of an atmosphere
3. Rotation rate
4. Surface conditions
5. Development of life

You might also initiate a discussion about terraforming, or altering an existing planet's conditions to allow it to become more Earth-like. How could terraforming be accomplished on a planet such as Mars or Venus? Should it be done at all? Would terraforming provide an option for survival when the sun becomes a red giant?

Stellar Scripts

Have students write an article on how life on Earth would change as the sun evolves from its present state to its red giant phase, and eventually to a white dwarf. Encourage them to include the effects on Earth's environment, society, and technology and on human evolution.

Vocabulary List

Word	Word Description
Black hole	An invisible area in outer space with gravity so strong that light cannot get out of it.
Constellation	A group of stars that forms a particular shape in the sky and has been given a name
Core	The central part of something
Diffuse nebulae	Are extended and contain no well-defined boundaries (see Orion Nebula)
Electromagnetic spectrum	The entire spectrum, considered a continuum, of all kinds of electric, magnetic, and visible radiation.
Galaxy	Any one of the large groups of stars that make up the universe.
Gamma rays	Powerful invisible rays that are sent out from radioactive substances
Globular star cluster	A spherical collection of stars that orbits a galactic core as a satellite.
Gravity	The natural force that causes physical things to move towards each other.
Milky Way	A broad band of light that can be seen in the night sky, and that is caused by the light of a very large number of faint stars.
Nebula	1 A cloud of gas or dust in space that can sometimes be seen at night; 2 A group of stars that are very far away and look like a bright cloud at night.
Nuclear fusion reactions	This is a reaction in which two or more atomic nuclei collide at a very high speed and join to form a new type of atomic nucleus, where matter is not conserved because some of the matter of the fusing nuclei is converted to photons.
Orion Nebula	A diffuse nebula situated south of Orion's Belt in the constellation of Orion.
Pulsar	A type of star that gives off a rapidly repeating series of radio waves.
Radio telescope	A piece of equipment that receives radio waves from space and that is used for finding stars and other objects.
Radio waves	An electromagnetic wave that is used for sending signals through the air without using wires.
Red giant star	A luminous giant star of low or intermediate mass.
Spectrum	The group of colors that a ray of light can be separated into; including red, orange, yellow, green, blue, indigo, and violet. The colors that can be seen in a rainbow.
Supernova	The explosion of a star that causes the star to become extremely bright.
Telescope	A device shaped like a long tube that you look through in order to see things that are far away.
Ultraviolet	Used to describe rays of light that cannot be seen and that are slightly shorter than the rays of violet light.
X-rays	Powerful invisible rays that can pass through various objects and that make it possible to see inside things (such as the human body)
Yellow dwarf star	An ordinary star such as the sun at a comparatively stable and long-lived stage of evolution.

Some good books to use with *Stars*

The Sun

Hill, Steele and Michael Carlowicz. 2006, Harry N. Abrams; First Edition.

A photographic book devoted entirely to the sun, illustrating the star we know and revealing recent discoveries.

The Little Book of Stars (Little Book Series)

Kaler, James B. 2013, Copernicus (Softcover reprint of the original 1st ed. 2001 edition)

The Little Book of Stars answers, in the clearest language, the questions anyone might have about our heavenly canopy.

The Cambridge Encyclopedia of Stars

Kaler, James B. 2006, Cambridge University Press.

This encyclopedia begins with an overview of the stars and constellations which then proceeds to chapters covering the location of stars, magnitudes, cosmic distances, the galaxy in motion, spectra, stellar properties, types of stars, the sun, and stellar evolution.

The Brightest Stars: Discovering the Universe through the Sky's Most Brilliant Stars

Schaaf, Fred. 2008, Wiley.

Meet the twenty-one brightest stars visible from Earth and discover their remarkable secrets.

The Sun

Simon, Seymour. 1989, HarperCollins (1st Mulberry Ed edition)

A fascinating introduction to the star that is the center of our Solar System and essential to life on Earth.

Some good web sites to use with *Stars*

stereo-ssc.nascom.nasa.gov/solar_conjunction.shtml

Solar Terrestrial Relations Observatory.

www.skyandtelescope.com/observing/sky-at-a-glance/

Celestial Current Events

Lessons From The World Wide Web

Also, a wide variety of lesson plans and activities can be found on the World Wide Web. These sites are dedicated to lesson planning in a variety of subjects.

multiverse.ssl.berkeley.edu/

The Multiverse (formerly known as the Center for Science Education) at U.C. Berkeley Space Science Laboratory home page.

btc.montana.edu/ceres

Maintained by the Burns Telecommunications Center, this page links to educational activities and classroom resources.

spaceplace.jpl.nasa.gov/spacepl.htm

This California Institute of Technology and NASA Jet Propulsion Laboratory site for kids offers information and activities.

discoveryeducation.com/teachers/

This Discovery Channel education site allows teachers to search for lesson plans by grade and subjects.

edhelper.com/Science.htm

Science lesson plans from the Educator's Reference Desk.

Astronomy Web Sites Worth a Visit

astro.umaine.edu/

The Emera Astronomy Center and the Maynard F. Jordan Planetarium & Observatory home page.

space.jpl.nasa.gov

NASA's Jet Propulsion Laboratory web site

ssd.jpl.nasa.gov

A site about our solar system maintained by the Solar System Dynamics Group of the Jet Propulsion Laboratory.

www.dustbunny.com/afk

A web site about astronomy, designed for kids, with tons of information

hawastsoc.org

The Hawaiian Astronomical Society's home page

www.calacademy.org/planetarium

Alexander F. Morrison Planetarium home page

www.nss.org/

The National Space Society webpage

stardate.org

Learn what's going on TODAY in astronomy on the "Star Date" web page, maintained by the University of Texas' McDonald Observatory

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Emera Astronomy Center

The Maynard F. Jordan Planetarium does not guarantee that the information given on the above web sites to be accurate, accessible, or appropriate for students.