

Lesson Plan G2

The Stars

Introduction

We see the stars as tiny points of light in the sky. They may all look the same but they are not. They range in size, color, temperature, power, and life spans.

In these hands-on and Starry Night computer exercises, your students will explore the nature of stars. They will see how different from one another individual stars can be. They will observe a glowing body as it changes temperature and color. Your students will plot some properties of stars and learn how these different properties of stars are related to one another and to the mass of the star. They will learn that the apparent visual brightness of a star is not a good indicator of its distance. In Starry Night they will examine several different stars and they will see how some stars end their lives.

Key Concepts

- Stars are born, evolve and die.
- Stars have a life cycle that depends on the initial mass of the star.
- The composition and structure of stars changes at different stages in their life cycle.
- Stars in the **Milky Way** can be different from the Sun in size, temperature, age and brightness.
- The Sun is a main sequence star.
- Stars can be described as having apparent magnitude, absolute magnitude and **luminosity**.
- Other planets orbit around other stars.
- Elements heavier than lithium are created in the cores of stars.

Materials Required

Activity Part One

- *Small lamp with a clear (not frosted) bulb*
- *Electrical socket with a dimmer switch (rheostat)*

Activity Part Two

- *Student worksheets*
- *Pens or pencils*

Activity Part Three

- *1 small flashlight*
- *1 large and bright flashlight*
- *A room that can be darkened*

Time Required

Hands-on Activity Part One: 10 minutes
 Hands-on Activity Part Two: 30 minutes
 Hands-on Activity Part Three: 10 minutes
 Starry Night Computer Exercise: 35-45 minutes

Conceptual Background

All stars form from cold clouds of hydrogen gas that collapse under their own gravity. The center of the cloud heats up from the resulting increase in pressure and friction. Eventually the heat and pressure are great enough to force hydrogen nuclei to fuse together and form helium nuclei. This **nuclear fusion** process releases energy and the star shines with its own light.

Stars are made of mostly hydrogen, which is the most abundant element in the universe. Stars use hydrogen as a building block to make heavier elements. As a star ages it fuses hydrogen into helium, and later the helium will be fused into a series of increasingly heavier elements. As stars age and continue the fusion process, the percentage of hydrogen in the stars decreases and the percentage of other heavier elements increases. The heaviest elements are fused in the most massive stars. This planet and all that it contains, plus other planets in the solar system and around other stars, comes from the star-formation process.

Most of the characteristics of a star are governed by how much **mass** the star contains when it first forms. Low mass stars survive for billions of years. They burn their fuel slowly and at low temperatures. They die a quiet death and leave behind a small white dwarf star that slowly cools into a black dwarf.



High mass stars only survive for a few million years. They burn their fuel at extremely high temperatures and rates. Big stars die in spectacular **supernova** explosions. The supernova can leave behind either a **neutron star** or a **black hole**.

Even in a telescope, stars are so far away that they look like tiny points of light. But stars come in a range of sizes, colors, temperatures, energy outputs, and life spans. Most stars are small, dim, red, and cool. They are so small and dim that we can't see them. When we look into the night sky we see mostly the big, hot, and bright stars.

We think of the Sun as an average star. But if we look at all the stars in the Milky Way **galaxy**, we find that 90 per cent of them are smaller, dimmer and cooler than the Sun. So, although the Sun fits in the middle of the range of stellar properties, it is bigger, brighter and more powerful than most of the stars in our galaxy.

Activity Part One

Stars are hot, glowing objects. This activity is a simple demonstration that shows the relationship between the temperature and color of another hot, glowing object. Our Earth-based experiences often give us the idea that blue is cool or cold, and red is hot, as in “red hot.” With stars, the opposite is true. It's all a matter of scale.

1. Set up the lamp with the clear, unfrosted bulb so all the students can easily see it.
2. Plug the lamp into a rheostat or an electrical outlet that is connected to a dimmer switch.
3. Darken the room.
4. Turn on the lamp and dim it until it is just barely on.
5. Ask the students to observe and note the color of the glowing filament in the bulb.
6. Slowly turn up the bulb so it gets brighter and brighter (hotter and hotter).
7. Have the students observe and note the changing color of the glowing lamp filament.

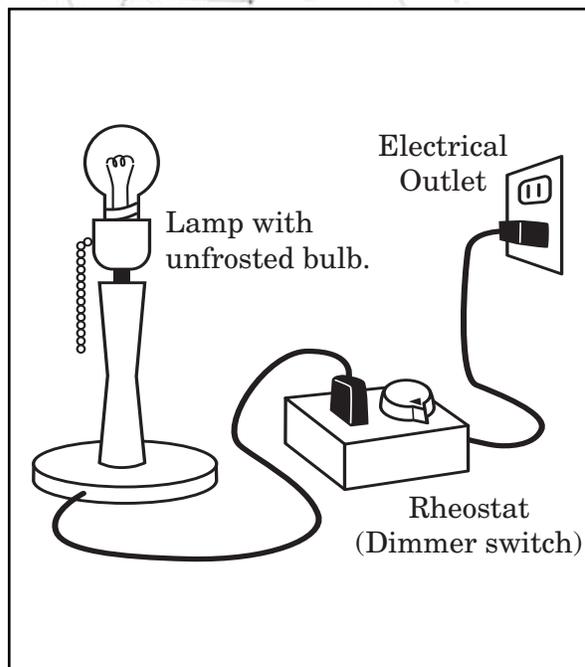


Figure G2.1

Set up to demonstrate the relationship between color and temperature.

Activity Part One Discussion Questions

- A. When the lamp is turned down very low, what color is the filament in the bulb?
- B. When the lamp is turned on full power, is the filament hotter or cooler than when it is turned down low?
- C. What color is the filament when the lamp is turned on at full power?
- D. What progression of colors did you observe as the lamp was turned from minimum power up through full power?
- E. At what power level did the lamp glow most brightly? Why?

Many students think of something very hot as being “red hot.” They seldom think of blue as being a “hot” color. With the lamp turned down to a minimum, the filament glows a dim red



color. The filament glows because it is hot, but it can get much hotter and glow much more brightly.

As the lamp is turned up the filament receives more power. It gets hotter and glows brighter. Its color progresses from dim red to orange to yellow to white. As it gets hotter it glows brighter. There is a relationship between the temperature and the color of the glowing filament. If the filament could be made to glow even hotter, it would progress from white to blue in color. At even higher temperatures it would glow with invisible ultraviolet light.

Most students have seen this color progression from red through yellow to blue in the flame of a propane torch or a propane camp stove. The cool flame is red or orange and the hottest flame is blue. The same color progression holds true for the stars. The coolest stars at 3,000 degrees Celsius glow red. The hottest stars have surface temperatures in the tens of thousands of degrees and they glow with a fierce blue light. Such stars are extremely bright, powerful, and easy to see from great distances. Much of their radiation is in the form of energetic ultraviolet, X-ray and gamma radiation.

Activity Part Two

This is a graphing activity that shows the relationship between color, temperature and mass in stars. **Table G2a Star Comparison Chart** gives data for 12 stars.

Your students will use this data to make a **Hertzsprung-Russell (H-R) diagram** that plots star color versus temperature. A clear relationship will emerge. Astronomers call this curve on the graph the **main sequence**. The main sequence is where stars spend most of their lifetimes. Main sequence stars are powered by hydrogen fusion.

As you examine the data in Table G2a, you will notice a pattern that follows through, more or less, in descending order, for color, temperature, mass and power.

The students' plots should look similar to the one shown in figure G2.2.

Table G2a Star Comparison Chart

Star	Color	Temperature in degrees Celsius	Mass in terms of solar mass	Power in Suns	Radius in terms of Solar Radii	Distance in Light Years
Sun	Yellow	5,700	1	1	1	8 light min.
Proxima Centauri	Red	2,300	0.1	Unknown	Unknown	4
Barnard's Star	Red	3,000	0.1	0.01	0.2	6
Epsilon Eridani	Orange	4,600	0.1	0.4	0.8	11
Alpha Centauri	Yellow	6,000	1	2	1.4	4
Altair	White	8,000	3	12	2	17
Vega	White	9,900	3	61	3.3	25
Sirius	White	10,000	3	27	2	8.6
Rigel	White	10,000	3	52,000	92	777
Regulus	White	11,000	8	221	4.3	78
Hadar	Blue	25,500	20	79,000	24	526
Alnilam	Blue	27,000	20	112,000	44	1,360



1. Give each student a Hertzsprung-Russell diagram worksheet.
2. Use the data from Table G2a to plot each of the 12 stars on the H-R diagram. Star color is on the horizontal axis and star temperature is on the vertical axis.
3. Label each star's data point with the name of the star.
4. Draw a curve as best you can that joins the data points smoothly.
5. On the outer vertical axis labeled "Mass in Solar Masses" mark the value of each star's mass in terms of solar mass.

- D. Look carefully at the data in table G2a. Can you see a relationship between power, color and temperature?
- E. Where does the Sun fit into the pattern?

Stars come in different sizes and they produce different amounts of energy. The energy a star produces is related to its temperature and color. White and blue stars burn their fuel at the highest temperatures. They produce the most energy, and are the most powerful and most luminous stars. These stars are also the most massive stars.

Mass is everything to a star. More mass means more self-gravity so the star presses in on itself more strongly. This means it gets hotter in the core than a smaller star, so it burns faster and at a much higher temperature. Because it burns hotter it also gives off more energy than a smaller, cooler star.

Activity Part Two Discussion Questions

- A. Is there a relationship between the color and temperature of a star?
- B. What is the relationship between color and temperature?
- C. Generally speaking, are the most massive stars also the hottest?

The Sun fits in the middle of the range of stellar properties. It is a yellow star. Compared to other stars, it is neither very hot nor very cool. It is neither very massive nor very powerful. Because of this we think of the Sun as an average star.

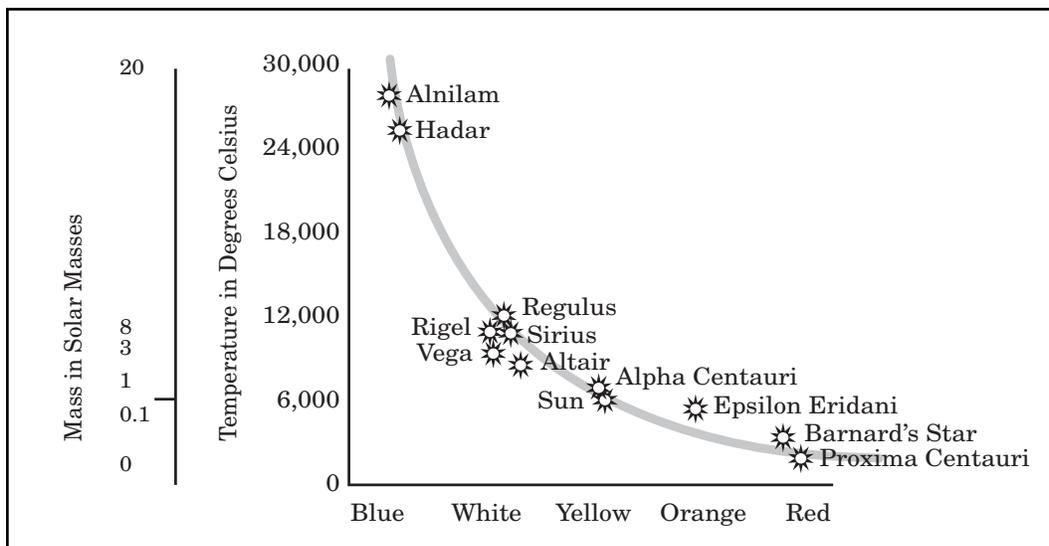


Figure G2.2

Your students' star plots should look similar to this illustration.



Activity Part Three

The thing we notice first about stars is that some are brighter or dimmer. It looks as though the brighter ones are closer to us and the dimmer ones are further away from us. We have just learned that stars vary a lot in the energy, and therefore the amount of light, they produce.

This is a simple demonstration activity to prove that the apparent brightness of a star cannot be used to judge its distance.

1. Place the small flashlight on a desk or table near the front of the room.
2. Place the large flashlight on a desk or table near the back of the room.
3. Have the students gather at the front of the room so they can all see both flashlights easily.
4. Turn on both flashlights.
5. Darken the room.
6. Observe and compare the apparent brightness of the two flashlights.
7. Move the two flashlights back and forth until they both appear to have the same brightness.

Activity Part Three Discussion Questions

- A. If you didn't know which flashlight was which, would you be able to tell which one produced the most light?
- B. From this exercise, and the data in table G2a, what conclusion can you draw about the stars Rigel and Sirius?

This is one of the most fundamental questions about the stars. Is it bright because it is close, or is it bright because it is intrinsically bright? This is why astronomers must know the distance to a star. Without knowing the distance, it's hard to get meaningful information about the other properties of the star. Some stars look bright because they are very near the Sun. Others look equally bright but are many times further away from the Sun. These more distant stars are extraordinarily bright. Without knowing the distance it's impossible to distinguish between the two.

The two flashlights can be compared to the stars Sirius and Rigel. Sirius is about twice as bright as Rigel, but Rigel is almost 100 times further away than Sirius. Sirius is about 27 times as powerful as the Sun, but Rigel has the power of many thousands of Suns. Sirius looks very bright because it is close. If Rigel were as close as Sirius it would be blindingly bright.

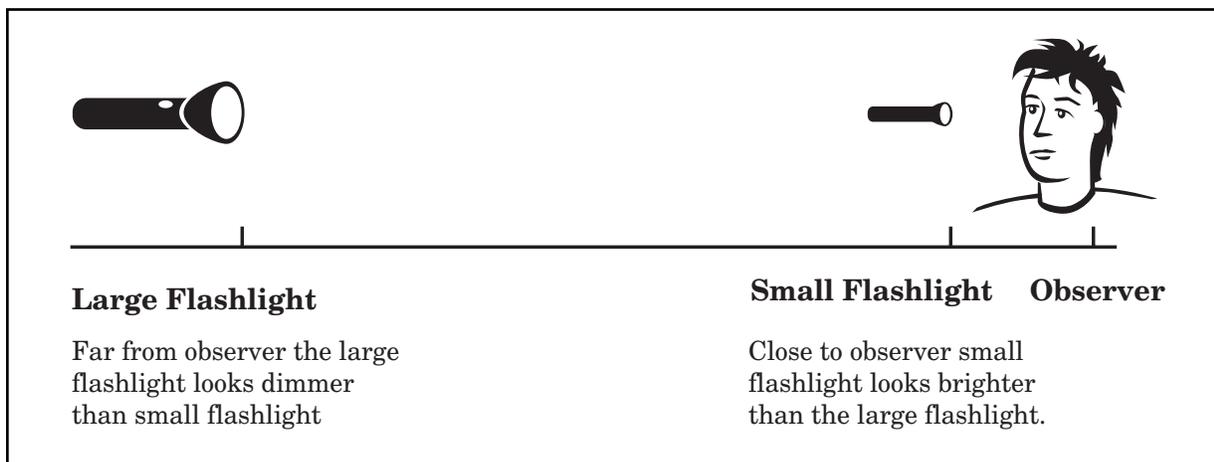


Figure G2.3

Two flashlights of different power placed at different distances can be used to demonstrate that apparent brightness is not a good indicator of distance.



Starry Night Computer Exercise

Lesson G2: The Stars

Even a cursory examination of the night sky shows that not all stars are the same -- some are brighter, some are fainter. A more careful inspection will show that star colors are not the same. But the difference is subtle. Astronomers can deduce a lot of information about stars from their properties. This exercise examines some of these.

Teaching Strategies

Students should be aware that all values entered in the database are approximate and subject to errors. Indeed, different sources will give different values for most of the parameters.

Colors are difficult to detect and have been exaggerated in Starry Night. If a more realistic appearance is desired, see **Using Starry Night** in the Appendix of this binder on how to change color saturation.

Stellar evolution is a complex subject but students should be able to understand that in general, hot bluish stars are young, yellowish stars are middle-aged and large reddish stars are near the end of their life.

Students might be interested in using the interactive H-R diagram on other stars. The status pane can be used whenever catalogued stars are visible in the main window. (Some stars do not have sufficient data to be plotted on the H-R diagram)

If a small telescope is available, it is strongly suggested that observations of some colorful stars like Albireo be attempted.

Students can be expected to complete this exercise in 35 to 45 minutes.

Conclusion

Stars are not simple points of light. After completing these activities and exercises, students should know that stars have a range of properties. They should understand that the color, temperature and mass of a star are inter-related. Students should know that the mass of a star governs everything about the star. Students should know the apparent brightness of a star cannot be used to judge its distance.

Lesson Specific Resources

SkyGuide

Guided Tours>Our Solar System, the Stars and Galaxies> The Stars

Guided Tours>Our Solar System, the Stars and Galaxies> Nebulae

Guided Tours>Our Solar System, the Stars and Galaxies> Novas and Supernovas



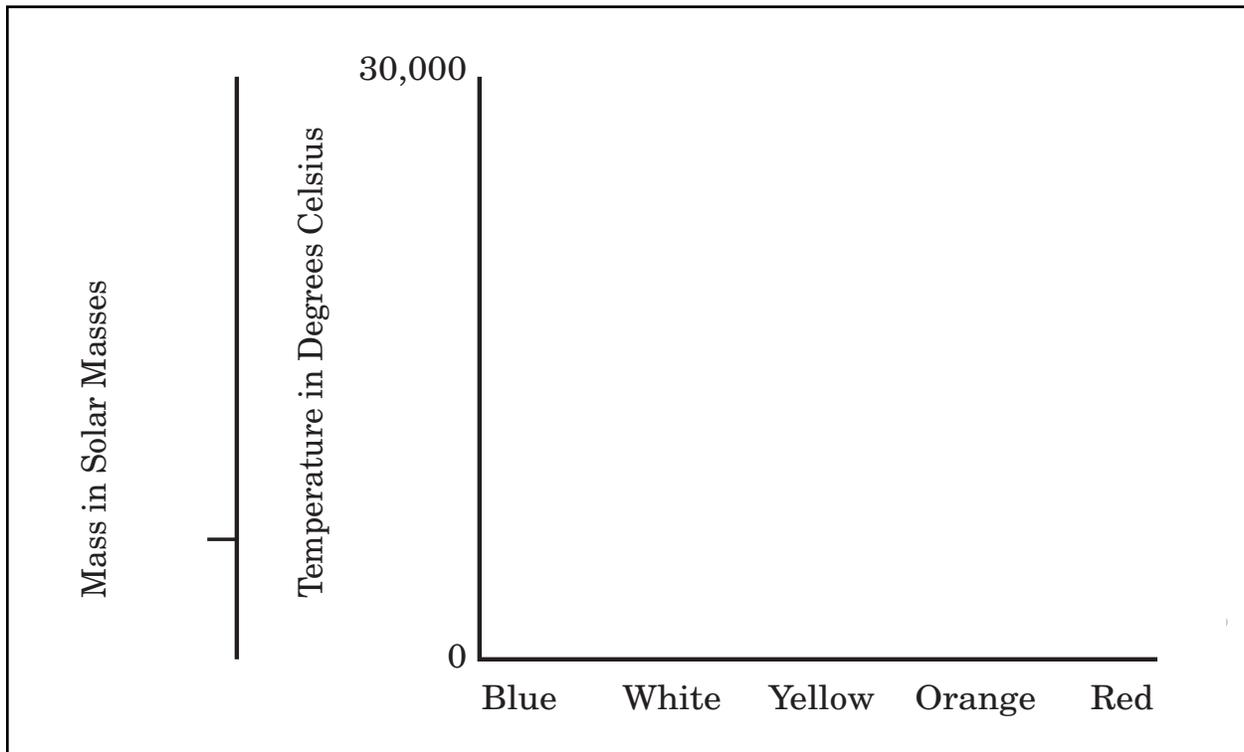
Lesson Plan G2 The Stars

Student Worksheet: Hertzsprung-Russell Diagram

Table G2a Star Comparison Chart

Use the information in this table to help build your own H-R diagram.

Star	Color	Temperature in degrees Celsius	Mass in terms of solar mass	Power in Suns	Radius in terms of Solar Radii	Distance in Light Years
Sun	Yellow	5,700	1	1	1	8 light min.
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Starry Night Computer Exercises

Name: _____

Lesson G2: The Stars

Class: _____

Instructions for the Student

Click on the **SkyGuide** pane, choose **Student Exercises > G – Stars > G2: The Stars** and follow the instructions given. Record your answers to the questions in the spaces provided. Leave the last column blank for now.

Right click on each star and choose “Show Info” from the menu. Under the headings “Position in Space” and “Other Data” you will find all the information you need to complete the chart.

Star Database

Star	Color	Distance from Sun in light years	Radius compared to Sun	Apparent magnitude	Temperature in Kelvins	Luminosity	
Sirius							
Aldebaran							
Pollux							
Capella							
Procyon							
	Orange						

Return to SkyGuide to complete the rest of the exercise.

Question 1: Colorful stars

a) Do all stars have approximately the same temperature? Explain.

b) What seems to be the color of stars that have a temperature in the 3000's degrees?

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Lesson G2: The Stars

c) Pick any other orange star in the main window and enter its name and temperature in the table. Was your prediction in b) correct?

d) Are all stars about the same size?

e) Do stars always appear brighter when they're closer to us? Explain.

f) Do bigger stars always appear brighter to us? Explain.

Question 2: In the beginning

Why are stars born in a nebula?

Question 3: Going out gently

Why is the central star of the nebula difficult to see?

Question 4: Going out with a bang

The Crab Nebula requires a telescope to see. Telescopes were not invented until the 1600's. How could the supernova have been seen in 1054?

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Lesson G2: The Stars

Question 5: The H-R Diagram

All the stars shown in the main window are plotted on the H-R diagram. Point to any star in the main window and a red dot will show its position on the H-R diagram. Go ahead, try it!

a) Now let's fill in the last column on your Star Database. Record to what group each star in your database belongs. (i.e. red giant, main sequence etc)

b) To what group do you think the star Rigel belongs? (Hint: read the introduction carefully)

Return to SkyGuide to complete the Extra Credit for this exercise.

Extra Credit

a) What appear to be the colors of Albireo and its companion?

b) What do the colors of these two stars tell us about their surface temperatures?

c) How would you find Albireo in the summer sky?

