Module 3: Constellations, Looking Far Away, and Stars/Stellar Evolution

Lesson 1: Constellations

Overview

The Touch the Stars Braille book contains a number of the well known constellations, plus guidelines on finding the North Star, the Ring Nebula, and the Orion Nebula, to name just a few. In this lesson, the students will work in developing an overview of constellations in discussing what they know, what constellations meant in the past, and what the difference is between a star and a planet.

Learning Outcomes

• List the differences between day and night time skies.
• Discuss the various ways constellations have been used and defined throughout history.
• Create an individual constellation and tell its story.
• Examine 5 different constellations and state 1 interesting thing about each one.
• State the difference between a star and a planet.

Materials

• Touch the Stars Braille book by Noreen Grice

Pre-assessment Questions and Discussion

Q. What do we mean when we talk about constellations?
   A. Patterns of stars, mythology, specific region of the sky

Q. What constellations have you heard about?
   A. Big Dipper (asterism), Orion, the Bull, Lion

Text

Students read about constellations in Touch the Stars, p. 1 - 29. Break the reading into sections; this is a lot of material for students. Following is a listing of the sections and 1 or 2 suggested questions for each one.

A. What Does the Sky Look Like?
   1. List as many things as you can that tell how the day time sky differs from the night.

B. The Constellations
   1. What cultures created many of the constellations we use today?
   2. How many named constellations are there today? These are the ones astronomers use.
   3. Why do we say that constellations are "connect the dots" pictures?

C. Legends About the Stars
   1. Which legend did you like the most?
   2. If you were to create your own pattern of stars (your own constellation), what would it look like? What story would you tell about it?
D. Some Famous Star Patterns

1. Ursa Major: Look at the pattern of the Big Dipper. What do you think it is picturing?

2. Ursa Minor and Polaris: Explain how we locate Polaris and Ursa Minor (the little bear) by using stars in the Big Dipper.

3. Lyra and the Summer Triangle asterism: What three stars make up the asterism known as the Summer Triangle?

4. The Ring Nebula: Describe what you see when you look at the Ring Nebula picture.

5. Orion and the Orion Nebula: Compare what you saw in the Ring Nebula (a star that has died) with that of the Orion Nebula, where stars are being born. Are there differences?

6. Is it a Star or a Planet?: How many differences can you list between stars and planets?

Follow-up Questions on Reading

Included in the sectional reading above.

Reinforcing Hands-On Activity

Modeling:

From the University of Texas at Austin – Constellations

"Students were given a set of coordinates representing the brightest stars of a few familiar constellations without identifying them. They used tactile graph boards to recreate the groupings, and were asked to guess how to connect the points, that is to make their own constellations. Some students with vision recognized the patterns. In the case of Cygnus they came close to the usual representation, but most of the time did not. Through this exercise they learned that the constellations are arbitrary forms, though often based on mythology. These images aided our ancestors in remembering the sky, thus enabling them to observe the motion of the planets, or use stars for navigation and telling time before maps and clocks became widely available."

Summary and Post-Assessment Questions

1. Summarize how this activity changed your view of the day and nighttime skies.

2. Discuss how creating your own constellation and inventing its story helped you understand what constellations have meant to humans.

3. Relate what you found most interesting about one of the five constellations we examined here.

4. We noted here that a planet changes its position when measured against background stars. Hypothesize as to the reason the stars don't change their positions as much.

Relevant Information and Links

Lesson 2: The Light Year and Look-back Time

Overview
This lesson covers the meaning of light years and why astronomers use such a measurement of distance. Because light travels at a finite speed, we can also refer to "look-back" time and how telescopes are really time machines: the farther away we look, the farther back in time we are seeing. We are seeing the object as it was hundreds, thousands, millions, or billions of years ago. Look-back time is demonstrated with a fun activity passing tiny-to-large plastic snakes on foam board to represent pictures taken at 1-year intervals going out to space stations light years away.

Learning Outcomes
• Explain what is meant when a distance is described in "light years."
• State why it is important for astronomers to have such a measurement.
• Define "look-back time."

Materials
• Touch the Stars Braille book, pages 72 - 74.
• 3 - 4 rubber snakes of various sizes (small, medium, large, and extra-large) each attached to a board (to represent a photograph of the snake), plus 1 extra board with nothing attached.

Figure 3.2.1. Various size rubber snakes representing the species “sunbeam” that lives 4 – 5 years.

Some students may be hesitant to touch a snake, even a plastic one, but this demonstration is a great and effective visualization of "look-back" time: The farther away we are observing a celestial object, the farther back in time we are seeing. The plastic snakes were purchased from a number of on-line sources, and from Archie McFee in Seattle, Washington. From the left: 1 year, 2 years, 3 years, 4 years old. (Final "image" says "R.I.P. SUNBEAM You were a good snake" with Braille labeling as well.)

Pre-assessment Questions & Discussion
Q. What do you recall about distances between the Sun and all of the planets from our solar system walk?
Q. What is a light year?
   A. The distance light travels in a year, about 6 trillion miles or 10 trillion kilometers.
Q. How fast does light travel?
   A. Light travels at about 300,000 kilometers per second.
Q. How long does the light from other stars take to reach Earth?
   A. The light from the closest star to our sun, Proxima Centauri, takes 4.243 years to reach us since it is 4.243 light years away. A beam of light reaching us today left this star 4 years, 2 months, 27 days, and 12 hours ago.
Text

Students read about Measuring the Universe: pp. 72 - 74 of Touch the Stars. This section covers distances, light years, and looking back in time very well.

Follow-up Questions on Reading

1. Why is it important to use "light years" when talking about distances in the Universe?

2. In what way can telescopes be considered time machines when they look farther and farther away at objects in the Universe?

3. The air travel distance between New York and Los Angeles is about 3900 km. Let's say that a jet has a cruising speed of 780 km/hr. Would it be clear to us if we said, "New York is 5 air-cruising hours from Los Angeles"? Why or why not?

4. The closest star, Proxima Centauri, is a little over 4 light years away. If there were a planet orbiting this star, and if there were aliens there with technology, how long would it take us to get an answer back if we sent a radio message to them?

Reinforcing Hands-On Activity

Exploring:

In this activity, an arm's length equals the distance light would travel in one year. Each participant (ideally at least 5, but the number can be adjusted) is seated one arm's length away from another. The teacher is located an arm's length from the first student, and his/her location is Earth (0 light years). The first student is at a space station 1 light year away, the next at a space station 2 light years away, and so on.

READ ALOUD: “We will passing around plastic snakes now to help us understand the idea of light travel time. This particular snake we will call a sunbeam snake, named after a real, non-poisonous snake native to Indonesia. The average life of a sunbeam snake is 4 years and over that time it grows to be about 1 meter long. The snake gets its name from the fact that its scales appear rainbow colored in strong sunlight. For this activity, let us pretend that I am taking photographs of a sunbeam snake here on Earth and sending it out to you in space.”

The first photograph is of the baby snake 1 year after its birth. I am sending it to the closest person to me at the speed of light. How long will it be before they receive the photo? Will my neighbor know about the baby snake before receiving the photograph? What happens to the snake during the time its photograph travels to the first space station?

Pass 1-year-old snake to first student

After another year has gone by, the person at the nearest space station has just received the the photograph of the one-year-old snake that I had sent them. Here on Earth the baby snake has grown and is celebrating its second birthday. To celebrate its birthday, I take an other photograph and send this one out to my friend at the nearest space station. The person at the nearest space station is simultaneously sending out the photograph of the baby snake that I had sent them the year before. How long will it take for these photographs to travel to their destinations? How much time has passed by since the snake hatched when the nearest space station receives the photograph of its first birthday? How about when the second space station receives the baby snake photograph? What does my snake look like now on Earth? Is it different from the photographs my space-station neighbors are looking at?

Pass 2-year-old snake to first student, while first student passes 1-year-old snake to second student.
Three years have now gone by and I took another photograph to celebrate the snake's third birthday. Remember these snakes live only 4 years on average. How much longer does my sunbeam snake have to live? What does the snake look like for the 3 different students at the space stations? Does the person at the farthest space station (4 light years away) know about the snake yet? I am going to send on the photograph of the 3 year old snake to my nearest neighbor. Will the snake still be alive when they receive it?

*Pass medium (3-year old) snake to first student, while they pass the 2-year-old snake to the second student, and the second student passes the 1-year-old snake to the third student.*

What does the last student think the snake looks like now? How about students one and two? How does the snake look like to me? Knowing that my sunbeam snake does not have long to live, I take one more photograph on its fourth birthday. With a touch of sadness, I send the photograph off to my neighbor on the nearest space station. Sunbeam has grown into a magnificent, friendly pet.

*Pass the large (4-year old) snake to first student, who passes the 3-year-old snake to the next student, who passes the 2-year-old snake to the third student, who passes the 1-year-old snake to the fourth student. The fifth student doesn't even know sunbeam exists yet.*

Another year passes. Since the sunbeam snake lives only four years the snake is now dead. I take a memorial photograph of the snake's tombstone and send it out to the first space station. How much time passes before each of the different stations find out the snake is dead?

*Pass the tombstone photograph along, and discuss the time passing as each station receives the picture.*

**Summary and Post-Assessment Questions**

1. Discuss the relationship between this activity and how the text describes a light year and look back time.
2. How might an echo of sound be similar to sending a message using light to another planet?

**Relevant Information and Links**

Lesson 3: Stellar Types and Stellar Life Cycles

Overview

This lesson addresses the life cycle of a sun-like star and bigger, more massive, stars, from their birth to their death. Students go through the reading and related questions, and then get an opportunity to work with tactile diagrams of the H-R diagram and life-tracks of a sun-like star. We work through definitions, comparisons of humans with stars, and end with student comments about whether or not those comparisons are realistic.

Learning Outcomes

• Summarize what is meant by "stellar evolution."
• List the various stages of a star's life.
• Define nebula, red giant star, white dwarf, supernova, neutron star, pulsar, black hole.
• List the different stellar types.
• Explain how the life track of a sun-like star differs from that of a much more massive star.

Materials

• Touch the Stars Braille book by Noreen Grice
• Tactile H-R diagram (Figure 3.2.1)
• Tactile life-tracks of a sun-like star (Figure 3.2.2)
• Tactile stages of the Sun's life (Figure 3.2.3)

Pre-assessment Questions and Discussion

Q. If we were to talk about the "life cycle" of a human, what would we say?
   A. Humans are born; they eat and grow; they learn to walk and talk; they go to school; they grow into adults; they get married and have children; they get old; they die.

Q. What do you think about the lives of stars? Have they always been around? Do they grow old?
   A. Accept all comments and exchange of ideas.

Text

• Students read The Life Cycle of a Star in Touch the Stars, pp. 74-77
• Students read What Happens to Bigger Stars in Touch the Stars, pp. 77-79

Follow-up Questions on Reading - Life Cycle of a Star

1. What does stellar evolution mean? How does it compare to the life cycle of a human?
2. What is a nebula? Giant star? White dwarf? Binary star?
3. What makes a nebula collapse (the material being brought closer and closer)?
4. What is nuclear fusion and why is it important to a star?
5. What happens when a star grows old and runs out of fuel in its core?
6. Return to page 19, Fig. 4, View 2, the image of the Ring Nebula. It was once a star like our sun. Describe its life story.
7. How might the evolution of a binary star system be different from that of a single star?

Follow-up Questions on Reading - What Happens to Bigger Stars

1. The text says "bigger" star rather than "more massive" star. Which term do you think is more correct?
2. Would it be a good idea to live on a planet next to a massive star when it goes supernova? Why not?
3. When does a massive star become a neutron star?
4. When is a neutron star called a pulsar?
5. How can we detect black holes when, by definition, they are "black" and they are "holes"?

Reinforcing Hands-On Activities

Predicting and exploring the H-R diagram:

Read aloud. “The graph of how the temperatures and luminosities of stars are related is known as the Hertzsprung-Russell or H-R diagram. From this graph, we can also get an estimate of the size of a star, its radius. Astronomers worked with this graph long before they knew why stars varied in this way. You will be given a tactile H-R diagram, but before we study it, come up with some guesses as to how stars are.”

1. Why are some stars big (massive) while other stars are small (have masses only a fraction of the Sun's)?
2. There exists massive hot stars (temperatures of 30,000 K and radii of about 10 times the Sun's) AND small hot stars (temperatures of 100,000 K and radii about the size of the Earth). Would these different kinds of stars be putting out the same amount of energy? [HINT: Think about burners on a stovetop.]
3. Observations show that there are cool supergiant stars (temperatures of 3000 K and radii 1000 times that of the Sun's) and cool red dwarf stars (temperatures of 3000 K but radii of 1/10 that of the Sun's). Would these different kinds of stars be putting out the same amount of energy?

Figure 3.3.1. A tactile H-R diagram is made from foam and wood balls and beads attached to a foam board. All axes and objects are labeled in Braille.

Give students the tactile diagram of the H-R diagram (Figure 3.3.1) and have them explore the x- and y-axis to get a sense of what the graph is comparing. The O-stars are the most massive (60 times the mass of the sun) on the diagonal (called the main sequence) and the L stars are the least massive (barely 1/10 the mass of the Sun). Stars are born with a given mass and that determines how their lives go.
Exploration should also help answer questions 2 and 3. The amount of energy put out per second, that is, its luminosity or how many watts or power the star has depends on both the temperature and the size of the star. We say that the luminosity is proportional to the radius of the star squared and its temperature raised to the 4th power. It doesn't take much of an increase in the temperature of a star to dramatically increase its luminosity.

Students can find the giant star, a white dwarf, a sun-like star and approximate the relative sizes, temperatures, and luminosities. The diagonal line is where the stars are fusing hydrogen to helium in their cores, and once the "sun" is located on this line, the emphasis that the Sun will stay at its current size, temperature, and luminosity for a very long time.

**Figure 3.3.2.** Tactile diagram comparing the luminosity, temperature, and representative size of a sun-like star as it ages and dies. The life tracks are represented by stiff florist wire. The y- and x-axes are labeled in Braille.

Modeling the evolution of the Sun:

It is difficult for some students to realize than an H-R diagram with life tracks given (Figure 3.3.2) is showing only how a star changes its luminosity and temperature as it goes through its life. Some think that the graph is figuratively showing how a star actually moves around in the sky. By emphasizing the changes in temperature, luminosity, and size for a star staying in one spot in the sky, the student will better understand what will happen to the Sun in the future.

The green, curvy diagonal line represents those stars that are fusing hydrogen to helium in their cores. The bead on that line represents the Sun. Students should work to follow the wire from the diagonal line through the change in luminosity and temperature to the top of the red giant branch. The Sun will be about 100 times its current radius. After the red giant stage, helium to carbon fusion will start in the Sun's core, and the Sun will drop to a slightly lower luminosity and slightly higher temperature. When all of the helium in the core has been fused into carbon, the Sun will again go up to higher luminosities and lower temperatures (the second wire to follow), and be slightly larger that before. The Sun will expel about 30% of its mass in a planetary nebula and leave behind a white dwarf, its former core and interior. The third wire track shows the white dwarf decreasing in luminosity while staying hot for a while, and then going to cooler temperatures. This final process of cooling takes over 30 billion years.

Bring the concepts into greater clarity by having the students look at the relative sizes of the Sun as it ages (Figure 3.3.3). The red giant sun - depicted with the largest Styrofoam ball with the netting - will be many times larger than what we are able to show here. If the tiny beads representing the Sun now are 5 millimeters in diameter, the Sun as a red giant would need a ball 500 mm, or half of a meter in diameter.
Figure 3.3.3. Tactile diagram comparing the relative sizes of the Sun during its lifetime. The scale along the bottom is time in billions of years, and indicates that the Sun spends most of its life just as it is today. Examination of this diagram could be part of an extension of this lesson. Use the tactile diagram of the sizes of the Sun as it evolves for additional insight into what our Sun will be like in the very distant future.

Summary and Post-Assessment Questions

1. During the time a star grows old (millions or billions of years), is it correct to say they evolve? Explain.

2. For the following pairs of stages of the lives of sun-like stars, state which one comes first:
   a. main sequence or white dwarf
   b. red giant or planetary nebula
   c. white dwarf or red giant

3. Where do the red giant, white dwarfs, and sun-like stars lie in the H-R diagram?

4. Where do the most massive and least massive stars lie in the H-R diagram?

5. Pick two of these terms and define them: nebula, red giant star, white dwarf, supernova, neutron star, pulsar, black hole

6. Explain how the life track of a sun-like star differs from that of a much more massive star.

Relevant Information and Links

- The Evolution of Stars — https://youtu.be/uCz-uXRP4rA
- Death by Black Hole as explained by Dr. Neil deGrasse Tyson (YouTube) http://www.youtube.com/watch?v=h1iJXOUMJpg
## Learning Outcomes

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