

The Stargazer's Notebook

A Yearlong Study of the Night Sky



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Blair H. Lee, M.S.

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Month 1 - The First Stargazing Night

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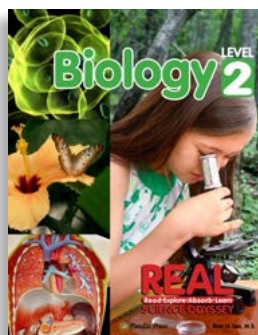
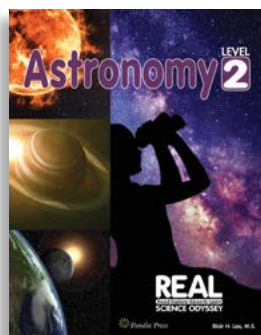
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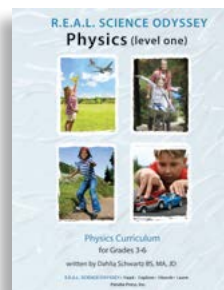
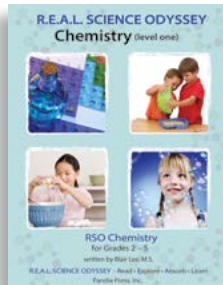
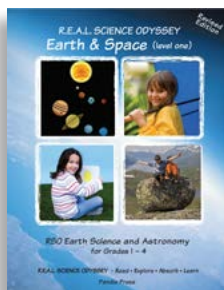
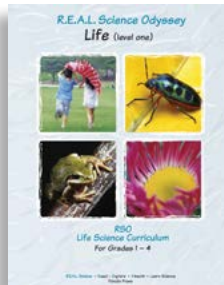
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Blair H. Lee, M.S.



Illustrations by Donald McIntire

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The Stargazer's Notebook

A Yearlong Study of the Night Sky

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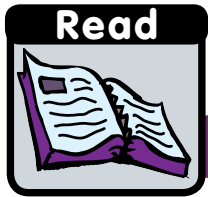
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The Stargazer's Notebook

Get Ready to Stargaze



This book is part night sky journal and part astronomy course. It can be used as an adjunct to a formal astronomy course or as a stand-alone study of the night sky. Every month you will learn about an interesting aspect of the cosmos, such as the colors of the stars and why stars appear to “twinkle” in the sky. You will also spend some time each month of the year studying the night sky and drawing what you see. You will chronicle the patterns and locations of constellations and their movement across the night sky. You will find planets, galaxies, and stars. You will even prove that Earth revolves around, or orbits, the sun and not the other way around. In addition, you will aim to see special night sky events as they occur. Your goal is to view and draw meteor showers, falling stars, and maybe even a lunar or solar eclipse.* Is a comet coming your way? Are the planets in a special alignment at any time this year? If so, you will learn how to view and draw these events.

You might think that mapping the night sky could be done once and then you wouldn't need to do it again. After all, if you made a map of your house and the neighborhood around it, one time would be enough. You might need to add information once or twice a year but you would not need to make a new map every month. What if your house moved all the time though? As your house moved, the neighborhood around it would change too. The house across the street today might be two streets over three months from now.

Of course, your house does not move, but the planet on which it sits is continuously moving. Earth spins, or rotates, on its axis, and it also orbits a star—the sun. Each day, Earth makes a full rotation on its axis, and each year, it makes a complete orbit around the sun. As Earth orbits the sun, the “neighborhood” around it changes. During this year, you will map the night sky once each month. At the end of the year, you will have a map of the different parts of the universe that are visible from where you live.

* But do not ever stare directly at the sun. It will damage your eyes.

Tools for Mapping

It has been estimated that between 5,000 and 7,000 stars are visible with the naked eye across the globe. With binoculars that number increases to approximately 9,000 stars, and with a telescope, 11,000 to 20,000. These numbers are very small compared to all the stars in the universe, but they still represent a lot of stars to map! Don't worry—you are not going to have to map all of them.

You will need some tools to help with this job though. Certain tools will help you determine the names of the stars you are looking at as you map the stars this year. You will want help finding constellations and planets, too.

Planisphere



A **planisphere** is an important tool for night sky mapping. A planisphere is a sky map that shows the placement of stars (and only stars) in the sky. It includes stars that are millions of light years away. A planisphere looks complicated at first glance, but it is easy to use with a little practice. With the help of a planisphere on a clear night, you will be able to find and name the visible constellations and stars. Before you go out the first time to map the night sky, you should figure out how your planisphere works.

I recommend the planisphere entitled “The Night Sky” designed by David Chandler (www.davidchandler.com). Whatever planisphere you choose, be sure to select one that matches your latitude, that is, your location on Earth's surface. For example, Orlando, Florida, is located at latitude 28.54° and Vancouver, Canada is located at latitude 49.28°. The appropriate planispheres for these locations are the ones designated for the latitude ranges of 20°–30° and 40°–50°, respectively. To determine your latitude visit <http://myNASAdata.larc.nasa.gov/latitudeLongitude-finder> or another latitude finder website.

How to Use a Planisphere

The following directions relate to “The Night Sky” planisphere by David Chandler. The directions may need to be adapted for other brands of planispheres.

The basics of a planisphere are easy. You turn a wheel to a specific time and date and you have a map of the stars that will be visible at your location for that time and date. Take your planisphere into your hands and look at it. Below are a series of instructions that explain each part of the planisphere.

The Two Sides: The planisphere has two sides, and they together map the entire night sky for a given date and time. One side shows the stars that are visible when you are facing north. The other side shows the stars that are visible when you are facing south. Look at the side for the northern direction. The word *horizon* is written between the words *east* and *north* and between the words *north* and *west*. The stars shown at the blue line with the word *horizon* on it are at the horizon. The stars in the center are directly overhead, the stars on the right edge near the word *east* are on the eastern horizon, and the stars on the left edge near the word *west* are on the western horizon. Polaris, the North Star, is located at the grommet in the center of the wheel (for the Northern Hemisphere only). Turn the planisphere over to the other side, and notice that the planisphere shows a lesser portion of the south sky. Also notice that the stars near the upper portion of the southern sky are repeated at the very top edge of the north side of the planisphere. Picture the sky as a dome over your head; by flipping between the two sides of the planisphere, you will be able to map stars across the entire night sky.

The Wheel: Turn the wheel and watch what happens: the stars rotate on the disk. With the north side facing up, look at the times written on the blue crescent. They span from 6 p.m. to 6 a.m. Turn the wheel again and watch how the months and dates rotate along the outer circle. Set the wheel so that midnight (12) is pointing at August 15th. What you are now looking at is a star map of the northern sky for the date of August 15th at midnight. It is also the map of the stars as they will appear on November 16th at 6 p.m., November 30th at 7 p.m., October 15th at 8 p.m., and so forth. Turn the wheel of the map to December 20th at 9 p.m. Watch the star positions change as you do.

Using the Planisphere for Both Directions: With the north side facing up, turn the date to March 17th at 10 p.m. Look at the map of the night sky when you are facing north. Turn the planisphere over. This shows a map of the night sky on March 17th at 10 p.m. when you are facing south.

Distances: The map on the planisphere is small. The sky is big. Looking from west to east on the planisphere, you are looking at a representation of the sky from the western horizon all the way across to the eastern horizon. Constellations and star patterns appear small and clustered on the planisphere map, but they will be much larger when you are looking up at the real thing. Look for a specific constellation each night that you are viewing and use its position to work your way to other objects in the sky to make your night sky map.

Monitoring the Changing Time: If you are outside long enough, the stars will appear to gradually move as the time passes. You can track this movement by changing your planisphere on an hourly basis. To see how this works, set a date on the wheel to 9 p.m. Move the wheel counterclockwise until the time is at 10 p.m. and then at 11 p.m. Notice how the position of the stars on the planisphere shift. (The stars, including our sun, actually do ever so slowly orbit the center of the galaxy, but the changing position of the stars that you observe over the course of a night and throughout the year is caused by the movement—rotation and revolution—of Earth.)

Daylight Saving Time and Leap Year: If you live in an area that practices daylight saving time, when it is in effect, you will need to subtract an hour from the time indicated on the planisphere. In addition, the planisphere does not account for leap year, but the apparent movement of the stars over a two-day period is so small that the difference during a leap year is negligible.

Phone App, Computer App, and Compass

A phone app can come in handy for night sky viewing, but it will not take the place of a planisphere. A planisphere gives you a view of the entire sky over many hours, while an app only shows a very narrow view of the sky at the specific moment you are viewing. But these apps can be helpful for finding and naming stars, constellations, and planets. A compass app on your phone can be used in place of a physical compass to determine directions. Many computer programs have great information as well. However, looking at a computer or phone app is a problem when you are stargazing. The light from a screen prevents your eyes from adjusting to the dark, which affects how many stars you can see.

Red Light Flashlight

Although light can be a problem, you still need to be able to see your Night Sky Map when mapping the night sky. Using a red light (rather than a white light) will make things much easier. When you are in darkness, your pupils dilate, which allows more light to enter your eyes. It can take up to half an hour for your eyes to fully adapt to the darkness, allowing you to see the most objects in the night sky. Using a white light will cause pupils to constrict, or become smaller, and you will have to wait for your eyes to adapt to darkness again. A red light significantly reduces

the loss of your hard-earned “night vision.” Red LED flashlights are readily available, including ones specifically made for stargazing (preferred). You can create your own red light though by covering the end of a standard flashlight with red cellophane, securing it with a rubber band. You may need to use several layers of cellophane so the red light is dim enough that it doesn't cause your eyes to lose adaptation, but still bright enough so you can see your map—not to mention your snacks and refreshments! You might have to experiment and make adjustments to the red light to make it perfect for you. But it is worth the effort because dark adaptation is crucial to successful stargazing.

Unaided Eye vs. Binoculars vs. Telescope



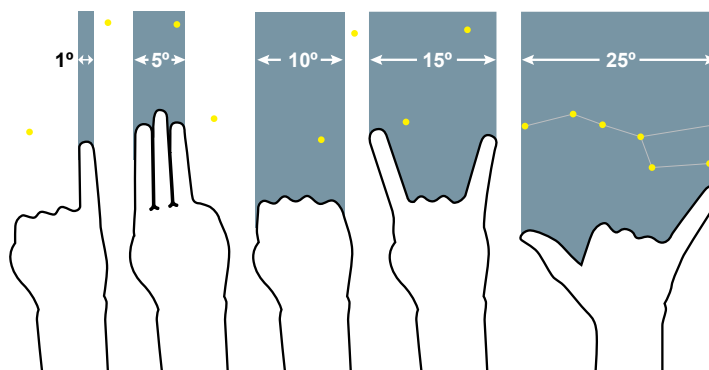
You do not need expensive equipment to stargaze. All of the objects you will be asked to locate in this course can be seen with the naked eye. In fact, objects such as constellations and meteors are best viewed using just your eyes because they give you a wider field of view than you would have with binoculars or a telescope. Finding stars in a constellation is also easiest with just your eyes. But binoculars or a telescope can have a role in stargazing because they let you see objects that are deeper in space than your eyes alone can detect. Jupiter, for example, looks like a very bright star in the sky without any special equipment. With binoculars, however, you will likely see Jupiter as a white disk and you may even be able to see some of its moons. With a telescope, and a lot of practice, you can see Jupiter's red spot. Also, the beauty and complexity of some objects can only be viewed with the use of binoculars or a telescope. For example, the Beehive Nebula looks like a fuzzy glob if you look at it with your unaided eye. With binoculars, you will see it as a glittering collection of stars. (I think it looks like a happy face made from stars.) Uranus and Neptune cannot be seen without the aid of special equipment.

With unaided eyes, on a clear night, many people can view approximately 3,000 celestial objects from their location. With binoculars (standard or astronomy) the number increases to well over 10,000. The binoculars I used were designed for looking at the night sky. They are bigger and heavier than normal binoculars. Standard binoculars (such as 7×35) are adequate for looking at the night sky, but if you decide to use a pair of astronomy binoculars, you may need a tripod. Astronomy binoculars are often too heavy to hold steady for a length of time. Several companies make astronomy binoculars and tripods, and I used ones sold by Celestron.

If you have never used binoculars or a telescope though, you will most likely enjoy stargazing more with just your eyes. If you do choose to use binoculars or a telescope, get familiar with how to use the equipment and set it up before you go out at night. No matter how you choose to look at the night sky, by the end of the year, you will have a much better understanding of what we see as we rotate, revolve, and hurtle through space.

Estimating the Distance Between Stars

Sometimes you need help deciding exactly which stars are in a constellation. For example, if you are wondering how far the constellation Cancer extends or which star is at the end of the constellation, being able to estimate distances between stars will be helpful. To measure the distances between stars, astronomers use the fact that there are 360 degrees, 360° , in a circle. Stellar distances are measured in degrees, and measurements are also shown in degrees on most planispheres. To match the distances shown on your planisphere to the sky, all you need is your arm, hand, and fingers.



Directions for determining distances between celestial bodies:

- ★ Stick your arm out straight with your elbow locked, not bent.
- ★ Make a fist with only your pinky finger sticking straight up. Your pinky finger measures 1° across the sky. From Earth, the distance across the moon and sun are each one half of a degree. Your pinky finger covers each of these. The moon is closer than the sun to Earth, so they both appear the same distance across from Earth.
- ★ Make a fist with only your three middle fingers sticking up. This width of three fingers measures 5° across the sky.
- ★ Make a fist with no fingers sticking up. The width of your fist covers 10° across the sky.
- ★ Make a fist with your pinky and pointers finger sticking up. From one finger to the other is 15° across.
- ★ Make a fist with your thumb sticking out and your pinky finger sticking up. This distance is 25° across.

Example: I saw a bright star near the end of the Cancer constellation. I was not sure if the star belonged to the constellation. So I looked at Cancer on my planisphere and saw that the width of the constellation was about 15° across. With my arm up towards the sky, I measured 15° and I was able to determine that the bright star was not part of the Cancer constellation. I then realized that I had found Procyon, a star that belongs to another constellation, Canis Major.

Night Sky Mapping, Planning, and Labs

There are two parts to each stargazing month:

Part 1: Make a map of the night sky

Part 2: Learn about an astronomical event or a topic through a monthly astronomy lab.

- 1) Once a month for a full year, you will be mapping the night sky. The monthly Night Sky Maps start on page 15. The maps are grouped together so you can easily find and compare them. At the end of the year, or even after several months, when you compare the maps you will notice constellations and stars move across the sky relative to Earth. It will seem like the stars are moving, but what you are really observing is Earth's changing position as it orbits the sun. Because the stars appear in different parts of the night sky depending on Earth's position in its rotation on its axis and where it is in its orbit around the sun, it is important to view the stars at the same time each night and roughly the same week each month. It is also important to stargaze on a cloudless night. So, for example, if you map the night sky at 9 p.m. on a beautiful clear night during the first week of Month 1, then schedule your stargazing for the rest of the year at 9 p.m. on the night with the best weather during the first week of Months 2 to 12. Consistent scheduling will give you the most accurate perception of the changing night sky.

Each time you go outside to study the night sky, you will follow the Night Sky Viewing Instructions listed on page 13. General viewing instructions are not repeated each month, but after the first couple of times you will know what to do. You can always refer back to page 13 if you forget anything.

- 2) Each month has a lab that focuses on a specific astronomy topic. Topics include light pollution, meteor showers, planets in the solar system, parallax shift, and satellites such as the Hubble Space Telescope. The monthly labs start on page 41. Some monthly labs include a lab sheet that you will complete by following the monthly lab instructions. I recommend that you read and complete these lab sheets, if applicable, and the monthly lab during the day before stargazing and mapping the sky that night. Alternatively you could complete the lab a day or two before the stargazing night. A couple labs require observing an object in the night sky. For these labs, I recommend that you complete them on the same night that you map the night sky.

Special Events and Stargazing Calendar

Plan your stargazing year on the Stargazing Calendar (page 10). Begin with the month you plan to start your stargazing year, and record the date you plan to complete the Month 1 lab and the night you plan to stargaze and map the sky.

Check the Special Events list on the next page every month to determine if any events are happening that you don't want to miss, such as an eclipse, a planet coming into view, or perhaps a meteor shower. Mark these events on the provided Stargazing Calendar so that you can observe them while you are doing your usual monthly lab and sky mapping.

In addition to the special events, note on your calendar any specific stars or constellations that will be viewable. Continue planning the year with the next month and so on to complete your stargazing year.

Table of Stars

The Table of Stars checklists start on page 11. Use these checklists to mark off the celestial objects you have viewed and see which ones you still need to find. The list might seem overwhelming at first. As the months go by though, the list of what you have seen will grow larger, and the list of what is left will become smaller. If you are having trouble locating a star, conduct an online search to determine the best time to observe it and mark that time on the Stargazing Calendar. Note that most of the stars listed belong to constellations. Before you go out to view the night sky, research the constellations you will be viewing that night and check whether any of the stars from the list are a part of those constellations.

There are two Table of Stars checklists, one for the Northern Hemisphere and one for the Southern Hemisphere. You will not use both lists unless you do some traveling, so choose the list for the hemisphere you live in. Many celestial objects can be seen from both hemispheres but some cannot.

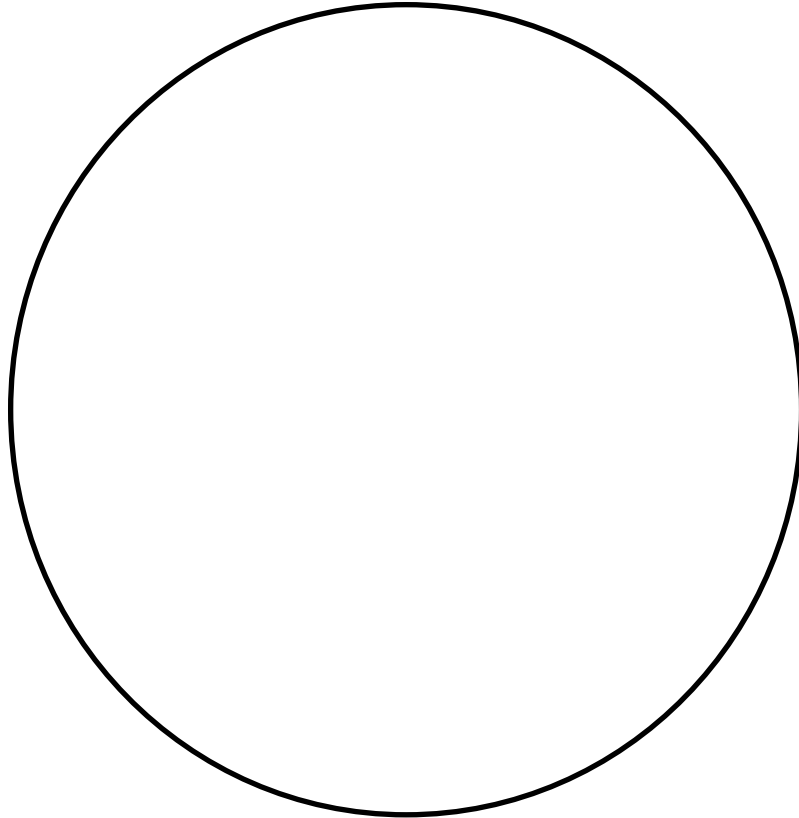
The checklist for your selected hemisphere is organized so you can check off the name of each object as you find it in the night sky. Have fun with the list! For example, the list includes many of the zodiac signs that are the constellations of the horoscope. When you find your horoscope constellation, circle it, celebrate it. Did you find the constellation close to your birthday? You could make a game or a contest from the checklist. Challenge a fellow viewer to see who can complete their checklist first. Have a race to see who can name the most objects in the night sky.

The Stargazer's Notebook

Month 1: Night Sky Map #1

The night sky at _____ on _____ at _____ with _____.
(longitude and latitude) (date) (time) (fellow stargazers)

North



Notes

The phase of the moon:

The weather:

The three times I plan on observing the sky:

The constellation I will be following throughout the year:

Observations:

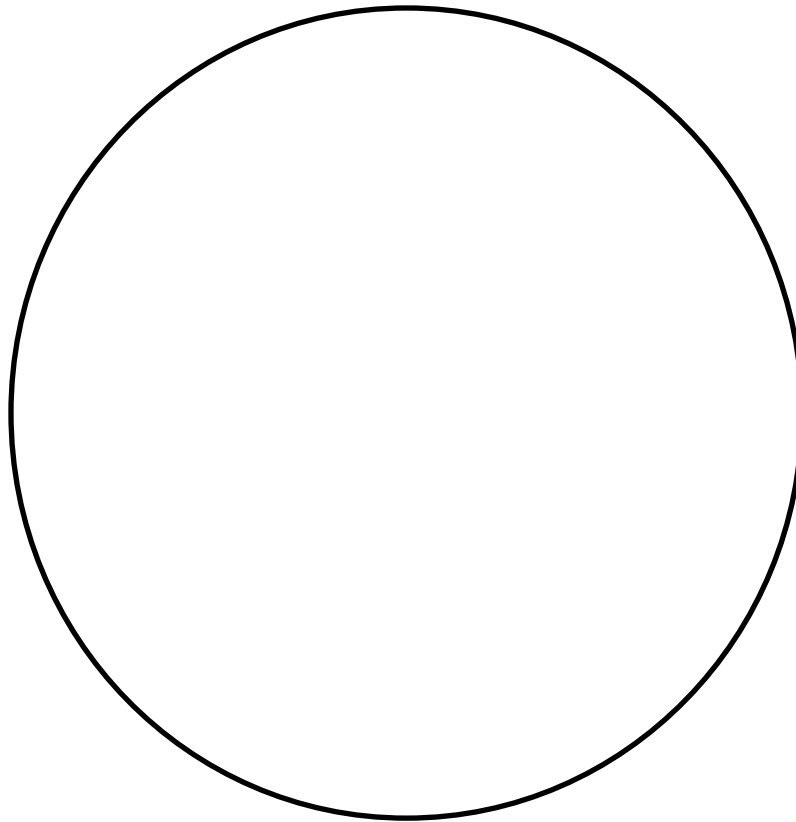
(Remember to check off the planets and constellations you saw tonight on your checklists.)

The Stargazer's Notebook

Month 1: Night Sky Map #2

The night sky at _____ on _____ at _____ with _____.
(longitude and latitude) (date) (time) (fellow stargazers)

North



Notes

What changes did you notice?

Did the stars' positions change in a clockwise or counterclockwise direction?

Name of a star I want to learn more about:

Observations:

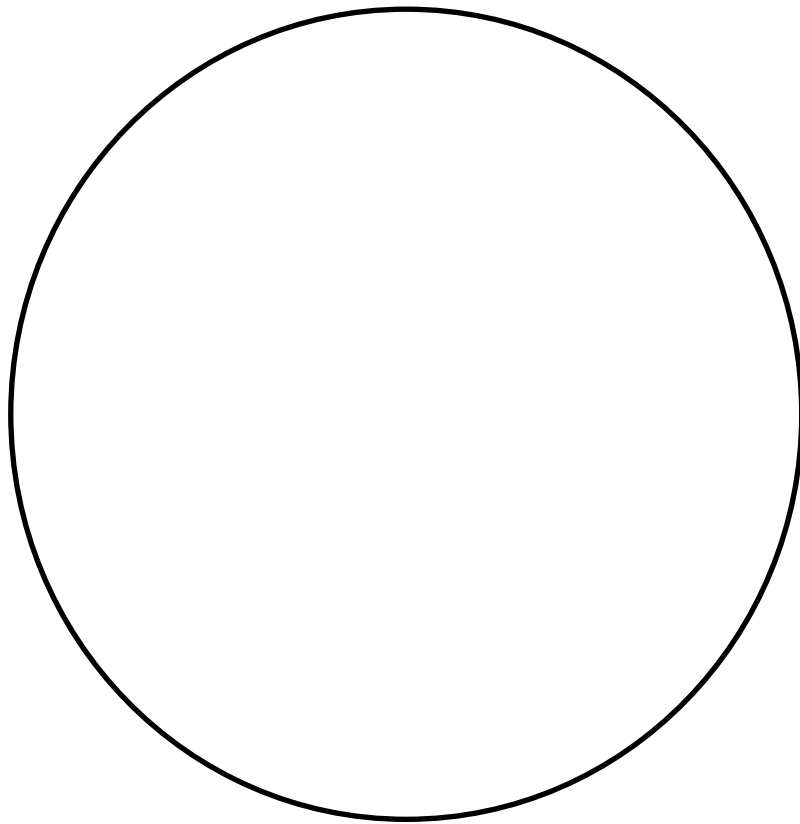
(Remember to check off the planets and constellations you saw tonight on your checklists.)

The Stargazer's Notebook

Month 1: Night Sky Map #3

The night sky at _____ on _____ at _____ with _____.
(longitude and latitude) (date) (time) (fellow stargazers)

North



Notes

What changes did you notice?

Why do you think the stars' positions change in the sky over the course of the night?

Did the stars' positions continue to change in a clockwise or counterclockwise direction? In which direction does this show Earth is rotating?

Observations:

(Remember to check off the planets and constellations you saw tonight on your checklists.)

Notes



The First Stargazing Night

Month 1: Night Sky Lab

Ancient Egyptian
stargazing mural
found in the tomb
of Irynefer
(a necropolis builder
who lived during the
13th century BCE)



How many times in your life have you looked up at the night sky and gazed at stars? Hundreds of times? Thousands? Did you notice that the position of the stars in the sky changes over the course of a year? Or over the course of the night? If so, you have that in common with people who lived in ancient times. The ancient Egyptians built pyramids to line up with the only star that did not appear to move across the sky—Polaris (the North Star). Ancient stargazers in Portugal planted crops and moved cattle according to astronomical observations. When you are observing the night sky tonight, you can be sure you are doing something that one of your long ago ancestors did as well.

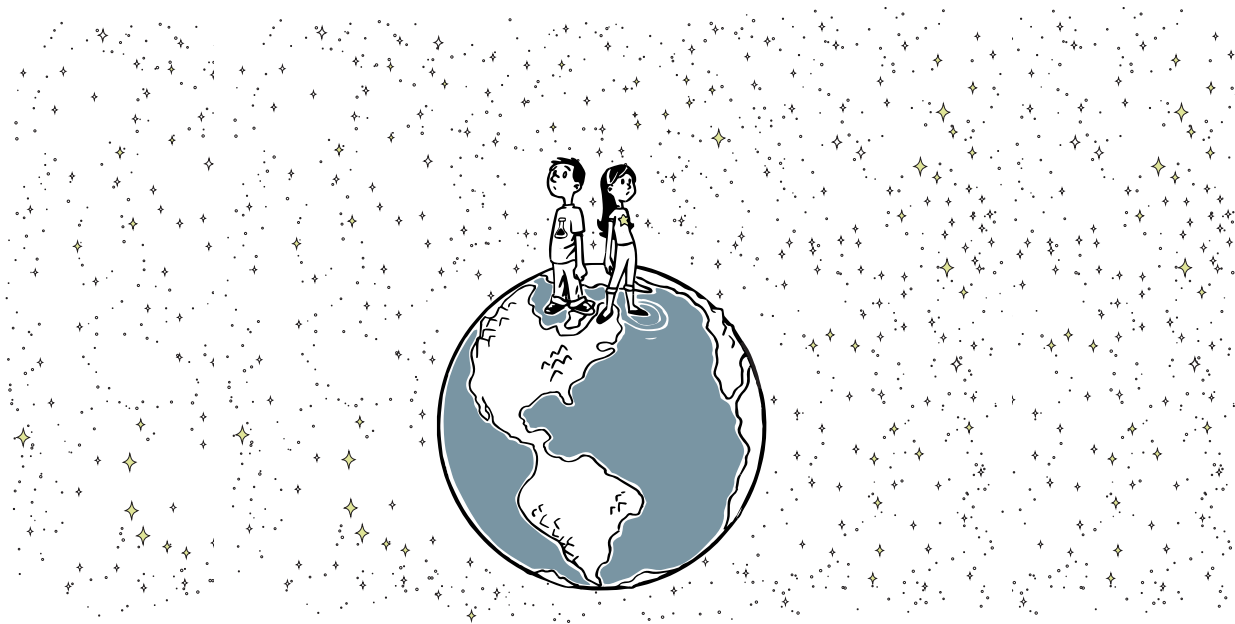
This year you will map the stars in the night sky in your area. You will observe how this map changes during the year. Maps like yours are a type of **scientific model**. Your map will model how the positions of the stars in the sky change through the year as observed from your location. You will start tonight by observing how the stars' positions change over the course of just one night. This activity is a science lab though, so there are some procedures to follow while you are making your observations. Gather the materials needed for stargazing, read over the following instructions, and get ready to begin stargazing and mapping the night sky.

Materials

- Month 1: Night Sky Maps #1, #2, and #3 (three pages starting on page 15)
- Items found on the Night Sky Viewing Supply list (page 13)



Month 1: Night Sky Lab *(continued)*



Procedure

Welcome to your first night of stargazing! For the first stargazing month, you will be viewing and mapping the stars three times in one night. For best results, start this lab on a night when you have clear skies. Do not do this lab on a cloudy night.

Getting Ready to Go Out

1. Read the Stargazer's Notebook instructions.
2. Fill in the Special Events chart found on page 9 with the best dates to view the celestial events in your area. Make sure you keep track of these dates throughout the year so you don't miss any events.
3. Choose a time, date, and place that works best for your night sky viewing. Choose a spot where there are no trees or structures blocking your view of the sky. Be thoughtful about the time you choose. If you choose a time that is too early, it might not be dark enough. But if you choose a time long past your normal bedtime, you might find it hard to stay up.
4. Decide the three times you are going out stargazing for the first time. The times need to be a minimum of one hour apart. Two hours apart works well, but it might be very late by the time you finish. You cannot begin until it is dark enough to see the stars well.
5. Read over the Month 1: The Night Sky Map #1 and fill in the blanks to complete the title at the top of the page. Do this before going out each time. Fill in any parts you can (for example, moon phase) before heading out to stargaze.
6. Familiarize yourself with how to use a planisphere and your red light flashlight.
7. Set your planisphere for the date and the time that you plan to start tonight's viewing. Choose one constellation that is on the planisphere to track throughout the year. On the monthly Night Sky Maps

Month 1: Night Sky Lab *(continued)*

you will be making notations regarding the position (or absence) of this constellation in the sky each month.

8. Before it gets dark, you should set up your viewing gear. It takes a while for your eyes to adjust to the dark, and you do not want to be turning lights on and off when you are getting ready to view. The best way to view night sky events is to lie down on a lawn chair so you can see everything above you without getting a sore neck. Make sure you have blankets and jackets in case the night is chilly. Food, drinks, and company all make night sky watching more enjoyable and sociable.

Right Before You Go Out

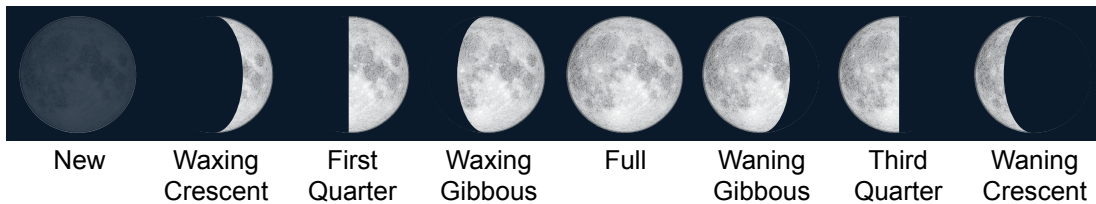
9. Turn off all of the lights around and inside your house. If your neighbors have outside lights that are on at night, ask them if they could turn them off while you are stargazing. You could even invite them to view the stars with you.
10. Read the instructions below so you know what you are supposed to do. Most of this lab is conducted in the dark or with the use of a red light flashlight, and reading may be difficult.
11. Plan to locate all of the constellations and planets on the list by the end of the year. You haven't located any stars or constellations yet, so this month is easy. Each one you see can be checked off on the Table of Stars checklist.

When You Are Out

12. Your eyes will need 20 to 30 minutes to adjust to the dark outside. During this time, do not turn your flashlight on or stare at any lights. You want your pupils to be as big as possible so the most amount of light can get into them. That will give you the best night vision possible. You will be surprised how much better you can see at night after 30 minutes with no lights. Only use a red light when you need light until you are done viewing the night sky.
13. Use the compass to find north. Then, turn around in a circle, imagining that you are standing under the exact center of a dome. The outline of the circle on the Night Sky Map represents where the dome meets the ground. It represents the horizon in all directions around you. Draw some of the landmarks (trees, buildings, mountains, etc.) you see on the horizon when you turn in a circle. This will help you in comparing views from different days because if you always stargaze from the same location, the objects on the horizon will be in the same place on all of the Night Sky Maps.
14. Using your planisphere locate a constellation or part of one. It doesn't matter which one you choose. Use this constellation or a group of stars within it (known as an **asterism**) as a starting point to help find other constellations and asterisms. For example, if you locate the Big Dipper, you can use it to find and map Ursa Major. From Ursa Major, you can easily locate of Lynx, Leo Minor, Leo, and Boötes. From these you can work your way across the sky, constellation by constellation.

Month 1: Night Sky Lab *(continued)*

15. Using a pencil so you can easily erase and correct any mistakes, begin mapping the night sky on Month 1: The Night Sky Map #1. Make sure the North label on the circle on the map ALWAYS points north. Use dots to represent stars and small circles to represent planets. The planisphere does not show the location of planets, so you will need to use the information you found online or a planet finder app to locate planets. Label the constellations, stars, and planets you see. You can do some of this labeling later with the help of your planisphere after you go inside. Label constellations, like URSA MINOR, in all caps, label asterisms, such as the (Little Dipper), in parenthesis.* Also be sure to label prominent stars, such as Polaris, if you see them. Draw the shape of the moon as it is in the sky and record the moon phase.



16. Use Month 1: The Night Sky Map #2 to map the night sky when you go out to view the sky for the second time tonight. Use Month 1: The Night Sky Map #3 to map the night sky when you go out to view the sky for the third time tonight.
17. In addition to stars and planets, you might see airplanes, satellites, meteors, and shooting stars. These objects can be seen moving, and in the case of airplanes, with flashing lights. If you want, you can include them on your map. Make sure to label them.
18. Optional: Use binoculars or a telescope to see more objects in the night sky. Draw and label these objects.
19. When you are finished mapping the night sky three times tonight, answer the questions at the bottom of the three Night Sky Maps

* Read ahead to Month 3 if you don't yet know the difference between an asterism and a constellation.

Thank you for previewing The Stargazer's Notebook.

We hope you are enjoying the course so far.

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Map the night sky:

- ★ Learn how to stargaze using just your eyes
- ★ Chronicle the patterns and locations of constellations
- ★ Locate planets, galaxies, and stars
- ★ View exciting cosmic events including meteor showers, eclipses, and auroras
- ★ Map the sky to prove scientific theories and concepts

Supply list:

- ✓ Planisphere ("The Night Sky" by David Chandler is recommended)
- ✓ Compass
- ✓ Red light flashlight
- ✓ Household lab supplies
- ✓ OPTIONAL: Astronomy binoculars

About the author: Blair H. Lee, M.S.



Blair is a former college science professor and the author of The Science of Climate Change: A Hands-On Course. She is a primary author for the critically acclaimed R.E.A.L. Science Odyssey Series published by Pandia Press. Blair is a featured speaker at conferences and the founder of the organization Secular, Eclectic, Academics. She is an advocate for innovative academics where the focus is on how subjects are best learned. Her experience has shown her that science is best learned when information is thoughtfully paired with direct hands-on application of that information.

