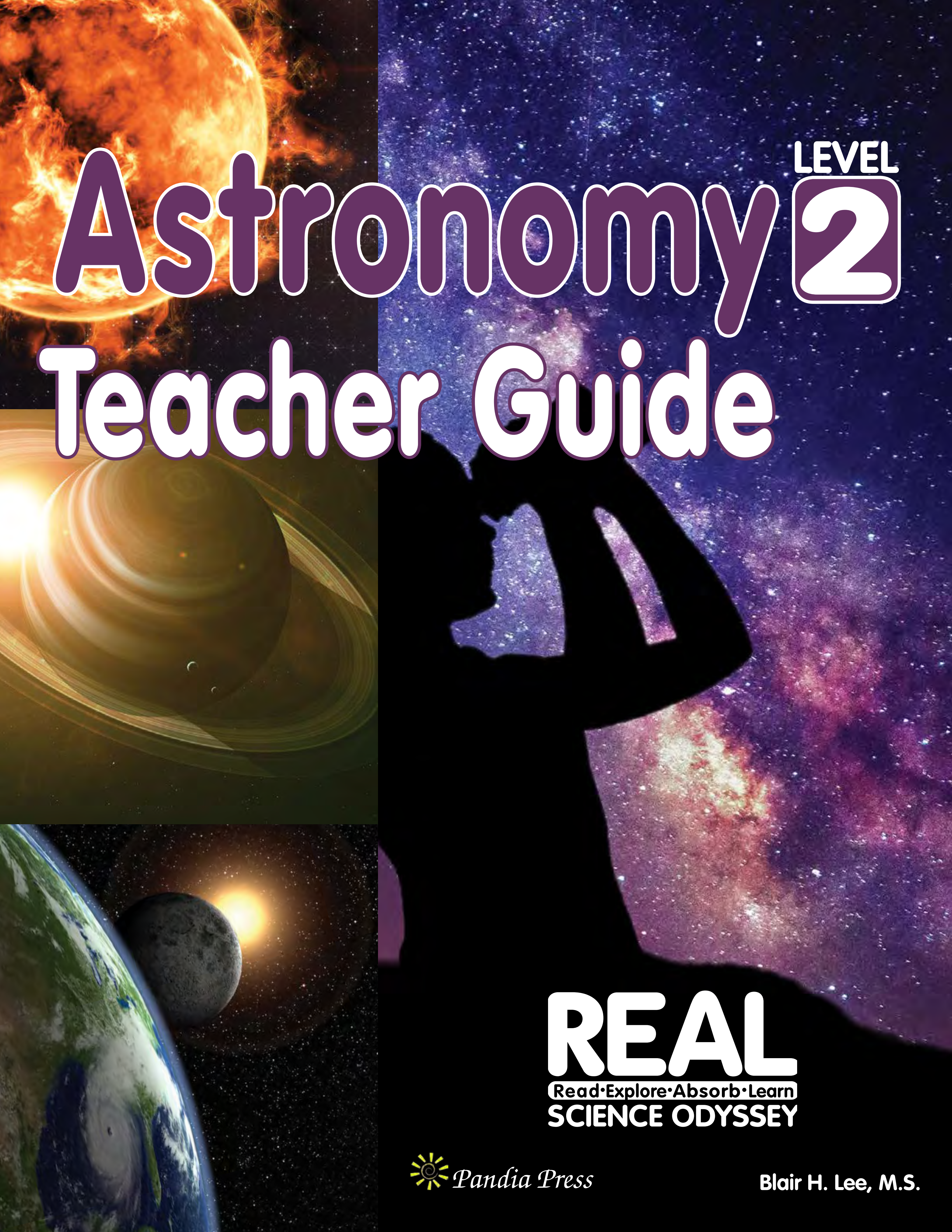

Astronomy LEVEL 2
Teacher Guide

REAL
Read·Explore·Absorb·Learn
SCIENCE ODYSSEY

Pandia Press

Blair H. Lee, M.S.

REAL SCIENCE ODYSSEY
ASTRONOMY LEVEL 2 TEACHER GUIDE
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REAL Science Odyssey

Astronomy 2

Teacher Guide

Blair H. Lee, M.S.

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The publisher and author have made every attempt to state precautions and ensure all activities and labs described in this book are safe when conducted as instructed, but we assume no responsibility for any damage to property or person caused or sustained while performing labs and activities in this or any RSO course. Parents and teachers should supervise all lab activities and take all necessary precautions to keep themselves, their children, and their students safe.

Pandia Press

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REAL Read·Explore·Absorb·Learn SCIENCE ODYSSEY Astronomy 2 Teacher Guide

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Teacher Guide

RSO Astronomy 2 Teacher Guide

Introduction to the Course

RSO Astronomy 2 is a complete, semester-long course.* The student guide and teacher's guide contain all the information you need to teach astronomy this semester. These books were written so that they could be taught by all educators, even if you do not have a science degree. It is my goal to make astronomy accessible to all, educators and students alike.

Structuring a good science course is like building a house. A well-built house starts with a strong foundation on which all other floors rest. RSO Astronomy 2 starts with the fundamentals, and fact by fact builds from there, creating a strong foundation for future science knowledge to rest on.

While learning the fundamentals of astronomy, students need to learn and practice the methods used by astronomers to establish the scientific models, facts, and theories that form the basis of those fundamentals. Understanding the scientific method and application of the processes used by scientists guides students to an understanding of the open-ended thinking that is a part of science. The labs are closely paired with the written material; that way students can see how the results of experiments have led to a better understanding of how the living world works. The experiments also demonstrate the application of science principles. All of this together gives you a complete science course that teaches the core principles of astronomy while teaching the processes used to develop these principles.

Course Structure

RSO Astronomy 2 consists of two core books: the student text and the teacher guide. There is also an optional add-on unit study called *The Stargazer's Notebook* (see page 10). RSO Astronomy 2 contains 12 chapters designed as a 12 to 16-week course, assuming each chapter is completed within one week, plus some extra time for review, lab work, and testing.* The lab in Chapter 1, Investigating Shadows, is a yearlong lab that continues after the main course is complete. Each chapter of the course has several sections:

- 12 Chapters of written lessons
- 12 General astronomy labs and activities including 10 scientific modeling labs
- 12 Famous Science Series (research assignments)
- 12 Show What You Know (short answer and multiple-choice quizzes)
- 3 Unit exams (found in the appendix of the student guide)

The course is divided into three units:

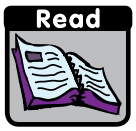
I. Universe and Cosmology
II. Our Solar System
III. Homeward Bound

*For the high school student, RSO Astronomy 2 plus *The Stargazer's Notebook* is equivalent to one science credit.

The Student Text

The student text functions as a textbook and a workbook, organizing the student lessons, worksheets, lab sheets, research, exams, and lab instructions all in one place. The text is designed so that as students read through the text, they are engaged through thought-provoking questions and, in many cases, by writing or coloring parts of diagrams. This type of direct engagement, when incorporated into learning material, gives students ownership of the material. Since students will be writing directly in their text, it is recommended that each student has his or her own copy of the course book.

The following are the parts and the activities of the student text found in each chapter. They are represented by the RSO acronym R.E.A.L.—Read, Explore, Absorb, and Learn. They are presented here in the order you will find them in the student text. Although you can switch the order of the general labs, the modeling work, and the Famous Science Series, you should not change the order of the chapters. Each chapter builds upon the prior one.



READ: The Lesson

This is the written lesson where the fundamentals of astronomy are explained and built on. These lessons start with material for the student to read. They are designed to get students thinking about key concepts, asking questions, and applying what they are learning to things they observe in the world around them. The written lesson is at a reading level so that most students in grades 6 through 10 can read it independently. Science vocabulary and terminology are introduced in context. They are written in **bold** within the lesson. Formal definitions can be found in the glossary of the student text.

EXPLORE: General Labs, Activities, and Model This

This section is where students explore concepts through experimentation and scientific modeling. They learn how scientists investigate and practice the scientific method in a meaningful way; gaining new insights into astronomy in the process. The general astronomy labs relate directly to the written lessons. The two are cohesive. Written lessons with labs that support the material studied is living science and is important to the understanding of science. Some labs have a math section. All math concepts are clearly explained with examples. Middle school and high school science is a good place to begin applying the abstract math concepts students have been learning all these years. Please note that several labs require adult supervision.

Lab reports are a formulaic type of writing. Even so, many college students cannot write them well. This is a writing skill students should be able to do before going to college. Some labs are conducive for write-ups, and some are not. I indicate those that are recommended for writing a lab report in the student text.

There is a heavy focus in this course on scientific modeling. Scientific modeling is used in every area of science. It is essential to science literacy that students learn how to create, develop, and interpret scientific models. To learn this process, students will create and develop their own scientific models this semester. Students will learn how to interpret scientific models, how scientific models are developed, and how scientists use scientific models to gain a deeper understanding of complex systems. Students will do this by reading about, thinking through, and using existing working scientific models. There is also some discussion of how scientific models evolve and change as new information is discovered.

ABSORB: Famous Science Series (FSS)

The skill of researching a topic is essential to being proficient at science. As the famous scientist Isaac Newton once stated, "If I have been able to see farther than others, it was because I stood on the shoulders of giants." By giants he means other great scientists. Scientists research what is known about a topic and build on that knowledge when making new discoveries.

The purpose of FSS is to sharpen the researching skills of students taking this course while they learn some interesting history relating to astronomy. **Students are expected to research the questions in FSS on their own; the information is not found in the course material.** Choosing the ways students do their research is up to you. I feel that Internet research is adequate for FSS. But you might want to have your student do some library research as well.

There are 12 Famous Science Series topics. The topics include famous scientists, famous space vessels and programs, famous maps, and famous scientific discoveries. These topics are relevant to the week's lesson. Students will use FSS to learn topics more in depth as they relate to the lesson. If you want to reduce the amount of writing for students, you can have them orally report the results of their research to you.

LEARN: Show What You Know (SWYK)

This section helps you and your student determine if they have learned the material covered that week. Astronomy can be technical with a lot of new vocabulary words. I have tried to make the text as interesting as possible to keep students engaged in the material, but it is still important to have weekly assessments to ensure they have learned the key concepts. Show What You Know is the title of the question-and-answer section at the end of each chapter. I strongly recommend that your students complete these. They might look like workbook work, and they are. However, it is not busy work. This section will help you assess whether students understand the material being covered. If students do not do well in this section, you know they need to go back over the material before moving on to the next chapter. You can use this section like an individual written test, or you may choose to use SWYK as a format for question-and-answer open discussion. If students are taking the unit exams, this section will help with their performance on the exams.

The Teacher Guide

Your teacher guide is set up to resemble the student text. Each chapter section is reviewed in the teacher's guide with further explanation not found in the student text, as well as answers and suggestions. In addition, the teacher's guide contains the following:

Weekly Schedule

I have provided you with suggestions for scheduling each chapter based on teaching science for two days, three days, and five days. The schedules will help ensure that you complete the main course in twelve weeks, if that is your intention. A couple of the labs continue beyond completion of the main course.

Learning Goals

These are a list of all the important concepts in the chapter. Reviewing the learning goals can be particularly helpful when deciphering main ideas that shouldn't be missed from details, which are nice, but not necessary.

Extracurricular Resources

This is a list of books, videos, and/or websites for further research. Use these resources when your student's interest is sparked, or when you need further clarification on a concept.

Math This Week

The math concepts presented in the chapter are reviewed in your teacher guide. The math has been written as a sectional part of most of the labs that have calculations. That was done so that the math can be treated as optional, although I recommend that students do the math. Math is integral to a good science background. Math and science are intertwined in the same way spelling, punctuation, and grammar are to good writing.

Lesson Review

The lesson reviews included in this teacher guide are written as class notes. They can be used as notes or you can use them for question and discussion with your students. They are the main points from the lesson and are provided to assist you in teaching this course. When I taught as a community college professor, I would use a sheet of written notes, my lecture notes, as a guide to make sure I covered the important points and reviewed the material from previous lectures that related to the material being taught that day.

Unit Exam Answer Keys

The student text contains the unit exams in its Appendix. There are six of them. See the following page for information about administering and grading exams. The answer keys for the exams are found in the teacher guide Appendix. The student book is designed so that most of the written work required for this course can be done directly in the text. For that reason, the exams are included in the student text.

Grading

Grading is up to you, the instructor. Below are two possible grading schemes based on whether you are administering the unit exams. There are grading scales provided for each unit exam, but you will have to determine the grade for each of the other parts of the course. The grading schemes below suggest how to weigh each part, if you choose to assign a grade. You, of course, are the teacher and will do what works best for you and your student.

1. Using all parts of the course:
    Unit exams = 40%
    General labs = 30%
    FSS = 10%
    SWYK = 20%

2. Not using unit tests:
    General labs = 40%
    FSS = 20%
    SWYK = 40%

Teacher Guide

RSO Astronomy 2 Teacher Guide

Introduction to Unit Exams

There are three exams spanning three units. The exams are found in the Appendix of the student text. Answers to the exams are found in this teacher guide in the Appendix. The exams have multiple-choice questions, vocabulary matching, true/false sections, and short written answers. There is no cumulative midterm or final exam. One could be made by combining questions from the unit exams.

What each exam covers:
Exam 1: Unit I–Universe and Cosmology, Chapters 1-4
Exam 2: Unit II–Our Solar System, Chapters 5 – 8
Exam 3: Unit III–Homeward Bound, Chapters 9 – 12

As the instructor, it is up to you how the exam is administered. Possible options are:

1. A closed-book exam with no notes
2. A closed-book exam with one sheet of notes (more pages of notes than this just get in the way)
3. An open-book exam
4. Don't use it as an exam at all; use it as a review

Structure of the exams:

- Multiple choice questions
- Vocabulary match
- Short-answer questions
- Except where indicated, the material from the Famous Science Series and the labs is not tested.
- All of the exams have opportunities for extra credit.

Grading the exams:

- The questions that require written answers can make grading a little more difficult. Use my answers as a guide. Just remember, partial credit should be applied to these questions if students get most, but not all, of the answer correct.
- Students can get more than 100% on the test if they get the extra credit points.

After the exam:

- Go over with your students any questions they missed. Use mistakes as an opportunity to learn.
- You can hand back the exam with incorrect answers marked and give half or full credit for any exam questions students correct. I like to do this because it keeps the focus on the primary reason for studying a course: to learn the material, NOT to get a grade.

Material List–by Chapter

Below is a list of items needed for the labs and activities in each chapter. Refer to the student text for quantity and other details.

Chapter 1–Introduction to Astronomy

- ☐ Flat plywood
- ☐ Wooden dowel
- ☐ Drill with drill bit
- ☐ Wood glue
- ☐ Marker
- ☐ Drawing tools
- ☐ Protractor or string and ruler (optional)
- ☐ Internet access

Chapter 2–The Big Bang

- ☐ Spherical balloon
- ☐ Black permanent marker
- ☐ String
- ☐ Metric ruler
- ☐ Another person

Chapter 3–Stars

- ☐ Periodic table
- ☐ Clay
- ☐ Dry macaroni
- ☐ Internet access
- ☐ Phone or tablet with a star-finding app, or a planisphere

Chapter 4–Differentiating Stars

- ☐ Old CD or DVD that is not scratched
- ☐ Cardboard box that fits the CD
- ☐ X-Acto knife or scissors
- ☐ Black pen
- ☐ Aluminum foil
- ☐ Tape
- ☐ Business cards
- ☐ Ruler
- ☐ Cardboard tube
- ☐ Color pencils
- ☐ Camera (optional)

Chapter 5–Formation of the Solar System

- ☐ Color pencils (red, reddish orange, orange, black)
- ☐ Small ball
- ☐ Large marshmallow
- ☐ Lamp with bulb that is not fluorescent
- ☐ Stove burner
- ☐ Pot
- ☐ Food coloring (red, yellow)
- ☐ Glitter
- ☐ Oven mitt
- ☐ Thermometers
- ☐ Aluminum foil
- ☐ Timer
- ☐ Another person
- ☐ Can of sterno
- ☐ Fireproof plate
- ☐ Clear baking dish
- ☐ Lighter or matches
- ☐ Water
- ☐ Books

Chapter 6–Planetary Motion

- ☐ Thumbtacks
- ☐ String
- ☐ Metric ruler
- ☐ Blank paper
- ☐ Tape or clips
- ☐ Cardboard
- ☐ Pencil

Chapter 7–The Rocky Ones

- ☐ Another person
- ☐ Polyethylene foam pipe insulation
- ☐ Plastic zip ties
- ☐ Big rubber band
- ☐ Scissors
- ☐ Metric tape measure
- ☐ Meter or yard stick
- ☐ Tack
- ☐ Cardstock
- ☐ String
- ☐ Duct tape
- ☐ Protractor
- ☐ Washer (for a bolt)
- ☐ Distance markers (rocks)

Chapter 8–The Grassy Ones

- ☐ Clay
- ☐ Playdough
- ☐ Wire twist ties
- ☐ Wood skewers
- ☐ Tennis balls
- ☐ Ping-pong balls
- ☐ Utensil to cut holes in the balls
- ☐ Dirt
- ☐ Metric ruler
- ☐ Metric tape measure
- ☐ 48-in beach ball
- ☐ Large space
- ☐ Paper strips
- ☐ Camera (optional)
- ☐ Crushed ice

Chapter 9–Mapping

- ☐ Small spherical object (ball or orange)
- ☐ GPS receiver
- ☐ Online geocaching account
- ☐ Transportation
- ☐ Another person
- ☐ Small item to trade

Chapter 10–Happy Birthday, Earth

- ☐ Periodic table
- ☐ Nail
- ☐ Coin
- ☐ Rock
- ☐ Drinking glass
- ☐ Water
- ☐ Balloons
- ☐ Measuring cup
- ☐ Salt
- ☐ Tablespoon
- ☐ Ruler
- ☐ Stove top
- ☐ Pan
- ☐ Tall glass

Chapter 11–Earth in Space

- ☐ Compass
- ☐ Access to Internet
- ☐ Alarm clock
- ☐ Timer

Chapter 12–Fly Me to the Moon

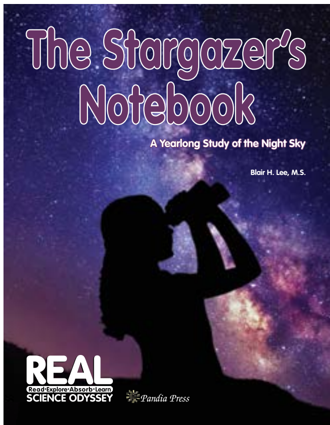
- ☐ Binoculars
- ☐ Internet access
- ☐ Tide schedule for your area
- ☐ Blank paper
- ☐ Color pencils (gray and black)
- ☐ Basketball (or similar)

Material List–Alphabetical

Below is a list of items needed for the entire course in alphabetical order. Refer to the student text for quantity and other details.

- ☐ Alarm clock
- ☐ Aluminum foil
- ☐ Another person
- ☐ Baking dish (clear)
- ☐ Ball (small)
- ☐ Balloons
- ☐ Basketball (or similar)
- ☐ Beach ball (48 in)
- ☐ Binoculars
- ☐ Books
- ☐ Business cards
- ☐ Camera (optional)
- ☐ Can of sterno
- ☐ Cardboard
- ☐ Cardboard box that fits a CD
- ☐ Cardboard tube
- ☐ Cardstock
- ☐ CD or DVD that is not scratched
- ☐ Clay
- ☐ Coin
- ☐ Color pencils
- ☐ Compass
- ☐ Dirt
- ☐ Distance markers (e.g. rocks)
- ☐ Drawing tools
- ☐ Drill with drill bit
- ☐ Drinking glass
- ☐ Duct tape
- ☐ Food coloring (red, yellow)
- ☐ Geocaching online account
- ☐ Glass (tall)
- ☐ Glitter
- ☐ GPS receiver
- ☐ Ice (crushed)
- ☐ Internet access
- ☐ Lamp with bulb that is not fluorescent
- ☐ Large space
- ☐ Lighter or matches
- ☐ Markers and pens
- ☐ Marshmallow (large)
- ☐ Measuring cup
- ☐ Meter or yard stick
- ☐ Metric ruler
- ☐ Metric tape measure
- ☐ Nail
- ☐ Oven mitt
- ☐ Pan
- ☐ Paper (blank)
- ☐ Paper strips
- ☐ Periodic table
- ☐ Ping-pong balls
- ☐ Plate (fireproof)
- ☐ Playdough
- ☐ Plywood
- ☐ Polyethylene foam pipe insulation
- ☐ Pot
- ☐ Protractor
- ☐ Rock
- ☐ Rubber band (large)
- ☐ Salt
- ☐ Scissors
- ☐ Small item to trade
- ☐ Spherical object (small ball or orange)
- ☐ Star-finding app or a planisphere
- ☐ Stove top
- ☐ String
- ☐ Tablespoon
- ☐ Tack
- ☐ Tape
- ☐ Tennis balls
- ☐ Thermometers
- ☐ Thumbtacks
- ☐ Tide schedule for your area
- ☐ Timer
- ☐ Tool to cut holes in tennis balls (e.g. wine screw)
- ☐ Transportation
- ☐ Twist ties
- ☐ Washer (for a bolt)
- ☐ Water
- ☐ Wood glue
- ☐ Wood skewers
- ☐ Wooden dowel
- ☐ X-Acto knife or scissors
- ☐ Zip ties

The Stargazer's Notebook: A Yearlong Study of the Night Sky



Pandia Press also offers *The Stargazer's Notebook: A Yearlong Study of the Night Sky* by Blair Lee. At least once a month, students study the night sky where they live. They chronicle the patterns and locations of constellations and their movement across the sky. Students also plot planets, galaxies, and individual stars. In addition, they record special night sky events as they occur and conduct several labs and stargazing activities. *The Stargazer's Notebook* is a standalone unit study or an excellent add-on to RSO Astronomy 2. For the high school student, RSO Astronomy 2 plus *The Stargazer's Notebook* is equivalent to one science credit.

About the Author

Blair Lee M.S.—scientist, writer, public speaker, and homeschooling mom—is a passionate advocate of innovative academics using secular materials. Through her speaking and writing, her goal is to empower educators to dare to be innovative and academically rich when crafting a child's journey through learning. Blair Lee is the founder of Secular Eclectic Academic (SEA) Homeschoolers, a vibrant, dynamic community that advocates for the exclusive use of secular academic materials when homeschooling. Blair has been handcrafting the education of her nonlinear thinker son for over 11 years. During that time, she has learned as much about how learning happens from him as he has learned from her. Blair loves to read, cook, hang out with friends, and travel.

Connect to Blair and other secular academic homeschoolers at seahomeschoolers.com.

Also by Blair Lee from Pandia Press:

REAL Science Odyssey–Chemistry Level 1
REAL Science Odyssey–Biology Level 2
The Stargazer's Notebook: A Yearlong Study of the Night Sky
REAL Science Odyssey–Earth and Environment Level 2 (coming in 2018)

Published by Blair Lee:

The Science of Climate Change: A Hands-On Course

Teacher Guide

Unit I: Universe and Cosmology

Chapter 1: Introduction to Astronomy

WEEKLY SCHEDULE

Two Days

Day 1
- ❑ Lesson
- ❑ Long-term Lab
- ❑ Activity

Day 2
- ❑ FSS
- ❑ Lesson Review
- ❑ SWYK

Three Days

Day 1
- ❑ Lesson
- ❑ Long-term Lab

Day 2
- ❑ Activity

Day 3
- ❑ FSS
- ❑ Lesson Review
- ❑ SWYK

Five Days

Day 1
- ❑ Lesson

Day 2
- ❑ Long-term Lab

Day 3
- ❑ Activity

Day 4
- ❑ FSS

Day 5
- ❑ Lesson Review
- ❑ SWYK

FSS: Famous Science Series
SWYK: Show What You Know

Introduction to Unit I

Unit I is four chapters long. It gives an overall explanation of the formation and defining characteristics of the universe and what is contained in it.

Beginning in Chapter 1, and throughout the course, there is a focus on scientific modeling. A scientific model is a representation—whether physically, conceptually, or mathematically—of a real phenomenon in science that cannot be experienced directly. Examples of scientific modeling include creating a scale model of the solar system or making a model rocket. Every area of science today uses scientific models. Astronomy and cosmology rely heavily on scientific models because astronomers and cosmologists often deal with systems that cannot be observed directly. It is essential to science literacy that students learn how to create, develop, and interpret scientific models. To learn this process, students will create and develop their own scientific models this year. This begins with the lab in Chapter 1 where students work through the creation and development of a scientific model. In later chapters of this text, students will be given less instruction as they become more adept at creating and designing their own scientific models. Throughout this text, students will also learn by reading about and using existing working scientific models. In this manner, students will learn how to interpret current scientific models.

Introduction to Chapter 1

Chapter 1 begins by defining the branch of science called Astronomy. Early in the Chapter I, students are asked to think about five questions they are interested in learning the answers to this year. I like to begin a course with questions, and I hope your students think about the answers and ask questions of their own. If they ask a question you do not know the answer to, I encourage you to look it up and help them figure it out, even if it gets you off track every now and then. I am a big fan of child-led learning, and use it often when homeschooling my son.

Lab 1 is a long-term lab that requires students to track the sun one time a week for a full year. Most likely students will be working on this lab long after this course is completed. I encourage you to continue the lab for a full year and perhaps combine it with work done in the RSO Astronomy add-on—*The Stargazer's Notebook*.

Learning Goals

- **Learn and understand how to apply the definition of light-year as a measure of distance.**
- **Learn some basic distance units and how they are applied including light-year and astronomical unit.**
- **Recognize that light is the fastest-moving thing in the universe and moves at a speed of 3×10^8 m/s.**
- **Understand that electromagnetic radiation from objects in the universe is the main thing astronomers use to learn about the universe.**
- **Learn three basic properties of electromagnetic radiation used by astronomers.**
- **Learn about the electromagnetic spectrum.**
- **Learn why astronomers must have high altitude/elevation sites when using telescopes.**
- **Learn some of the basic tools astronomers use to take in and interpret electromagnetic radiation.**
- **Learn about manned and unmanned space exploration.**
- **Recognize the enormity of the size of the universe.**
- **Learn about scientific modeling and scientific models.**
- **Work to create a scientific model.**

Extracurricular Resources

Books

Almost Astronauts, 13 Women Who Dared to Dream by Tanya Lee Stone

Team Moon: How 400,000 People Landed Apollo 11 on the Moon by Catherine Thimmesh

The Scientists Behind Space by Eve Hartman

How Do Scientists Explore Space? by Robert Sneddon

Eye on the Universe: The Incredible Hubble Space Telescope by Michael D. Cole

Destined for Space: Our Story of Exploration by Don Nardo

The Mighty Mars Rover: The Incredible Adventures of Spirit and Opportunity by Elizabeth Rusch

A Wrinkle in Time by Madeleine L'Engle – The wrinkle referred to in this classic fictional book is a wrinkle in the space-time continuum that the protagonists travel through.

Scholastic Discover More: Night Sky by Giles Sparrow

Alien Hunter's Handbook: How to Look for Extraterrestrial Life by Mark Brake

Out of This World Jokes about the Solar System: Laugh and Learn about Space (Super Silly Science Jokes) by Melissa Stewart

Out of This World: Poems and Facts about Space by Amy Sklansky – This is a little young for this age group but the poetry is very good

Extracurricular Resources

Web/Video

An original song about the electromagnetic spectrum (my son thinks it is cheesy)
http://www.youtube.com/watch?v=bjOGNVH3D4Y&list=PL249113232EE15DCA

There are so many good videos for this chapter. These are just a few.

This 32-minute video from NASA is an introduction to electromagnetic radiation and some of the telescopes used to study them. It also discusses some of the discoveries using electromagnetic radiation that have led to a better understanding of the radiation. I highly recommend taking the time to watch this video: https://www.youtube.com/watch?v=HPcAWNlVl-8

This is a movie of some galaxies seen using the Hubble Space Telescope:
http://www.youtube.com/watch?v=loXDVGi_lK0

Voyager at the Final Frontier from NASA: http://www.youtube.com/watch?v=EFnJzyxd78o

This is about the James Webb telescope that is under construction:
http://www.youtube.com/user/NASAWebbTelescope

These are about the Mars Rover Curiosity from The Jet Propulsion Lab. If you like these there are many more from that source and from NASA:
http://www.youtube.com/watch?v=MlpFgump7so
http://www.youtube.com/watch?v=P4boyXQuUlw
http://www.youtube.com/watch?v=B8OUL9QYNpl
http://www.youtube.com/watch?v=UUVmyl9yjyU

An hour-long video about a new kind of technology that warps space and time, so that distances in space are more accessible:
https://www.youtube.com/watch?v=9M8yht_ofHc

Read

Lesson

What Is Astronomy?

The science of astronomy is closely meshed with physics, chemistry, and math. After a short introduction, there is an explanation of the distance measurements used in astronomy followed by a basic explanation of the physical properties of light used by astronomers. I do not believe in having students memorize a list of facts and principles without teaching how scientists came to know these facts and principles. Without an understanding of the properties of light, there is no way to understand how astronomers know what they do. The particle nature of light is not covered.

Light is a type of electromagnetic radiation. I use the term *electromagnetic radiation*, not light. These two terms are often used synonymously, which I think is confusing for students learning about this subject. For example, when most people think of light they generally do not think of radio waves, x-rays, or microwaves, but these types of electromagnetic radiation are studied by scientists when objects radiate them from space. Along these lines, the speed of light includes the speed of wavelengths that make light, but it also includes the speed of wavelengths such as x-rays.

Answers to questions in the lesson

It takes light 100,000 years to travel across the Milky Way Galaxy.

What units should you use?

The distance between the planet Saturn and the sun: *astronomical units (AU)*

The distance between your two eyes: *centimeters (cm)*

The distance between the star Vega and the star Betelgeuse: *light-years (ly)*

The length of a room: *meters (m)*

The distance between New York and Minnesota: *kilometers (km)*

Math This Week

Throughout the text students will find use of scientific notations, use of the metric system, common abbreviations for units of distance and time measurements, and different distance units compared and discussed. Light-year and astronomical units are specifically taught.

The mathematics in this chapter include addition, subtraction, and multiplication of two and three-digit numbers. Scientific notation is used in a few places in this chapter. Your students may skip these if they need to, but numbers in astronomy are so big and even occasionally so small, a basic working knowledge of how scientific notation works is helpful. Here is a link to a series of free tutorials explaining the topic of scientific notation from Khan Academy:

http://www.khanacademy.org/math/arithmetic/exponents-radicals/scientific-notation/v/scientific-notation.

The metric system is used throughout the course. Scientists use the metric system. Now is as good a time as any to learn how to use this system if your students do not know how. Here is a link to a series of free tutorials explaining the topic of the metric system from Khan Academy:

https://www.khanacademy.org/math/cc-fourth-grade-math/cc-4th-measurement-topic.

Explore

Lab

Model This: Investigating Shadows

The first lab in the course is a long-term lab that takes a year to complete. Note that this experiment, like most of those done in astronomy, makes observations using light. This lab begins the process of instructing students how to develop and interpret scientific models. A scientific model is a simplified representation of a real system. I wish, for this lesson, I could be holding your student's hand as he goes through this modeling lab. I give lots of information and ask lots of questions in an attempt to do that. Some students will have no problems with modeling. Others are going to need help. I suggest you closely monitor your students' progress throughout this lab.

Scientific models are important to all disciplines of science. They are especially important in astronomy, in which scientists cannot directly interact with the objects they are studying. Scientific modeling has become an increasingly important tool used by scientists. Every student of science from middle school on up should understand how scientific models are created and be able to interpret them. I will be weaving talk of scientific models and labs, using them throughout Astronomy 2. If students stick with it, by the end they will have a good basic understanding of how to create and interpret scientific models.

Once a week or so, students will mark the position sunlight strikes a set location. This needs to be done on the same day at about the same time each week. Again, a couple of weeks off are not a big deal. The only possible stumbling block with this experiment is forgetting to check the sun's position at the same time each week. If after a couple of weeks you realize there would be a better time or day to check this each week, make a note on the lab sheet and switch to the better time/day. Once a month students must also remember to note their observations on the lab sheet.

Below is a link to a teacher's resource explaining scientific models. No study of astronomy, geology, atmospheric science, or oceanography should be considered complete without an understanding of scientific models. You as the teacher are going to need to understand scientific models at least a little bit in case your student gets stuck when trying to learn about models and when applying knowledge to develop a scientific model.

http://www.learner.org/courses/essential/physicalsci/session2/closer1.html.

If you want more information about the teaching pedagogy of this important skill, this video covers that: http://www.youtube.com/watch?v=aDgulnEVE10.

Lab Sheet Suggested Answers. *Students will be referring back to this lab sheet to answer questions as they learn more astronomy in later chapters.*

Part I–Observations to make today

What is coming to Earth from the sun that you are using for this experiment?
Solar radiation

What do you observe about the sun's position in the sky over your house?
Answers will vary. My answer: It moves across the sky in an arc or in a straight line.

How do apparent changes in the sun's position affect shadows? Based on these observations, what do you think it means if there is a change in the position of a shadow measured from the same location at the same time of day over several months? *The direction of the sunlight coming to that location must have changed.*

Part 2–Answer these questions while completing Chapter 6

How is your chart on the plywood going? Are you starting to see an analemma?
Answers will vary.

Have you been tracking the sun's apparent movement across the sky? Why is it called the sun's *apparent* movement? What is really moving? *Earth is moving not the sun, but it appears that the sun is moving because Earth is moving.*

In Chapter 6, you learned how Earth orbits the sun. You learned that the shape of Earth's orbit is an ellipse, and that the sun's distance from Earth changes over time. How does this affect the speed Earth is moving during its orbit? *Earth moves faster when it is closer to the sun and slower when it is farther away from the sun.*

Ask another person to walk quickly across a room while you count to 10 with your eyes closed. When you get to 10, tell the person to stop. Open your eyes and note the location of the person in the room. Repeat this task, but this time ask the person to walk slowly. Open your eyes and again note the location of the person in the room. Did changing speed over the same time period affect the person's location? *Yes. The person was farther across the room when he/she was moving faster than when he/she was moving slower.*

Considering the simple example above, imagine that you are the sun shining on the person. When you open your eyes, will the position of the shadow you see be different or the same for the two locations? Apply this concept to the model explaining why a shadow cast by the sun changes position. *Different. The shadow will be pointed in a different direction, because the person will be at a different location. When Earth is moving faster it will seem that the sun has moved a farther distance over the course of a week than when Earth is moving slower. (The point of this exercise is to show how variations in speed can have an affect on the changing position of shadows.)*

Why do you think the analemma circles back around to where it starts? *Because Earth's orbit loops back to its starting point over the course of a year.*

Part 3–Answer these questions while completing Chapter 11

How is your chart on the plywood going? Is the analemma starting to appear? *Answers will vary.*

For Lab 11, you monitored the sun's apparent movement across the sky. Draw a rough illustration of the sun's path over the course of the day. Does it look like an analemma? Like many things in science it takes more than one data set to really understand what is happening. *Answers will vary. My answer: It does not look like an analemma; it looks like an arc.*

In this lab you have been monitoring the change in the angle and direction of the dowel's shadow as Earth orbits the sun. What did you learn about in Chapter 11 that would cause a change in the angle of a shadow cast by the sun? *Earth's axial precession–Earth's tilt*

Because of Earth's axial tilt and elliptical orbit (which causes Earth to speed up and to slow down) the location of the sun above the horizon changes during the year. Why does Earth's axial tilt cause the location to change? *Over the course of a year, Earth's tilt causes a change in the angle of radiation of light reaching a location.*

The one-day graph of the sun's apparent movement across the sky is an arc. The arc is (*lower*) in winter. The arc is (*higher*) in summer. This is because the (*angle of incidence of light from the sun*) changes over the course of a year.

The day of the year when the arc is lowest is (*winter solstice*).

The day of the year when the arc is highest is (*summer solstice*).

Explore

Activity

It's a Big, Big Universe

I spent quite a bit of time trying to develop a lab to give students some perspective about the size of the universe, how far apart objects in the universe are from each other, and how fast the speed of light is. But the universe is so big, objects are so far apart, and light moves so fast that everything I came up with wasn't feasible. But it is important for students to have some understanding of the size of the universe when studying astronomy. I decided that the best way to grasp this concept is through good videos. One of the videos is interactive. The other video is a 45-minute look at size, distance, and the speed of a light-year for the universe. You might want to watch these as a family.

Absorb

Famous Science Series

Famous Space Vessel

The Famous Science Series (FFS) is the research portion of the course. Students need to research outside of the text to answer the questions found in the FSS sections. If your student does not have much experience researching questions, he might need you to tutor him. He might need help with key words when using a search engine, like Google.

Even if your student isn't excited to do the math or to learn about the scientific instruments and what they do, you should still check out Curiosity on NASA's website. The experiments being conducted are very interesting. I think NASA does a good job with its informational websites.

Suggested Answers

1. Curiosity needed a launch vehicle to carry it to Mars. What is the name of the launch vehicle that carried Curiosity to Mars? *The launch vehicle was United Launch Alliance, Atlas V.*
2. What date and time did it launch? *It launched on November 26, 2011 at 7:02 a.m. PST.*
3. What date and time did it land on Mars? *It landed on August 5, 2012 at 10:32 p.m. PDT.*
4. Do the math: How long did it take Curiosity to get from Earth to Mars*?

* Don't forget about the leap year in your calculations. Subtract 1 hour from the total hours, because of daylight savings time.

The math:

For Nov 2011 = 4 days + 16 hours + 58 minutes

From December 2011 through July 2012 = 31 + 31+ 29 + 31 + 30 + 31 + 30 + 31 = 244 days

For Aug 2012 = 4 days + 22 hours + 32 minutes (4 days, 22 hours, 32 minutes)

Because of daylight savings time being in effect in August we subtract 1 hour for a total of <u>253 days, 14 hours, and 30 minutes</u>

Mars Science Laboratory Entry Descent and Landing Instrument (MEDLI): *MEDLI is collecting engineering data about the spacecraft's entry into the Martian atmosphere.*

Rover Environmental Monitoring Station (REMS): *REMS is studying atmospheric pressure, humidity, ultraviolet radiation, wind, and air and ground temperature.*

Radiation Assessment Detector (RAD): *RAD is measuring the amount of radiation that the surface of Mars experiences. It is monitoring high energy radiation with short wavelengths such as gamma rays and cosmic rays.*

Dynamic Albedo of Neutrons (DAN): *DAN is studying neutrons leaving the Martian surface to help determine if there is subsurface water on Mars.*

Sample Analysis at Mars (SAM): *SAM has three instruments on it: a mass spectrometer, a laser spectrometer, and a gas chromatograph. These instruments are looking for the presence of carbon, oxygen, hydrogen, and nitrogen. The presence or absence of these elements will give information about whether life and or water were present on Mars in the past.*

Chemistry & Mineralogy X-Ray Diffraction (CheMin): *CheMin is studying the abundance of various minerals on Mars.*

Chemistry & Camera (ChemCam): *ChemCam shoots a laser a distance away which allows it to determine:*

- *Type of rock, ex. volcanic or sedimentary*
- *Composition of rock*
- *Abundance of some elements*
- *Presence of ice or minerals with water in them*

Alpha Particle X-Ray Spectrometer (APXS): *APXS uses X-Rays to measure the amount and type of some elements in rocks and soil.*

Mars Descent Imager (MARDI): *MARDI took a color video of Curiosity's descent to help scientists plan the best path for exploration.*

Mars Hand Lens Imager (MAHLI): *MAHLI provides a close-up view of minerals, textures, and structures of Martian rocks.*

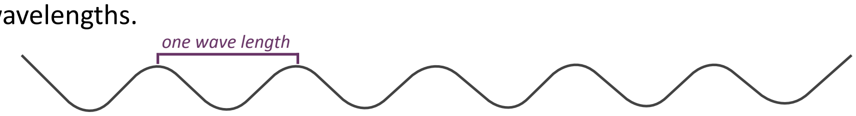
Mast Camera (MastCam): *MastCam takes color images and videos of the Martian surface.*

Learn

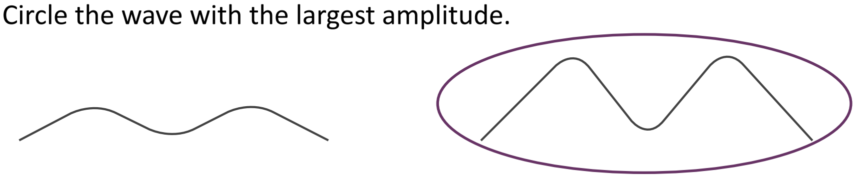
Show What You Know

Introduction to Astronomy

1. The line below has been drawn in a series of waves. Label one of the wavelengths.



2. Circle the wave with the largest amplitude.



The wavelength is the same for these two waves. What does it mean that the amplitude is different?

The wave with larger amplitude comes from a higher energy source.
The wave with the smaller amplitude comes from a lower energy source.

3.

R	**O**	**Y**	**G**	**B**	**I**	**V**

4. How long would it take to travel to this black hole traveling at the speed of light?
It would take 28,000 years to get there traveling at the speed of light.
The math:
60 sec(per minute) x 60 minutes(per hour) x 24 hours(per day) x 365.25 days(per year) = 31,557,600 seconds per year (3.1558 x 10^7 sec/yr)

31,557,600 sec/year x 300,000 km/sec = 9,467,280,000,000 km/year

9,467,280,000,000 km/year x 28,000 year = 265,083,840,000,000,000 km (2.6508 x 10^{17} km)

31,557,600 sec/year x 186,282.4 miles/sec = 5,878,625,466,240 miles/year

5,878,625,466,240 miles/year x 28,000 years = 164,601,513,054,720,000 miles (1.6460 x 10^{17} miles)

5. Why are observatories at high elevations? *Observatories are at high elevations, because the gases in Earth's atmosphere interact with the electromagnetic radiation coming from space, absorbing it, radiating it back into space, or blurring it.*

6. Astronomers use *electromagnetic radiation* to learn about the universe. *Light* is a type of this. Electromagnetic radiation travels through space in *waves*. The *amplitude* and *wavelength* of the waves depend on the source of the electromagnetic radiation.

7. Astronomers use the electromagnetic spectrum to learn more about many characteristics of the universe. Which three things from the list on page 20 are you most interested in learning more about? *(Answers will vary—my purpose with this question is to get students to read over the list in the text and think about each of the items on the list.)*

8. *centimeter –cm*
meter –m
kilometer –km
astronomical unit –AU
light-year –ly

9. *Answers will vary. My answers:*

I would measure *hair growth* in centimeters.
I would measure *the length of a pool* in meters.
I would measure *the distance to Grandma's house* in kilometers.
I would measure *the distance to Mars* in astronomical units.
I would measure *the distance across the Milky Way* in light-years.

Read

Lesson Review

What Is Astronomy?

- A light-year measures distance.
- 1 light-year–ly, measures the distance all types of electromagnetic radiation travels in the vacuum of space in one earth year.
- Electromagnetic radiation travels at 3 x 10^8 meters/second (m/s)
- Nothing moves faster than light.
- Distances in space outside of the solar system are measured in light-years.
- 1 astronomical unit, AU, measures the distance between Earth and the sun. Distances in the solar system are measured in AU.
- Astronomers use electromagnetic radiation to learn about the universe.
- Light is one type of electromagnetic radiation.
- Electromagnetic radiation is generated at a source and radiates away from the source in waves.
- Astronomers use four properties of electromagnetic radiation:
  1. Wavelength – The waves come in different wavelengths depending on the type of electromagnetic radiation.
  2. Frequency–Frequency is the number of wavelengths passing a given point every second. Frequency is inversely proportional to wavelength.
     - When wavelengths are small, the frequency is high.
     - When wavelengths are large, the frequency is low.
  3. Speed–The distance between objects in the universe is measured using the amount of time it takes light to travel from one object to the other
  4. Amplitude–Amplitude is the height of the wave.
     - High amplitude = high energy source
     - Low amplitude = low energy source
- The electromagnetic spectrum = the continuous range of wavelengths at which electromagnetic radiation occurs.
- Visible light is part of the electromagnetic spectrum.
- Earth's atmosphere interferes with wavelengths from outer space; because of this, observatories are at high elevations on Earth or orbiting Earth outside Earth's atmosphere.
- Telescopes capture and focus large amounts of electromagnetic radiation across the electromagnetic spectrum.
- Astronomical spectroscopy separates the spectrum of wavelengths radiated by an object.
- Space exploration: Astronomers have used manned and unmanned spacecraft to study space.

Teacher Guide

Unit I: Universe and Cosmology

Chapter 2: The Big Bang

WEEKLY SCHEDULE

Two Days

Day 1
- ❑ Lesson
- ❑ Lab

Day 2
- ❑ FSS
- ❑ Lesson Review
- ❑ SWYK

Three Days

Day 1
- ❑ Lesson

Day 2
- ❑ Lab

Day 3
- ❑ FSS
- ❑ Lesson Review
- ❑ SWYK

Five Days

Day 1
- ❑ Lesson

Day 2
- ❑ Lab

Day 3
- ❑ FSS

Day 4
- ❑ Lesson Review

Day 5
- ❑ SWYK

FSS: Famous Science Series
SWYK: Show What You Know

Introduction to Chapter 2

The area of science covered this week is cosmology. I think cosmology is one of the most important areas to learn about when studying astronomy. It is the area of science that studies the origin and structure of the universe, including how chemical elements are made. Cosmology and astronomy both rely on chemistry and physics to explain and understand many of the basic tenets of their disciplines. I do not presuppose students have studied either yet. I explain the chemistry and physics as needed.

Learning Goals

- **Learn the scientific definition for the universe.**
- **Learn, review, or relearn some basic chemistry.**
- **Learn the scientific definition of the word “theory.”**
- **Learn how the big bang model explains the beginning and evolution of the universe.**
- **Understand the three types of evidence supporting the big bang theory.**
- **Learn that the universe is expanding and how Hubble determined this.**
- **Learn about the Doppler effect, redshift, and blueshift.**
- **Learn what cosmic microwave background radiation is, and how it is evidence supporting the big bang model.**
- **Understand that the cosmic abundance of the elements is evidence supporting the big bang model.**

Extracurricular Resources

Podcast

This podcast is about the big bang: http://www.astronomycast.com/2007/10/episode-58-inflation/

Books

Hyperspace: A Scientific Odyssey Through Parallel Universes, Time Warps, and the Tenth Dimension by Michio Kaku. This book is 359 pages and non-fiction, but if you or your student is interested in the question of universes beyond our own, other dimensions, or even time travel, this is an excellent book and very readable.

The Big Bang by Paul Fleisher

The Magic of Reality How We Know What’s Really True by Richard Dawkins. This book covers much more than just the big bang. It does a great job of explaining the redshift and how Isaac Newton discovered that white light is made up of a mix of wavelengths.

Extracurricular Resources

Books (continued)

Really, Really Big Questions about Space and Time by Mark Brake

Out of This World: All the Cool Bits about Space by Clive Gifford. This book covers some material not covered in this chapter, but you could have students read relevant chapters when they encounter them later in the text.

The next three books show a reading level of 9 to 12. If you have an advanced reader I would still check them out. These are complicated topics. Often good science texts should be looked at for content, not reading level. All are written by theoretical physicists trying to make complicated topics accessible:

George and the Big Bang by Stephen Hawking (with his daughter, Lucy)

George's Secret Key to the Universe by Stephen Hawking (with his daughter, Lucy)

The Space and Time of Uncle Albert by Russell Stannard

Web/Video

http://www.fromquarkstoquasars.com/the-star-that-exploded-at-the-dawn-of-time/

Doppler effect:

https://www.youtube.com/watch?v=I1ykNQijOC8

https://www.youtube.com/watch?v=h4OnBYrbCjY

Very good video explaining the scientific definition of the word theory:

http://www.youtube.com/watch?v=ltxVLu8J_d0

NASA demonstrates the big bang in 14 seconds:

http://www.youtube.com/watch?v=TOhzLnD1xW8

This rather dry talk explains what led to the modern understanding of the formation and origin of the universe: http://www.youtube.com/watch?v=uTxjNIIZ5jM

On Edwin Hubble: http://www.youtube.com/watch?v=hVApTLE7Csc&list=TLFPLTR06xGZU

Proof for the big bang explained:

http://www.youtube.com/watch?v=uyCkADmNdNo

Read

Lesson

Bang! Let's Get This Universe Started

The definition of the universe includes all matter, energy, space, and time that exist now and have ever been. The big bang model describes how the universe came into being and how it has evolved since then. This model describes how all matter, energy, space, and time began, evolved, and continues to evolve. What was before the big bang and exactly what was at the instant of the big bang is not explained by this model, and scientists do not have a definitive answer. Strange—yes, hard to comprehend—definitely, but the evidence for the big bang model is very strong. I do not go into all of it in this course, it is too technical. I only touch on the theory of relativity in this course, but its findings support the big bang model.

There is a basic chemistry section in the chapter that goes over the parts of an atom. I will go over basic chemistry when I get to chapters where it is needed. If your student has never studied chemistry, you might need to go over these sections with him.

RSO Biology 2 Connection

This course is part of a series: REAL Science Odyssey Level 2. All areas of science connect to each other. For those of you who have used RSO Biology 2, this course will have lesson material and labs that relate back to RSO Biology 2.

RSO Biology 2, Chapter 20–Evolution: A Timeline Lab:

If you still have your geological timeline from RSO Biology 2, you could add the following events from the big bang model to your timeline:

1. Add a marker 93.2 feet before the formation of Earth marker. This marker is when the big bang occurred. The successive markers will be placed between the big bang marker and the marker for Earth's formation.
2. Immediately add a marker for protons and neutrons.
3. Right next to that add markers showing helium and lithium nuclei.
4. The first atoms formed just 0.0442 inches from the start of the big bang, so mark it next to the helium and lithium nuclei.
5. Two feet from the big bang marker, stars begin to form.
6. One foot before the formation Earth, our solar system began to form.

Explore Lab

Model This: Expanding Universe

This scientific model is easy to set up. It can be hard to conceptualize how a group of points or objects can all move farther away from each other at different amounts. This short and simple model demonstrates how this works.

Lab Sheet Suggested Answers

Why do we use a scientific model to study the expansion of the universe?
The universe is too big and objects in it are too far apart to do an experiment on it directly. A balloon, on the other hand, can get only so large before it explodes.

How could this model be used as evidence for the big bang?
As the balloon was blown up, the distances between the home galaxy and other galaxies grew larger as they expanded away from each other. The galaxies that were the farthest away from the home galaxy moved the most. This models what astronomers have observed happening in the universe. The universe is still expanding because of the effects from the big bang with those objects that are the farthest away moving the greatest distances. This models what you would expect after the big bang occurred.

What happened to the distance between the home galaxy and the other galaxies as you blew up the balloon? Which galaxies moved the greatest distance from the home galaxy, those closer to or farther away from it? *The distances increased, those farthest away moved the most.*

If you were standing on the home galaxy when these galaxies moved farther away from it, would you have observed the color of the galaxies shifting towards the red end or the blue end of the color spectrum? What is this color shift called?
The red end. This is called the redshift.

The balloon model demonstrated the principle it was supposed to. But like all simplified models it has limitations. Can you think of any?

1. *The balloon model is 2-dimensional, the universe is 3-dimensional.*
2. *There was no way to see a red shift as the points moved away from each other.*

Absorb

Famous Science Series

Edwin Hubble

Edwin Hubble is the founder of cosmology. I stayed with the science aspects of Edwin Hubble's life and discoveries. But his biography is very interesting. His father wanted him to be a lawyer, so Hubble obtained a bachelor's in jurisprudence. The problem was he didn't love the law. His real passion was astrophysics. After his father died he went back to college to study astronomy and became one of the top astronomers of his age. If you are a history buff, you might enjoy learning more about Hubble's life.

Suggested Answers

Edwin Hubble has been called the Founder of Modern Cosmology. What does the word *cosmology* mean? *Cosmology is the study of the origin and structure of the universe.*

What did Edwin Hubble do to earn this moniker (nickname)?

1. *He devised a classification system for galaxies.*
2. *He observed redshift in light emissions from these galaxies that proved that the universe is expanding. From this he proposed a scientific model called Hubble's law, which helped astronomers determine the age and expanding nature of the universe.*

Hubble's law led to the proposal of the big bang theory. What is Hubble's law? *Hubble's law states that galaxies are moving away from each other (expanding) and that the farther away a galaxy is the faster it is moving*

Edwin Hubble formulated his law in 1929. In 1917, a very famous scientist produced a model showing that the universe was expanding. This scientist did not believe in his own model. Instead he decided that the universe must be a constant size. Who was this scientist? And what did he have to say after Hubble's discoveries? *Albert Einstein. Einstein said that his refusal to believe in his own findings on this issue was, "the greatest blunder of my life." Being the great man he was, Einstein visited Hubble to thank him for the work he was doing.*

Resources:

http://www.edwinhubble.com/hubble_bio_001.htm

http://encyclopedia.kids.net.au/page/hu/Hubbles_law

Learn

Show What You Know

The Big Bang

Multiple Choice

1. When you look at a star 25 light-years away you are seeing the star as it *was 25 years ago.*
2. The universe is *all of the above.*
3. The two most abundant elements in the universe are *hydrogen and helium*.
4. Hubble discovered that light from galaxies has *a redshift.*
5. Based on his discovery about light from galaxies, Hubble concluded that *the universe is expanding.*
6. Cosmic microwave background radiation is *all of the above.*

Define

1. The big bang model–*a scientific model that explains how the universe began and how it has evolved since its beginning 13.82 billion years ago*
2. Cosmology– *the study of the origin and structure of the universe*
3. Scientific theory– *a widely accepted explanation of something observed in science. Theories are based on experimentation, observation, and reasoning—the scientific method. Before something can be called a scientific theory, it must be tested many times by different researchers, who get results that are consistent with that theory.*
4. Doppler effect– *the change in wavelength of electromagnetic radiation when the source of the radiation is moving toward or away from an observer*

Matching

9 Atoms–*The building blocks of molecules and matter.*

8 Nucleus– *The center of an atom, where the protons and neutrons are.*

2 Neutron–*The neutral particle inside the nucleus.*

6 Proton–*The positive particle inside the nucleus. These determine the type of element.*

5 Electron–*The negative particle that orbits outside the nucleus*

7 Molecules–*Atoms create these by linking together and sharing electrons.*

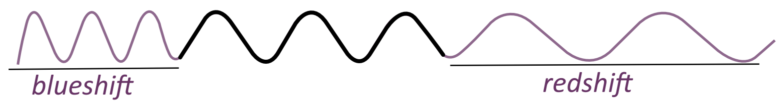
4 Hydrogen– *This element has 1 proton in its nucleus, with 1 electron orbiting.*

3 Helium–*This element has 2 protons in its nucleus, with 2 electrons orbiting.*

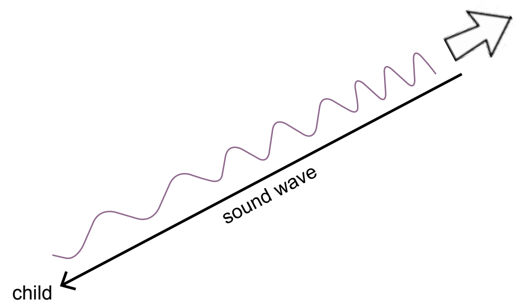
1 Element–*A group of all the same type of atoms.*

Draw

Student's drawing should show that blueshifted wavelength has a shorter wavelength and the redshifted wavelength has a longer wavelength.



Student's drawing should show that the wavelength will redshift; therefore, it will have a longer wavelength when it reaches the child.



Timeline

13.82 billion years ago–*the big bang, the universe began*
Immediately after the big bang–*the universe expanded*
Soon after the big bang–*protons and neutron formed*
100 seconds after the universe began–*atomic nuclei for hydrogen, helium, and lithium formed*
380,000 years after the universe began–*the first atoms formed, mostly hydrogen and then helium*
2 million years after the universe began–*the first stars began to form*
9.22 billion years after the universe began–*our solar system began to form*
9.32 billion years after the universe began–*Earth began to form*
10.02 billion years after the universe began–*life evolved on earth*
13.8198 billion years after the universe began–*humans evolved*

Math

How long have humans walked the earth?

13,820,000,000
– 13,819,800,000
= 200,000 years

Read

Lesson Review

Bang! Let's Get This Universe Started

The universe is defined as all:

1. matter
2. energy
3. space
4. and time – past, present, & future

The big bang model:

1. Explains how the universe began
2. Explains how it has evolved from its beginning to now
3. Because the definition of the universe includes time in the future it also attempts to explain how it will evolve.
4. Gave rise to the big bang theory
5. Despite the name did not start with a BANG! It started with an expansion event.

Scientific theory:

- A scientific theory does not mean the same thing as the general usage of the word theory.
- Scientific theories are based on the scientific method and are based on the results of experimental evidence not a person's opinion.

The Doppler effect, happens on the earth and in space:

- When the source of electromagnetic waves is moving away from the observer. As waves elongate, they shift toward the red end of the electromagnetic spectrum = redshift
- When the source of electromagnetic waves is moving toward the observer. As waves shorten, they shift toward the blue end of the electromagnetic spectrum = blueshift

Evidence supporting the big bang model and theory:

1. The universe is expanding–Hubble looked at the chemical signature from elements in galaxies. He saw they had a redshift, which shows these galaxies moving away from Earth and from each other.
2. Cosmic Microwave Background Radiation–This is radiation left over from an early time in the evolution of the universe.
3. The abundance of hydrogen and helium is what is expected and was predicted from the big bang model.

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