

Astronomical Observing from a Biblical View

A course of instruction that is designed to teach practical skills for observing the wonders of God's created heavens.

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Course download: www.cwm4him.org under <DOWNLOADABLE COURSES>

Change Record

Version 1 – May 10, 2010 (minor changes installed during the year)

Version 2 – Dec 28, 2014 (significant changes to several chapters; Addendum 5 added)



Acknowledgments (2014)

We thank the students and users of our material. You drove the need for the course. Our first users were children and adults that came to our home but the course material consisted of pages of notes and some exercise aids. Presentations for a two-day seminar at a Haitian church led us to expand the notes and better organize the material. The needs in a Ugandan church added some chapters and some materials for training. The needs at the Institute of Foundational Learning in the Philippines pressed us to finalize a draft and eventually produce the first published version, which was made available through the CHRISTWORKS MINISTRIES web site. The process was a bumpy road, but it enabled us to learn what would work among people who had no prior experience with observing the heavens and did not know what God had to say about his created heavens.

The questions about origins and creation were so common in our outreach sessions and mission trips that we halted plans for a second version until we could produce a study on biblical creation, which was completed in 2014. With the questions from students in mind, more experience with astronomy outreaches, and lessons learned in the field from the first version, a revised or second version was published in late 2014 with some reorganized chapters, changed graphics, and added addendum material. The material was also compiled into a single file for downloading.

Our objective is unchanged: provide a practical course to teach observing the created heavens to people who cannot afford costly courses/books and have never observed the created heavens. For our friends in that category, working with you is our privilege. Without exception, however, whether rich or poor, we have seen people get excited about the created heavens once they get started on the lesson exercises and actual observing. We have seen so many students get excited as they master disciplined observing skills. Our experience with you helped us adjust the content of the course. Thank you.

Disclaimer

We take responsibility for any deficiencies in the study. We are fully aware of some inherent limitations. We wanted to avoid teaching a full astronomy course but introduce enough on the subject to help practical observing. We wanted to maintain the biblical creation context but not make it a full Bible study. We wanted to get people observing the heavens but knew most of our targeted audience had severe limitations in equipment and money, so we had to employ simple materials, instruments, and exercises. We hope the balance we chose is helpful. Comments are welcome to suggest corrections and modifications.

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Authors' Preface

Astronomical Observing from a Biblical View (AOBV) is a course of instruction that is designed to teach practical skills for observing the heavens from a biblical creation world view. The student learns observing techniques, which include using modest instruments and recording observations. Basic reading/writing skills (a typical level for a twelve-year-old child) are needed but the lessons presume the student has no practical knowledge of the heavens or what the Bible says about them. Enough basic astronomy information is introduced to facilitate learning to observe. When a student has completed the course, he should have adequate skills to discover the heavens for himself and probably teach others the same skills.

AOBV is specifically oriented to help disadvantaged people groups, where children and teachers often have limited access to tools for science learning, finances are limited, and internet access is poor. The astronomical observing disciplines taught in AOBV help fill the science gap by encouraging good observing disciplines using the mind, eyes, and hands, although a low power binocular or small telescope helps. The graphics and literal size of the course are kept small (about the size of a digital photograph) to facilitate downloading when internet services are limited.

So why study the night skies, especially from a biblical view? It is rarely taught anywhere! Night skies are beautiful, which will be discovered by the student. The night skies also invariably lead to this question: How did they get there?" They are present every night for observation if there are reasonably clear skies. They contain a wealth of detail and features that are easily observable with the unaided eye or with the assistance of modest optics. But there is a two-sided problem why their beauty seems hidden:

1. Although the Bible, whose original author is God, illustrates the importance and goodness of the heavens through numerous scriptures, few people learn or believe what God says about them. The Bible is too often viewed as having little impact on the world we see around us, so God's comments on the heavens and their creation are typically unknown or disregarded.
2. The average person does not have observing skills for the heavens for a number of reasons. Light pollution in city areas discourages observing. The attraction and amount of media that people regularly see tends to overload people--supplanting interest in observing skills that require more time and discipline. Courses are rarely offered that train people to observe in a disciplined manner—especially the heavens.

Therefore, it is not surprising that teaching observational astronomy with a biblical view is uncommon. It was considered a valuable skill in the distant past for the wealthy, but has not been a regular part of most education processes for centuries. For that matter, practical Bible instruction about the physical world around us is rare. Although the Bible clearly states that the heavens—like the rest of creation—speak of God's character and glory, it is a truth seldom applied to the rapidly expanding body of information about sky objects. Spacecraft and earth-based telescopes continue to deliver information that accents the complexity and beauty of sky objects but relating it to God's creative and sustaining

hand is uncommon. In the meantime, the practical sky-observing skill of most people remains limited and unaffected.

In contrast, our experience in the field has shown us that skilled observing of the skies from God's point of view is both exciting and encouraging. The course is oriented to fuel these attitudes—especially among those who are young, young-at-heart, curious, or looking for the reason, order and beauty of the heavens. Course is designed so people start observing. The skills can be expanded with experience but are sufficiently presented in this course for a person, if the skills are mastered, to begin observing with confidence. These skills can also benefit other areas of expertise, where disciplined observing, as applied to many professional fields, involves steps that are similar to those presented in the course.

We encourage students to enjoy learning and observing the heavens. We recommend a thankful heart to God for the heavens. They are available for observation for a lifetime. While silent, the heavens speak loudly about the One who created and sustains them. Our theme is simple: Psalm 19:1 says, “the heavens declare the glory of God.”

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Course Organization and Method

The course is designed to be taught by a person who has completed AOBV training. The material can also be mastered by an individual without an instructor, but it can be more difficult since the equipment, materials, vocabulary, and disciplines are often unfamiliar. CHRISTWORKS MINISTRIES can be contacted for training information (email: cwm4him@embarqmail.com or use the web site: www.cwm4him.org). Printed copies of the course are not provided. Please download the PDF file for local printing.

There are 12 lessons that are designed to be scheduled on a regular basis. Each lesson has a section for reading/study during the day and exercises are designed for both day and night. Take note that lessons 4 through 7 are quite long. They can easily be subdivided. Repetition is built into the material to help learning but the benefits are lost if the lessons are too far apart. We recommend trying to finish a single lesson (including the exercises) during a one- or two-week period. The lessons can be taught at school but can just as easily be taught in a community, church, or home. A basic materials/equipment list is located at the beginning of each lesson.

There are practical day and evening exercises for each lesson that are essential for this course. The night exercises, which require reasonably clear skies, can be done as early as an hour after sunset or an hour before sunrise. They can be accomplished in small groups or as individuals. Starting equipment is simple: eyes to see, a piece of paper, and a pencil. In later lessons, one rotating sky map, which is called a planisphere, is added. A small binocular guidebook, a pair of 7 to 10 power binoculars or a small telescope, and a small star atlas will be helpful in the last few lessons. A teacher or assistant is needed for most exercises if students need oversight and have no prior knowledge of practical observing.

There are a series of addendums to assist with the lessons and general observing. They are summarized at the end of this section. If you want to get references or equipment before the course has begun, read Addendum 5 for some general recommendations.

Learning a skill requires testing or evaluation to demonstrate mastery. While this course does not have formal written tests, student participation is designed to demonstrate lesson objectives. The student will demonstrate a skill or produce an observing sheet that shows the results of the learning process. The same terminology is repeatedly used during the lessons; equipment is introduced then repeatedly demonstrated; observing of sky objects occurs several times using a common observation sheet. The repetition is designed to reinforce the learning and build confidence in the student that is learning to observe.

The final exam is not a traditional academic exam—it is an observing period that applies the practical skills and knowledge that have been learned during the lessons and exercises. If a person has mastered the course skills, he or she should be confident to be able to find a variety of types of sky objects, record what is observed, and keep those skills for years.

The table that follows provides a summary of each of the lessons, which includes a text summary, the key Bible reference, the sky object that is reviewed, and the titles of the practical exercises.

SUMMARY OF LESSONS

#	LESSON TITLE	TEXT SUMMARY	Bible Reference & Object Review Day exercise: lesson#--D#(1,2,...) Night exercise: lesson#--N# (1,2,...)
1	Introduction	An overview of a Bible-based view of the heavens, the importance of observing, and practical skills that will be taught	Colossians 1:15-17 Earth 1-D1 Basic Orientation 1-N1 Apparent Sky Movement
2	The Wonders of the Heavens	A review of primary solar system and deep sky objects from recent photographs using a Biblical point of view.	Psalms 19 Various 2-D1 Remembering Night Sights 2-N1 How-Many-Stars Experiment
3	What the Bible Says—Overview	The basics about the heavens—how they were created, what was created, what it means, and the strength of the Bible statements on the heavens.	Genesis 1:14-19 Moon 3-D1 Sunrise/Sunset Locations 3-N1 First Stars After Sunset? 3-N2 Seeing in the Dark Experiment
4	Tools to See the Sky: Hands and Eyes	The basics about how the eyes work to see things in the dark, an introduction to angular measurement, and how hands/eyes can be used to measure angles.	Isaiah 40:25-26; Psalm 147:4 Saturn 4-D1 Measuring Experiment by Day 4-N1 Star Magnitude Experiment 4-N2 Measuring Experiment by Night
5	Finding Things in the Sky with Hands and Eyes	An introduction to sky motion, constellations, seasonal changes, and measuring your way around the sky.	Job 9:8-9 M42 5-D1 Star Patterns & Magnitudes 5-N1 Cardinal Directions and Season 5-N2 Star Position & Color Experiment
6	Sketching to Record Observations	An introduction to basic sketching techniques as a method of technical and disciplined observing.	Amos 5:8 M45 6-D1 Shading Exercise 6-D2 Outline Exercise 6-N1 Locate & Sketch A Constellation 6-N2 First Sketch of the Moon
7	Astronomical Tools to Help the Eyes – Part I	The planisphere and star charts: an introduction; an introduction to binocular observing.	Proverbs 3:19, 8:27 M13 or M22 7-D1 Set Planisphere & Get Oriented 7-D2 Proper Use of Binoculars 7-N1 Binocular Observing Period 7-N2 Finding a Deep Sky Object
8	Astronomical Tools to Help the Eyes – Part II	A review of binoculars and an introduction to telescopes.	John 1:3 NGC 253 or M31 8-D1 Small Telescope Review 8-N1 Telescope Observing Exercise 8-N2 Sketching One Open Cluster
9	Observing the Moon and Using an Observing Sheet	The observing sheet – recording observations – and observing the Moon as a practical example.	Romans 1:20 The Sun 9-D1 Observing Sheet Exercise 9-D2 Moon Crater Exercise 9-N1 Moon Crater Exercise at Night 9-N2 Observing Sheet for Crater
10	Observing Sky Objects and Using an Observing Sheet—Part I	Use of the observing sheet and a review of observing techniques; introduction to observing a sky area.	Hebrews 1:2-3 Moon by Day 10-D1 Observing Review 10-N1 Sky Map Sketch Exercise 10-N2 Sky Object Sketch Exercise

#	LESSON TITLE	TEXT SUMMARY	Bible Reference & Object Review Day exercise: lesson#--D#(1,2,...) Night exercise: lesson#--N# (1,2,...)
11	Observing Sky Objects and Using an Observing Sheet—Part II	Use of an observing sheet and disciplined observing techniques to sketch a deep sky object.	1 Corinthians 15:40-41 The Milky Way 11-D1 Review of Types of Objects 11-N1 Find & Sketch a Nebula 11-N2 Find & Sketch a Cluster
12	Complete Observing Period – A Review	Review of the tools, techniques, and the reasons to consider what is observed.	Job 41:11 & Acts 17:24 Earth 12-D1 Dry Run Exam using real equipment then making an observation sheet with a picture of an object for the exercise (surprise object)
	Final Exam	Complete observing period using binoculars or telescopes. Turn in a final observing sheet. Teacher observes the use of equipment & observing methods. Student turns in an observing sheet.	Psalm 8:3-4 None No exercises; night exam period (approximately two hours, not including setup)

NOTES FOR LESSONS

Each of the 12 sequential lessons begins with a review of a significant Bible reference and a major sky object. These two lesson elements are reminder of the reason for the heavens and a review of especially prominent objects that can be seen with the unaided eye, binoculars, or a small telescope. Lessons 1-3 orient the student to the heavens and discuss the Biblical basis for their existence. Lessons 4-7 contain the basic astronomy and sketching skills that are needed to observe. They take a little longer to complete. Lesson 7-8 introduce the practical use of binoculars and telescopes but also include observing periods. Lessons 9-11 are primarily observing periods for different kinds of sky objects. As lessons progress, emphasis on observing increases—applying what has been learned in earlier lessons.

Although most of the lessons take about two hours, this does not include the time for exercises. Exercises in early lessons are usually less than an hour but can take more with a sizable group of students. Lessons in later exercises are actual observing sessions, which can take a couple hours.

Day and night exercises are identified at the end of each lesson. They can be done individually or as a group. Day exercises can be done at the end of the lesson or during a separate period during the same day or week. The night exercises can be done shortly after sunset or at least an hour before sunrise. Exercises can be accomplished at a location other than a school as long as the equipment requirements are met. Some oversight is usually required for children. Most exercises can be divided in parts or repeated. We highly recommend doing the exercises because they reinforce the skills being learned and they are designed to help the mindset change that is a key to observing the heavens. (Exercises help the change that takes place as we shift observing from earth to the heavens, which are usually unfamiliar.)

Lesson 12, which is a practice for the exam, uses the information learned in the first 11 lessons. The student will have the opportunity to demonstrate the use of equipment, observing techniques,

recording observations, and relating the observation to a pertinent Biblical principle or statement. The exercise is intended to be a review of all course material and equipment. If actual observing is not possible due to weather, the sky object will be a picture of an object at a distance under reasonably dark conditions so observing/sketching can be practiced. Lesson 11 is designed to be fun, open, and confirm what has been learned. It will take a couple hours. It is normally conducted with small teams of people.

The exam is a normal observing session that involves setting up/properly using assigned equipment, finding an assigned object, and sketching it using an observing sheet. The observing period, while it might seem a little intimidating, is meant to be exciting and fun—not a fearful challenge. It can be done by an individual or a small group (probably no more than 3-5 students per set of binoculars or a small telescope. Each student, however, must make an individual observing sheet and record what they observe. The exam can also be public, where the parents or local villagers can watch the students. The exam period will typically take at least 2 hours and requires night conditions. The authors of AOBV typically conduct this exam individually or in small groups and require the observers to answer questions and demonstrate specific skills.

Any of the observation activities in the lessons can be easily expanded. The heavens are full of objects to observe, so sky exercises and actual observing for a lesson can be repeated or varied. Teachers are encouraged to exercise latitude to promote interest, increase skills, and take advantage of sky conditions.

ADDENDUMS

Five addendums are provided that will assist observers and teachers with observing skills as well as the biblical view of the heavens. Summaries follow:

Addendum 1. Table Summary of Key Scriptures Regarding the Heavens. The addendum provides the more significant biblical references to the created heavens. Although each lesson contains key references, this list is a more complete compilation. It can be a Bible study guide in itself, or can be used by students to choose verses for application to individual observing sheets.

Addendum 2. Moon Observing (Day and Night) During the Lunar Cycle (Teacher Hints/Helps). The content provides a practical guide for observing the moon during each moon cycle. The material is complete enough to be used as a basis for observing the moon over a long period of time, which is helpful for places that have poor sky conditions. (Moon observing is less affected by poor conditions because it is so bright compared to stars.)

Addendum 3. Related Subjects and Applications. Many teachers and parents are trying to fit the content of this course into a larger context of course material for students. This short addendum provides some ideas about related subjects. Many subjects and disciplines use similar disciplined observing skills like those taught in AOBV.

Addendum 4. Observing Sheet Guidelines. Developing an observing sheet, which is a record of an observation period, is a primary goal of the course and provides teachers/parents with a way of

evaluating the skills being learned by the student. However, the content of this record can vary greatly. We provide some guidelines and a form for those who want a consistent structure.

Addendum 5. Recommendations for Equipment and Helpful References. Teachers and parents commonly ask for equipment recommendations and book references. This set of recommendations is brief and knowingly biased to what we have successfully used in our backyard or overseas. It includes a summary of the particular materials that are used during the course for those interested in getting them before the course commences.

OPTIONAL COURSE TRAINING

Training is sometimes available that is dependent on the authors' location and schedule. Training outside the US is possible. Use the contact information on the cwm4him.org site to request information. Training for a school or a group by the authors requires a local group to have a plan and commitment to employ and teach the skills to others. Part of the "skill set" is a belief in biblical creation as presented in the course.

Consider these guidelines for considering whether you want to request training: it takes 24 hours of class time and four night observing periods for a team of two trainers to train a group of 15-25 teachers. This cannot be accomplished in less than a week. Accomplishing training during a two-week period usually works better.

Portions of AOBV are presented in other venues. The authors (and some graduates of the course) hold outreach sessions, where just a few hours for a group of people provides an opportunity to introduce the origin of the heavens from a biblical creation viewpoint, some equipment used for observing, and the observation of several key night sky objects. An abbreviated version of the AOBV can also be recommended that can be presented at camps or seminars.

A good percentage of people who take the course are individuals that simply want to learn how to observe themselves. We urge them to complete all the lessons, because the skills they learn can also be used to help others, including children in their own neighborhoods.

CLOSING NOTE

When we (the authors) started observing, we had very little assistance and no experience. It would have been wonderful if we had this course at our fingertips as we learned to observe. In that light, we hope this helps others getting started. God has made the heavens that we might observe them. They point to Him.

AOBV Lesson 1: Introduction

Materials: paper and pencil

Reference: Colossians 1:15-17

Sky Object: Earth

THE BIBLE AND THE REFERENCE SCRIPTURE

Each lesson begins with a scripture reference from the Bible. Why? It is because the course uses a Bible-based world view of the universe. Lesson 3 is devoted to some of the elemental scriptures that address the heavens but each lesson is also opened with one key reference.

The student is not required to believe this biblical world view or to be familiar with the Bible. Belief is a matter of the heart. But it does require the student to learn about the biblical world view. While learning to observe the heavens will not make a student a Christian, it will provide some important elements for consideration that may influence a person's decision regarding Jesus Christ.

The following paragraphs provide a synopsis of this Book, which is the source of the individual book references that are spread throughout the lessons.

The Bible is a compilation of 66 smaller books that have material written by men but given by God. For this reason, it is said to be "inspired". The Bible addresses beginnings and endings (the creation of all things and the projected end of the physical universe). Creation by God includes time, space, and things in that space (including earth and mankind). The Bible has two major sections that are called the Old and New Testaments. The "old" section points to Jesus Christ; the "new" section points "back" to Jesus Christ. Jesus Christ, who is called the Messiah, is the Son of God. Hebrews 1:3 states that Christ is the express image of God to us.

In essence, it is said that God made us so perfectly that we were given the ability to freely decide whether we believe in him and what he claims to have done (or is doing). We can also choose not to believe in Him. God makes it clear that we need to be related properly to him to have true life but he does not coerce or force us to believe. God chose His Son, Jesus Christ, to be that message of help or good news for those who believe.

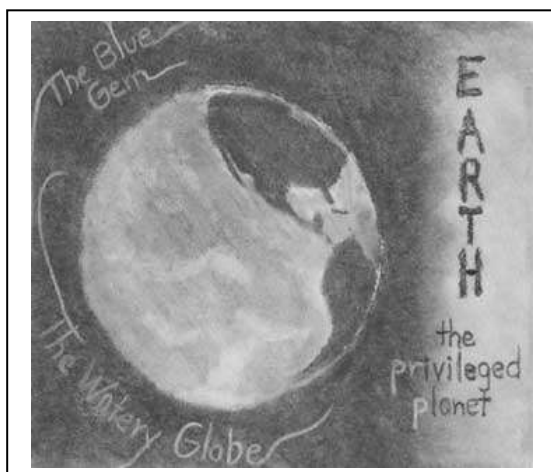
According to the Scripture, the universe, which was created through Jesus Christ, includes the heavens or night skies, which we will learn to observe. The heavens are one important way, as stated in the Bible, to see God's handiwork and his attributes. The first book of the Bible (Genesis) describes creation. The last book (Revelation) describes some history and the end of time—primarily in allegorical form or with imagery—that includes the end of the universe as we presently know it. We will present Bible references about the heavens during the course that are found in many of the individual books. The most numerous or significant references to the heavens are in Genesis and Psalms. Many scriptures, however, address the earth, moon, stars, constellations, and key objects with respect to their origin, effects, or meaning. Even if a person is not a believer in Jesus Christ as the Son of God (a Christian

viewpoint), a review of the content of the Bible references on the heavens is beneficial for understanding how a biblical world view affects such a dynamic subject.

The Bible reference for this lesson is from Colossians 1:15-17. The verses explain that through Jesus Christ everything was created by him. It specifically mentions the heavens, or those things that can be found in the skies, which include those things in the atmosphere of earth but also beyond the earth (the rest of the universe). This is a most interesting statement and parallels other references.

The implications of this scripture (and others) are the fact that the heavens did not self-evolve. Rather, their complexity, order, expanse, and characteristics were created or set into existence by God's command—they were brought into being from nothing. In terms of observing, this means we are observing God's handiwork when we observe the heavens. So we see and interpret some of its expanse, complexity, and characteristics—as much as our eyes and our equipment will permit. The verses go a step further by saying that the heavens are held together by his sustaining power. The statement gives the impression of the universe being held at a certain state of being, so we are able to observe the heavens in this "holding" state. Last, the scripture says it was created "for" him—an indicator that it is

excellent, or well designed, or worthy of study, or has his signature upon it like an excellent painting. This is why the wonder and majesty of the heavens is exciting. The skies are a window through which we get a glimpse of God's work.



THE SKY OBJECT: THE EARTH

In less than an average lifetime ago, the first astronauts and satellites began sending images from space—taking some of the first detailed pictures of earth and planets. As more pictures are taken and more information is received on other planets, the more we understand the

radically unique characteristics of earth. The pictures of earth are so common that people pass them too quickly. Here is a sketch from one of those photographs but without the dramatic color that an astronaut would see from space. Consider the earth's general characteristics that we can see in a color picture: a blue globe dominated by water, lights from cities that show on the dark side, an atmosphere with clouds of many shapes, land colors that vary from dark to bright, continents with complex shapes, poles with whitened regions, and the list goes on. With the scripture in mind that was just reviewed, we are observing a created planet whose design and attributes were deliberate. We observe through the nearly transparent atmosphere of this extraordinary planet. While we consider studying objects that have beauty, do not forget that the most beautiful and colorful object is the one we stand upon. And, like the universe, the earth is held or sustained by God but it is held in a more delicate and perfect balance that permits life as we know it. It is truly a privileged planet. It is the only privileged planet.

WHY OBSERVE THE HEAVENS?

In all the toils, cares, and pleasures of life around us, why bother observing the heavens? We know they are there. They don't affect us. Or do they? If you have ever seen a lake or river, it might be unimpressive or not make sense by itself. However, it is the contrast between an object and what is around it that sets it apart and makes it special or unique. The framework of an object or its context is an important ingredient to understanding what it is. In a similar view, the universe has been created and placed where we can observe it from earth. No matter where on earth we stand, if we look up from earth's rich and life-filled surface, we see the heavens. By day we see the heavens as consisting of clouds, atmospheric phenomena, and blue sky. By night, the absence of light from the sun permits us to see the heavens beyond the atmosphere. The heavens are a dramatic contrast to our vantage point on earth.

With a casual first glance at the heavens, nothing may seem particularly significant. With a practiced or disciplined look, however, the heavens incredible intricacy or complexity as well as a beauty, which the Bible says is not by chance, begins to unfold. Many of these features, placed where most people can see them, are meant to be objects of our curiosity and desire to discover. What better way to discover things about God than to observe heaven's features that have been so eloquently and carefully placed? Pure astronomy is said to be the science of studying the stars. That science is very interesting, but it can be impassioned or motivated when one realize's that God is the Author.

HOW TO OBSERVE

As just suggested, there is a large difference between a casual glance at the skies and a practiced or disciplined observation. This course teaches practiced observation of the skies because it is essential if one wants see more. Disciplines are introduced that encourage repeated looks and the use of techniques to get as much detail as possible with the equipment that is available. Part of the observation process for bible-based astronomy is to consider the observation in its spiritual context. The scripture that was reviewed in Colossians is clear—things we observe are held in place or held together by the One who created them. The heavens beckon us to observe, investigate, and discover. In a sense, observing details of the things around us on earth, which is more common in education, is parallel to the approach in this course: practiced and disciplined observation reveals wonders.

SKETCHING OR DRAWING THE HEAVENS

So where does sketching or drawing the skies come in? Why make the effort? This course teaches recording observations for key reasons:

--We forget what we see. Sketching a subject commits what we have seen to memory. There is something about making notes and pictures about anything that causes us remember more easily. Making careful drawings of a sky object does this even more.

--The sketch is the record of our observation of a sky object. Details in a sketch mean that we have studied the sky object—not just glanced at it. The sketch is a personal record of our observation of the object because it is from our vantage point—reflecting our ability, the conditions of the atmosphere between us and the sky object, and the effects of our observing location. Sketching ability is developed

over time; it reflects the development of a trained eye and thinking—both of which contribute to the interpretation of a scenes that we observe. One might suggest getting a camera and taking a picture, but a picture is taken and quickly forgotten. Sketching, however, demands attention to the scene over time that gets translated into detail that we physically record during an observation period. In nearly every professional field there are people who take notes and make sketches for the same reason—it causes a registering of detail that is pertinent to the subject at hand. Sketching is also a process by which study of objects produces refinement in observing ability. In short, sketching improves ability to observe the heavens.

--An observation sheet is developed that is a meaningful report of the observation period. A sketch of an object needs other information to be a complete record of an observing period. This course teaches an observing sheet format so the sketch is given a context—providing information about the sketcher, the sketch process, the object, and the conditions. Last, but not least, the sketcher is encouraged to think about the observation, associate a pertinent scripture and make a comment on the observation sheet. These last steps are usually not part of observing, but since the course is bible-based and so many scriptures speak of the heavens, the sketcher is encouraged to do it. The sheer contrast of empty outer space with beautiful sky objects begs us to think about what we are seeing. Likewise, the fact that we observe deep space from a protective earthen platform full of life and color suggests that we should think about what is observed with respect to our observing “platform.” It is no accident that God points to His creation (including the heavens) in Job as He corrects Job’s limited view of his situation. Therefore, we encourage the observer to be complete an observing sheet with many more elements than just a sketch of what has been observed, including a scripture and comment about the observation.

--A sketch and observation sheet provide a teacher a way of grading a student’s progress. Observing sheets are helpful for student evaluation. The observation sheet provides a product where lesson objectives are applied and a teacher can monitor a group of students. Furthermore, observation sheets become an object of pride and accomplishment for individual students. Many parents and friends point to the observation sheets as an accomplishment. Experienced observers keep them as important documents; they are a record of observations. Any number of references (star charts, pictures of objects and the teacher’s own observations) can be used to check student observation sheets, so there is no need for an elaborate set of “answer sheets” or guides that are specially designed as part of the course.

PRACTICAL EQUIPMENT SKILLS

This course is “hands-on,” which means students will handle equipment. Observing the heavens requires three basic functions: finding objects, observing them as best we can, and recording what we have observed. Most courses on the heavens concentrate on teaching astronomy. This course teaches a very limited amount of astronomy but concentrates on teaching observing skills through which one can learn some astronomy.

The basic functions start with “body basics”: our eyes and brain. Our eyes are precisely designed so that we see in certain ways. One of the first lessons will teach some fundamentals about how our eyes work (or do not work) because ignoring those facts can affect what we observe in the heavens. But the eyes are not sufficient without the thoughtful interpretation of features. The process and relationship of seeing and understanding are critical when we study a visual object in the sky. The skills are important and transferable to any field that requires careful observation.

As we look upward, anyone can see that the sky is big. If people need maps to find their way across a country or a sea, it should be no surprise that map of the sky might be helpful. We will use two different kinds of sky maps and learn how to use them. Like using a map of a country or town, after some time a person knows how to get around without the map. When someone first learns basic features of the sky, a map is critical. As the sky becomes familiar to the observer, the map is less critical but still important to quicken searching for objects and to understand relative positions of objects. Since God has designed a precise set of motions for the earth, sun, and sky objects but also holds things together (including the relatively static position of the deep sky), sky maps remain accurate for a long period of time.

We also have optical devices to help our eyes see some objects better. The course will teach the proper use and care of binoculars and small telescopes, which are optical devices that contain lenses that permit us to see objects with magnification. Like sky maps, this equipment needs proper care. Safety and proper use of equipment will be covered. Telescopes, which are the most complicated physical equipment we will use (not including our eyes), require more care than other observing equipment if they expected to last. Since the course has an observation emphasis, we will not cover optics or details of optics designs. This is usually covered in physics, which is a standard school science course and not a pre-requisite for observing. Nevertheless, observing may stimulate interest in these topics and information on them is readily available.

SAFETY NOTICE: DO NOT LOOK DIRECTLY AT THE SUN

No observing class or session is complete without this safety statement: never directly look at the sun. The warning will be repeated during the course. God has made the sun powerful in terms of light, energy, and position. The sun cannot be observed with our eyes without serious eye damage that is permanent. It only takes a glance at the sun to cause damage. Do not look at the sun. Although the sun can be observed with proper astronomy equipment, this course does not include it because it is too easy to have an accident without direct oversight and the right equipment to make solar observations.

REVIEW

The elements of each lesson include beginning with a scripture reference and a review of a sky object.

This lesson covered a scripture in Colossians and Earth.

The importance of Bible-based and careful observation was defined and discussed.

The importance of recording observations on an observation sheet and the general elements of an observation sheet were reviewed.

Practical equipment skills that will be taught and used during the lessons include proper use and function of eyes, binoculars, and telescopes with respect to observing the heavens.

Remember: never look directly at the sun.

EXERCISES

1-D1 EXERCISE: BASIC ORIENTATION

Local horizon and zenith are directions from a point on earth. Stand in a location outside where you can see around you for some distance. Raise your arms to a position where they are parallel to level ground. The tips of your fingers are pointing to one place on the local horizon. If you turn around but keep your arms parallel or level to the ground, then you have pointed to local horizon completely around you. If you raise your arms directly overhead, you are pointing to local zenith. Zenith and horizon are common terms that will be used in the future. Now observe a globe of the world. Find your country and turn the globe so that you can see your location. If you put a small figure on the globe and did the same exercise, that would be correct, because horizon and zenith are local terms. If you were talking to a friend on the North Pole, their local zenith and horizon would differ from a global perspective, because your friend's local horizon and zenith are different than yours.

Now pick any horizontal direction from where you are standing. The horizon line is a line that crosses in front of you that would define the meeting of earth and sky as far as you could see in any direction. Since the earth is large and its rate of curvature is small compared to our size, it would appear to be flat if there was no interference from trees or hills or buildings. However, local interference causes the local horizon to be obscured. Observing the skies at night is best when a spot has little interference from other things, or where the local horizon can be seen with the least amount of interference. The spot you might choose might not be perfect, but choose one where you can see best or where there is least interference. On a piece of paper, draw a line across the bottom of the page. This represents the perfect horizon. From the observing spot you have chosen and facing in the direction you have the best view of the sky, draw a line above your perfect horizon line that is your estimate of the horizon that is defined by local hills or trees or other types of interference. Now turn to the direction where the horizon is the worst—where you cannot see the horizon very well because higher hills or trees or other things that interfere. Draw a second line for a perfect horizon and then draw a line above it that outlines the interference as you face this new direction. Compare the two drawings so you have a practical understanding about how things can obstruct your view of the sky. When you pick observing spots in the future, you will do this exercise automatically in your head as you choose the best area to observe.

Where could you go to have nearly perfect view all the way to the local horizon? Why?

1-N1 EXERCISE: APPARENT SKY MOVEMENT

During early evening just after the sun has set, go outside to a place where you think observing the sky would be good. Locate the moon or a bright star that is low in the sky close to where the sun has set (not far from your local horizon). If you stretch your arm out and open your hand toward this direction,

make sure the moon or bright star is at least one open hand above the horizon or any trees or hills near the horizon. On a piece of paper, draw a rough line for the horizon with the trees or hills or other objects included. Put a dot on the paper above the horizon to represent where you saw the moon or the star you chose. Label it with the time or mark it as number one. Later in the evening (at least one or two hours later) locate the same object you chose. Mark it on the piece of paper where you find it in the sky this second time. Label it with the time or mark it number two. Draw a dotted line from the first to the second dot. This represents the way the sky appears to move. If you were unable to record the times of these observations, try to estimate the time between the two observations. Be prepared to discuss the results and compare it with others. You can do this same experiment with three or four hours between the times you have observed. Then you will get a better idea about how the sky appears to move.

Note: Measurement of angles by using hands, arms, and eyes will be covered in a future lesson. This exercise is preparation for that lesson. For those who understand angles and measurement, the answers to the questions (above) can be more precise, but the course does not presume that everyone has learned how to do it. Nearly everyone, however, can draw simple lines and point with their arms to do the preliminary exercises and answer the questions that will be asked. The objective is to get a sense of the apparent sky motion from a point on earth.

If you think about it, the sun moves in the same manner as the stars at night. Again, the sun does not really move. Rather, the earth rotates about an axis.

Do not forget the most important safety rule for observing the sky: never look directly at the sun. The damage to eyes would be immediate and permanent.

AOBV Lesson 2: Wonders of the Heavens

Materials: ears to hear, eyes to see, and a mind to understand

Reference: Psalm 19:1-4, 6

Sky Object: Various

Note: a set of teaching aids is needed by the teacher for this lesson that consists of images of sky objects. Thumbnail images (very small pictures) are included in the lesson, but larger versions of the images can be found on the web by doing searches on the NASA site (www.nasa.gov) or by doing a Google search on the object names that are in listed in the lesson text. The images on the NASA site are available for educational and non-commercial use for anyone in the world, so they can be sized by the user and downloaded.

THE BIBLE AND THE REFERENCE SCRIPTURE

Psalm 19:1-4 and 6 follow:

V1: The heavens declare the Glory of God; the skies proclaim the works of His hand.

V2: Day after day, they pour forth speech, and night after night, they displayed knowledge.

V3: There is no speech or language where his or her voice is not heard.

V4: Their voice goes out into all the earth, their words to the ends of the world. In the heavens he has pitched a tent for the sun.

V6: It rises at one end of the heavens and makes its circuit to the other.

Psalm 19:1 says, "The heavens declare the glory of God." These words encourage the person reading them to question how the heavens could possibly declare God's glory. A person from centuries ago, whose only time outside observing the night sky was with unaided eyes, marveled at the beauty he saw. He imagined and questioned what was beyond his sight in the heavens. The advent of the telescope allows us to view more of the heavens and makes it possible to see the astonishing creativity of God's handiwork that decorates the night sky. Many Bible-believing Christians throughout history have no doubt marveled at the words of Psalms 19:1 and wondered how the heavens declared the glory of God. After looking through a telescope, the meaning of these words becomes abundantly clear. The sky declares that our God is beyond any doubt an incredibly powerful God. The materials we are going to show you are just a very few examples of the thousands of deep sky objects that pervade the universe.

Upon observing the awesome sights of the heavens, it is incredible to think that anyone can believe there is no God, which would mean that the heavens happened without direction and by chance. This would mean innumerable events repeatedly occurred until the trillions of sky objects came into existence on their own. After becoming a little familiar with the images of heavenly objects, the vastness and complexity of the heavens can result in a sense of astonishment. How can this be without purpose

and direction? Indeed, the verses in Psalm 19 stand out when they say the heavens "proclaim the work of his hands."

The statement, "proclaims the work of his hand," indicates that someone (God), performed work to put these wonders in place. He fashioned them with His own hands, and He put them where He wanted them. Verse 2 tells us that the stars never stop speaking. It says, "day after day and night after night." This implies the past, the present, and into the future. Except for a few classes of objects he designed to change rapidly, most objects have remained in the same general position since He created them. Nevertheless, they all speak, and they keep speaking.

Galaxies, each containing trillions of stars, are of many types and spread throughout the heavens. A couple can be seen, if the skies are dark, without optics. Star clusters range from a few hundred to millions of stars. They are also all over the sky. Stellar clouds, called "nebulae," have magnificent colors and many shapes. God created sky objects to speak of His glory and draw our attention to him.

Not only can the heavens cause amazement, but they were once quite useful for the people who studied and applied the knowledge. Ancient Egyptians studied the night sky and made a vast study of the stars. This led to their using the night sky as a type of navigational tool, or perhaps we could say the night sky became a travel map. The creation of this map supplied us with one of the earliest complete studies of the stars. Other cultures, like the ancient Chinese, also drew up a map of the sky, but they were not as complete as the earliest one devised by the Egyptians. The Chinese did not attempt to link their night sky map with any practical everyday use as did the Egyptians.

After the constellations received names, the larger stars were given names, also. The bigger stars pointed the way for many ancient travelers, who used their knowledge of the stars and how they change throughout the night to navigate. Early explorers used star- and sun-based navigation techniques. Some ancient cultures used constellations to depict objects or people they imagined as pictured in the sky. Most of the objects were animals or items typically used around homes. The Chinese and Egyptians made up stories using the constellations, which they related to the object pictured in the star pattern. These stories taught historical events, morals, or principles valued by the culture. This proved to be an ingenious method of assuring memory of the constellation in that the student had only to go outside at night and look up to be reminded of the story. Remembering the stories also insured the cultures could pass down important information on the stars to future generations.

Psalm 19:3 says, "There is no speech or language where their voice is not heard." It refers to the fact that most everyone everywhere can see the stars. The sky is God's map and storybook. It points to his power and glory in a universal way. Anyone traveling far from their own country would soon encounter people speaking a different language, but the language of the stars is universal. Regardless of their nationality, people receive the same message from the stars: God is great and powerful but also meticulous and detailed.

"He has pitched a tent for the sun." Psalms 19:4 gives us a picture of the sun rising and filling the day with light, then setting to reveal starry heavens until the next night. It paints a picture of the sun surrounded by or housed in a tent. The stars and the space of the universe are like tent because they

surround the sun/earth system. If you could get far enough away from the earth we live on, you could look back and see the sun, which would look like a star, with other stars all around it. Verse 6 describes the sun's circuit through the skies from the view of the observer on earth.

WHAT IS OUT THERE?

So the heavens declare the Glory of God. But many people have not had or taken the opportunity to see what is in the heavens, especially what has been revealed through the last few decades of space exploration.

Some of you have possibly walked out of your front door and looked up into the night sky wondering what was out there or what would we see if we could traverse through space. What you did see was blackness sprinkled with little bright stars, which appeared as sparkling miniature lights. A few astute viewers may have noted some of these lights were red or yellow, but most appear to be white. During specific periods of the month casual observers would also see the moon in one of its phases. But now people can see detail on the moon with small telescopes. Thanks to a space-based telescope called "Hubble," which was named after a famous astronomer whose studies of the universe inspired its creation, detailed images of deep sky objects became widely available in the 1990s.

Images taken by Hubble broadened the public view of the heavens considerably, as have several modern and large earth-based telescopes. Since Hubble is out in space and free of our atmosphere, it sent back to earth beautiful images that were clearer than most earth-based telescopes. It captured images of distant galaxies in all directions. Many of the galaxies were much larger than our own Milky Way Galaxy. All the images we have, whether taken with earth- or space-based telescopes, suggest we have not seen the edge of the universe. The number of galaxies seems endless in the great converse of space. Now anyone can see incredible images of globular clusters, nebula, and spiral galaxies in all types of public media. Here are some examples:



This is part of an image taken by Hubble of an area of deep space, which was previously believed to be a region sparsely populated with galaxies. At the time it was captured, it was one of the deepest images ever taken of this portion of our universe. It shows galaxies as if they are tumbling over each other. The complete image is the equivalent of a tennis ball in diameter seen at one hundred meters, but it shows over 3,000 galaxies. We can see them clearly, because Hubble is outside

our atmosphere, enabling this image to show us objects many times fainter than anything visible from Earth. This image was a record breaker since it penetrated the cosmos from outside our atmosphere in a new way, which permitted a view far beyond anything astronomers thought possible a few decades ago.



The Eagle Nebula is a favorite of many Christian astronomers. Within it, are several of the most beautiful formations of nebulosity visible by any of our sky- or earth-based telescopes. It has a large array of lovely colors and it appears as a window that is beckoning you to enter it. It seems to invite you to come in and have a look. The nebula seems to say, "I contain endless adventures for you to experience." The object is a great example of a stellar gas cloud. The object got its name because when

viewed in a small telescope it resembles an outline of a bird of prey. In its center are pillars of gas that are nicknamed elephant trunks.



The Eagle Nebula is 6,500 light years away from earth and measures about twenty light years across its center. It is massive, exceptionally brilliant, and beautiful. This image shows some pillars of stellar gas that are a small part of the nebula.



Globular Clusters are collections of tens of thousands of stars appearing as a ball of dazzlingly brilliant tiny lights. Globular Star Clusters were created as a system, where the stars are gravitationally related. There are a large number of star clusters that an amateur astronomer can observe with a small telescope. This is one of them, although the view through a small telescope will not be as good as what you see here.

Open Clusters are small groups of stars; there may be several hundred stars loosely clustered together. Many open clusters have a small amount of nebulosity intermingling within them. On the other hand, globular clusters are denser and can have thousands of stars. The Pleiades (on the left) is a famous open cluster that is mentioned in the scriptures. It is easy to see for most of the earth's population for several months of the year. There are dozens of open clusters like this that are as spectacular. they look like faint little snowballs with soft edges if one uses a small



In contrast, globular clusters so dense that they look like faint little snowballs with soft edges if one uses a small telescope (like the one on the right that was imaged with a camera on a small telescope). With a smaller scope you will see a faint round whitish area where the center is the brightest. Larger scopes are able to resolve some of the brighter stars. Most globular clusters have no discernible stellar clouds (very thin gas in space).



A galaxy is a vast island of stars, dust, and gas that form one system. Galaxies can be different types, such as spiral, barred, elliptical, or irregular. There are several classes within each type. Galaxies are also described with respect to how they appear to us, such as an edge-on or face-on galaxy. The one on the left is a good example of a face-on spiral galaxy. Some galaxies take on an oval or ball shape in appearance; some nuclei are concentrated but others are more complex and spread out.



Spiral galaxies are galaxies in a circular pattern with arms that fan out from the center of the galaxy. Some appear like a ball with several arms. Others seem to be round clouds with dust and dirt particles in them. Most galaxies have a brighter, fuller nucleus region in their center causing them to take on a soft glowing appearance, like the Sombrero Galaxy on the left. The apparent brightness of the center and the general brightness and size of a galaxy define an "apparent visual magnitude," which is a description of its overall brightness relative to a local observer.

“Apparent brightness” is a term that needs some explanation. It means what an object looks like from earth compared or in relationship to other objects. The apparent brightness or apparent size of the object may be entirely different from true brightness or size because of the distance to the object. Many objects may appear bright, but their true brightness may actually be relatively small in stellar terms. So close objects in stellar terms, even if they are not that large compared to similar objects, may have high apparent brightness. The sun is a good example. It is very bright to us, but with respect to star size, it is on the small side.



The Andromeda Galaxy is the closest major galaxy to us but is over 2 million light years away from the Milky Way Galaxy, which is our home galaxy. Distances like this do not make much physical sense. Consider this: if you could travel at light speed (186,000 miles per second), it would still take 2 million years to reach Andromeda. It is twice the size of the Milky Way Galaxy, which is 100,000 light years in diameter.

Andromeda’s apparent visual magnitude is 3.5 on a scale that is commonly used. It spans 2.5 degrees of the sky in length and is one half of a degree in width. On a clear night in an area where there is low light pollution, this galaxy looks fuzzy or like a blurred spot with the unaided eye. It is the one of the only galaxies (outside of our own) that can be seen with our unaided eyes. When seen with the use of an astrophotography camera this fabulous object is a wonderful example of a dazzlingly lit spiral galaxy. Estimates state that it contains over 400,000 million stars.



The beautiful object below is titled, “Light Echoes.” It records a rare event but is a tremendous rebuttal to the belief in an old earth and old universe time table. This huge deep sky object changed quickly. Getting progressive images began with a happy accident. Hubble’s sky cameras were aimed in exactly the right direction to capture these pictures of star V838 Monocerotis as it became a supernova. A supernova is a luminous burst of light and radiation as an unstable star explodes. The light that is emitted can outshine the light of an entire galaxy if it is large enough. The force of the explosions connected with super novae is one of the mightiest stellar forces in the heavens that we can observe.

This new sky object (shown in the teaching aid) was recorded over a very brief period from 2002 – 2006. It shows that the heavens can change in some respects. The images revealed how quickly an unstable star becomes a supernova and then a newly formed nebula. The light echoes pictured here continue to expand. The record of the event clearly shows some of the magnificent objects we see today did not have to take billions of years to develop. From a Bible view, stars were created and placed on the fourth day of Creation, as referenced in Genesis 1. Many stars are inherently unstable, so they can be a dramatic sight if they explode. From God’s point of view, the universe and its objects are not stable, since they need his sustaining power—even after he created them.



No story or teaching of the Universe is complete without learning about the Solar System. The sun is at its core and is the source of light and energy for the solar system. It is precisely the right size, when coupled with earth’s characteristics, to offer the light that we need. The sun is relatively small for stars but it perfect for the system we live in. Our sun’s characteristics are essential for earth but it also serves as the

dominant influence on solar system objects (planets, comets, and asteroids).



The visual surface of the Sun, called the photosphere, which means sphere of light, has a temperature of 6,000 degrees centigrade / 11,000 degrees F. Its diameter is 865,000 miles or 1,392,000 km. By classification it is considered a yellow dwarf star. Most of the sketches that will be shown in this course are of planets and distant sky objects, but a special filter on telescopes can be used to observe the sun as well.

NOTE: A regular telescope or binocular cannot be used to look at the sun without special filters. The sun should never be observed directly—it will cause serious and permanent damage to a person's eyes.

With proper filters installed on a telescope, two main sun features can be observed: sun spots, which are cooler spots or depressions in the photosphere, or prominences. Sunspots take on the appearance of various sizes and shapes black splotches when seen with a blazing bright background of yellow orange fire. At times, you will see only one sunspot, but they can change quickly during the course of a few days. A sun prominence appears to be a flame of fire being hurled away from the sun into outer space. They can visibly change an hour. Both of these sun characteristics are beautiful to view and make excellent sketching material if the proper equipment is used that permits solar observation.



God placed our exceptional planet in the right location (third planet from the sun at 93 million miles) with the correct rotation, axis tilt, atmosphere, and a host of other detailed characteristics to insure life. In fact, Isaiah 45:18 and several other scriptures are specific: the planet was made to be inhabited. No other planet fits the amazing set of attributes that we consider so common. Any marginal deviation in any of these characteristics would radically change conditions on the earth's surface and make life impossible as we know it. It is also a safe platform from which we can observe the heavens, which point to their Creator. The atmosphere, which is also unique, is thankfully transparent—permitting us to see the heavens without gross distortion. The only humans mentioned in the Bible live on the planet Earth. While evolutionists and others suggest that life might exist somewhere else, God is very specific about the earth's purpose for habitation by mankind, who were created in God's image and given a home on the planet. Of course, earth is only one of many planets or planetoids that orbit the sun.

We can divide the solar system planets into 2 distinct categories: first are the four inner solid mass planets and second are the next four gaseous giants. Mercury, Venus, the Earth, and Mars are small in comparison to Jupiter, Saturn, Uranus, and Neptune. The last objects we will discuss are solid planetoids. Pluto, one of the planetoids, seems out of place trailing behind the gas giants its size and composition is similar to the smaller solid mass planets. Recently scientists discovered two additional small solid mass planetoids (small planets) that are beyond Pluto. Others may be discovered.

God's creative variety and power reveal themselves in the planets and moons. Both major types of planets have similar characteristics, but they also have a host of unique features. All four inner planets, along with Pluto and most planetoids, have rocky compositions and heavier elements. They are much smaller than their gas giant cousins that were created with lighter elements such as hydrogen and helium. All of the solid planets except Pluto and the distant planetoids are close to the Sun. The gas

giants all have very large diameters and their orbits show more separation from each other. Scientists refer to the gaseous planets as the Jovian planets.

Observational evidence through recorded time shows the orbits of all of these planets to be regular and cyclic. Their periods and movement in space are an illustration of clockwork precision. The planets that can be readily seen with the unaided eye (Mercury, Venus, Mars, Jupiter, and Saturn) have been noted for centuries since they are relatively easy to spot. The advent of fly-bys by satellites, producing thousands of images and measurements, has multiplied information on the solar system in just a few decades. Astounding information on each planet system has been found, including unusual volcanic activity, high intensity storms, unique elements, surprising magnetic field characteristics, and many other details. Planetary moons vary as much as the planets, and are also a testimony to God's creative hand.



Mercury is the hardest to see among those planets that can be seen with the eyes because it is so close to the sun. Since it is only 36 million miles from the sun, the angle between it and the sun from our observing position on earth is small. (The angle between us, a planet, and the sun is called their 'elongation.') When it can be seen, it is around sunset or sunrise. The Mariner 10 Space Probe sent an amazing array of photos back to earth as it flew by Mercury and gave scientists their first spectacular glimpses of Mercury's rugged crater-strewn surface. Mercury's traverse around the sun is only 88 days. When it is behind the sun, its position is called a superior conjunction (an inferior conjunction when in front of the sun).



Venus is the closest planet to the Earth some of the time. Because it is closer to the sun than earth, it appears in the early morning or evening (like Mercury). Its only viewable form is that of a dazzlingly bright dot through most small telescopes because its poisonous atmosphere is not transparent and reflects light. Only the Sun and our moon glow brighter in our viewable sky. Observers with a small telescope that watch Venus over a period of a few months can see Venus in its phases: from a silvery crescent to a nearly full disc. It is a popular event among astronomers to see Venus during its transverse across the Sun but special instruments and filters must be used to protect eyes and optics for this to be possible.



Mars, the bright red planet, is associated with all sorts of fables and stories through years. Some believed that Mars was the home of an advanced civilization, inhabited by humans like ourselves. Some believed that if it was flooded in areas with water, we might be able to go there to live. While similar to the earth in size, its distance from earth and surface conditions, which include large dust storms, makes it a popular but hard target to see planetary detail. Simple observation is possible in a small telescope or a good set of binoculars. A small telescope can make out its whitish polar caps and reddish terrain on good viewing nights at high magnification. Mars has been popular for study by scientists because of recent robotic vehicles that have taken pictures, measurements, and samples of parts of the surface. It's changing visual features a popular target among amateur astronomers, who like to track the changes.



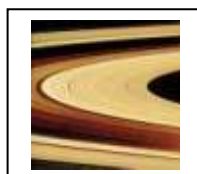
Jupiter, the mighty gas giant of the solar system, is much larger than the other planets. Its diameter is 88,000 miles and it is over 390 million miles from Earth. Small telescopes allow observation of its light and dark bands, which appear to circle the planet like belts. The areas that appear brighter on Jupiter's surface are flows of warmer gases rising up from the planet's gaseous surface. These warm gases suffice to the top of the clouds because they were compressed and heated with the mighty crushing pressure from inside Jupiter's atmosphere. At the same time the dark cooler bands of gases are falling in cascading leaps back down towards the surface of the planet's interior where it will be reheated to rise again. This process, as far as we know, has repeated itself since the planet's creation. While surface conditions are violent and grossly unlivable, it has a beautiful appearance for observation.

When Jupiter is in the right position, it is the brightest object in the night sky. Many small telescopes can see the largest and most prominent bands on the surface and sometimes the characteristic larger spot that is on the darkest and most notable band. Scientists and amateur astronomers remained puzzled by the spot until measurements and studies showed it to be a huge storm. Because Jupiter's rotation rate is rapid, amateur astronomers who study and sketch go back to the planet often to record surface features because they change so often.

There are several counts through history of Jupiter's many moons. A recent count is 37 moons. These moons are not all the same with respect to size, color, and features. One of the amazing additions to images from spacecraft in the last few years has been the close-up pictures of the moons. Differences among them provide a picture of the dramatic variety of God's creative hand. The four largest of Jupiter's moons are usually visible with small telescopes and binoculars. They are called the "Galilean" moons because they were discovered by Galileo. These are popular to track and can often be seen with a good pair of binoculars. New as well more experienced observers with small telescopes repeatedly observe Jupiter to enjoy the changing positions of these moons as well the bands of rotating gases on the planet's surface.



Saturn is the second largest planet with a 75,000 mile diameter. Most observers know Saturn for its rings. When seen in a small telescope in the 1600s, it seemed to be a yellowish oval. (It appears to be about 1/10 the size of Jupiter because it is not as bright.) In 1665, when Christian Huygens saw the planet, he could see the rings. His new telescope was good enough to see that the planet was not oval but round; the reported oval appearance was because of the rings and poor optics. Since its discovery, Saturn has remained popular to observe. The planet has 17 small moons but the largest are not visible without a large telescope. Titan is the only one that can be readily seen by amateur observers. Some of the others are Mimas, Enceladus, Tethys, Dione, Rhea, Hyperion, Iapetus, and Phoebe. Like the moons of Jupiter, their characteristics are truly beautiful but also unique as recent information from satellite images has shown.



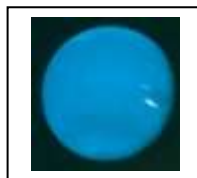
While the moons are interesting, the rings remain one of the most fascinating and physically unique characteristics of the solar system. Here is one of many views of the rings from a fly-by satellite. In a small telescope with good magnification, observers cannot see the detail of the rings, but they can distinguish the whole ring system and

its angle with a small telescope. With a medium sized telescope and observer can see the major gap in the rings, which is called the Cassini Division.



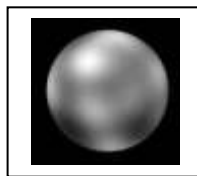
We want to move further away from the sun to Uranus, which is also a gas giant but remained a mystery until a happy accident in 1781 by William Hershel. The ancients had considered the planet a star. Later it was thought to be a comet. Hershel is credited for identifying it has a planet.

Although Uranus is the third largest planet in our solar system, it is hard to see with small aperture telescopes because of its lack of brightness and distance from the earth. The rings and other important details on the surface were not discovered until Voyager 2 had a fly-by in the late 1980s. Its greenish appearance comes from its atmosphere. The greenish atmosphere of clouds consists of hydrogen and methane. It also has a ring system and 15 moons. The planet measures 32,500 miles across and is 19 times the distance of Earth from the Sun. The planet-moons system is very unusual. Some of the irregularities of the planet's orbit led scientists to search for an additional space object that could be causing an apparent gravitational pull on the planet.



Neptune's discovery took place sometime after John Couch and Urbain Leverrier (independent of each other) calculated that a planet must exist beyond Uranus because Uranus's irregular orbital motion. They postulated its distance, size, and mass. Couch was in England and Leverrier was in France when they each developed their separate theories. Neptune's double discovery happened when Leverrier

reported his discovery to the Berlin Observatory on September 23, 1846. Couch also reported his find that same night and soon others using their information reported that they too found the new planet. Because of the tremendous distance, Neptune is from the Sun and, therefore, far from the earth, there was little knowledge about the planet's physical properties for years. All of that changed in 1989, when Voyager 2 sweep-by revealing a tremendous amount of information about the dynamic turquoise clouded atmosphere. Voyager also revealed an Earth sized darkish vortex on Neptune suffices. Scientist appropriately calls it the Great Dark Spot, which is floating in several layers of bright wispy clouds. At the same time, Voyager 2 provided scientist with information on the thin strip like rings circling the planet and Voyager 2 discovered six new moons to add to Triton and Nereid, the two moons previously seen in earth based telescopes.



Pluto, once called "Planet X," was believed to be the last planet in our solar system until a few years ago. While finding Neptune was relatively uncontroversial, the opposite was true of Pluto. A long argumentative twenty-five year search finally ended when Clyde Tombaugh discovered Pluto on February 18, 1930. The discovery took place while Tombaugh was using a specially designed camera. He was at the

famous Lowell Observatory when he saw a small dim spot of light in the sky over Flagstaff, Arizona. Pluto might have waited years for discovery if it had not been for the photographic plates used to

develop the film from the camera. The light fuzzy spot moved to different positions in the different plates.

Another controversy emerged recently as experts debated and eventually re-defined the definition of a planet. As a result, Pluto is considered a planetoid. Of course, the object has not changed but most experts consider it too small to be considered a regular planet.

With advent of information from fly-by satellites and more advanced instruments, information on the planets has changed dramatically in the last 40 years. New discoveries continue. Two additional small planet or planetoids were discovered beyond Pluto in the early 1990s. More details on individual moons for planets have been discovered. Close-up views of asteroids and comets have been received and studied by experts. The list of new and exciting details goes on and on.

For observers with small telescopes, self discoveries remain exciting since Mercury, Venus, Jupiter, Saturn, earth's moon, and Mars are viewable on a regular basis. Comets continue to appear and are popular to watch as they traverse the solar system. There is something special about personally seeing objects from the solar system neighborhood or deep sky objects like galaxies, star clusters and nebula—even with small telescopes or a binocular. This is the skill that will be learned in this course so that new observers can see some of the glory of the heavens for themselves!

The images, which are presented in this lesson, are used to excite the student about discovery. Now that recent images from satellites and earth-based telescopes are readily available in books and on the web, nearly anyone can see frame after frame that shows the beauty of our sister planets, parts of our galaxy, and beyond. However, personal observation, which includes making notes and sketches, is where the amateur observer owns the information in a personal way.

Note: During a regular class period for this lesson, this is the time for a break, where students can be encouraged to examine some of the detailed teaching aids or available references that show some of the sky objects that have been presented during the talk.

EXERCISES

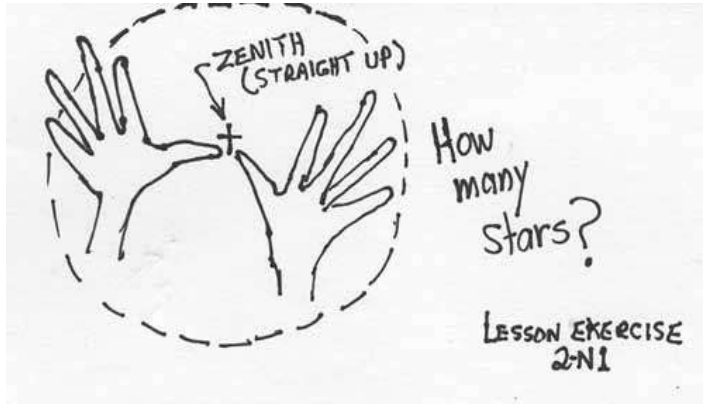
2-D1 EXERCISE: REMEMBERING NIGHT SIGHTS

You may have seen things that are interesting or beautiful in the night sky. What do you remember? Was it a pretty moon, a “shooting star” or meteor, or a rising or setting sun? God has made our minds so we remember many scenes for a long time. Pick one of these observations that you remember and make a very simple drawing of it. Provide a few sentences to describe what you saw, when you saw it, and where you were when you saw it. Sign the paper and date it; be prepared to discuss it at the next class.

2-N1 EXERCISE: HOW-MANY-STAR EXPERIMENT

Throughout the ages people have appreciated looking at the sky to see the stars but few go a step further to discover more. This exercise is one of those steps. Try to be in a dark place for about 15

minutes. Try not to let your eyes face any bright lights during that time. Then go outside where you can see the sky. Stretch both arms out straight up then open your hands and fingers as wide as you can. Using this area of the sky at zenith, count as many stars as you can that represents a circle that is about the size of your two outstretched hands (see the picture).



Answer the questions:

How many stars could you see?

What time of night did you do this?

Record your answers but also give the approximate time you made your observation, the date, and the place. Sign the paper with your name.

At the next class, numbers will be averaged among several students. The number will be multiplied by a factor to make a general estimate the number of stars in the whole sky that you can see with your eyes. How would you come up with that factor? Why will this not be a very accurate number? Think about these last two questions and be prepared answer them in class.

AOBV Lesson 3: What the Bible Says – Overview

Materials: paper and pencil

Reference: Genesis 1:14-18 (for this lesson, have a Bible to check the references cited)

Sky Object: Moon

REFERENCE SCRIPTURE

Genesis 1:14-18 is a foundation portion of Scripture for the heavens. The words are plain and clear yet astounding as we consider the work of God on the fourth day of creation. The previous days began with his work creating things that are in contrast: light and darkness; atmospheric water and water on the earth; and land and seas. The third day he creates the wide array of vegetation, which includes the creation of photosynthesis. This brings us to the fourth day, where he returns to the heavens to perform the extraordinary things in the skies by creating a variety of objects, giving them substance, location, motion and characteristics. He also purposefully gives them characteristics that mankind could observe from earth's vantage point. With this creation event, the laws of the heavens are in force, as referenced in his conversation with Job (Job 38:33).

Genesis 1:14 shows the commanded motions of earth in the solar system in relation to the "lights" in the heavens. The heavens, therefore, become light for the earth and a precision timepiece. The intent of the apparent motion of the sky that we see every day is declared in the verse—to mark seasons, days, and years. God wants us to know that time passes. It can be measured but not re-set for us. We have one life in this universe, and the universe has both purpose and direction as defined by God.

He constructs and constrains visible light and earth's motion so that we have the delicate dance between sunlight and moonlight—acting as time governors for the passage of days, nights, and seasons. In the middle of these verses is a sentence that is extraordinarily simple with a subject, verb, and single class of objects: "He made the stars." In five short verses God explains the creation of all sky objects and states that they mark time, provide light, provide contrast between light and darkness, and are good. The word "good" is an understatement but plain in its meaning: God's conclusion of the quality, appearance, substance, and purpose of this part of creation is that it is GOOD. Because it is good, it has excellence that is a reflection of the attributes of the Creator. As we were created to live on earth, which was deliberately made to be inhabited, we were also meant to discover the heavens in their vast array. This makes our observing the skies purposeful as we discover some of their features for ourselves and affirm what he has done. The heavens can be subject to meaningful and disciplined observation, study, measurement, and thought.

SKY OBJECT: MOON

The moon is our object of review for the lesson. Unlike the sun, which we cannot safely observe with our eyes directly because of its intensity, we can observe the moon with our naked eyes. Before clocks

and calendars, the moon was the governing time piece because of its regular cycle, which is called the lunar cycle. Every 29.5 days the cycle repeats itself.

The night skies are, as God explains, ruled or dominated by this beautiful but dead object. Although it has no life or atmosphere, its motion governs the tides of water on earth, which are very important for



sea life. The moon's size, rotation and earth orbit definition are all precise—having a multitude of beneficial effects. If any of these defined and created attributes were substantially different, things on earth would be quite different. And for observing, the moon has a stark beauty all its own. While we only see one side from earth, we observe the visible side in phases. Successive observations can be different as light from the sun strikes the surface differently.

Details of the marred surface have sparked many questions. We do not know how the moon appeared when He first

created it, only that it was accomplished on the fourth day of creation. Many scientists, who believe in the Genesis account of creation, think that the heavy cratering and other evidence of violence on the surface occurred when the fall of man or the Genesis Flood occurred (the latter is favored), but the Bible is not specific. While space probes and astronauts have provided much technical detail on the moon, it remains a wonderful object to observe and sketch from earth.

Note on the moon image: This is a sketch by Mark Siebold, who observes and sketches the heavens. The original sketch was developed watching the moon rise in Portland, Washington using a telescope at low power. [Used with permission]

AN OVERVIEW OF WHAT THE BIBLE SAYS ABOUT THE HEAVENS

The scriptures about the heavens (stars, moon, and sun) are found in more than 20 of the 66 books in the Bible. While the key “creation” scripture is in Genesis, there are a host of scriptures that explain, proclaim or give praise to God for the created heavens. Since they are created, scriptures also warn that sky objects are not to be worshipped. Rather, as Deuteronomy 4:19 explains, they are divided or apportioned to the nations to see and observe, because they mark time and point to the One who created them.

Since the words in Deuteronomy 4:19 are in the context of observing the heavens, He knows we will look up and wonder about them. Consider this: each observation opportunity provides unique opportunities. No two observing periods are the same. This is exciting since every observation by each person is different, because our different locations, season, time of day, and local atmospheric conditions. Every observing opportunity permits us to see an object a little differently or add to what has already been seen. It is no surprise that other verses (like 1 Cor 15:41, Psalm 8:3, Psalm 148:1-3) exclaim the wonder and beauty of the heavens. Sky objects are products of God's work and we, who are also created, see them through our personal view and abilities. Verses in Acts 17:26-27, which are similar to the passage in Deuteronomy, explains that God creates and appoints people to live in specific times and

places to have the opportunity to reach out to him. So anyone learning observing skills and using them can have two benefits: greater knowledge of the universe and God, who made them. In all cases, however, the heavens are NOT to be worshipped.

Several Bible references state or infer that God's creative detail in the heavens is far beyond our ability to completely understand. For example, Isaiah 40:26 and Psalm 147:4 state that he named each star. As we observe star clusters, galaxies, and unique star patterns (called "asterisms") we begin to get an idea of the extent of God's claim. It is not a surprise in the book of Job (38:31-33) that God answers Job's complaints of a difficult time by including a rhetorical question about Job's ability to move heavenly bodies and to have knowledge of all the laws of the heavens. Job (and we), of course, cannot move stars and we certainly do not know the extent of the laws of heavens. We can nonetheless appreciate many its characteristics and observe some of its beauty as clear indicators of God's enormous power but also his attention to detail. Even the simple exercise, which we include early in the course, of observing how stars differ one from another, can illustrate the same point for new observers.

The heavens show that God is personally involved in displaying his nature and his concern for each of us. Also, the language of some Scriptures clearly points to his heavenly handiwork as specifically and intricately made by Jesus Christ, whose life and purpose on earth was a demonstration of God's personal care for each person. Consider the following words from verses 23 and 27 in chapter 8: "I was appointed from eternity, from the beginning, before the world began...I was there when he set the heavens in place..." It is apparent that God's wisdom is not only a quality but is actually God himself. Verses 35 and 36 apply these statements in a personal way as they explain that a person who finds God (who made the heavens) is finding life, but one who fails find God actually hurts himself. In the New Testament, this Wisdom is given a Name, which is Jesus Christ. Scriptures, like Hebrews 1:2-3 and Colossians 1:15-17, explain that the "wisdom" that created the heavens is, in fact, Jesus Christ. So God's attention to heavenly detail is parallel to God's attention to us, and his attention is demonstrated in a personal way through Jesus Christ. In a manner speaking, when we observe the heavens and can obtain a sense of God's concern for each one of us. So exploring detail in objects, recording features that impress us, and thinking about the wonder of it all is meant to be part of our life experience—to show us that He is great but cares for something as small as a single star, a small child, or a sparrow. If he does not forget the name of a single star, he will not forget us, whom he loves—the sentiment reflected in Psalm 147:3-4.

There are a host of scriptures that point to the excellence or qualities of sky objects. In other words, the heavens are an exhibit of the handiwork of God, who is excellent in every respect. Observing with attention and skill from a Bible view, therefore, can have rewards. As our observing becomes more skilled and thoughtful, then the detail of sky objects becomes more obvious and appreciated. God specifically points to some specific sky objects to illustrate the point. Amos 5:8, Job 9:8-9, and Job 38:32-33 mention specific objects or the placement of major star patterns (constellations). God states in Genesis that the created heavens are "good". 2 Kings 19:15 and Jeremiah 32:17 both give praise to God because the heavens portray the excellence and power of God. The Psalms say that the sun, moon, and heavens, because of their exquisite design and appearance, give praise to God. These examples indicate that observing sky objects is the process of observing the product of a Master Craftsman. People buy

things made by superior craftsman because they can enjoy looking or touching its detail over and over again. Likewise, as we observe the heavens—even familiar objects that we see have seen before—we can increasingly appreciate their detail as well as the One who made them. Practiced and disciplined observing, which includes recording observations, enhances the process.

In this day it is admittedly uncommon for people to consider the heavens in view of the Bible. This is interesting! Famous authors often stage events where people can purchase their latest popular book. These events are staged so buyers can talk to the author and get his signature on the book. In the same manner, consider the heavens as the signature of God—available for anyone to see and discover for themselves as they read and consider the simple statements in the Bible that concern the heavens. He has provided a reference whose content He declares as authoritative. The Bible has been preserved by people who follow him and includes brief descriptions of the Author's created heavens. The Biblical view of the heavens is meant to provide impetus to our discovery process and point to their Author.

The Bible has sold more copies than any other book in the world, so it is commonly available almost everywhere. A person, however, can read a book and never know its author, just like a person can observe the heavens and never know their Creator. But it is so exciting to both observe the skies and become aware of the Author and Creator of them. For this reason, AOBV takes a biblical point of view for practical observing.

Note 1: **Addendum 1** lists most of the significant scriptures about the heavens, including those referenced in this lesson. A review or study of all of them is highly recommended but it is not included in detail as a part of the course. This lesson highlights some of the more significant scriptures. Other key references are explained at the beginning of each of the lessons.

Note 2: For more detail on subject of **biblical creation**, users are encouraged to download the Creation Study from the CHRISTWORKS MINISTRIES web site (cwm4him.org or christworksministries.org) under the <Courses> drop-down menu.

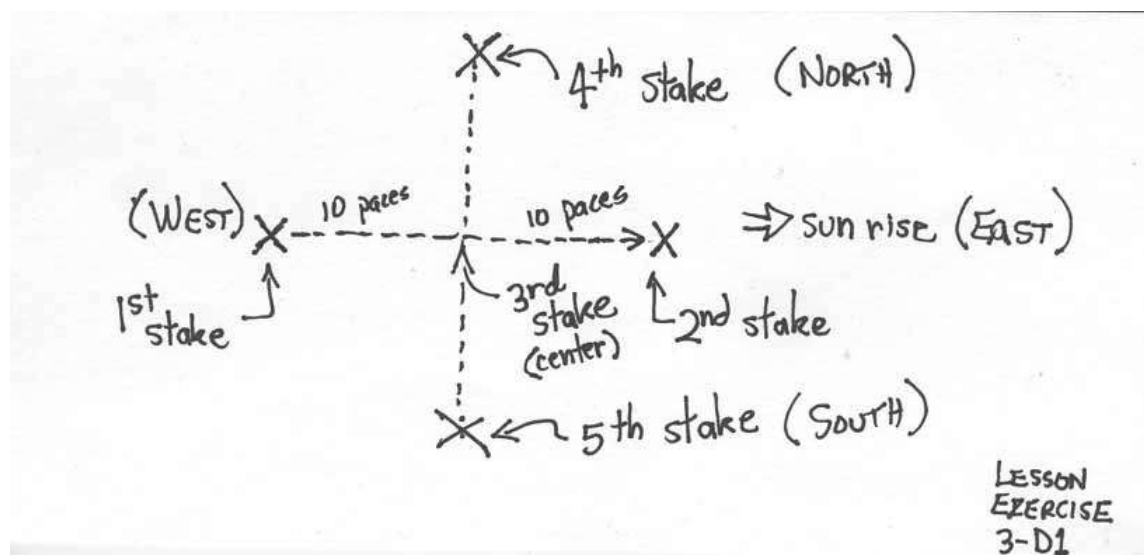
Note 3: **Exercises** become successively more important as the lessons progress. They do more than review the lessons; they are designed to provide a practical foundation for observing skills. It is important for students to make sure they complete each exercise for each lesson, including those for this lesson, which are listed below.

EXERCISES

3-D1 EXERCISE: SUNRISE AND SUNSET LOCATIONS

At the location where observing is likely to be done, place a flag or stake. Stand on that spot early in the morning and check where the sun rises. Place a flag or stake at least 20 paces away that is in the same direction. This defines the approximate direction for "East". The reverse direction will be an approximation of West. You can check this at the end of the day if you note where on the horizon the sun sets. Your line should roughly define an East-West line.

Find the center of line and mark it with another stake (3rd stake). Stand on that center location so that the direction of East is on your right and the direction of West is on your left. North is straight ahead; south is in back of you. Set stakes about 10 paces to the North and to the South. The picture below shows you the same steps; follow the stake numbers.



You have now constructed a rough “compass rose” which is a phrase used for compass directions that have been laid out on the ground or some other surface. Knowing these approximate directions will become very helpful for locating constellations and key stars in the sky. While the directions are not particularly accurate, no compass is needed and they are good enough to get started. When you point or look straight up from the center of a compass rose on the ground, it is local zenith. If you look straight out and turn around, you are looking at local horizon. Anything above the horizon has some elevation, which is the angle above horizon. We will learn to measure elevation with our hands in coming lessons.

Now take piece of paper and draw a circle. Divide it into 4 equal parts and label them N (north), S (south), E (east), and W (west) – just like your compass rose on the ground. Mark the outer line “horizon”. The lines for North/South and East/West cross in the circle’s center. Stand at the center of your compass rose and face N. As you do this, hold the paper above your head with the N “end” lined up with the N line on the ground. You have drawn a flat representation of the whole sky. If you could neatly bend the paper down at edges, like the inside of a half of a soccer ball, you can see how you could have the paper represent the whole sky from horizon to zenith. So if you see a bright star in the East that is halfway between zenith and horizon, how would you mark it on your paper? If a star was southwest (at an angle half way between S and W) and half way to zenith, how would you mark it on your paper as you hold it above your head (as if it represents the sky)?

3-N1 EXERCISE: FIRST STARS AFTER SUNSET

Using the location for observing chosen above and standing in the center of your “compass rose”, make a note of the directions of the first stars that you can see after sunset and when you see them. They will not all appear at once. Stop after you have located 5. Note the locations of each star in terms of general direction on the ground compass rose but also make a note about how high (somewhere between horizon and zenith) each star is. Put your notes on a piece of paper, where you have drawn the compass rose. Remember that the round circle represents the whole sky when you observe. Be sure to line up the paper with N/S/E/W on the ground. When you are done, include your name, date, and time that you observed on the piece of paper. Be prepared to discuss your results with classmates at the next class. See if they found the same first stars and if they were in approximately the same position.

Note: using the instructions for the last two exercises, a student can set up a compass rose and the piece of paper at any location (home or school). It may take doing this together one time before a student can do it alone. The exercise is not hard, but it does take a little time to get a sense of compass directions and relate them to star position in terms of both compass direction and the elevation (their position relative to horizon and zenith). But the learning will help the student more quickly understand future lesson material as well as introduce a little competition to see who sees the first stars and notes where they appear. The directions are not exact since they are only estimated from where the sun rose or set, but it is sufficient for now.

3-N2 EXERCISE: SEEING IN THE DARK EXPERIMENT

Sometime after sunset, try to keep your eyes adjusted to looking at light (fire, flashlight, or cell phone light) for at least a couple minutes. After that, quickly go outside in the dark and look toward the North and above the horizon. With your arms outstretched and your hands open, count the number of stars that you can see in the area of your outstretched hands touched together between your thumbs. Record the number. Stay in the dark or keep your eyes closed for 10 full minutes. Make sure that you do not look at any artificial light during the period. Go outside to the same location and face the same direction. Count the number of stars that you see. Record the number. Compare the two numbers with classmates at the next class. You have just learned why it is important to adapt your eyes to the dark before you observe the stars and what to expect to be limits of observing if your eyes are not adapted to the dark. Note: full dark adaptation takes 30-45 minutes, so vision of the night sky will continue to improve if your eyes are not exposed to bright light.

AOBV Lesson 4: Tools to See the Sky: Hands & Eyes

Materials: paper and pencil

Reference: Isaiah 40:25-26 and Psalm 147:4

Sky Object: Saturn or Jupiter

REFERENCE SCRIPTURE

Isaiah 40:25-26 are quoted as follows: “To whom will you compare me? Or, who is my equal?” says the Holy One. Lift your eyes and look to the heavens: Who created all these? He who brings out the starry host one by one, and calls them each by name. Because of his great power and mighty strength, none of them is missing. (NIV)

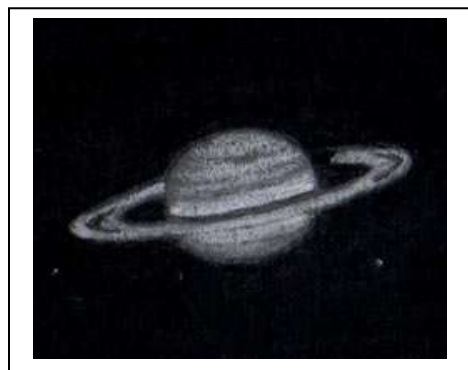
Psalm 147:4, which is very similar, states that God can list the number of the stars and that He called all of the stars by their names.

Space scientists invented a special telescope in a recent decade that is named Hubble. It was to become a useful tool for researching the heavens. The platform could observe outside the atmosphere, where humans could not observe easily and could send back data that are recorded using several different types of telescopes. It would be capable of feeding scientists images so they could try to answer many sought after questions. It truly has provided data, but the images also opened the door for many more questions. One question sounds simple: how many stars are in the heavens? All one has to do is go outside and look at the night sky to see that the number is vast. Some believed that Hubble could reach a point where it could see the end of the stars and declare a limit to the universe. Hubble has traversed way beyond the point that scientists thought would reveal the end of stars but no end is in sight. (Note: recent imagery from the largest earthbound telescopes show mature galaxies as far as they can see.)

At one point Hubble was placed to point at one spot for a long time to image one particular area in space. The equivalent angle is about the size of a tennis ball at 100m. It was directed to reach further than before. When the images came back to earth, where scientists analyzed them, they were amazed. Instead of seeing an end of galaxies, Hubble's images, which are now called the deep sky images, reveal an endless stream of galaxies—a seemingly endless menagerie of cities of stars with no end in sight. (Each galaxy is estimated to contain millions of stars.) It would seem as though we were foiled once again by our own folly: to believe that we can count the number of stars or the folly of thinking we could know as much as God. The number of stars remains unanswered to everyone except God. All we can say is that there are many more stars than we ever believed possible; we can never count them. The best we can do is appreciate that the large number is not comprehensible. Truly our God is an awesome God, who is full of power and might beyond our understanding. The vastness of space remains a visual testimony as to the glory, majesty, and creative powers of our God. The heavens serve to remind us of the extreme greatness of our God.

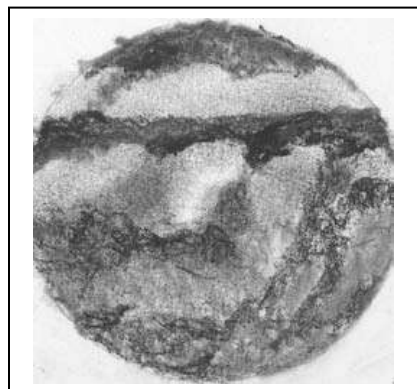
We are told that not only does God know the number of stars in the universe, but he also has named each one of them and can readily name anyone of them at any given time. This is the point of Isaiah 40:25-26 and Psalm 147:4. These verses contain a staggering amount of information. Even the most astute of scientist questions whether in our human understanding we will ever know the answer to the simple question of how the number of stars in the heavens. These verses shows each one of us that God is greater than our minds can reach, yet he names each star just like he is able to create a single person. It should provoke thankfulness that we can know this mighty God. It is humbling that we can put our lives in his hands and trust that he will care for us, because of his great love for us.

THE SKY OBJECT: SATURN or JUPITER



Space probes from the last few decades have completely overwhelmed previous levels of knowledge for planets of the solar system. Saturn, which is known as the ringed planet, and Jupiter have been the target of many recent probes as they have been designed to make deliberate close approaches to the two planets. Saturn's moons, rings, and the planet itself are under constant investigation using images received from space probes in the last three decades. There is so much recent data that it will take years to be analyzed. From an

amateur observer's viewpoint, nearly every new observer reacts the same way when they see the Saturn and its rings for the first time through a small telescope. We have heard the same exclamation many times: "It's really there!" The rings, a majestic but very refined object in themselves, are beautiful to observe. Among the moons there are vast differences, which are a testimony to the variation within God's hand of creation. Their surfaces are radically different yet they surround the same planet, yet the planet is much different than its moons.

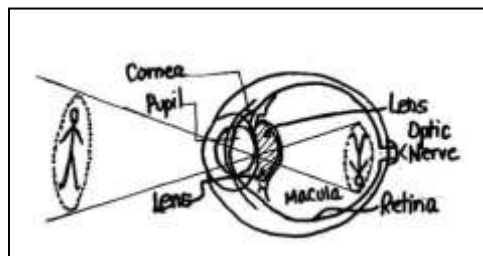


Jupiter is very similar in popularity and bright in the sky during a good portion of each year. These two gas giants can easily be observed with small telescopes. Jupiter is large and bright enough so our eyes can detect color in the bands with a medium sized telescope. Observers often enjoy tracking the rapidly changing positions of the four largest moons (the Galilean moons).

Note on the sketches: The sketch of Saturn was rendered by Frank McCabe [used with permission] using a telescope during an observing period in the US Midwest. The Jupiter sketch is by Roland

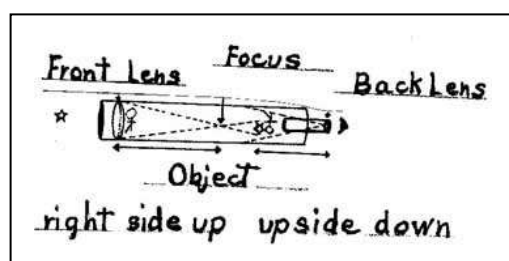
Beard. It was developed using an 8 inch telescope that was fitted with an astro-video camera. Both Frank and Roland are fellow sketchers, and often share their observations with each other. Both enjoy studying objects and then recording those observations, which is one objective of this course.

OUR EYES AND HOW THEY WORK



The first thing we have to consider for observing the heavens is our eyes. It is amazing how a sophisticated camera lens or a powerful telescope mechanism works like our eyes. Our eyes are made to automatically detect light that gets to the retina, just like a bit of light works through a telescope. Our eyes are complex optical systems which collect light from our surroundings, change the light signals to electrical systems,

and deliver them to our brain for interpretation. Our eyes quickly adjust to varying levels of brightness in our surroundings. They quickly focus but are also capable of seeing a very large area. Our eyes regulate the intensity of the light that comes into the eyeball through the cornea. The iris, which is the colored part of the eye, controls the amount of light allowed to pass farther into the eye.



The front end of a telescope also has a lens, which somewhat like the lens of our eyes. A telescope collects light like our eyes but cannot adjust quickly to light changes without our changing the setup; our eyes do it automatically. We can focus light in a telescope; our eyes change focus automatically as we change what we are viewing—whether the object is inches from our face or far

away. We need cameras to record images from our telescope; our eyes relay information that our brain records, and we are able to remember quite a bit of detail.

Consider the subject of seeing black and white versus seeing color. Our eyes have a feature that is very sophisticated that transitions from color to black and white (or the reverse) instantly. Equipment is generally not designed to do this. Our eyes have rods that allow us to see black, white, and shades of gray when there is insufficient light for interpreting color. The cones, which automatically detect a larger amount of light, serve a similar purpose but permit us to determine the colors we are seeing. Then both cones and rods can operate together, so we see colors as well as shades of gray to help us be able to see dark shadows and shapes. All of this happens quickly.

Our seeing involves changing what is seen to electrical impulses while interpretation of the scene is ongoing. The image is inverted or changed a couple of times in the process. We can also radically shift where we are looking, which is called our “field of regard.” And, our “field of regard” is huge. Then, in an instant, we can focus our attention on one small detail in one particular area. This is called our immediate “field of view.” We do not think about this nearly automatic process but it is truly remarkable. Most fixed optical systems, or even optical systems with computer assistance, do not show this level of capability.

Many of our telescopes and cameras have similar features. Telescopes can ‘see’ better in the dark because they “gather” light, but their field of view is more limited. Without our magnificent eyes to help and interpret images, these instruments are useless. We use our eyes to properly point the lens of our telescope or a camera at an object. Then we look through the viewfinder of the camera or the eyepiece of the telescope, focus on an object, and our eyes and brain take over to complete the process. There is

no telescope, camera, or binocular that equals the visual capabilities of our eyes coupled with the interpretive capability of our minds. The eyes are our most valuable observing tool, and they are still critical in the use of binoculars or telescopes.

THE IMPORTANCE OF NIGHT VISION

Most people have a certain amount of night vision, but not everyone has good night vision. However, if observers respect how their eyes work, they can take full advantage of the night vision they possess. Night vision is made possible because a decrease in light causes our iris to get bigger and the rods to “kick-in” and become the primary way we see something. The most important factor is this: our eyes take over 30 minutes to be **fully** adjusted to lower light levels. Conversely, a lot of light can quickly temporarily ruin our night vision. Night vision is God’s wonderful gift to us all, and the wise observer will make good use of it to view the heavens. To improve night vision before observing, spend time in a safe but dark environment without turning on lights. After some time, your night vision will enable you to see better when moving around in the dark, but you will also have a much better view of the night sky. Once your eyes have adapted to night vision it is a good idea to stay in a dark environment as long as you are observing. It takes over 30 minutes of get **fully** dark adapted but you have most of your night vision after 10 minutes. Each time you go into bright light for more than a few seconds, your eyes adjust to the light and your night vision is lost. If you go out into the dark again you will have to readjust to night vision. That mean your eyes will not be able to see dim objects (like stars) very well for another 10-15 minutes. (One of the exercises from Lesson 3 illustrates this point.)

Another important piece of equipment is a flashlight but there is a big qualification. It must not be too bright. A little light can help when getting around an observing area with equipment but also provide enough light to record observations. It is best if you can get a medium/small flashlight that has a red light instead of a standard white light. Red lights, if they are not too bright, will not disturb night vision very much. One thing you can do is use red finger nail polish to paint the lens of a white light flashlight red. This works because fingernail polish is clear and will change the color of the lens but will still allow the red light to shine through enough for you to see what you are doing. It will block just enough white light to protect your night vision. If you do not have a flashlight, a weak light of any kind can be used if some of the light is blocked or covered with a piece of red tape or red cloth. When any light is used, avoid looking straight at the light source because it quickly reduces your night vision.

THE IMPORTANCE OF PERIPHERAL VISION AND AVERTED VISION

Peripheral vision allows us to see objects that are outside of the center or focus of our vision. If you focus on a distant object, you will notice that you can see things around that area without looking directly at it. This is called peripheral vision. In other words, you can look slightly away from an object and still see it. For instance, when riding a bike, you can hold your vision steady in front of you but still pay attention to what you can see to the far right and left of the path. Often the objects that are farthest away from our central vision are a little blurred and at times can be harder to identify but “seeing” them helps. Having two eyes seeing at the same time is the key to depth perception. Depth perception is our

ability to interpret things at different distances. For situations where someone is observing in the dark around equipment, both peripheral vision and depth perception are valuable characteristics.

Practice peripheral vision by holding your hand straight out in front of you and look straight ahead. Slowly move your hand out to the side of your body the hand is on until you can no longer see your hand. Next move your hand back into a position just barely into sight but do it without moving your head or diverting your focus from being straight in front of you. You are using peripheral vision. Later practice using peripheral vision on objects in your observing section that are easy to see. Progress to objects you can barely see. It will not be long before using peripheral vision will be easy and comfortable.

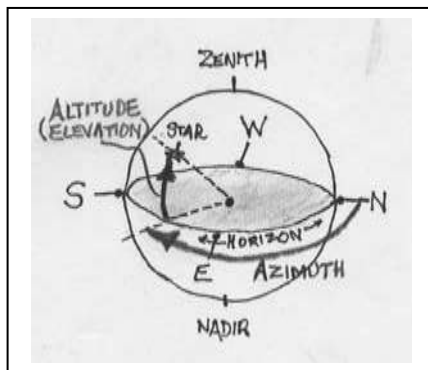
For night skies it is a key for watching meteor showers. In this case, looking up at the sky can actually be de-focused, where the eyes are relaxed. Peripheral vision, when your vision is relaxed, can quickly see meteorites when they are far from where you are facing, yet you can quickly focus if you need to. When looking through a binocular or telescope, the same principle works. One looks near the center of the field of view, but not with strain. The eyes should be relaxed. Then objects near the edge of the field of view will be noticed, and you can shift and concentrate more as you find what you want.

Averted vision is somewhat different than peripheral vision. When light levels are low, the sky is dark, and you are looking at dim stars, the very center of your vision has a blind spot or a weak spot because of the way your eyes are designed. So if you concentrate and look directly at a dim object, it will seem to disappear. However, if you look slightly off or away from the object, your peripheral vision enables you to see the object much better. The practice is called “averted” vision. Let’s try an example. If you look directly at a dim star and concentrate on it, that object becomes almost impossible to see. If we intently look at the object, we have a hard time finding it. Peripheral vision will be helpful in situations like this. Under these circumstances, we avert our vision just a little bit, which allows our peripheral vision to see the object better. When we learn to do this correctly, peripheral vision at night will actually bring an object into sharper focus than when we look directly at it. This makes peripheral vision and averted vision valuable observing tools for dim objects at night.

ANGULAR MEASUREMENT

We are familiar with measuring distance with units like meters, feet, miles, and kilometers. The observer must change his mindset if he is going to measure things that are in the heavens. The observer must learn to measure the location of objects in the sky by using angles to replace earthbound units of measurements for distance. Most people do this but have not thought about it. For instance, we say someone is in front of us, or in back of us, or on one side or the other. That is measuring by the position or angle from us to someone or somewhere else. It should be an easy transition because the only thing we are really doing is expanding that same concept to measure more specific angles. It makes finding and measuring things in the sky much easier. The angular unit, called a degree, will be used to describe the positions of the things in the heavens. So, we will learn some “angle-basics.”

To see how measuring by angles works, refer to the drawing below as you do the class exercises. For many students, this is a review from mathematics or an introduction to geometry.

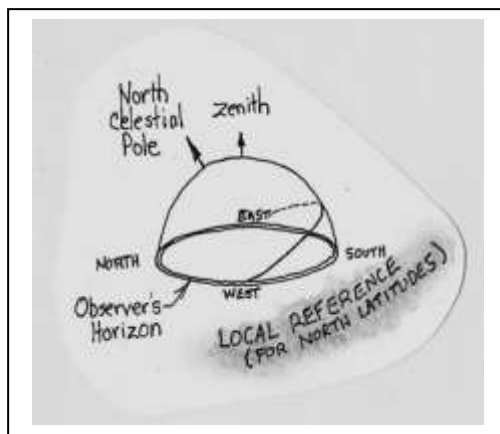


Four words we need to understand before we can communicate when we are observing are horizon, zenith, azimuth, and altitude (elevation). Horizon or horizon line is the distance as far out around us as we can see, until we reach the point where the sky seems to meet the earth. Zenith is the point directly over the observer's head. The angle between zenith and any point on the observer's horizon is 90 degrees (or $\frac{1}{4}$ of a circle). Each observer has a local zenith and horizon. Azimuth is measuring from a Northern direction starting at 0 degrees and always moving clockwise to the right until it reaches the 360 degree point on the

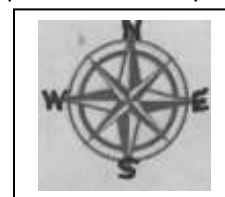
horizon (or one full circle of turn). To see this look straight ahead then look around the room in a clockwise direction and pick an object. Turn to face that object and pick a second object, again in a clockwise direction. You are measuring a change in azimuth. You can pretend you know where North is located, but it would be better if you use a compass to show the Northern direction.

Altitude (sometimes called elevation) is the simplest one of the definitions we will be using. Altitude is the angle between horizon and a point or object in the sky. It is a measure of how far up an object or point is located from horizon. Like the other terms we have introduced, it is measured in angles or degrees.

The diagram below (on the left) shows some of these local terms with respect to an observer, who becomes familiar with horizon, zenith, and compass positions with the addition of the north celestial pole and the celestial equator, which are also shown. We will discuss these last two terms in detail a little later.



We also did an exercise that taught us how to make a compass rose. We're going to use a compass rose to help us find stars relative to cardinal directions. The little diagram shows a compass rose as if you were standing above it. This exercise would be a little bit easier if we were outdoors



and we could see North, South, East, and West. For now, pretend that you know where they are located in your classroom. Set two strings on the floor at right angles. Mark one for N and S and the other for E and W like you see in the

diagram of the compass rose. The edges of the room's floor define the horizon. The ceiling and the walls are the whole sky. Now you could pick any single object in the room and note its location with respect to all the terms we have used. The object's altitude (elevation) could be defined in degrees (or an angle) above the floor from the center of the compass rose. An object's azimuth could be defined by the angle measured clockwise from N. So, every object could have a defined location. In the same sense, all

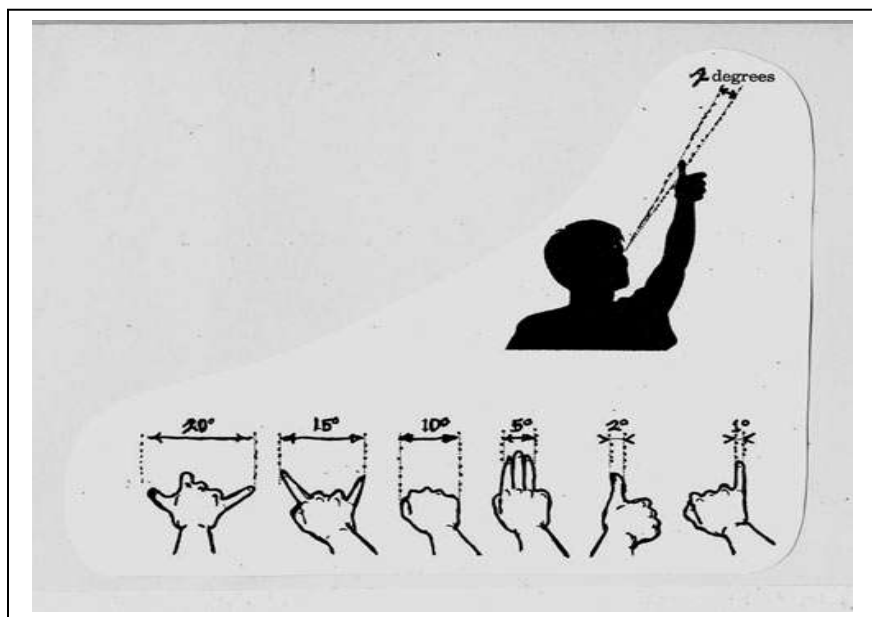
objects in the real sky have defined locations but we have to learn a little more about measurements before we discuss this in detail.

MEASURING ANGLES USING THE HUMAN BODY

Scientists have all kinds of fancy instruments to assist them in finding objects in the sky, but one of the quickest and easiest instruments is the human being. God made our proportions so consistent that we can use our bodies to measure angles. Earlier in this lesson we learned about the marvelous human eye. Your eyes are an important part of observing. However, the rest of the observer's body can help immensely. The vastness of space can be measured in terms of angular position using our fingers, hands, and outstretched arms. While measuring distances to objects is complicated and even a challenge to scientists measuring extremely long distances, measuring angles with our eyes and the human body is quick and easy.

Using our hands and arms to measure angles is both interesting and fun. We have already determined that every circle has 360° . We have covered some large angles that are important, too. But observers need a way too quickly and accurately measure without an instrument. Study the diagram on the next page and do the exercises in the paragraphs that follow.

--Hold your arm and hand straight out in front of you with the palm of your hand facing away from you. Make a fist with your outstretched hand and extend your thumb up. The area of the sky blocked by the width of your thumb is two degrees (just like you see in the next picture). For any of these exercises, it is important for accuracy that you make sure the arm is straight and outstretched.



--By touching the end of your fingers to the center of your hand and wrap your four fingers over your thumb. Bend your wrist up and raise your little finger so it sticks straight up. The width of your finger in this position is about one degree. The same exercise with the end of your index finger gives about the same angle.

-- If you raise your first three fingers, the angle across all three near the end of the fingers is five degrees. Add the smallest finger (not shown in the diagram) and you have about 7 degrees. Just the index and largest finger (not shown) gives you about 3 degrees

The next few angular measurements are larger and used a lot in star hopping, which will be discussed later.

--Make a plain tight fist and count the width of the thumb as well as the four knuckles. The angular measurement across your entire fist is equal to 10° . Simply tuck our thumb into the palm of our hand and fold all four of our fingers over our thumb making a fist (not shown), and the angle shrinks to about 8 degrees.

--Stretch your index and smallest finger as far as you can, the angle is about 15 degrees.

--Open your hand as wide as you can. The angle between the tip of your thumb and smallest finger is a little over 20 degrees. This measurement is used a lot because it is relatively large and easy to use to measure large angles between things in the sky.

Whether a child or an adult, tall or short person uses these techniques, the answers for most people are nearly the same. Normally proportioned people (length of arms, fingers, and the distance to the eyes with arms outstretched) will almost always get the same results in an exercise if the measurements could be checked.

To show this, try a little exercise: If you are wearing glasses please take them off for a moment. Now using your thumb, locate the temple area on the same side of your body that the hand you are using is on. Next use your middle (longest) finger by placing it on the opposite temple. You should now be reaching across your face with your hand in front of your face. Last rotate your hand in a rocking motion over your face. Almost everyone's hand will rock smoothly from their forehead down to touch their nose. This is true because the distance across your face is in its proper proportion to the distance across your hand. This experiment gives us some proof that our proportions are very close. There will be exceptions at times, but not often.

Here are a couple of examples that will enable you to see what these hand motions can do when using them in observing. If it is night time, pick a star that is at zenith (if you have chosen wisely you have chosen a star that is directly over your head). Since the star is at your zenith, it has an elevation of about 90° . Now you can measure the angular distance from horizon to the star you have chosen by using your outstretched arm and hand (it measures 20 degrees). Place your thumb at the spot where you see the land and sky meet as if there were not trees and the land was flat. Then rotate your hand by pretending your little finger is a pivot point. Now you are 40 degrees up from horizon. Two more widths of the hand make 80 degrees. In other words, $4\frac{1}{2}$ rotations of your outstretched hand measure an angle from horizon to approximately 90 degrees of elevation, or zenith. The same exercise can be done during the day by standing next to the trunk of a tall tree. When standing against the trunk, measure from horizon to the vertical direction of the trunk. The answer should be about the same: about $4\frac{1}{2}$ rotations from horizon to straight up (zenith).

You may also practice this exercise by using your fists. Make a fist with your hand, holding your hand out as far as possible on your outstretched arm. Point the thumb side of your hand towards the ground. This time you will use your arm as a focal point and you will rotate your hand so that your thumb is up and stays in place then bring the part of your hand with fingers up until the opposite end of your hand is pointing up to the sky. Repeat this process by rotating your hand and each time moving your hand up a little bit higher until you reach the star you picked out above you at your zenith. It usually takes about nine rotations of a fist to reach from the ground to a star near zenith. This shows you that measuring angles with your hands is fairly accurate. It is accurate enough to locate things in the sky for most people once they become accustomed to working with the angular measurements by using their hands when observing.

Now you can measure the angular distance between two points in the sky. You can do this by having someone stand in the center of the compass rose. Pick two points where you are. Make sure the two points you have picked are above the horizon. If you are doing this at night you can use any two bright stars that are available in your viewing area, but if it is in the daytime select some distant objects and pretend that they are stars. Determine the angular distance between them by using either your outstretched hand or your fist and rotate the one you chose from one object to the next object. You can try this several times using different objects each time.

Here are two class exercises. Before you do them, make sure you understand the direction of your personal zenith and have an approximate idea where the sun sets:

If someone tells you that the sunset location was in the West – Southwest and the moon was 50° above but slightly south of that location where is the moon located? Go outside and demonstrate where the moon is located.

Someone tells you that a star is 30° to the Southwest from zenith at 7 o'clock at night. Demonstrate finding that position.

You can often practice finding imaginary stars or deep space objects in your classroom or outdoors in daylight until you become very familiar with using the hand signals. Soon you will be quite comfortable using hand signals to measure angular distances. So, everything in the sky from an observer's position can be measured by angles. Different hand combinations make measuring quite accurate.

EXERCISES

4-D1 EXERCISE: MEASURING EXPERIMENT BY DAY

Since we have learned how hands and fingers can be used to measure angles, we will attempt to verify the accuracy of this method by measuring one half of a circle or 180 degrees. Draw a straight line on the ground about 10 steps long with a place marked at the midpoint. Stand on the midpoint facing one end of the line. With your arm outstretched and using your fist, how many fists does it take to turn from one end of the line to the other? (Hint: use things on the ground to help you be accurate as you mentally note fist locations as you turn.) Divide the number of fists it takes by 180 degrees. The answer should be

from 17 to 19. Do this same process using an outstretched hand. It should take about 9 outstretched hands to make the turn from one end of the line to the other. Now find a vertical wall, post, or tree and measure the angle from horizontal to vertical in terms of fists and then open hands. You should come close to (nine fists) or (4 open hands plus one fist). This exercise should verify to you that outstretched hands, or fingers, or fists can be used to measure angles in the sky or angles between objects. One outstretched hand can measure about 20 degrees; one outstretched fist can measure about 10 degrees. Review the measurements that you learned in the class.

4-N1 EXERCISE: STAR MAGNITUDE EXPERIMENT

Locate an area of the sky around zenith (straight up) and stand facing South (sunset would have been on your right side). Find an area that shows at least 5 stars that seem to have different brightness or magnitude. Using a pencil, represent these five stars with a small dot on a piece of paper. Put the dots in approximately the same pattern that you see in the sky and represent their differences in brightness or magnitude by making the dots lighter or heavier. How clear was the sky at the time you observed? Write this down. Sign the paper. Compare your result with others.

4-N2 EXERCISE: MEASURING EXPERIMENT BY NIGHT

Draw a large circle on a piece of paper like the one done in the last lesson exercises. Put a label on 2 sides of the circle that represent where the sun rose and set (east and west). Draw a North/South line. Mark the edges of the circle "horizon". In the center of the circle put a small "X". It represents zenith (when you look straight up). Pick three bright stars in the sky and pretend there are lines that connect them. Note the direction you face in order to see them. Put the stars on a piece of paper the same way they appear to you. Measure the angles between the stars with your hands. Put each angle on the line that connects the same two stars on your piece of paper. Record the direction you were looking and how far up from horizon the lowest star was found (measure this with your hands). Compare your result with others. This exercise is good to do with someone so you can check the angles and position or direction of the stars together.

Student Note 1: With the exercises you have done this far, you are already learning that all stars are not the same in terms of magnitude and their positions can be measured by the angles between them compared to your observing location, which is represented by the center of the paper. The center of the paper is also the sky at zenith. This same orientation is true for most rotating sky maps (called planispheres).

Student Note 2: In an early exercise you noted that the sky changes position over time. Since the earth is rotating, star positions seem to change but the motion is apparent (not real). It is your observing position that is changing because you are rotating with the earth. Depending on when class members made their observations, the same stars may have a different position on their pieces of paper, but the angles between them will be the same.

AOBV Lesson 5: Finding Things in the Sky with Hands and Eyes

Materials: paper and pencil

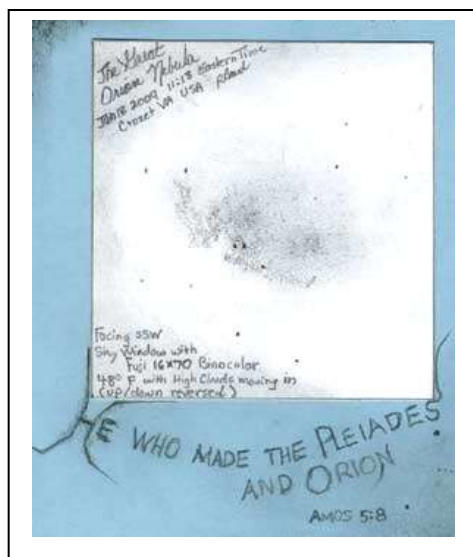
Reference: Job 9:8-9

Sky Object: M42

REFERENCE SCRIPTURE

The proclamation by Job in chapter 8 verse 9 is both general and specific. It is a general proclamation about God's authorship of creation. It is a specific proclamation that names constellations—arrangements of prominent stars in recognizable patterns. Because the constellations are obvious, they are also time pieces for the seasons because their positions in the heavens at specific times of night and year. The reference in Job is delightful as God brings attention to His handiwork on three specific patterns of stars—each well known by observers and observable by most of the earth's population during a good part of each year. It is no surprise that the closing words of the verse, using the heavens that He mentions as a context, state that God's wonders [of creation] cannot be fathomed. Our knowledge and discovery process is intensely exciting but it will also be never-ending (as long as the universe remains) because the creation cannot be completely understood by created beings within it.

SKY OBJECT



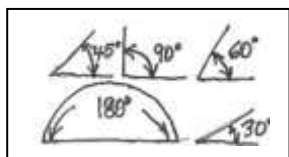
M42 (the Orion Nebula) is a heavenly object that nearly everyone on earth can observe. It is large, beautiful, and full of color if larger telescopes or imaging techniques are employed for an observation. It is the brightest observable nebula in the sky. The sketch by Roland Beard [used with permission] is with a large binocular at 16 power, but even small binoculars show the nebula. Observations with small telescopes will reveal even more of the shape; large aperture telescopes see a hint of color; astro-photography or astro-video show more color. Many professionals have spent life times observing M42. The unique detail in the object has been subject of more books and discussions than nearly any other sky object. It is a delightful object to sketch. The constellation of Orion surrounds the area, and is mentioned twice in the scripture. It is notable for its

beautiful patterns of stars, and is actually a large open cluster. Since the constellation and object is relatively high for several months for most of earth's population, it is an ideal choice for new observers to study.

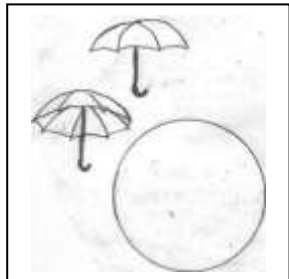
REVIEW OF LESSON 4

During the last class we learned how an observer becomes a useful scientific instrument by using his hands, arms, and fingers to measure and help travel from object to object in the dazzling night sky. It does not take long for new observers to be amazed at what they can find. Since the observer takes his body everywhere he goes he will be able to look up, measure angles from point to point, and find locations of objects. In this way the observer can also demonstrate his knowledge to a teacher or use it to teach others about the sky.

Here is a quick review about angular measurement learned in lesson 4. A circle has 360° . A half circle has 180° . A fourth of a circle has 90° and a $1/8$ of a circle has 45° . Rotating one arm in a complete circle means you have rotated 360° , and the other angles can be demonstrated with motions as well.



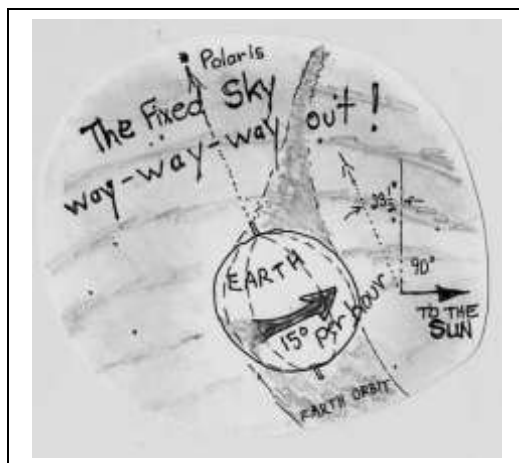
Look at the drawings on the left. The angles that are commonly used in angular terms (other than 360 degrees for a circle and 180 degrees for a half circle) are also angles easily divided into 360 . They are also easy to demonstrate with an observer's arms. 45 degrees is half way to the local vertical line or zenith. 30 and 60 are one third and two thirds, respectively of angle between flat ground and vertical or zenith. Flat ground as far as we can see and where it would meet the sky represents horizon. If we rotate an arm pointed to horizon and rotate our arm over our head to horizon in the opposite direction, we have measured 180 degrees. If we stop the rotation where our arm points straight up, we have noted local zenith— 90 degrees from any horizon point. These are common angles and terms used in astronomical observing.



To picture the sky in another way, place a circle of material on the ground or floor in a room. Pretend that it represents the flat ground of earth. When you stand in the center of the circle, imagine being under an umbrella that you hold just above your head. The underside of the umbrella represents the hemisphere of the heavens that you can see from where you stand. Now pretend you are standing on the North Pole. The sky would move in a circle if you looked directly overhead—just as if you spun the umbrella. Who is really turning in this case? Is it the sky, or is it the earth? It is plain that the earth rotates while the sky remains fixed. The practical reality of this is a little harder to grasp because our sense of motion is very local. After all, it looks like the sky moves, the sun moves, and the moon moves. The motion during our day/night cycle, however, is only “apparent” since it is the earth that is rotating. We will talk about this some more in the next section.

GRASPING APPARENT SKY MOTION

We have been talking about local definitions for observation, where the observer understands he is the center of a local flat area that reaches to a local horizon. The umbrella example helps us see the sky as the underside of a giant sphere, but the earth is also sphere. While the spherical shape of earth is common knowledge, it takes more thinking while observing the heavens to have a sense of this, since our local observing position appears to be what is flat and fixed while the sky seems to move. Our thinking has to be shifted when we observe the heavens to picture what is happening. Let us try an



example. Refer to the illustration to the left, where we have backed away from the earth to see it in its local orbit on December 21st, when earth is tilted away from the sun. Earth is pictured as going on a darker grey path around the sun, which is far to the right. The fixed sky, which surrounds everything, is way beyond the sun and the earth. The far-away heavens are like the inside of a huge ball with Polaris at one point on the inside of the “ball.” The diagram shows light ribbons of grey as if they were marks on the inside of this celestial “ball.” This is where other stars would appear but are omitted for clarity. As the earth rotates as fifteen degrees per hour, the sky

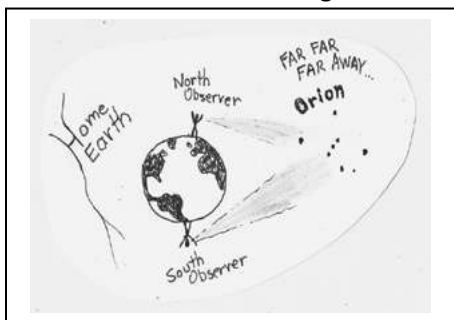
appears to move but really does not. Polaris will not appear to move, but that is because it is closely aligned with our planet’s axis. *Note: We will discuss the earth’s “tilt” later, which is relative to the plane of earth’s rotation around the sun.)*

The illustration shows the speed of the earth’s rotation as 15 degrees per hour (360 degrees of rotation during 24 hours = 15 degrees per hour). Apparent sky motion, then, will be 15 degrees per hour. At the earth’s poles, one will see a star near Polaris making 15 degrees of a circular path around Polaris. At the equator, a star overhead will have motion that makes a straight line. Another way to see this is by imagining standing at a location on a model globe that is in a classroom. As you turn the globe, how will an object on the far wall appear to move as the earth rotates if you are at one of the poles? How will it appear to change if you are on the equator? If the object or star is near the axis of the North Pole or South Pole, it will appear to rotate about the earth’s axis. If the object is straight out from the equator, it will appear to move in a straight line. When you observe the heavens at night, this exercise can be done under the real night sky to make it a little easier to understand what is happening as a stars apparent position changes after an hour or two of observing.

The real lesson is simply that the sky only appears to move, but it is earth that is “moving” or rotating. The far-away celestial heavens are fixed.

HEMISPHERE AND ORIENTATION CONSIDERATIONS

The parts of the sky that are observable in a local observation site are heavily dependent on the latitude where we live. Use the diagram for the explanation that follows. The Orion Constellation, which is a well



known constellation (or recognizable pattern of stars), is depicted. (Later we will talk about constellations, which are patterns of brighter stars.) In particular, an observer near the South Pole will have a substantially different view of the sky than someone at the North Pole. There is overlap between their respective views of the heavens, but each one also observes unique skies to the far north and south that the other observer cannot see. The diagram uses the key stars of the Orion

Constellation for an example of something both observers can see, but they see it differently. The view each observer sees is reversed with respect to up and down as well as left and right. You can visualize this in a classroom by taking a globe, choosing a spot on the opposite side of a room that you want to observe, and seeing how it would appear from each hemisphere.

Views of the heavens, then, can appear with different orientations that are dependent on the latitude of the observer but the angles and distances among stars remains the same. Views also change apparent position through the night as earth rotates under the sky (15 degrees per hour). Observers get accustomed to these changes with experience, but it takes a change in orientation and thinking for a new observer. This is why the practical exercises at the end of the lessons are so important. They are designed to help that “change” in orientation make observing easier.

A HISTORICAL NOTE

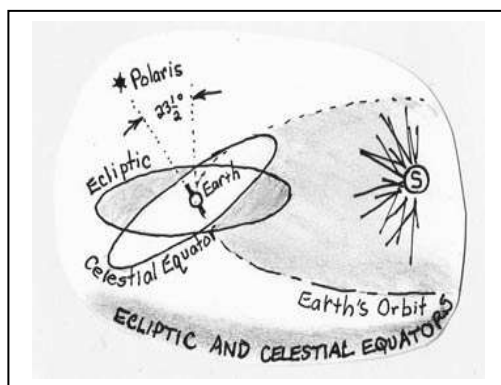
There have been periods in history where large numbers of people were unable to differentiate between local and solar or celestial heaven perspectives. For some, it was easier to picture the earth as flat and the sky moving. While the notion has some truth, it is not accurate. A few early observers believed the world was flat and the sky moved in relation to a flat fixed earth. While this perspective works for things directly around us, the view is not accurate in a larger context and yields false conclusions about the heavens as well as the earth. It is interesting to note that the inspired scriptures describe both a local observation perspective (like Isaiah 40:26) and distant-earth or ‘God-above-all’ (Isaiah 40:22) perspective. Is 40:22 is clear that the earth was a sphere—a view taken by vast majority of early Christian observers through the ages. The verse also fits very well with Job 26:7 (and our simple illustrations), where God’s action in creating space and the earth is described as spreading out the northern skies and suspending the earth over nothing. In other words, space is huge and empty while the spherical earth is “hung” in place with no apparent support.

Note: There is a myth that the Church taught or believed the earth was flat. Believing scientists and church historical figures, almost without exception, consistently believed and taught that the earth was round. [For further reading on the subject, visit www.creation.com and enter “flat earth” in the search window.]

Note to teachers: this lesson is long. It can be divided into three sections, and this location is a good one for the first stopping point. The exercises can be divided also.

SEASONAL CHANGES IN THE SKY

Night sky changes over a year period are commonly related to seasons for a local observer and where he is located. The seasonal changes are due to the position of the “tilted” earth as it orbits the sun, but the position of earth around the sun also dictates what part of the inside of the celestial “ball” can be seen the easiest. Previous diagrams show the earth fairly large, but we want to enlarge our view and talk about the subject by making the earth smaller. The discussion that follows refers to the illustration at the top of the next page.



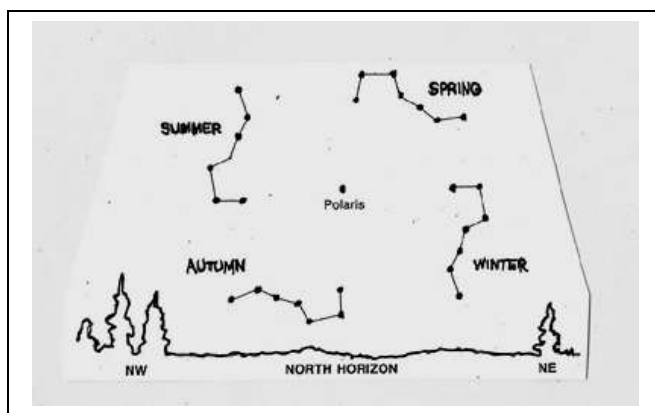
If you will note the diagram, the earth is represented by a tiny sphere with an axis. About half of the orbit of the earth around the sun is represented, but it is enough to show that earth's orbit around the sun defines a flat disk. If this disk was level (as shown), the earth axis is 23.5 degrees from vertical because our axis points to the Polaris.

Now we have some new terms to introduce. The path of the sun, if it was marked on the earth as earth orbits about the sun, is called the *ecliptic*. If the ecliptic is extended out in space a little bit from the earth, as the diagram shows, it would define a disk that is in the same plane as earth's orbit around the sun. Earth's equator, however, is aligned with earth's axis that points to Polaris. If the equator was extended out in space indefinitely, it would be called the *celestial equator*. The illustration shows it extended just a little bit from earth's equator. Now you can see that the angular difference between the celestial equator and the ecliptic is the tilt of the earth (23.5 degrees).

If the ecliptic line were drawn on the earth's surface as the earth orbits the sun, it would cycle above and below the equator, dependent on the position of earth in its orbit. On earth we relate this to a local season or seasonal changes. So, the path of the ecliptic marks the seasons. So how does this all change what we see at night? The part of the inside of the celestial ball that we see the best is defined by the time of year, which we relate to our local season, as we are looking out in space. Look at the illustration again. If you were on the night side of earth as it is pictured, you would see the part of the celestial ball (called the celestial sphere) to the left. If you were on the night side of the earth 6 months later, the earth would be to the right of the sun and you would see the celestial sphere to the right the easiest. So, seasons (specifically, the months of the year) are used to understand what you can see from your local observing position on earth. So during every year as we observe, our view of the celestial sphere repeats, and our best views of certain parts of it change from month to month. In addition, northern and southern hemisphere observers will also see parts of the northern or southern, respectively, parts of the celestial sphere much easier throughout each year.

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THE POLE STAR AND THE BIG DIPPER



The picture to the left shows seasonal change of the heavens with respect to the axis of the earth that points to the Pole Star (Polaris) if you were observing at 10 pm local time from a middle north latitude. Polaris can easily be seen above the horizon. The closest major pattern of stars (and the third largest constellation) is the Big Dipper (or Ursa Major) as shown in diagram. (It is also called the

“Bear.”) This means an observer can easily gauge the season of the year by noting the constellation’s orientation in the middle evening period. A southern hemisphere observer does not have a “pole” star, but there is a key constellation (the Southern Cross) that can be used as a seasonal clock in the south like the Big Dipper in the north.

OBSERVING BY MONTHS AND SEASONS

On a daily basis at a consistent time of night, changes in the sky are not very apparent. Over several months, however, the changes become more obvious. Months of the year and a local time are the key factors to set or orient sky charts, which we will learn to use in Lesson 7. The most popular astronomy references online or in magazines most typically portray the sky by the month of the year. A few calendars portray astronomical events by the year. All of this information is valuable for the observer because it enables him to know when he can observe certain objects in the heavens in terms of time of month. This information enables observing to be organized and have a better chance of success. A more complicated obstacle for an observer having a successful observation period is predicting the local weather, which is much less predictable than astronomical events. In a realistic way, planning for observing depends on local time, time of the year, and weather. We will teach you how to use star charts and maps, which are keyed to time and date. Weather, on the other hand, will always have to be locally determined by the observer. Understanding local seasonal and daily variations in weather helps successful planning.

Note: The effects of the tilted earth axis relative to the solar-earth disk are remarkable—even with respect to observing the heavens. If there was no tilt in the axis, local conditions of temperature during day/night conditions for most positions on the earth’s surface would make observing very uncomfortable or impossible. The temperature transitions at between day and night would be extreme. Winds would be much higher. An issue as simple as temperature stabilizing telescope optics would be a challenge. It is fascinating to consider the wonder of God’s placement and assigned movements of earth and sun relative to the heavens. The perfect tilt of the earth, the perfect distance to the sun, and the right rotation period are keys to the stable conditions that we enjoy. As a result, God makes it pleasant and possible to observe from nearly any latitude. While some local conditions we have might be considered extreme, they are (in a larger perspective) very mild and somewhat predictable. Although local weather can cause cloud cover that can stop observing on some nights, the atmosphere is usually clear enough and laden with sufficient moisture so reasonably good and stable observing conditions at most locations on the earth’s surface are possible. In short, Psalm 19 is very true: the “speech” of God’s handiwork in the heavens is universal—it can speak to all people in all locations, if they will “listen” and observe.

LOCAL LONGITUDE AND LATITUDE CONSIDERATIONS

Our local observing location is dictated by a latitude and longitude reference system that is common and standard in geography. The longitudinal system has a reference point that was arbitrarily developed over history. Everyone has used the same reference system for a long time. The longitudinal reference point (0 degrees longitude) runs through Greenwich, England. All E-W positions on the globe are relative to this point and given in terms of degrees E or W and 0 to 180 degrees (half way around the world at

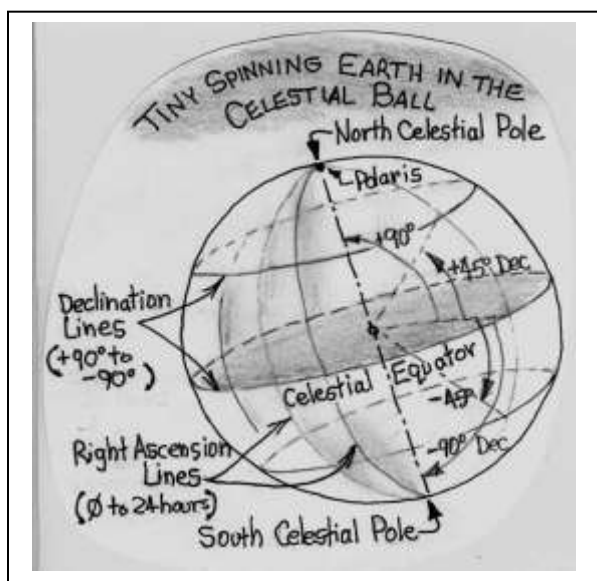
the international dateline). Latitudes are expressed as degrees away from the equator (0 to 90 for the N hemisphere and 0 to -90 for the S hemisphere). The terms and some of the units change as an observer shifts from understanding an earth location to understanding a position of something in the heavens (the inside of the celestial sphere). We will discuss those changes shortly.

Time zones, which approximately correspond to bands of longitude on earth, are used so local day/night conditions for any person around the world is at relatively common local time of day. Sunset for an observer in Africa is about the same local clock time during the day as sunset for someone in Mexico, although the event occurs at these two places several hours apart. Time zones are also defined in relationship to the time at Greenwich, England, so an observer anywhere in the world can convert his local time to a “universal” time or UT. This is mentioned because most astronomical events and many globally important events or processes are announced or monitored in terms of UT. It is easy to convert UT to local time (or the reverse) if you know the local time zone difference from UT. Most astronomical reference material uses UT.

INTRODUCING THE CELESTIAL SPHERE

We have talked about the celestial sphere as the inside of a huge “celestial ball” with earth at the center. We look “out” at the inside skin of the ball or sphere. There are, however, some differences in terms associated with the celestial sphere compared to the earth reference system as mentioned in the previous section. We will discuss those differences and introduce the terms that are needed to understand mapping the heavens and finding things on this map. The important fact about the celestial sphere is that God created it to be relatively fixed. This means locating things in the night skies can be mapped, and the maps stay current for a long time. Star positions do not change very much relative to each other; planet positions (called wandering stars by early observers) change slowly and are predictable. We will use the figure below for our discussions. We will review the diagram together but remember this first: earth is the tiny dot in the center. You, as the observer, are on that tiny dot. The axis of the earth has now been extended to infinity (to the inside of the “ball” or the celestial sphere), and the N and S positions are clearly marked. The celestial sphere, of course, completely surrounds us.

It is one thing to have a book understanding of the heavens. It is entirely another to be under the night skies and have the same understanding. The objective is to have a little orientation in these discussions then apply it to the night skies as you physically observe. Then you can appreciate and enjoy the finely tuned motions as you watch them occur. This practical understanding also helps an observer more effectively plan and find what will be seen. The same terms and concepts that you are learning will be helpful as you learn to use star



maps in later lessons. Use the diagram on the previous page for the rest of this section.

Earth is at the center, where you are as an observer. The celestial equator (extended from earth's equator) marks 0 degrees of declination. Declination goes from 90 degrees at the poles to 0 at the celestial equator. Declinations are negative south of the equator and positive north of the equator. Thus, at 90 degrees positive or negative declination (location of N and S poles) is the axis about which the earth turns. The axis to the N points to Polaris (called the North Star or Pole Star). The S polar axis does not point to an apparent bright star, but one of the closest stars along the southern polar axis is Octanis. The common term for declination is "Dec," as shown on the figure. As examples, the diagram shows +45 and +90 degrees Dec (N of the celestial equator) and -45 and -90 degrees Dec (S of the Celestial Equator).

Let us do an exercise to reinforce declination measurements. Please stand up and give yourself a little distance from the next person. Pretend you are in the center of the earth with your body aligned to earth's axis, which means Polaris is straight over your head. Raise your right arm and point straight out, so your arm points in the direction of the celestial equator. As you raise your arm up in 10 degree increments (0, +10, +20, +30, +40, +50, +60, +70, +80, +90 or vertical) you are measuring declination 10 degrees at a time until your arm is straight overhead—aligned with your body that points to Polaris. At that point, declination is a positive 90 degrees. Now the south polar axis is directly under your feet. Put your right arm so it points straight out beside you. This time you will lower your arm in 10 degree increments (0, -10, -20, -30, -40, -50, -60, -70, -80, -90 or straight down along side your leg. You have just measured declination from the celestial equator to the south polar axis or from 0 degrees to a minus 90 degrees. There is no star directly at the south polar axis, although a star named "Octanis" is not far away.

The remaining term in the diagram is "right ascension," which is commonly known as RA. The earth-bound equivalent is longitude and is measured in degrees. On the Celestial Sphere, however, the RA is measured in hours, which is measured eastward. The 0 hour RA location is at the point where the sun, whose path is called the ecliptic, crosses the celestial equator from south to north. This location, as located on the celestial sphere, is currently in a constellation called Pisces. The units for RA are hours, minutes, and seconds—running from 0 to 23 h 59m 59s after going around the celestial sphere completely. It is a bit hard to grasp at first, but RA is a celestial sphere reference for east-west direction in the sky, and its reference point is in the sky also.

The net result is that any star or object in the sky is located by Dec and RA. However, for major objects using binoculars or small telescopes, celestial coordinates are not needed. The reference system becomes more important for faint objects and computerized telescopes. However, the Dec and RA are marked on nearly all star maps, including the star maps we will use on a regular basis. Understanding Dec and RA can also help when going from star maps to other references, such as star atlases, which we will also use.

Vocabulary and review note: The ecliptic is the apparent path of the Sun's annual motion if it was extended to make a mark on earth. It annually cycles between plus and minus 23.5 degrees of the

equator, dependent on the position of earth in its orbit around the sun. Because the ecliptic represents a plane of the earth's orbit around the sun and most planets are approximately on that same plane, solar system objects are typically found close to the ecliptic. Eclipses of the sun or moon can occur only when the moon crosses the ecliptic, because this means the moon is tracking on the track of the sun. If the moon is on the far side of the earth from the sun, it is a lunar eclipse. If the moon is on the sun-side of earth, it is a solar eclipse. Lunar eclipses are more common because the earth is larger than the moon, so it more frequently shadows the moon from sunlight. The rarer solar eclipse is possible because God made the size of the sun and moon such that they have the same apparent diameter from an observer's viewpoint. To see a total solar eclipse, one must be in a very defined location and track on earth when it occurs.

Note to teachers: For teachers wanting to divide this lesson into three parts, this is a good location to end the second of three parts.

CONSTELLATIONS (MAJOR STAR PATTERNS)

It is helpful for an observer to identify the date and time of a planned observing period. This information allows the observer to identify what prominent stars or constellations (major star patterns) are observable. The constellations, in turn, are sign posts for stars and sky objects in their vicinity. The process of working from a known constellation or star to another star or sky object is called star hopping. The hand and finger combinations with an outstretched arm, which was presented in the last lesson, will be a primary method of measurement, if it is needed when star hopping from one place to another.

Constellations (major star patterns) are probably the most valuable aids and reference points for observers to find things in the sky. Constellations were used from times of old. Many of them are identified with pictures of people, objects, or animals. Many of pictures do not resemble what they allegedly represent, but the pictures and stories have been carried forward for a long time so people still use them. The ancient people of Babylon, China, and Egypt drew pictures around connected stars as a reminder of star patterns; the pattern often related to a specific story in that culture. While some pictures and stories are still with us, others fell into disuse and were forgotten. While constellation pictures are helpful to some observers, nearly all observers recognize the star patterns in major constellations as they become accustomed to the night sky. There are 88 constellations currently in use today, but learning them will happen gradually as a new observer gains experience.

Most of the constellations we will address in this lesson include a set of twelve that intersect or are close to the ecliptic during the course of a year. The set is called the Zodiac. They are roughly in a line along the ecliptic. As a year progresses, different constellations in the Zodiac become more noticeable in the sky. The observer will make observing easier if he identifies and becomes familiar with the star pattern of one of these Zodiac constellations during each month of the year. If one of those is identified along with a significant constellation or two near the south or north poles, finding other things quickly becomes faster.

To find any month's significant constellation the observer must wisely choose an observing location that permits a clear view of the night sky. This special place is called an observing site. Many observers have several, but they have common denominators: they have a good view of the sky and the cardinal directions (N,S,E, and W) are predetermined. The next step is to learn the constellation that is most prominent and high in the sky for that month. Others can be added as the months progress until all twelve are identified along with some prominent ones near the poles. The table below shows the 12 popular Zodiac constellations and the month in which they are highest in the sky in the early evening (about three to four hours after sunset). When we begin learning about rotating star charts, finding these Zodiac constellations that are prominent for an observing period is helpful for finding things in the sky.

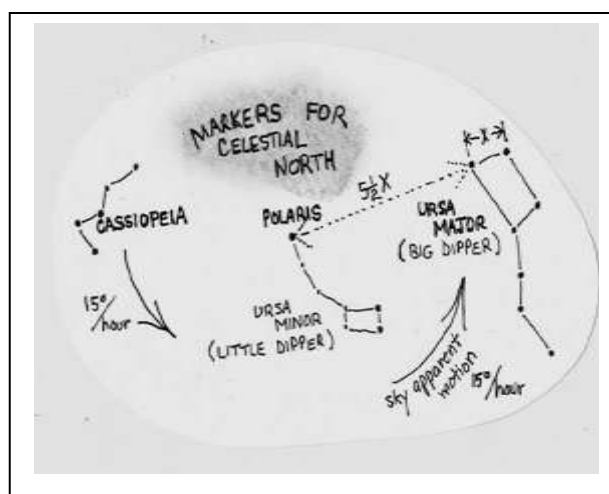
Month	Constellation	Month	Constellation	Month	Constellation
January	Gemini	May	Libra	September	Aquarius
February	Cancer	June	Scorpio	October	Pisces
March	Leo	July	Sagittarius	November	Aries
April	Virgo	August	Capricorn	December	Taurus

SPECIAL NOTE ON URSA MAJOR AND CASSIOPEIA

Since most of the world's population lives N of the equator, this section is included because of the special significance of two primary constellations, Ursa Major (The Big Dipper) and Cassiopeia. Knowing how these two constellations are positioned around Polaris is used by many people to get oriented to the sky during observing periods.

For this discussion, we will use the figure on the right. Remember that the Big Dipper looks like it is named; Cassiopeia looks like a "W." Middle N latitude observers, if the local horizon is clear, can see both constellations most of the year. Only one of the constellations may be seen for months at a time if an observer is closer to the equator. Each constellation is about the same distance from Polaris, and you can use either constellation to find Polaris. Just remember that the picture will rotate counterclockwise as the night progresses. A

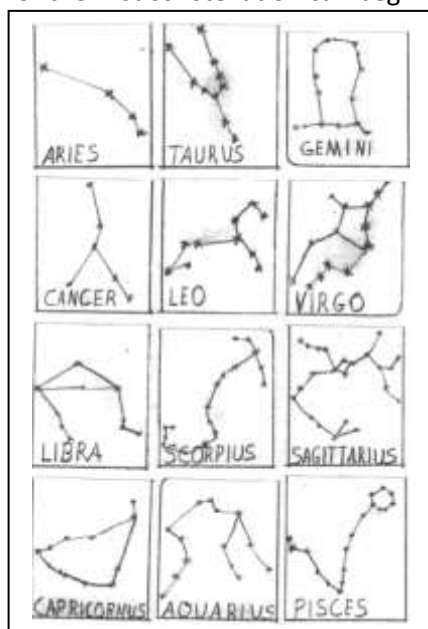
previous discussion already presented the how you can associate the Big Dipper's shape with a season. The other measurement, which is handy and shown on the picture, is the apparent distance of the last two stars on the Big Dipper. Five and half times this distance, in a line extended from those two stars, will locate Polaris. The diagram is also what you will see around February and January around 9 pm, or after midnight in November-December, or after sunset in March.



Note: Remember: the sky appears to move at 15 degrees an hour, so constellations appear to rotate once around earth's axis (that points to Polaris) in 24 hours. Two hours change means a 30 degree rotation will be observed. On the other hand, earth's orbit around the sun completes one rotation each year, so Cassiopeia and the Big Dipper will appear to rotate around Polaris 30 degrees from one month to the next at the same observing time. Think about it! Think about it, because it can help you understand how to plan what stars, constellations and objects can be seen later in an evening or later in the year! You will confirm this with experience, but also with the use of a rotating star map in Lesson 7.

FIRST NIGHT FINDING A CONSTELLATION

All the learning is incomplete until the observer tries identifying constellations during those first observing nights. After the observing site is determined and cardinal directions are identified, the hunt for the first constellation can begin. A set time of night to find constellations for the first time is helpful



since the apparent sky movement is quite fast. For this lesson, we will presume an observation time around 10 pm local time during the middle of a month. At that time, the observer can face toward the equator (north or south, depending on which hemisphere the observer is in). He should look up at an elevation or altitude that is 90 degrees minus the number of his home latitude. This will put his sight in a general section of the sky that is roughly near the celestial equator and not far from the ecliptic. The brightest stars in the area will form a pattern, which the observer can try to match with a constellation pattern. The figure to the left shows the constellations that are prominent for each month along the ecliptic about 10 pm from November (Aries, top left) to October (Pisces, bottom right).

If an observer is at mid latitudes (north or south) or further away from the equator, there are key constellations that are readily identifiable near the polar axis areas. In the N, find Cassiopeia or the Big Dipper as discussed in the last section. In the S, find the Southern Cross (or the Crux).

Note for teachers: If there is time in a class, the following exercise can be done to familiarize children with some of the major constellations. Using a constellation chart, a set of cards with pictures for each Zodiac constellation can be constructed. Three sizes of nails, which correspond to the magnitude of the stars, can be used to puncture holes that correspond to each major star in the constellation. The card can be mounted on top of a box. The back side of the box can have a hole through which a light is mounted. (A shoe box is just the correct size to use for this project.) If a partially darkened room is used, the light will shine through the punctured holes and show the shapes of the constellation's major stars. Information can be added to each card that identifies the constellation name and names of some of the prominent stars, which can be found in most reference material that discusses prominent constellations.

STAR HOPPING

All that remains in this lesson is for the observer to learn how to use angular measurements and lines extended among stars to hop from a known star to another location. The hand and finger signals learned in lesson four will be used to cover the angles. This kind of celestial excursion (trip) is called star hopping. After a little practice star hopping will be both interesting and fun.

For the observer's journey he will be traveling light and has studied ahead of time. His luggage will consist of only a list of the brightest stars and some major constellations. Here is the list of the 20 brightest stars:

Our sun*	Arcturus	Procyon	Betelgeuse	Spica
Sirius	Vega	Achernar	Aldebaran	Pollux
Canopus	Capella	B. Centauri	A. Crucis	Fomalhaut
A. Centauri	Rigel	Altair	Antares	Deneb

**The sun is not part of a constellation as viewed from earth, but it is certainly the brightest star in the sky that we can see. Remember: do not look at the sun with your eyes or through optics that do not have special filters for sun observation.*

It will be difficult for the observer to fathom the immensity of the distance between these large glowing stars, because he will remain here on our planet for all of his travels and measure by angle rather than distance. Traveling from star to star by angular measurement and lines extended from major stars, the observer can become aware of the constellation he is in, and where it is in relationship to all other constellations surrounding it. After observing becomes more regular, the pathways and angular distances among them become familiar. The observer will soon be capable of forming different pathways to every constellation in the heavenly community. Many of the same constellations were used to help direct travels several centuries ago. The list of many major constellations was first written down in 2400 to 2500 years ago. The first list contained 48 constellations; a list of 88 constellations remains part of the standard list today. Today's students may amuse themselves by making up their own list. This can be done by going out at night and looking at the sky. You can find a pattern of stars in the sky, picture an object in the pattern, and name it yourself. As an observer keeps records of observations through the year, he can see how his "new" constellation appears through the night or through the seasons when it is observable.

Armed with the concepts we have discussed, a list of prominent stars, identification of the constellation around the ecliptic for the early evening of each month, and an observing area with cardinal points determined, the new observer is ready to try some practice star hopping with an inside/classroom exercise.

Class exercise #1 Teacher Instruction

Make about 6 small circles of yellow or white material that are about 6-12 cm in diameter. Of the 6 that are made, a few should be made a little smaller or a little larger. Using a marker, number them in large numerals or the students can make up names for the stars. (The stars can be kept for future exercises.)

Select a large classroom wall or on an outside wall of a building. Tape or tack the circles in a random pattern over an area at least 6m wide and 2-3m high. Make sure that at least two of the circles are no more than 0.5m apart. Make 3 in an approximate line but not the same distance apart. Some should be high but some should be low or in the middle.

Locate a place where the students as far away as possible in the same room, from which they will measure star “distances” (angles between them using arms and hands, as taught in Lesson 4). They will observe imaginary lines among stars. From where they will do these measurements, the teacher can mark a compass rose with a pieces of tape or thin strip of material or chalk. (The kit provided to some groups includes the materials for a compass rose.) Make S directly ahead in a direction toward the center of the opposite wall where the “stars” have been placed. A cross line for E and W can be put can be put down and marked properly. (Remember that N in this case is in back of where people will stand at the center of the compass rose, so be sure that E and W is on the correct side.)

Explain the scenario as follows: it is night time (darken the room a little bit if you can), they are pretending to be facing S outside and looking at the stars. They see six stars that form a pattern (the stars you put up). Instruct them to measure the angular “distances” among the stars. You should specify several “distances” to measure (such as: angle between #1 and #6, #2 and #3, etc.). The pairs you assign should vary from very small to very large distances. You can specify whether they should use fingers, fists, or open hand measurements.

Have the students take turns standing at the center of the compass rose. If this is done in small teams, they can select a team member to do the measuring while the others record and check the measurements.

When they are all done, they can compare or check their answers with yours.

Now do the exercise again, but this time have them find pathways among the stars that might be almost in a line, so that two stars with a line extended almost run into a 3rd star. Have each student or team locate some pathways and specify them. For instance, a line between #1 and #3 may extend in a straight line or a slight curve and run into #6. This would be a pathway. You can change the star positions to cause them to find and select pathways.

Class Exercise #2 Teacher Instructions

Using the same or similar array of stars from exercise #1, have the students note the angular distances for 3 stars that are wide apart. Have them use the compass rose to note the direction of each of the stars. Have the students note the general direction they have to go in order to travel from the center-most star to the star on either side (E or W) and how far that distance is in terms of angles (using hand/arm motions to measure the angles).

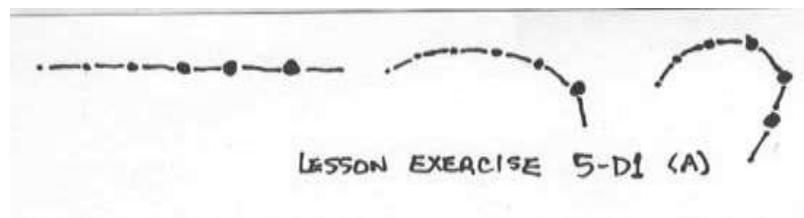
EXERCISES

5-D1 EXERCISE: STAR PATTERNS AND MAGNITUDES

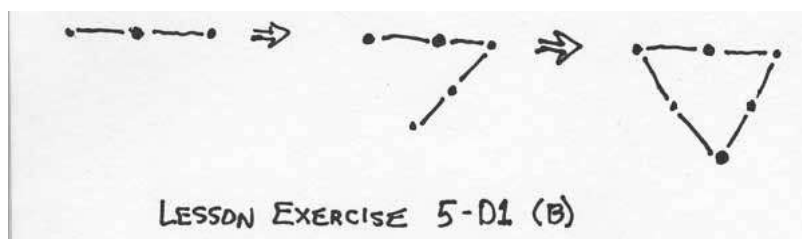
Recognizing star patterns and magnitudes is a developed skill but is fundamental for beginning to observe stars. The exercise can be divided into two or more sessions and done by one person or a whole class together. It is designed to help students observe stars with some accuracy and includes an introduction to recording what is seen. While many observers have never had geometry or may have forgotten it, the exercise also includes learning a simple method that teaches aspects of common shapes and geometry without having had any mathematics classes that teach these basics. It teaches a simple way to recognize star patterns and magnitudes.

The first step is to find six small stones. They do not need to be the same size. Then find six sticks or plant stems that are about the same length (about as long as your longest finger). We will pretend that the stones are stars and the sticks are the imaginary lines between them. Do the following exercises:

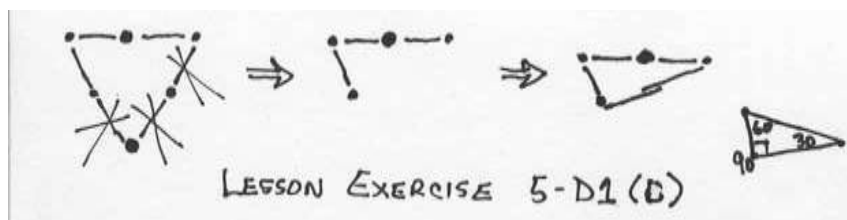
Line the stones (representing stars) in a line from largest to smallest with sticks between the stones. Make the line of stones and sticks as straight as you can (left figure below). Now take the same line and make it curve a little bit (center figure below). Remove the sticks to see how the stone pattern looks then replace the sticks. Then take the curved line and make it curve a lot (right figure below). Again, remove the sticks so you can see what the stars look like without the connecting lines. Any of these shapes can be found in the sky. Lines of stars can be found in many places. Sometimes they are not the same distance apart, lines may be slightly or greatly curved, and, of course, some stars will be much brighter than others within the pattern. You are training your eyes to connect lines between stars by recognizing them in various kinds of lines.



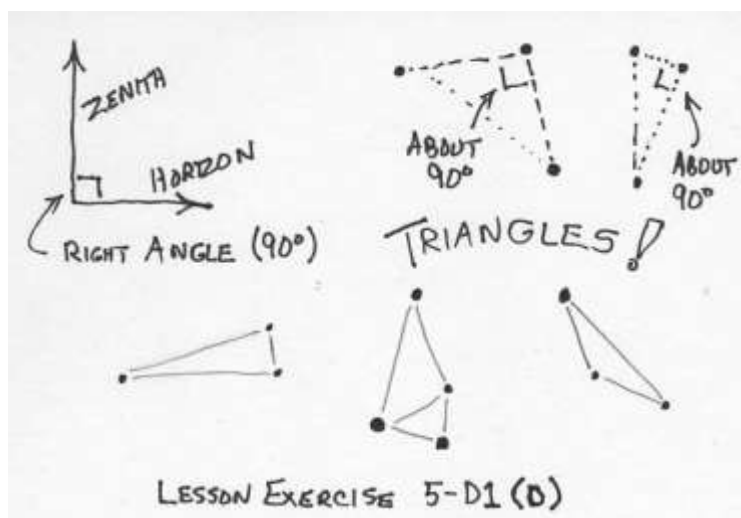
Put 3 stones in a line and connect them with two sticks. Make a second line of two stones that connects to the first line at the stone at one of its ends. Put the last stones and sticks so they connect the ends of the two lines. Make all lines as straight as you can. You have formed an equilateral triangle or a triangle with sides that have the same length. (See the figure below.) In the night sky, observers will often look for this kind of triangle to help place stars on a sketch. Of course, there are many other types of triangles that can be seen if we connect imaginary lines between stars.



Now take away one side and half of another side. Put two sticks together to make a line and close the open part of the figure (the next figure shows the steps). This is a famous triangle called a right 30-60-90 triangle, because the angles are 30 degrees, 60 degrees, and 90 degrees.

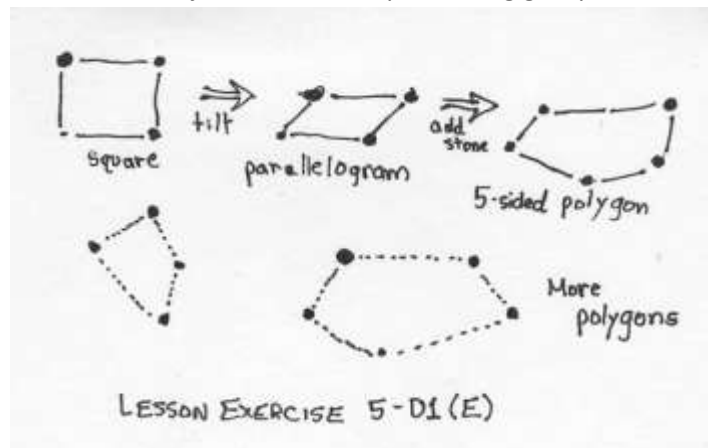


The 90 degree angle is known as a right angle. It is the same angle that represents the difference between zenith and horizon. Right angles between groups of stars are common ways for observers to identify star positions. See the figure below for an illustration of triangles with 90 degree angles and several without right angles.



Star patterns that form imaginary triangles are very common to identify and the imaginary shapes help us to see stars in their correct position if we draw them. The triangle shapes can vary greatly. To illustrate this, take 3 stones and drop them on the ground. They will form a triangle. Put sticks between them as best you can. Now take the other three stones and arrange them the same way. Try this several times. The triangles you make each time (and then arrange the same way with the other three stones) will be different each time. But you are learning to recognize patterns of stars by seeing the triangle shapes that they form, and how different they might look when you see them in the night sky.

Now take 4 stones and 4 sticks and try to make a square. Put the sticks between the stones to help you see the square. Then “tilt” the square to make a parallelogram. Last, stretch out one or two sides of the figure and add another stone to make a 5-sided figure, which is five-sided figure. Many-sided figures can also be readily seen among stars. The figure below shows a few examples, but the possibilities are endless. The object is to see shapes among groups of stars, then duplicate them with the rocks.

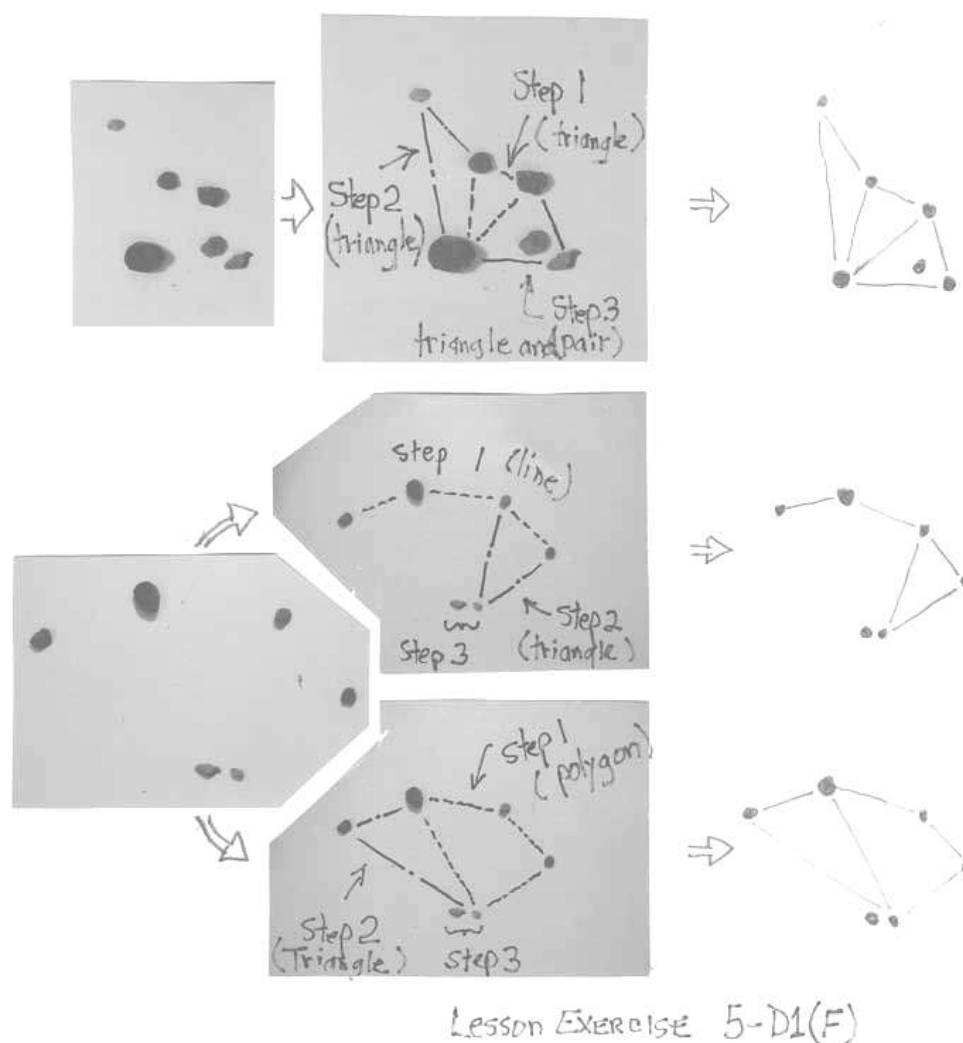


Eventually, you put the pattern on a piece of paper. When you look up at the night sky and see stars, an observer can easily pretend there are lines between 3, 4 or even more stars. They will make figures like those we have done. Stars also have magnitude, so the star groups can also be represented by the amount of brightness each star has. The 6 stones you have collected are not the same size, so pretend the brightest star of a group of six stars is the biggest stone and the smallest stones represent the faintest star. At night you could take any group of six stars and try to represent the same group with the six stones and sticks. It will not be exact but it will give you practice in identifying both star patterns and star magnitude. The sticks can be used to help you see the shapes of the star groups as you represent them with stones. The next figure (on the next page) shows two groups of six stones that are dropped on a white board. At the center are the same groups but shown with lines added. A right column shows you a pencil sketch of the same pattern. One group is shown twice because there are many ways to see the shapes in a group of objects.

You can do the same exercise. In the end, a person can get very accurate by learning to quickly repeat a group of objects that are seen. The objective is always the same: draw the shapes that help you see the objects in their pattern so you can repeat that pattern with the right spacing and the right magnitude. Note: the sticks were selected to be about the same length for convenience and as a simple aid to see the line between two objects—like an imaginary line between two stars in the night sky but the distance between objects may vary a lot.

When you are looking at actual stars, you can go through the same process: see the shapes and magnitudes of a group of stars, decide an order to draw the stars by deciding for yourself which shapes are the best for you to do first, and arrange the set of stones to show the same pattern and relative brightness or magnitude. Or, you can go ahead and sketch the star pattern on a piece of paper using the same techniques.

At night you can take any group of stones and a few sticks to make patterns on the ground that you see in the sky. The nice thing about stones and sticks is that you do not need to erase and start over. Instead, as you look at a pattern of stars, keep adjusting the stones and sticks to get as close the patterns and relative brightness (magnitudes) of the stars you are observing. The practice will improve your ability to sketch patterns of stars with paper and pencil.



5-N1 EXERCISE: CARDINAL DIRECTIONS (north, south, east, west)

From your observing position, recall where the sun rose and set at the east and west horizons, respectively. With a line drawn between them and facing south (east will be on your left), then identify an area of the sky about 3 hand-widths above the horizon (about 60 degrees above horizon). Choose a bright star in this region and identify the brightest 10 stars within one hand-width of the star. (As your hand goes around the star, your outermost finger will scribe a circle that is two hand-widths in diameter or about 40 degrees). Mark them on a piece of paper with their relative positions as close as you can get them. The bottom of the paper will represent horizon. Do the same thing facing north. You have now identified the major star patterns for the north and south directions for this time of year and time of

day. Your teacher can use a planisphere to verify the star patterns for the brightest stars that would have appeared in the night sky for the date and time that the exercise was done.

5-N2 EXERCISE: STAR POSITION AND COLOR EXPERIMENT

This exercise takes at least two people.

When fully dark adapted, find at least two major stars that are red/orange or yellow. On a piece of paper, put each of these stars in the center of a circle and put lighter dots around them that represent the stars you can see with your eyes within a 10 degree radius (one fist held up at arm's length and rotated around the chosen star). Each student can do this then they can compare their diagrams. Discuss the relative magnitude and the color of the brightest 3 stars. Count the number of stars that were placed on each diagram. Be sure your name, class, the instrument used to observe (eyes or binocular or telescope), and the sky conditions are noted on each sheet. If one student or the other seems to have missing stars, then help each other try to identify those stars. Be patient, because each person's eyes see a little differently and the level of dark adaptation may be slightly different between the two students. The exercise can be done alone, but color detection in stars and finding faint stars is a little easier when two people are working the exercise.

AOBV Lesson 6: Sketching to Record Observations

Materials: paper and pencil

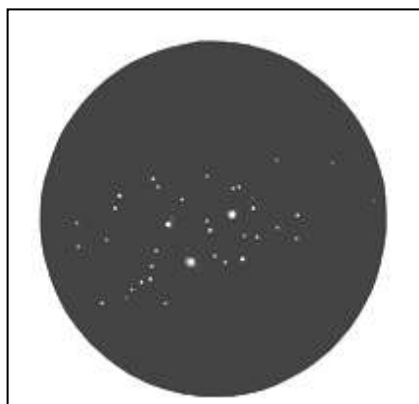
Reference: Amos 5:8

Sky Object: M45

REFERENCE SCRIPTURE

Amos is in the Old Testament section of the Bible. Amos was a working man but also chosen by God to be a prophet to the Jews of his day in Israel. In the middle of the book and during one of the recorded messages, as God calls Israel to seek him but also provides a statement about himself in terms of the heavens. In essence God explains in verse 8 that he is the same one who made the Pleiades and Orion – two magnificent and well-known star groupings. Each one is mentioned twice in the Bible—an indicator of their well-known placement in the heavens, their beauty, God’s authorship of their creation, and His sustaining hand to keep them. The Pleiades is a beautiful open cluster. Orion is a well known constellation that contains the famous Orion Nebula, which is visible by naked eye and one of the best known sky objects that nearly everyone on earth can see. With his creation of these objects in view, which draw attention to his power ability to create and sustain things, he admonishes Israel to seek him to have life.

SKY OBJECT: M45 (THE PLEIADES)



The Pleiades (also called M45) is classified as an open cluster or grouping of bright stars. This is in contrast to a globular cluster, which is much denser and whose member stars are gravitationally related. Open clusters are found all over the sky, but M45 is one of the most famous. The sketch of M45 on the left [used with permission] was developed in about 40 minutes by Frank McCabe in Oak Forest, Illinois in late November 2010. He is a fellow observer who also records his observing with sketches. He used a 4.5 inch Dobsonian telescope at 22-power for his observation and a graphite pencil on white copy paper to develop the sketch. Note the differences the size of the stars, which indicates apparent magnitude to the observer.

Six or seven of the stars can be seen by eyes alone; more stars can be seen with binoculars. It is a very beautiful and popular cluster to observe. Since the Pleiades can be seen by most people in the world, it is well known. God’s mentions the cluster twice in the Bible. The object can be studied at different magnifications and fields of view with equal enjoyment. With low magnification or binoculars it appears to be a small group of crystal white jewels. At high magnification on larger telescopes, individual stars have their own character and some nebulosity (like a faint cloud) can be seen in larger scopes.

SKETCHING TO RECORD OBSERVATIONS

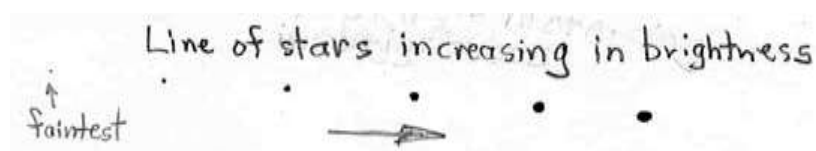
Many famous explorers made notes and sketches of observations. The records have since become important documents, because they provided a written record that was more reliable than a spoken word. While photographs and video are now more common, sketching and notes are still taken by professionals in many fields. Even when computers are available, note and sketch pads are often handy because they provide a manner to make quick notes and sketches of ideas, concepts, and images. When modern digital methods are not available, then sketching and notes remain the primary means of recording observations. Field conditions in many jobs and environments often demand notes and sketching skills.

Observing the heavens requires studying complex objects. Optical instruments make the object clearer but the instruments require the coordinated use of eyes and hands together in an environment with almost no light. A very dim light or a red light is used to provide just enough light to see a star chart. Sketching an object is done at the same time and in the same environment. When sketching is accomplished as a parallel activity with observing, the characteristics of objects become more obvious since sketching demands repeated looks. Imagine seeing an object for the first time through binoculars. Most observers see an object with the first look, but what is remembered is very limited. But as a person looks at the object several times and then commits details to memory to place on a sketch, the process re-enforces what is discovered and expands what is seen. Objects have complexity that becomes more apparent as the sketch develops during an observing session. With this process in view, some basic sketching skills are needed.

Three skills are most common for sketching sky objects: making points, outlining, and shading. Making points of various sizes is used to mark stars according to position and magnitude, outlining is used to mark basic shapes of sky objects—typically planets and the moon, and shading is used to show lightness or darkness or transitions in nebula, galaxies, star fields, and lunar/planetary features. Pencils, pastels, pens, and sometimes paints are used for sketching but the same skills are involved. We will confine our exercises with pencils—they are the most commonly used medium and the one we will use for this course.

SKETCHING STARS

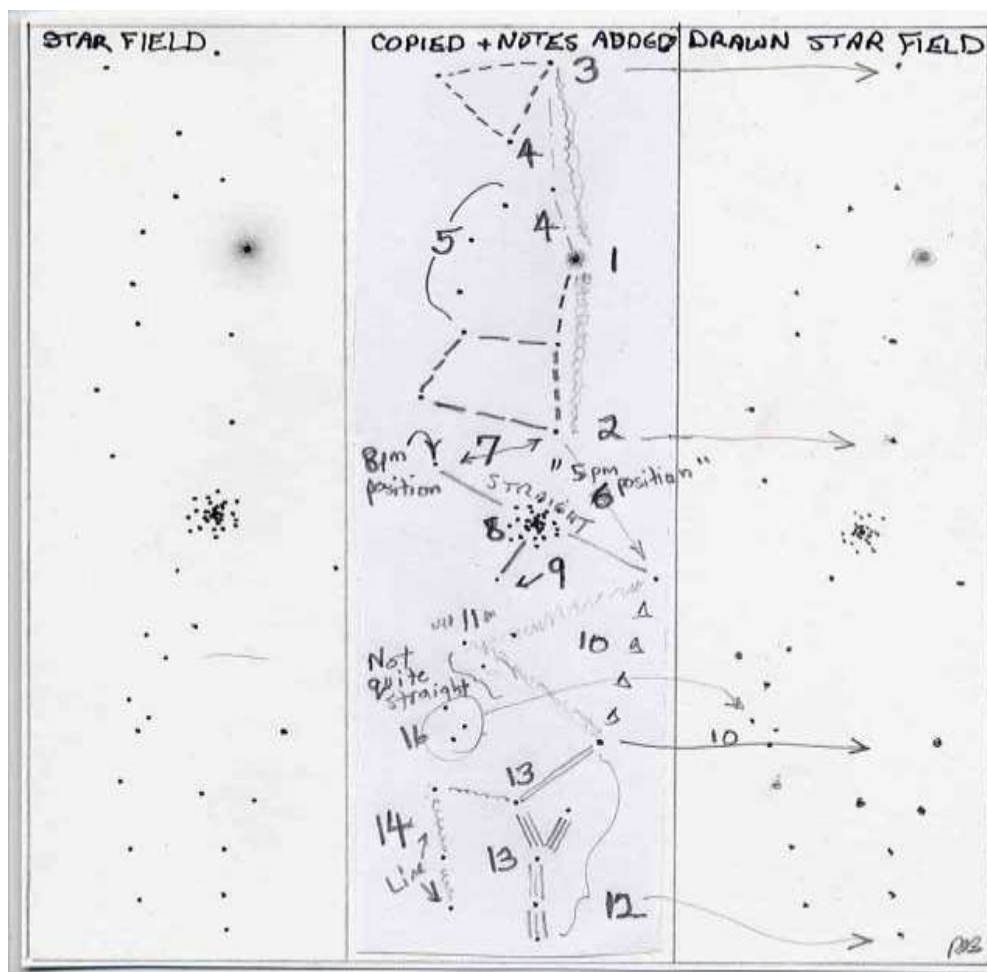
It may seem like a simple thing to make point on a piece of paper but a practiced technique will make things much better. First, the pencil needs to have a rounded point (not extremely sharp). Using a scrap piece of paper or a rough hard surface, a pencil can be sharpened and the point rounded if a small hand sharpener is not available. Draw a star by holding the pencil vertically and applying a little pressure on the paper as the pencil is rotated. If the star is bright, apply a little more pressure and rotate the pencil more. If the star is faint, then only a little pressure is needed. Try making a line of stars from faint to bright using this technique by duplicating the line of sketched stars below:



IDENTIFYING AND SKETCHING STAR PATTERNS

Recognizing star patterns by imaginary lines and shapes is fun but also a necessary skill for drawing many sky objects. Positioning key stars correctly helps a sketcher present an accurate picture of both the star field and the intended object in the sketch. Even identifying crater locations on the moon and planet features involves similar skills where imaginary lines among features make shapes. An exercise for Lesson 5 included using 6 sticks and 6 small stones to represent shapes of star patterns. If you have not done this exercise, it is recommended as a way of quickly developing an eye to see shapes in star patterns, which helps a student position stars correctly. The exercises that follow serve the same function but incorporate a pencil/paper technique rather than using sticks and stones.

An exercise is illustrated below where dots represent stars. The left column shows an imaginary star pattern; the second column shows some examples of imaginary lines or shapes to help identify star position with example steps (numbered). Then the observer draws the star field (shown in the right column). You can repeat the same exercises on your own paper. Remember to represent bigger stars (brighter stars) by making slightly larger marks. There is no perfect or single way to lay out a given star field on paper but identifying star positions by shapes and lines makes the process faster and more accurate.



Remember that it takes practice to look at a star field and see how stars are situated. It does not take long, however, before you will see certain stars in a line, or a triangle, or any other shape. As you see the shapes—as if lines had been put between them—it will help you master the technique of drawing the star field on paper. It is best to start the process with the brightest stars that are farthest apart.

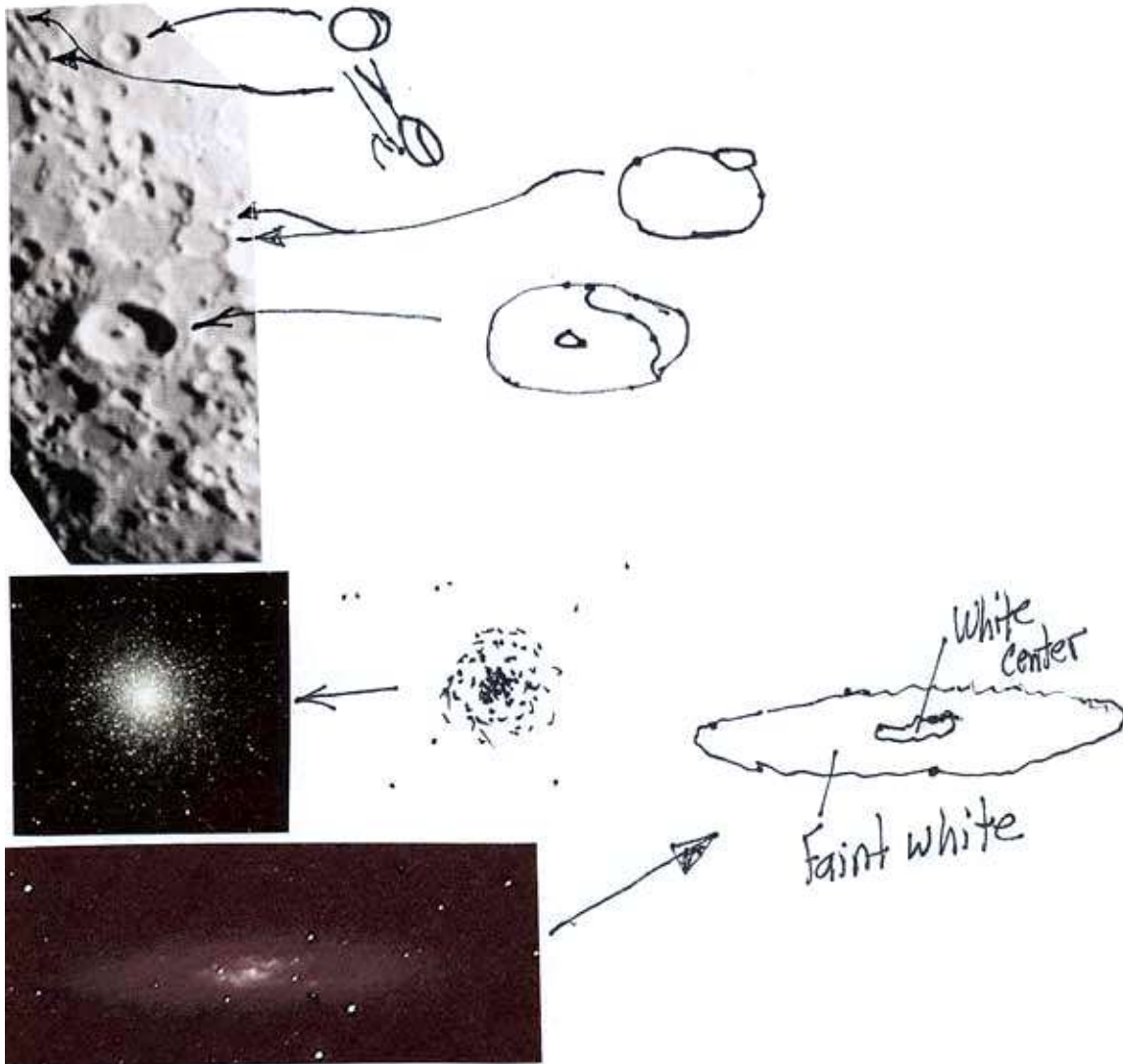
Note 1: the method of observing makes a large difference in the field of stars that can be included on a sketch. For beginners, using your eyes (not binoculars or a telescope) is recommended for sketching observations of star patterns at first. By choosing a particular part of the sky and then the brightest stars within that section, a new observer can begin to practice with sticks and stones or paper and pencil to identify and record star patterns, which will usually be the more obvious constellations (see note 2, below). A sketch of major stars in the night sky can easily include 30-40 degrees of sky area. If looking near the horizon, the observer can also record the outline of the horizon and any other sky interference. If a binocular is used, the field of view is a circle with a smaller field of view. Nevertheless, the stars within that circle can be identified in location using the same methods: seeing shapes or lines among major stars. The field of view of a binocular is typically about 5 degrees, and more stars will be apparent compared to observing with eyes alone. When a telescope is used the field of view drops to less than one degree of sky area. Of course, much fainter stars can be seen. Recording their positions uses the same methods.

Note 2: There are daytime exercises listed at the end of lesson 5. If they have not been done, it is recommended that students do those exercises before attempting a sketch of a large star field. Furthermore, these exercises are designed to be practice so the student will more quickly identify shapes among small groups of stars and be able to put those shapes with the proper star magnitudes (in relative terms) on a piece of paper.

SKETCHING OUTLINES

Faint outlines with pencil are used to outline lunar features, planets and their moons, or areas of faint white (nebulousity) in the Milky Way, galaxies, and star clusters. Drawing outlines are done at the beginning of a sketch process to help orient the sketch properly. An outline is a first step to shading or darkening an area later. Some people think they cannot make outlines, but simple practice steps make a big difference. Take simple objects (a cup, a pencil, or a bench) and outline its edges. You will find that a little practice helps the eyes see the correct shape so that it is translated to the paper with more accuracy. If you think about it, this is how most children begin drawing—they make outlines of something they see. In the case of observing a deep sky object, planet, or the moon, making outlines becomes an essential first step, so a little practice at seeing something then drawing its general shape in outline form is valuable.

Some examples of sky objects are on the next page with simple outlines placed to the right. Try the same examples on your own sheet of paper.



Top cropped photograph of lunar terrain: used with permission, Dave Mitsky

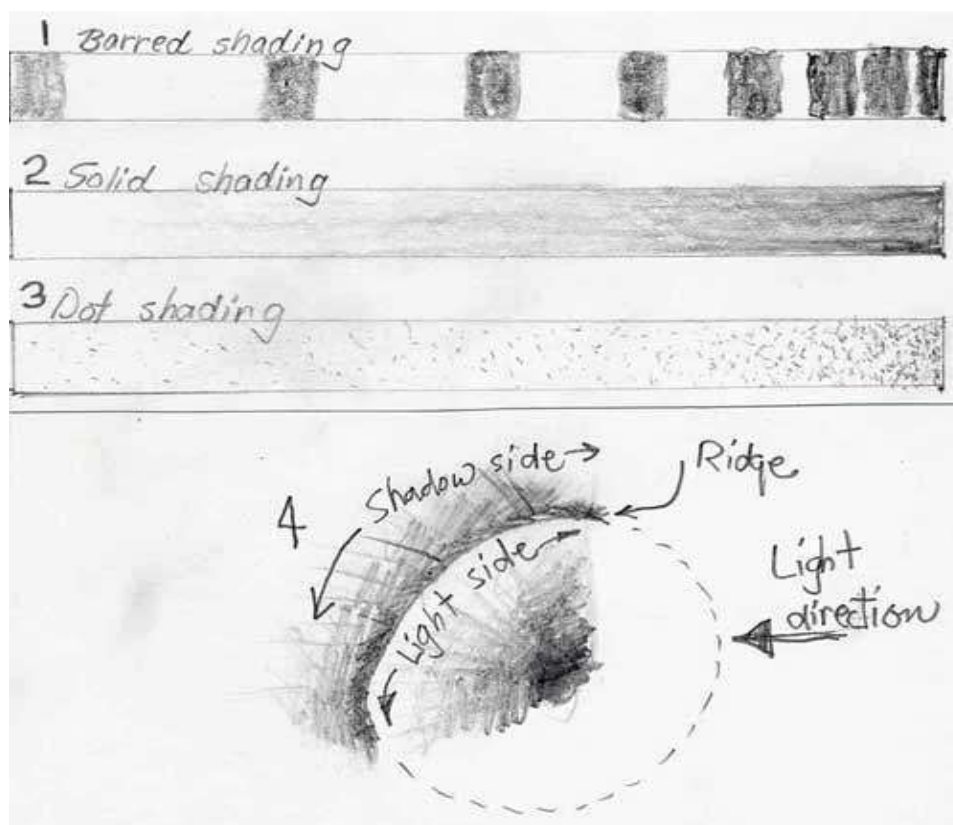
Center cropped photograph of M13: used with permission, Gus Smedstad

Bottom cropped photograph of NGC 253: used with permission, Gavin Bray

SHADING IN SKETCHES

Shading is the way a sketch shows light and dark regions as well as the transitions between them. It is usually the sketching technique applied after outlining an object is done. It is done with the side of a pencil or a pencil with a well-rounded point. This part of sketching takes a little more practice, but it is very rewarding and fun because it causes the sketch to have depth—giving it the appearance of being three-dimensional. Shading can also be done with bars, cross-hatched lines, solid but varying the amount of lead, or dots, where thicker or more dots cause a darker appearance. Three long rectangles are shown below that illustrate the technique. A 4th example shows a part of a circle where the outer

side is dark on one side but gets lighter going away from the center; the inside is dark in the center but goes to light near the circle outline. Try these techniques on your own paper.



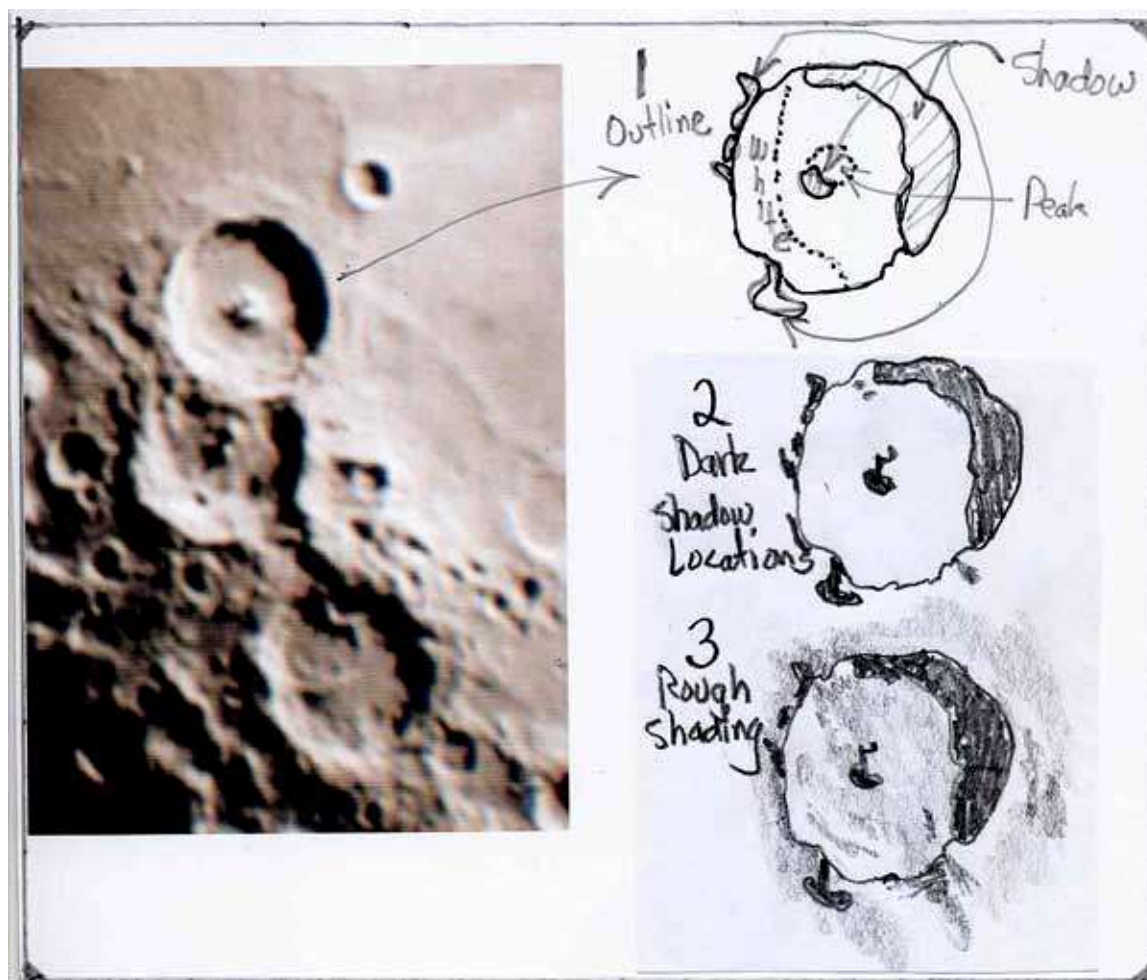
You will notice in the bottom part of the illustration shows a partial sketch of a crater that has a mountain peak in its center. In this case the light is coming from the right. While the central mountain peak is not specifically shown, it casts a shadow, which is shown.

As students examine moon craters, they will learn that craters are very different—some have central peaks but some do not. Some crater walls have even edges but some at the edges are jagged. In addition, craters near the edge of the moon appear to be elliptical because the moon's surface is angled away from our view point. Whatever the shape and appearance is observed, the observer can follow the same steps as used above to develop a sketch: outline the crater, identify the dark areas, identify the light areas, and use any of the shading techniques to provide the transitions from light to dark or dark to light.

COMBINING OUTLINING AND SHADING

The example that follows illustrates the combined techniques of outlining and shading for a lunar crater. First the crater is outlined, then the dark shadow is filled in, then the shading is done. Try the same series of steps on your own paper. Sometimes it helps to remember that darker areas are lower, the brightest areas are higher, and the direction of the sunlight causes a bright area to be marked by a

shadow area behind it. As you think about the scene and the direction of light, it helps as you interpret the features as you draw the same features on your paper.



Used by permission; Original photograph by Dave Mitsky; Sketch development by Roland Beard

As you can see from the original photograph, there are several craters that could be sketched. Each one has unique features. For lower magnification views, the sketch might include general boundaries of the one of the seas, or a pattern of craters but each having less detail than the example above. The same procedures apply: find the area of interest, outline the light and dark areas, draw in the dark areas, and begin to shade the grey tones. Always note here the light is coming from, where the high/low terrain appears, and practice putting what you see on paper.

BLENDING OR SMOOTHING

The last technique to introduce and practice is called blending or smoothing. Pencil marks can often be seen in sketches when shading is used, so rubbing a finger over the area or rubbing with cotton swab or a blending stump can smooth or blend the shading to make it appear more real. Blending can also take sharp edges in a sketch and make them blurred a little bit—just like they appear in a telescope. If you get too much dark area on a sketch, you can also lighten by lightly using an eraser, which is blending by

removing some of the darkness rather than smoothing it out. Two examples with notes are below. You can try the same technique yourself on your paper.



PRACTICE GUIDANCE AND SUGGESTIONS

Sketching objects can be done by anyone. Famous sketching examples of people with severe physical or mental handicaps are adequate proof that drawing objects is not just for practiced and professional artists. Children naturally want to draw—just as easily in sand or dirt as with paper and pencil. It is more an issue of practicing without fear. Sketching practice presumes only one thing: observing or seeing what you are sketching. Seeing is done two ways. A person sees an object but also remembers what was seen. Remembering what is seen is then translated to the paper with a pencil. If the process is practiced, sketching becomes faster and more accurate, so a student should not be dismayed that initial sketches do not seem right. After a little sketching, sketches show better shaping, more detail and increasing accuracy.

Practice with simple objects: a tree trunk, rock, or leaf. Observe the direction the sun is shining on the object then note the places on the object that are lighter or darker from the sunlight. Using the outline techniques, draw outlines of lighter or darker areas. Label what is lighter or darker. Then examine the object again and note where lighter or darker areas change, which can be represented by shading.

The moon can often be seen in the morning or late afternoon at certain times during lunar cycle. Look for it and try to sketch what you see by drawing part of a circle, then outlining the edge of the terminator (the light-dark boundary in the interior part of the circle), then identifying and drawing lines of lighter and darker areas. If a tree or bush or hill is in the same scene in the foreground where you are observing, put it in the sketch. One caution is given: do not sketch what is not seen or is not real. There is a place for art and imagination, but the techniques being taught in this course are for accurate observation of a scene. Students are, therefore, encouraged to be accurate: record what is seen.

Star patterns emerge shortly after sunset or can be seen shortly before sunrise. If you cannot sketch in the night, then try one of these times to see star patterns and sketch them. If you do not have sketching paper or a pencil, sketching practice can still be done. Use stones and sticks to represent star patterns

on the ground. As you stand, you can look over your representation and then look skyward at the stars to see how closely you have represented the pattern. This method of learning is under-utilized but very effective. We encourage students to use it.

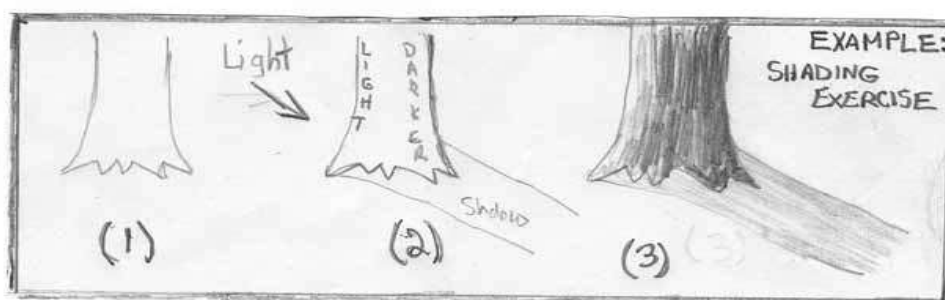
Do not be afraid to try different medium. Light/dark soils, juices from squashed berries or fruit, different shades of tree bark, small pebbles with different colors, mud, and many other things have been used for sketching or painting or even sculpting lunar terrain. Chalk or chalky rocks are also used for sketching on smooth and rough surfaces. In developing nations, small pieces of locally manufactured charcoal for cooking can also be used in place of pencils. When paper is not available, then sketch on a smooth piece of wood, painted metal, bark, cloth, or cardboard. In the end, the idea is to practice with whatever is available so that the eye, mind, and hands get practice and training recording what is seen in the sky.

In closing for this lesson, remember that God's created heavens are simply beautiful. Planetary objects or star patterns or sky objects have unique appearances that can be represented with many different medium to show texture, shades of grey, colors, patterns, and even relief. Part of discovering the detail of the heavens and their resident splendor is the process of developing a sketch to record what is seen. Practice rapidly develops the abilities of an observer to record observations and conversely improves observing skills. Enjoy the process of discovery.

EXERCISES

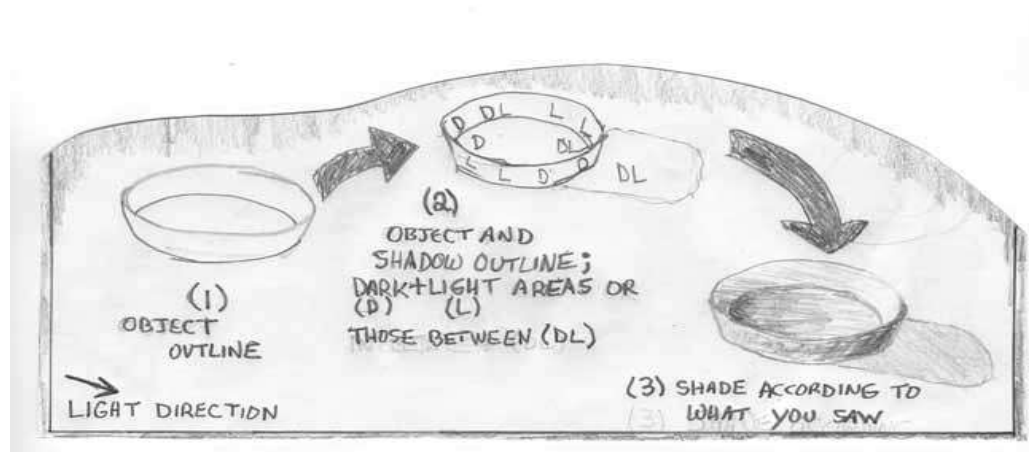
6-D1 EXERCISE: SHADING EXERCISE

In the morning or late afternoon when the sun is low in the sky, observe a small simple object like a tree trunk, post, or ball. It should be in the sun. Outline the object then study the dark and light areas to see how they change from dark to light or light to dark. Draw a simple outline of the object and shade the object by bars, dots, or solid shading. It is not hard to do this if you take your time and think about the steps to take: make a simple outline of the object, outline the lightest areas, outline the darkest areas, start to fill the dark areas, leave the lightest regions with no marks, lightly fill the areas that are between light and dark, shade by adding a little more or erasing a little bit or smearing with your finger to smooth the areas that change gradually. See the example below.



6-D2 EXERCISE: OUTLINE EXERCISE

In the late afternoon or early morning, find a tire rim or tire or kitchen pot/pan or dog dish. The shape is somewhat similar to a crater on the moon, so the exercise actually helps a person visualize a crater from an angle, which is a common way to see one through a telescope. Move the kitchen pot or pan or dog dish away from you about 5 steps. Make sure it is in the sun. It helps if the sun is low so one side of the object is lighted while the other side is in shade. Outline the object on a piece of paper, label the light and dark areas, and shade the sketch of the object. See the example below.



6-N1 EXERCISE: LOCATE AND SKETCH A CONSTELLATION

Your teacher will tell you about a prominent constellation that is observable in the current season. It will be noted by its brightest stars and the pattern they form if lines were drawn between them. Identify the constellation in the sky, draw the star pattern on a piece of paper, mark at least two cardinal directions on the piece of paper, measure the approximate angles between the key stars and label those angles on your sketch. If there are broken clouds, you may have to wait a little bit to see the stars appear in the clear parts of the sky. If the clouds are not moving, you can draw their shape and place them on your paper in the location they appear. Take your drawing to the next class. Remember to label your drawing with the time, date, your name and class.

6-N2 EXERCISE: FIRST SKETCH OF THE MOON

Your first sketch of the moon will be done using your eyes alone and recording what you see with a pencil and paper. (1) Mark your name, class, approximate time, date, and approximate sky conditions (how much cloud cover, cloud density, and how clear the moon appears). (2) Lightly trace a circle with a cup or can or something similar. (3) Watch the moon. Observe light and dark areas. Observe how much of the moon can be seen (its phase). (4) Sketch the moon on the piece of paper by outlining the part that can be seen. Go back to watching the moon as many times as you need to correct your outline. (5) Outline the darker areas within the moon surface that can be seen. (6) Add as much detail as you can see. If some areas appear a little darker or lighter, show this on your sketch. If the moon is near the horizon, outline the earth or other objects on your sketch. If you have a bible, pencil in a scripture at the bottom of the sketch that pertains to the moon. Make a comment on your drawing sheet if you wish. Bring your sketch to the next class.

AOBV Lesson 7: Astronomical Tools to Help the Eyes—Part I

Materials: Planisphere, small star atlas, binocular

Reference: Proverbs 3:19, 8:27

Sky Object: M13 or M22

THE BIBLE AND THE REFERENCE SCRIPTURE

In Proverbs, these two verses state some amazing truths:

3:19 “The Lord, by wisdom founded the earth; by understanding He established the heavens.”

8:27a “When He established the heavens, I was there...”

These scriptures from Proverbs are compelling descriptions of God’s brilliance. There is no room for doubt about the great wisdom it took to create the heavens. The presented evidence of the night skies is hard to ignore. The glory of the heavens demonstrates the great wisdom of our God in several ways. The sheer immensity found in the heavens, alone, is all that is needed to illustrate His ingenious hand is far greater than the abilities of the wisest human beings that have lived on the face of His earth. The pre-meditated placement of the stars and deep sky objects makes them observable, although study is difficult since the distances are too great, the objects too varied, and the processes that sustain them too hidden. The precise position and motion of our planet in relation to the sun permit regular opportunities to see the celestial sphere from a privileged location. His founding of earth—a key mark of His wisdom—is in stark contrast to the violent unlivable conditions in neighboring planets. Potential threats to earth are distant—ensuring our safe ability to continue to observe God’s wisdom displayed in the heavens.

One definition for wisdom is usually ‘having possession of a large amount of knowledge’. This definition serves to point out how many things God needed to know to create the universe and all it contains. Imagine the facts needed to complete such a project. None of the inhabitants of earth possesses that number of facts. The best computers with pooled memories could accumulate very little of the information that would be needed to define our local stellar neighborhood, much less the universe. Proverbs 3:19 takes it a step farther. It says in so many words that establishment of the heavens took nothing less than God’s tremendous understanding. The difference between wisdom and understanding is the difference between ownership of facts or information and applying those facts or information to do something. In other words, management of information and knowledge to construct something would be “understanding”. So having information about the universe and making it happen is a gap far too wide for our minds to bridge but the gap does not exist for God. His wisdom and understanding created and sustain the universe.

While we cannot understand creation, except in a very limited way, but we can discover some of the results by what we can see, study, and measure. The largest limitation is that we are created and placed within the confines of something far larger and more extensive than we can perceive. We observe a tiny

bit of the local neighborhood—a few planets, the sun, and parts of our galaxy. The local solar system and our privileged planet function correctly and repeatedly—permitting life as we know it. Some of the laws of the universe have been understood from our vantage point, but as distances increase, our knowledge, which is already limited, becomes very small very fast. As distance increases from earth, our confidence in accurate measurements drops and our assumptions about what is beyond our reach increase dramatically.

Without God considered as the Author and Sustainer of what we see, man has even more trouble learning or understanding the simplest of facts regarding the universe, because His core part in the matter is ignored. For the believer, however, it is like a treasure chest from God awaiting further discovery. We know from the Bible that He invites observation and investigation.

Proverbs 8:27a focuses on Jesus (God's son) being present when creation took place. To picture this, close your eyes and think of all the brilliant deep space objects pictured in books or those presented in Lesson 2. Pretend they were not there. An instant later they are present—created and sustained. Jesus, the personification of wisdom that is also mentioned in John 1:3, is speaking. He states that He was present when creation took place. He saw what His Father did and He understood it. Creation is not a mystery to Jesus; it is not complicated to Him. The word “established” in this verse suggests something was started or set, successfully put in place, and given permanence. Another definition of “establish” that applies equally well is ‘a statement generally recognized as being true or proclaiming a valid point’. When the word ‘established’ is used, it means you can count on what is said. It becomes unquestionable. Jesus, Himself, gives us His Word that creation was an action performed by God. There are several similar Biblical statements in other parts of the scripture that echo the same sentiment. The last part of verse 28 speaks of God making the skies or clouds firm. The sense of the verse is similar to the statements on the heavens. To firm up an object requires strength and power. The water cycle, of which the clouds are a key part, is established, made firm, and given longevity as part of a process that He created on a planet He designed to be habitable.

The Bible does not explain the creation of the heavens in terms of a physical process that we see today. Rather, it is a creation process. Jesus brings the universe into being and ensures its firm continuation. Man sees what God did but he will neither fully know nor fully understand what has happened. While God does not require man to have His understanding, He asks us to believe in and follow Him who made the heavens. He also invites study and discovery of the heavens, as indicated by the last chapters of Job, where God expected Job to have looked and considered parts of creation. Part of our response is the choice we make: choosing to believe Him or not. Whether we do or do not, the heavens testify of His wisdom and understanding.

THE SKY OBJECT: M13 or M22

Globular star clusters are a class of objects that are close and densely packed groups of stars—they are created, designed and sustained as a group. Many can be found in the skies; M13 (shown below) and M22 are two of the largest. On a clear dark night, many of them can be seen with binoculars and will appear as a circular fuzzy patch. Some of the larger stars begin to be resolved with small telescopes.



M13 stands by itself in a star pattern called the square of Hercules, although not far away is a second globular that is also beautiful. M22 is much further south in Sagittarius, where there are many sky objects. M13 can be seen in the early evenings from May to August; M22 can be seen in the early evenings from July to October.

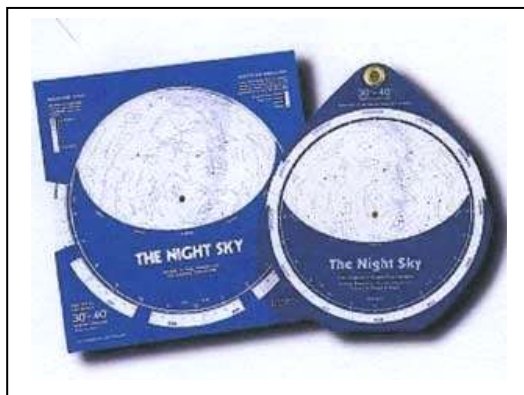
This sketch of M13 [used with permission] was provided by Brandon Doyle, who studied the object with a 10 inch reflecting telescope. His telescope field of view was large, so there is a second popular sky object that you can also see in his sketch that is a little bit left and lower than the center of the field.

Many globular clusters are easy to find for a new observer who has mastered the skills of using a planisphere and a small star atlas. Both of these tools, which are indispensable for observing the night sky for newcomers, will be taught in this lesson.

AN INTRODUCTION TO A PLANISPHERE

The planisphere can be tear-drop shaped, round, cased in a square covering, cardboard, or paper. Not all of them will look exactly like the one pictured in this lesson but the principles of operation are the same. Better versions are made of plastic or treated cardboard since they will resist moisture that often appears in the evenings as relative humidity rises.

Note: AOBV uses a Chandler planisphere, which we recommend because it is two-sided. This means the heavens are divided into two parts from an observer's point of view: the part he could see facing N and the part he could see facing S. The star patterns for this kind of planisphere have a little less distortion. However, all types work. Most of them are designed for specific ranges of latitude (usually 10 degree bands). AOBV most often uses one designed for 20-30 degrees but we use it for latitudes from 10-40 degrees. An observer can use a planisphere for latitudes 10 degrees beyond its label without serious problems. Beyond that point, a planisphere for different latitude is needed or an observer can use a universal star map, but distortion will be higher for parts of the sky.



Note: At this point in the lesson, display the Chandler (or other) planisphere that will be used during AOBV.

The planisphere is one of the more essential pieces of equipment the new observer will use. He can buy or make one. You can find instructions for making a planisphere online if you want to make one. Many introductory books on astronomy will also have instructions. They are not hard to make. A planisphere is also called a "star wheel" or a "rotating star wheel." Parts of the planisphere are

discussed below before we use it.

First, notice the differences between the sides of the planisphere. For a planisphere for 20-30 degrees N latitude, the north side will show more sky since the N polar region can be seen more easily from N latitudes. Conversely, the S side of the planisphere shows less sky. These are physical representations that relate to the real world since N latitude observers can see northern parts of the celestial sphere much better than southern areas. The opposite would be true for S hemisphere observers, who would use a planisphere made for S latitudes that would show a more complete sky on the S side but less on the N side. For the discussions in AOBV, we will assume the observer is from N latitudes, although planispheres for any latitude operate the same way.

As covered in previous lessons, the observer must first recognize his resident hemisphere and the cardinal directions (N,S, E, and W) where he is observing. With this in view, the observer should face N or S. If he faces N, then turn the planisphere to the N side. (The label "NORTH" or "SOUTH" is near the center at the edge of the blue area.) Hold the planisphere in front and level with your face. At the top of the planisphere is the label for the latitude for which the sky map is designed. The center of the planisphere is a grommet that permits an inner piece to rotate. As the inner piece is rotated, the map of the sky rotates.

The next thing the new observer must know is the importance of local time for observing. Earth's rotation is 15 degrees per hour, so it appears that the sky changes. The planisphere is only accurate if it is set to the correct time. While it does have to be moved all the time, it might have to be adjusted every half hour or so to keep up with the changes in the sky due to earth's rotation. The time reference on the planisphere is the inner ring of numbers in the dark blue area. The numbers correspond with hours on the face of the clock and run from 6 pm to 6 am (normal night time hours). While there is room for some observation to take place during the day, those observations are usually limited to the moon; a planisphere is not needed for lunar observation. Notice the "12 Midnight" in the middle of the time scale. Hold the planisphere so the grommet in the center and the "12 Midnight" on the time scale are in a straight line up and down.

What the observer sees depends on time of night but also depends on the month and day of the year. The practiced observer sometimes has trouble keeping track of what he can see by season, so it is not surprising that new observer might have trouble. The great news is the planisphere makes it easy. The outside scale shows months and days. It is on the center sheet of the planisphere with the star maps, so as the center piece is turned, the outside scale (or the month/day scale) turns also. The months are listed sequentially on the outermost part of the sheet and the days are on inside scale in marked increments of 5 days with smaller marks (not labeled) for each day. Smaller planispheres might have fewer divisions on their scales.

Helpful note on the dates on the outer scale: The marks for the days on larger planispheres show small increments that are correct for each month, whether the number of days for the month is 28, 30 or 31. Every 5 days is labeled, so February shows labels 5, 10, 15, 20, and 25 but also has unlabeled marks that

go to 28. Months with 30 days include a mark for day 25 with additional 5 unlabeled marks. A 31 day month will also have a label for 30 days with an additional mark for 31.

The overall planisphere set up makes sense if you consider that the earth rotates every 24 hours and an observer is watching the heavens one particular night of the year. So the planisphere requires these two key factors to be matched: the local time and the date (month and day) that are located on the two scales we have discussed. So the observer's job is to match the right date with the right local time by turning the month/day scale until the correct time of year is directly opposite the correct local time.

There are some other things to notice that are helpful on the planisphere, but we must set the planisphere for a pretend observing period so they will make more sense. Let us assume we are observing on June 15 at 7:30 pm local time and we live in the 20-30 degree latitude band. Our pretend plan is to look at the constellations in the N. First, make sure you are facing N. Flip the planisphere so you can read "NORTH" below the center grommet in the blue. Now turn the inner wheel that moves the outer scale (the month/day scale). Rotate the sky map until the center of the June scale and the "15" mark is opposite 7:30 on the inner time scale (half way between 7 and 8 pm). You have set the planisphere for observing for June 15 at 7:30 pm. Now raise the planisphere to eye level. You will see that the star map just above the grommet shows Ursa Major (or the Big Dipper) as if a dipper is upside down. Where the blue section starts near the bottom marks the horizon line. Since you are facing N, E is to the right (and is marked in the blue) and W is to left (and is also marked in the blue). The clear section that shows the sky map is what you can see in the sky. If you are facing S, then you must use the S side of the planisphere and E will be on your left, W will be on your right.

Note: Many time zones use "daylight savings time" during several months of the year. If an observer is in daylight savings time, he must subtract an hour, since the planisphere is set for standard time in each zone.

The planisphere is a small device but the sky is very large, so it takes some adjustment in thinking when going from the planisphere to the open sky. The planisphere is flat, but the sky it represents is a hemisphere around the observer. Notice that when you hold the planisphere in front of you with the settings we just dialed, the E and W edges of the horizon are representing the eastern horizon all the way to your right and the western horizon all the way to your left. The top of the planisphere is just past your zenith (you would have to tilt your head back a little bit to see it). In essence, the small map represents the whole northern hemisphere of the sky that you can see.

Using the same example (June 15 at 7:30 pm) on the planisphere, notice the right side on the map (a little more than half way out and half way up on the sky map). Find the constellation called "Bootes." The largest star, which is noted by the largest "dot" is called Arcturus. This means that on June 15 at 7:30 pm you should be able to see Arcturus in the NNE about 2/3 of the way up toward zenith. If you look near the top of the map (about 2/3 up) in the NW, you can find the constellation "Leo." The biggest star (largest dot) for the constellation Leo is Regulus. This means that Regulus will be very high in the sky as you traverse up from a NW direction (very high on your left hand side). If you flip the planisphere over to the SOUTH side and face South, you will see the Regulus is also pictured far up in the sky. So it

will be very high in the sky as you traverse up from a SW direction (now it is on your right hand side and is very high).

All of the parts of the planisphere have been covered. It is time for the observer to show off his newly acquired knowledge. He will do this by looking at the planisphere and practicing setting the star wheel in the planisphere for observing. Follow the steps below for observing to the S on January 22 at 8:30 pm.

Step 1. Hold the planisphere a slight bet out in front of you as you face S. Make sure the side facing you says "SOUTH". (If the observer wanted to see something in the N, then he would have the "NORTH" side of the planisphere facing him as he faced N.)

Step 2. Since we are assuming the local time is 8:30 pm, find the location on the time scale (in the blue area) that is half way between 8 and 9 pm.

Step 3. Recall that we are pretending it is January 22. Look at the month scale and find the location on the scale for January 22.

Step 4. The observer has all of the information needed to set the star wheel. So turn the star wheel around until the month of January is at the 8:30 time spot is directly opposite the spot on the local time scale for 8:30 pm (half way between 8 and 9 pm).

Step 5: The observer can now check the sky. The planisphere shows Orion is slightly E of zenith (high in the sky and slightly to the left if you are facing S. If you were doing this real life, Orion would be obvious and in the location shown on the planisphere.

This first set up of a planisphere may be hard because it is a new instrument. With a little practice, it takes seconds to manipulate. This is a good time to practice several times with an instructor's help. Try several more setups before the class ends so when it is used at night, the procedures are quick and easy.

Note for more experienced users of a planisphere: There is more detail on the planisphere that can be used when observers become accustomed to it. There are lines of RA about every 3h. On each line are small marks for every 10-degree change in declination. These scales can be handy when moving around the sky or noting approximate celestial coordinates for objects. You can also estimate an object's distance above horizon using the declination scales.

THE SKY ATLAS: AN OBSERVER'S SECOND SPECIAL FRIEND

Vocabulary: sky atlas – a book or set of star charts with celestial coordinates and locations of stars or other deep sky objects.

What is the benefit of a sky atlas? The sky atlas is the gateway to the universe with much more detail than a planisphere. It serves as a more detailed road map of the heavens just as a road map serves a traveler along on the face of the earth. It is a useful tool so the observer can reach into deep outer space and be led to the sky objects chosen for an evening's observation session. A sky atlas keeps observers on their intended paths and can show them passage from one deep sky object to another. The sky atlas

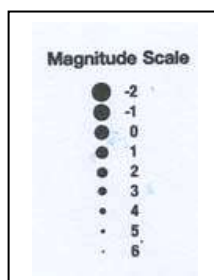
makes traveling around a constellation more complete than a planisphere, making it easier for observers to find things within a specific region of the sky.

The observer can use the coordinates on a sky atlas to instruct a computerized telescope to the correct position to find any object of his choosing. If the observer is not using a computerized telescope, then he will be able to use the sky atlas to help him put his manual telescope into the right position.

The discussion that follows is keyed to the Chandler Sky Atlas that is oriented for observers who are using binoculars or small telescopes. There are sky atlases that are larger and more detailed that are for more experienced observers or larger observing instruments. “The Chandler Sky Atlas for Small Telescopes and Binoculars” includes a description of significant and relatively bright sky objects within major constellations and marks them on the charts. The following paragraphs direct the reader to specific pages within the Chandler Sky Atlas, which we will call “CSA” in the text that follows.

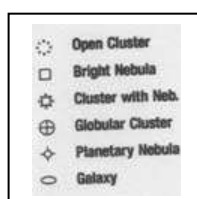
Author note: there are other pocket star atlases available but we have used this one successfully in a number of venues. It can be ordered online through major astronomy vendors. We provide a copy of the CSA with the kits that we send to disadvantaged groups that are part of our projects. Most of the detail discussed below is transferrable small atlases since many features are similar.

CSA MAP 1 THROUGH 8—HISTORICAL PERSPECTIVE AND GENERAL LAYOUT



For ancient observers that had no optics, only the brightest of stars could be seen. Their concept was simple: if they could not see a star, it wasn't there. They were limited by their eyes, and they did not comprehend that distance to a star as well as its size combined to give us apparent brightness. In other words, let us say they observed two stars by each other. The left one appeared bright; the right one could barely be detected. They did not understand that a bright star may be small but very bright because it is not far away in stellar terms. Likewise, a dim star might be huge

but its distance in stellar terms means it could hardly be seen. More understanding came centuries later as instruments and measuring schemes developed. While we have developed more understanding in modern times, the local observer still grades stars based on apparent brightness—how they appear from earth with our eyes but the scale now extends to apparent magnitudes as perceived through the use of optical aids. The CSA charts are limited to stars that the eyes can detect if the skies were perfect, but conditions are rarely this good due to different kinds of pollution or interference from moonlight. A star magnitude scale is used on all atlases but the CSA places it at the top left of every map for quick reference (see the figure on the left), and the magnitude limits are more restricted than those portrayed on a detailed atlas. It should be noted that the largest magnitude is -2. Next is -1 and on down to the dimmest stars that are pictured on the charts, which have a magnitude of 6. The higher the number, the fainter the star.

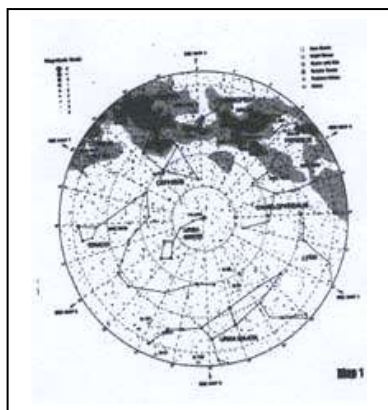


In addition to showing stars to the 6th magnitude, the maps of the celestial sphere include significant sky objects that can be seen with binoculars or small telescopes.

Objects are given standard symbols in most atlases. The CSA uses the same symbol set, which is pictured on the left.

It may not be obvious to a new observer that the CSA maps divide up the celestial sphere in connectable sections. Notice the shape of the sky charts in the next two figures. Connection of all of these charts with the printing to the inside would produce the celestial sphere. First we would connect maps 2 through 7. On each of those maps, the connecting maps are indicated, which help the observer when he is star hopping from one region of the sky to another. The hole at the top and bottom would be filled with maps 1 and 8. They also have notes on their borders to tell the observer which maps (numbers 2 through 7) connect at which point. With all pieces put together (and the printing to the inside, we would see the complete celestial sphere around us if we were at the center.

CSA MAP 1 AND MAP 8 DISCUSSION



A small replica of Map 1 is placed on the left for this discussion. Like the other maps, you can see prominent sky objects noted in blue print. Near the print will be a symbol that designates the type of object but also shows its location. The observer will become familiar with these symbols as he observes deep sky objects. These symbols are good to use in written notes, because they are regularly used in books, logs, and other useful astronomy charts and materials. This will also make the observer's material more user-friendly and standard.

Black print is used to denote constellations, and lines are placed between the major stars for the constellations. All CSA maps use the same scheme. (The planisphere shows the same constellations.)

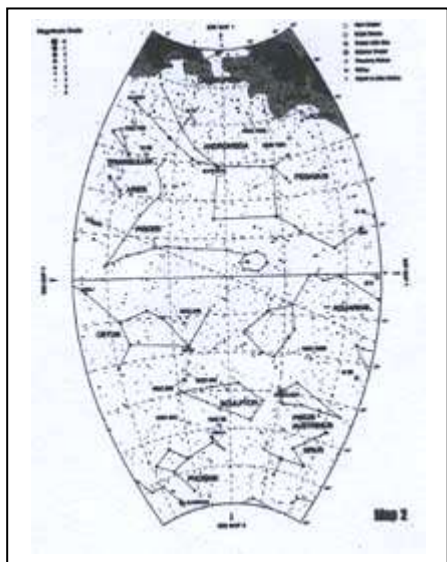
Map 1 and 8 are very handy for observers that live at mid latitudes, because they can see at least one polar region. Notice the lines on either map. Going out from the center in radials are lines of RA. Circular dotted lines are lines of declination. Since we are near the poles for either of the two maps, the declinations go about 50 degrees to 90 degrees in the N (Map 1) and -50 to -90 degrees in the S (Map 8). For equatorial observers the maps are still handy because the position of major stars and constellations that are above the horizon near both poles can be observed if the atmosphere is clear (the seeing conditions are good). The planisphere, when it is set correctly, will tell you which part of the polar region is above the horizon while the CSA can be consulted for the objects in that region that can be found with small instruments.

The page on the left of each chart has a list of objects by constellation that can usually be seen with a small instrument. So the page to the left of Map 1, for instance, lists the constellations in blocks that correspond to the same constellations that are on Map 1. Within each constellation block is a small list of objects within that constellation that can be observed with a binocular or small telescope (assuming the planisphere indicates that the constellation can be seen). Each object is briefly described by its alpha-numeric identifier, type, magnitude (Mag), size (minutes), and number of stars (if pertinent). For

objects that are significant but a little hard to locate, there are inset maps to help find them. The text description also includes comments that might help the observer.

CSA MAP 2 THROUGH 7

These map pages are laid out with the same general information, scales, and symbols as Map 1 and Map 8. Maps 2 through 7 are slices of sky between the polar maps. They comprise slices the celestial sphere from a declination range of 60 degrees (in the N) to a -60 degrees (in the S). Refer to the thumbnail of Map 2 for the discussion that follows.



Each map slice includes about 5h of RA (RA or Right Ascension was discussed in Lesson 5). Lines for RA are dotted and run vertically through each map. The center vertical line for each map is 4h from the center of the next map. Maps 2 through 7 are centered at 0h, 4h, 8h, 12h, 16h, and 20h, respectively.

An important reference line is across the center of the each map or chart, which is the celestial equator. As discussed in lesson 5, the celestial equator is an extension of earth's equator and marks a region of importance since most observers can see this region of the sky (unless they live too close to the poles). Lines of declination are shown on either side of the celestial equator in 10 degree increments.

Another reference line that is dotted is marked "Ecliptic" that shows the path of the sun and planets (discussed in Lesson 5). It is along this line that we can see Venus (near sunset or sunrise), Mars, Jupiter, and Saturn during parts of the year. Each of these planets is observable with small binoculars or telescopes if it is the right time of year. Most astronomy references (online or astronomical calendars or weather information that includes astronomy events) can be consulted about when the planets are visible during the year. As observers become experienced, they can also tell when planets are visible because they will be extra objects that are not normally part of a constellation along the ecliptic.

The ecliptic also marks the general location of the popular Zodiac constellations. As the year progresses, several of the Zodiac constellations are in parts of the sky that are easy to view for most observers. Whether the observer starts a search in parts of Canada in the N or Australia in the S, the Zodiac constellations are frequently used as a reference for some star hopping to find objects.

USING THE CSA MAPS

It is easy for a new observer to get turned around or lost looking at a CSA map to try and find an object. If this happens, set the planisphere correctly and note the area you want to see in more detail as a function of declination and approximate RA. Then go to the CSA map that has the similar declination and RA. If you happen to know which map has the prominent constellations you are seeking, go immediately

to the correct map. An observer will have to align the CSA map to mirror image the view in the sky or on the planisphere.

Teacher Note: This is a good time to conduct some exercises where small groups of students adjust the planisphere to a specific date and time, find the pertinent declination and RA on the planisphere, and finally find the map in the CSA that is appropriate. After a couple exercises, they will see how the sky atlas provides a more detailed map of the sky if they wanted to find more objects than shown on the planisphere.

INTRODUCTION TO BINOCULARS

Note: We recommend a little pamphlet titled, “Exploring the Night Sky with Binoculars” at this point in the lesson. It has an excellent but brief treatment for binocular observing. If you do not have a binocular at this point, then we recommend a 7 or 8 power binocular with at least 35 mm of aperture. These would be labeled 7x35 or 8x35. Smaller sets that are popular (8 or 10x25) will suffice for children to see bright stars and the moon if the recommended sizes are not available. We have trained groups with all of these sizes. A more suitable choice for viewing the heavens is 8 to 10 power with 42 to 56 mm objective lenses, but they are more expensive.

The goal of this section is to pave the way for your first observing session with optics and make it smooth sailing from the start to the finish. The skills that are needed will be presented. Many serious observers of the heavens use binoculars as their primary tool for observation. The advantage of binocular observing is the wide field of view, which is typically about 5 degrees of the sky. The instrument is light and relatively rugged, so it is popular for travel.

SOME RECOMMENDATIONS FOR TEACHERS AND TEAM LEADERS

As you pass the binocular around, ask yourself a couple of questions. If several people are to share a single pair of binoculars is a good idea to notice the people doing the sharing. The tendency of many new observers with all the excitement of a new tool, is to lose track of time and not share. Also be on the lookout for special vision problems. Glasses can be worn with some binoculars but not with others. Occasionally new observers have difficulty focusing or merging the images. Be ready to assist observers with a handicap since a firm standing or seated position is needed to keep the image steady when the binocular is being used. Once problems are identified, you are ready to begin.

We recommend grouping the observers with similar problems into their own groups. In this way you can identify special groups or people with special needs. It would be wonderful if you could have a separate pair of binoculars to assist people with the hardest adjustment problems, but forming them into a subset and smaller group can reduce some of the problems and provide a little more time per viewer as they adjust to using the binocular. This is useful because the larger group will move faster but their larger size will mean they will finish about the same time as a small group with some handicaps.

If there are enough binoculars, viewing with 2 or 3 people per set is best, but larger groups will work as long as a group leader ensures everyone takes the proper time to observe. A group leader should oversee the fair use of the binocular.

It is easy to underestimate how excited people are to try binocular viewing if they have never used optics before, so the following recommendations are given:

Since focusing a binocular and finding an object at night can be a problem, we suggest a day light session first.

When it is time to conduct a night session, it is best to have an order of viewing among the team members. It may sound over done to be this organized, but viewing in the dark is not as easy as daytime viewing.

When each viewer has the binoculars, make sure the steps for focusing and finding an object is according to the steps that are listed in the next section. Binoculars are frequently used incorrectly, so be sure the steps are taken as specified.

With large groups, it helps to give each viewer a number and only allow viewing in the correct numerical order.

None of these steps will eliminate the need to make individual corrections, so one person in the group or an instructor that is near several small groups has to be on hand to assist students as it is necessary.

There are conditions in the eyes that prevent a person from using a binocular. If a student cannot focus the binoculars or cannot merge the images of the two barrels, it is best to take the student aside. First check the instrument itself to make sure you can focus it case it was dropped or broken. If it works for you, then you have confirmed the instrument is all right. Redo the procedures with the student to see if the problem is rectified. If the problem cannot be corrected, it is likely that the student will need a medical check of his eyesight. He may still be able to see using one eye or the other through one of the barrels of the binocular, or he may be able to use a telescope, which only uses one eye and is covered in the next lesson.

Do not press your eyes against the eyepiece, touch, or breathe on the eyepieces. Most binoculars do not need cleaning if simple precautions like these are taken. If the glass gets covered with dust or dirt, blow it off first because it may take care of most of the problem. If the glass is still very dirty, only adults with experience should try to clean them. Use soft brushes to brush the lens very lightly. If the problem persists, use a microfiber cloth or a cotton swab with a little bit of alcohol to gently remove the dirt that is persistent.

ADJUSTING FIELD OF VIEW AND FOCUS

It is not difficult to use a binocular but it is easy to skip essential steps to make sure that the field of view and the focus is adjusted properly. The student should make a habit of going through the steps anytime

the binocular is used. Page 6 and 7 of the pamphlet should be read and reviewed at this point. A summary of procedures follows:

Make sure a strap is on the binocular and it is around the observer's neck. Look through binoculars before adjusting focus. Adjust the width of the binocular so that it is as wide as it can go. Then move the barrels closer by squeezing them closer until a single circle can be seen. Small observers typically have to squeeze the barrels quite a bit. Now you are ready to focus the binoculars.

Locate the focus knob for the binocular and try turning it so you know how much pressure it takes to turn it. Locate the single eye adapter on the right barrel. It is usually close to where your right eye will be against the binocular. Try turning it so you know how much pressure it takes to turn it. If it has a zero point or center point, turn the barrel so it is on that point.

Focusing is done with your eyes relaxed, so do not squint or concentrate your eyes. Focus your eyes on a distant object or bright star. Raise the binocular to your eyes while you are looking at the object. Once the object is located through the binoculars, shut the right eye. Focus the binoculars for the left eye using the center focus. Close the left eye, open the right eye, and turn the single eye adapter on the right barrel to fine focus the right eye.

Finding an object can sometimes be difficult at first. It takes a little practice. If you have trouble with the method explained above, there is a second method for objects that are low. First, put the binoculars to your eyes looking at the horizon directly under the object you want to find. Then raise your eyes with the binoculars until you find it.

If you have trouble steadying the binocular, place one arm against a solid object or put your thumbs on your cheek. Another way to steady the binocular is to rest your elbows against something solid or to lean against a pole or a tree. The steadiness of a binocular makes a big difference in what a person can see.

CLASS EXERCISE 1

After the students have each adjusted focus and field of view successfully, the next step is to have an exercise where everyone will observe the same object and sketch what they see. It will reinforce what they have learned but also give the teacher a tangible result of an observation. The sketch can be rough because it will be a quick observation. Instructions follow:

1. Organize the students so smaller groups can each use a set of binoculars.
2. Then give each student a separate sheet paper and a pencil.
3. Choose a place or object in the distance to see with the binoculars. A small picture of a sky object works well. The object should be something simple, have good contrast with the surroundings, and small so the students must properly focus and use binoculars to see it. Poor lighting is suggested since these conditions are typical of night observations. They can apply some of the guidance for

sketching that were presented in Lesson 6. Provide a time limit for the drawing but permit at least 15 minutes.

When they have finished with their drawings tack them up on the wall or piece of poster board for discussion. Let them provide response about steps they took to focus the binocular and develop the observing sketch.

CLOSING NOTES ON BINOCULAR MOUNTING

Many larger binoculars are fitted with a tripod adapting hole in the front. A $\frac{1}{4}$ x20 thread can receive a small bolt after it has been put through a piece of wood. The piece of wood acts as a monopod, which is a single upright pole that can have a base or be mounted on another surface. If the binocular does not have the adapting hole, the binocular can be rested on a raised stick to do the same thing.

Monopod, which means one pod or a single stick is in contrast to a tripod. “Tri” means 3. A tripod is a standard configuration for a sighting system and other kinds of instruments, including a telescope, which will be covered in the next lesson.

CLASS EXERCISE 2: A PRACTICE STAR HOP

This is a day-time class project that uses some of the skills that have been learned.

Setup a pretend-compass rose inside a large classroom or outside. Take 3 small objects (balls, colored circles, bright cups, or plates). Locate them on the opposite side of the room but spread widely apart. Number the objects from right to left. Put them at different heights. The 4th object that is farthest to the left should be a very small picture of one constellation. It should be small enough so that a binocular must be used to see the individual star locations. Measure the angles among the objects and their compass direction ahead of time since they will be the answers you will expect from the students

The exercise requires dividing the class into small teams. Give the instructions that follow and have each team turn in the results within 10 minutes. The first team with accurate results wins. Instructions follow:

Have the students use the hand/arms motions to measure the first object above the horizon, which is the floor line. They should measure the angles to every successive object from the previous object, and note the compass direction of each object. Instruct them to write instructions to reach the final object (the picture of a constellation). Have each team provide a brief sketch of the constellation major stars (the final object). They will have to use the binoculars to see it.

EXERCISES

7-D1 EXERCISE: SET PLANISPHERE AND GET ORIENTED

Set the planisphere for the proper date that assumes observing tonight at 9 pm. Use the side that says “face north”. Change the time to midnight and see what happens to star positions. Face south for the 9 pm observing time and change it again to show observing at midnight.

Return the planisphere to a 9 pm observing time. Then carefully rotate the plansisphere as if you were going to observe 3 months in the future at 9 pm. Note how the sky changes on one side (facing north) then the other (facing south). Now change the observing time to midnight and 3 am to see how the sky changes for both cases (the side for facing north and the side for facing south).

Think about how the sky changes for each case and how they compare to each other.

7-D2 EXERCISE: PROPER USE OF BINOCULARS

Using the instructions from the class, set a binocular using a distant object as the target. Be sure to follow the procedures that were taught for focusing each eye and finding an object. After doing this the first time, deliberately put the binoculars way out of focus and repeat the exercise. As a student does the focusing exercise, the time it takes to focus a binoculars will take less and less time (as a little as 10-15 seconds). Finding an object will also become faster.

7-N1 EXERCISE: BINOCULAR OBSERVING PERIOD

The teacher will select a prominent set of stars or the moon for an observing period using a binocular. The student should prepare an observing sheet with his name, class, binocular magnification and size, sky conditions, and the intended time of observation. The object that has been assigned should be found by the student. Select a starting time for observing. The student has 30 minutes to an hour to sketch the stars or objects that he can see in the field of view. If more than one student uses a single binocular, then students will have to share the time with the instrument and time can be adjusted accordingly. Be prepared to share the observing sheets.

7-N2 EXERCISE: FINDING A DEEP SKY OBJECT

The teacher will assign a deep sky object that he/she has found to be appropriate for new observers using binoculars. The first part of the exercise is to find the objective area with eyes alone, find the assigned object with binoculars, and sketch the object as seen with a binocular. The observing sheet should include the same information that was recorded in the last exercise.

AOBV Lesson 8: Astronomical Tools to Help the Eyes—Part II

Materials: paper and pencil

Instruments: binoculars and small telescope

Reference: John 1:3

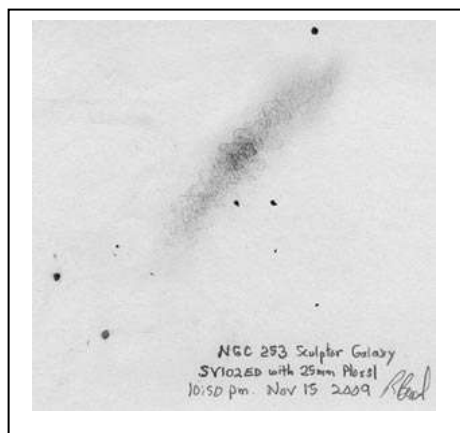
Sky Object: M31 or NGC 253

REFERENCE SCRIPTURE

The first few verses of John are profound and far-reaching; they encompass Jesus Christ, who is equated with the Word, God the Father, and the Creator of all things. The third verse parallels other key scriptures in Genesis and Hebrews in regard to creation. The statement is plain: all things were created through Jesus Christ. In other words, creation was not an experiment over deep time, where a gradual series of elements arising from nothing through natural means, or some mysterious process, yielded the universe. Complexity, in other words, for any part of creation we see, did not have an origin in something simple. In terms of observing the heavens, the scripture highlights that we are personal witnesses as we see and interpret God's complex and detailed handiwork in the heavens. The very God that is the Maker and Giver of Life is the one who made the heavens to observe, which encourages an observer to discover their characteristics. The heavens were made for us to see. Only in recent centuries did optics and other types of sensing devices permit a better view of some objects. While optics and techniques have grown sophisticated that shows no end to the detail that can be recorded, the practiced eye can still see amazing things.

SKY OBJECT: NGC 253 or M31

Two of the largest galaxies that are relatively easy to observe are M31 (the Andromeda galaxy) and NGC 253 (the Sculptor galaxy). M31 is easily viewable in the Northern hemisphere from fall to spring while



NGC 253 is viewable in the spring to summer from southern latitudes. M31 can be seen with unaided eyes if the skies are dark; NGC 253 requires binoculars. Each object is very large. Andromeda's full extent in angular terms is more than 5 full moons wide. Both are spiral galaxies that are viewed from earth at nearly the same angle of tilt—giving the appearance of a milky ellipse. Many astronomers have spent years studying the Andromeda galaxy because of the detail that becomes apparent with sophisticated instruments but it remains a favorite for amateurs with binoculars and low power telescopes.

If the Sculptor galaxy was higher in the Northern skies, it would probably be just as popular as Andromeda. For medium-sized scopes, the Sculptor begins to show structure in the galaxy arms. For equatorial or southern hemisphere observers, it is a wonderful object to observe that is high in the sky.

The sketch is a simple pencil on white paper using a four inch refractor—not much larger than a 3.5 inch (80-mm) refractor that we recommend for this course. A student who completes the lessons and exercises should be able to do a very similar sketch of either the Sculptor or Andromeda galaxies.

SAFETY WARNING: NEVER LOOK DIRECTLY AT THE SUN WITH A TELESCOPE OR BINOCULARS WITHOUT PROPER FILTERS.

BINOCULAR REVIEW

The use of a binocular was covered in the last lesson. To review some key points, remember that binoculars are an excellent low power and wide field viewing device. Many large objects and groupings of stars are better seen with binoculars than any other instrument. Make sure the binocular strap is on your neck; hold the binocular with both hands.

Focusing is done with your eyes relaxed, so do not squint or concentrate your eyes. Open the binocular (spread the barrels) as wide as they will go. Adjust the width of the two barrels so that a single image is seen with both eyes. Focus your eyes on a distant object or star. Raise the binocular to your eyes. Once the object is located, shut the right eye. Focus the binoculars for the left eye. Close the left eye, open the right eye, and turn the diopter on the right barrel to fine focus the right eye. Do not press your eyes against the eyepiece or breathe on the eyepieces.

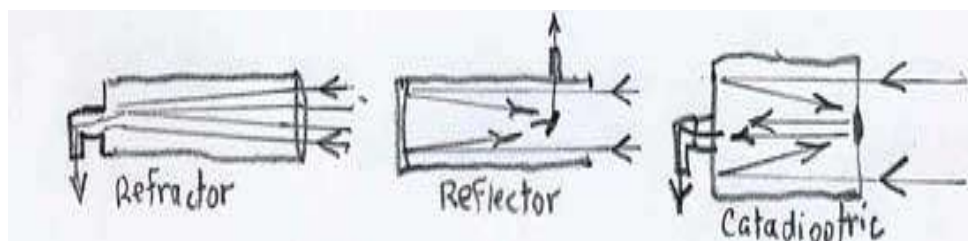
To find an object, look at it with your eyes and raise the binoculars to your eyes. If you can still not find the object, put the binoculars to your eyes looking at the horizon directly under the object you want to find. Then raise your eyes with the binoculars until you find it. To steady the binoculars, place one arm against a solid object or put your thumbs on your cheek.

INTRODUCTION TO SMALL TELESCOPES

The function of a telescope is to collect light with optics and bring it to a focus at a particular spot (called the focal plane). While there are different types of telescopes, the same function applies. It stands to reason that the larger the diameter of the telescope then more light is gathered. Magnification is done with an eyepiece (EP) that takes the focused light and magnifies the image. It is the eyepiece—not the telescope—that magnifies the scene where the telescope is pointed. Eye pieces (EPs) vary in focal length to vary magnification. A longer focal length means lower magnification. Highest magnification is usually not the best way to view objects. Most observing is done at magnifications of 30-150 times what the eye can see. Normally magnification is expressed as some number followed by an “x”, such as “30x-150x” or 30 to 150 times magnification compared to the unaided eye.

All telescopes have to be mounted in some way to make it easier to use them. Some are on stands or ground boards; most are mounted on tripods. A complete telescope kit means a tripod or stand for the telescope, the telescope tube (called an optical tube assembly or OTA), a diagonal (if needed to make the focused light turn 90 degrees), and an eyepiece. Like any precision instrument, each piece must be treated with care—especially any piece with optics. Every telescope optics must be aligned very carefully; the alignment can be disturbed or ruined if pieces are incorrectly assembled, dropped or are sharply jarred. Since optics are the most important ingredients to properly focus light, they must be protected against dirt, water, or being touched. Most telescope EPs or OTAs have covers, which should be used whenever telescopes are not being used.

There are 3 basic types of telescopes. They differ in terms of light path. The diagram below shows each of the three types (refractor, reflector, and catadioptric) with the light path for each one. Note that refractor and catadioptric OTAs require diagonals, which turn the light path 90 degrees to make observing more convenient for the user.



Refractors will be assumed in the discussions for this course but most of the procedures apply to other types as well. The paragraphs below assume a refractor that is mounted on a simple fully-manual altitude-azimuth (Alt-Az) mount. The mount is attached to a tripod; sometimes the mount and tripod are one assembly. A manual Alt-Az mount and tripod constitute the assembly commonly sent with AOBV equipment kits. The manual Alt-Az type of mount is the easiest arrangement to use and will be used for the discussions and examples. Its disadvantage is that it must be adjusted periodically to compensate for the earth's rotation. This is not difficult to do but may require a little practice for a new observer.

Always refer to the instructions for assembly and operation for any scope that needs to be polar-aligned or has automatic features since the instructions in this lesson are simplified and only pertain to a fully manual Alt-Az mount. The more complicated mounts automatically compensate for earth's rotation and frequently can slew to objects automatically if given proper input instructions.

GENERAL INSTRUCTIONS FOR ASSEMBLY AND FIRST USE

The telescope tripod should always be set up first. Most tripods for small telescopes are made to be 3 to 4 feet high. If the legs are extendable so the base plate or top of the tripod is 3 to 4 feet high. Usually no tools are needed. Follow instructions that accompany any telescope for details. Any plate at the top of the tripod should be approximately level when the tripod is fully assembled, so make a final adjustment for the legs to ensure this is the case. Screws, nuts and bolts should be tight enough so the tripod remains stable, which means it does not change in height and the legs are secure at an angle that will prevent the telescope from toppling the tripod. Usually there is a way to keep the legs spread at a

specific angle—either with a plate or spreader bars between the legs. If not, then anchor the legs so they remain spread and fixed. All nuts or screws should be firmly hand-tightened; do not use tools for tightening unless the directions specifically call for them.

Next, the telescope OTA can be mounted carefully following any instructions that accompany it. The optical tube assembly (OTA) should be handled carefully. There will be a mounting plate on the OTA or the tripod that is the means of attaching the OTA to the tripod. Please note that mounting an OTA to a tripod requires paying attention to weight and balance. Telescopes are usually designed to be balanced about a center of gravity. This means that the attachment point of the OTA is usually designed or adjustable so that when fully assembled the telescope wants to stay where it is set rather than topple over or tilt. Directions on an actual scope are specific about proper mounting to make sure the OTA does not accidentally fall or drop. Any screws or bolts or wing-nuts should be hand-tightened; do not use tools because it is too easy to over tighten the fasteners. Once the assembly is complete, take any covers off the OTA (usually there is one on the front (where the light enters) and one at the other end, where the diagonal will be mounted).

Once the tripod and telescope are assembled, insert a diagonal at the base of the telescope if it is a refractor, Schmidt-Cassegrain, or Maksutov type of scope. The last step is to choose an eyepiece (EP) with the longest focal length (lowest magnification) and place it in the diagonal. They are held in place on the telescope by one or two thumbscrews that keep them from slipping or falling out. Make sure the thumb screws are all hand tightened; do not over tighten them. Never use pliers to tighten a thumb screw.

Attach the star finder or finder-scope (both names are common), which is used to generally aim the telescope. It can be a small battery operated device that fits on the OTA but sometimes it is as simple as a tube that is fastened to the OTA with rubber bands. If this is the case, make it parallel to the OTA. In other words, if you look through it, it should point to the same general area as the telescope. You may have to adjust it a little bit (see the next section for instructions). If you do not have a star finder, then make one from a light round tube of paper or cardboard plastic pipe and tape it to the OTA. If a piece of plastic tube or pipe is used, attach it with two rubber bands or pieces of string. A sighting device like this makes things much easier to find things in the sky.

All parts are now assembled. If there are any adjustments to make the OTA balance correctly, this is the time to check them a final time.

A new observer should assemble the telescope in daylight for the first time. Most people try it once or twice before they intend to actually use the telescope at night. The assembly (at this point in the instructions) is complete but some adjustments need to be made before trying look at something through the scope. First, point the telescope at an object on the earth but as far away as possible. Adjust the focus so that the field of view that you see is sharp. You can use the star finder to help point the telescope to the area you want. It may take a few tries to get the scope pointed where you want it and focused. Once this is done, pick a specific object in the field of view and center it in the EP. Then adjust the finder scope arrangement so the same area is at the center of its field of its field of view. If it is a

battery powered red dot finder, then make sure the red dot is super-imposed on the object you have focused on. Now we are fully assembled, star finder is aligned, and rough focus has been set. To test your setup, you should be able to move the OTA in azimuth (horizontal) or elevation (up and down) without difficulty. It should stay where you set it. You should be able to move the telescope to point at different places without binding or interfering with anything.

A note on focusing and aiming at night with stars: focusing is similar to looking through one side of a binocular. Set the scope to look at a bright star. Use a relaxed look through the EP with one eye as the focus knob is turned. When the star is as pinpoint as you can get it, then focus has been set properly. The observer can turn the telescope slowly to a nearby faint star. You can fine tune the focus so that the faint star is pinpoint and the brightest. During observations, focus frequently has to be checked if observers change, there is a rapid change in temperature, the scope assembly is bumped, or observer switches eyes (one eye may not have the same vision as the other). Having to adjust focus every few minutes if these situations occur is normal. After observing a few times, checking and adjusting the star finder aim point at the beginning of an observing period and adjusting the focus of the telescope during an observing session are quick and easily accomplished.

GENERAL TELESCOPE POINTS REVIEWED AND FIRST OBSERVING EXERCISES

Make sure the lowest magnification EP (longest focal length) is always fitted to the telescope at first. When the scope, tripod, and star finder are all assembled, which can be done during the day, find an object that is at least a few hundred yards away. Center it in the finder-scope. See if it can be seen through the telescope. Center the object in the telescope optics by gently moving the telescope in the desired direction. Re-adjust the finder-scope so the object is centered in it as well. Now the telescope and finder-scope are considered to be co-aligned. This helps finding things faster and easier.

Find a bright star or center the moon in the finder scope. If the finder scope is adjusted correctly, you should be able to see the object through the telescope. Adjust your focus so that the star is a point or the moon is clear. Each person may have to adjust the focus a little bit because eyes are different.

Try finding a couple bright stars using the telescope setup to get accustomed to how it moves and how much force it takes to change its position.

Find a place in the sky where there are many stars. Notice how much you can see through the finder scope compared to the telescope. This gives you an idea of the differences in field of view and the effects of magnification.

Now find one star that is bright and set the telescope until it is centered in the eyepiece. Notice how long it stays in the eyepiece before it “drifts” out of the field of view. This gives you a sense of the speed at which the earth is turning. Do this with a star in the far south as well as a star directly overhead. Notice the difference.

Now find an object you would like to look at or you have been assigned using a low magnification EP (long focal length or highest number on the barrel of the EP). Change EPs to a shorter focal length

(higher magnification or lower number on the EP barrel). Notice the difference in what you see and how long it takes for the object to “drift” out of the field of view. If the moon is up, do the same procedure for the moon. This usually brings a practical understanding about the importance of using the lowest magnification possible, since the field of view is better and the image is brighter and sharper. Remember that most observers look through telescopes at 30-150X magnification at most objects. Higher magnification is only reasonable if the skies are really good, the telescope is large, and some automation features are present.

This ends the lesson. Now you are ready for your first assigned observation of an object. The teacher will suggest or assign one for you to view. The exercises start with an observing exercise during the day, where the student practices the proper assembly of the telescope, observes small object at least 100 yards or meters away, sketches the object, and properly disassemble the equipment.

EXERCISES

8-D1 EXERCISE: SMALL TELESCOPE REVIEW

The teacher will have introduced the telescope in class. This exercise period is intended to give the student his first experience assembling, properly using, and disassembling the instrument. The exercise should be repeated as often as necessary for the teacher to have confidence that the students can safely and correctly handle a small telescope. The hands-on experience is necessary for each student. The exercise can be done in small groups where the students can help each other as they follow the instructions of the teacher. Care should be taken to ensure that each student has adequate time on the scope. The daytime object that is to be found and observed should be at least 100 yards or m away. Have the students recognize the orientation of the field of view compared to the binocular field of view. Have the students note the difference in the diameter of the field of view. Remind them of the most important safety rule for day time observing: never look directly at the sun and never point optical devices toward the sun.

8-N1 EXERCISE: TELESCOPE OBSERVING EXERCISE

The teacher will select an object (major star, moon, or a planet) that is appropriate for small telescope observing and divide the students into small observing groups. The exercise is a combined effort to properly assemble the telescope with a low magnification eye piece, to focus the scope on a bright object, to find the assigned object and observe it, and to make a brief sketch of the object. The sketches should include the student’s name, class, telescope that is used, place of observation, time of observation, sky conditions, name of the object to be observed.

8-N2 EXERCISE: SKETCHING ONE OPEN CLUSTER

Depending on the time of year and day for the observing period, the teacher will select an open cluster of stars to observe. The same procedures and observation sheet that were used in the exercise above should be used. The observation sheet can be made ahead of time. Using a planisphere set for the

intended observation time and using the Star Atlas will help the choice of a significant open cluster that is appropriate.

The cluster should be observed with the lowest magnification possible. It would be good to have binoculars handy also so students can see the difference in the field of view of the instruments. The objective is not to have a detailed sketch; this will be done in later exercises. The primary objective is to learn to operate a small telescope, although the whole exercise can be done with a binocular. Once the exercise is done, students can be given some time to observe a few bright stars or planets that are observable. Sometimes a binocular can be used to find an interesting area then the telescope can be used to find the same area to observe it with higher magnification.

Once the observing time is complete and the equipment is properly disassembled, the teacher can give the student observers a pertinent scripture regarding the stars and oversee a general discussion of what was seen.

Note: Night time observing with a telescope takes some practice and procedure. At first, it may be difficult. Please be patient. Learning to use a telescope and adjust its position to keep a target centered in the eye piece (the field of view that you see) takes a little practice. Students can help each other to help the learning process will go quicker. Once the object is being observed, what each student is able to see may be different. Discussion among the observers and reviewing the object is helpful because the students will help each other avoid mistakes or correct problems. If the time is too short and the students need another session, this exercise should be repeated. By the end of this exercise, the students should be reasonably comfortable with both a binocular and a small telescope, be able to find bright objects (operate both instruments), and be able to handle equipment.

AOBV Lesson 9: Observing the Moon and Using an Observing Sheet

Materials: paper and pencil

Instruments: planisphere, small binocular or telescope kit, red light

Reference: Romans 1:20

Sky Object: the Sun

REFERENCE SCRIPTURE

This scripture in the first chapter of Romans states a simple principle: all mankind, regardless of place or time in history, has evident indication of God's qualities—His power and divine nature—through an examination of what God has created, which includes the universe. The qualities of earth alone—the complexity at every magnitude, the order of life, the balance of conditions that permit life, and the processes that are essential in it (like the water cycle and photosynthesis)—are evidence of God's qualities and power. While we cannot visit the heavens easily, many of their qualities can be discovered, observed, and measured to some extent. Heavens' qualities, like those of earth, show incredible complexity, variety, a sustained condition, and beauty. A unique quality is its space or volume within which reside a host of objects. The qualities, as the scripture indicates, comprise a body of evidence about the eternal nature, power, and depth of God but also show attention to the least details, such as the naming of every star. Hence, the scripture states that there is not an adequate excuse to ignore God, the maker and sustainer of the heavens.

SKY OBJECT

The sun is the nearest star to earth. Many space probes have been sent as near as they can survive to study its features. Special earth-based earth-orbiting instruments are used as well. No star has been studied more yet not much is known about the processes that take place or how they are self-sustained. It is also studied with many parts of the electromagnetic spectrum. Special offices are constantly monitoring its activity because of the effects of solar storms (storms with electro-magnetic effects) on communications. It is a beautiful object in its own right and mentioned many times in the scriptures in terms of its purpose, heat, and weather effects. Sunlight is the starting point for photosynthesis—the magnificent created process that is fundamental to life on earth. Our position and motion relative to the sun is a picture of perfection: permitting the right heating for the globe without extremes that would be nearly unlivable. The sun has a weather cycle of its own that can be observed in terms of radiation and sunspot levels. Eclipses of the sun, because the moon and sun have nearly the same apparent diameter as we observe them from earth, are a wonder to behold, but this also must be done with proper equipment to prevent eye damage. A life time can be spent studying the sun.

Many amateurs study the sun on a regular basis. Small telescopes with special filters can be used to study sun spots, some sun surface features, and prominences (ejected gases that form pillars and loops that change rapidly).

OBSERVING THE MOON

The moon is the nearest planetary object to earth. It is unique among moons in the solar system because of its size relative to earth's diameter and its apparent size relative to the sun. The moon's orbit and motion are pictures of the wisdom of God's creation with respect to marking passage of time (the moon acts as an excellent clock), effects on earth's ocean currents, effects on life in the intertidal zones along coast lines, and other more subtle effects. At a quarter million miles away (a small distance in stellar terms), it can be studied with the naked eye or small optical instruments. Sketching surface detail is an excellent way to learn to observe because of the amount of detail on the lunar landscape and the changing effects of sunlight. The scripture in Genesis rightly describes the moon as the ruler of the night because its light dominates the sky when it is anywhere from a one-quarter to three-quarter moon. The amount of moon light during this period when the moon is well above the horizon fainter stars hard to see because of the amount of moon light that is diffused through our atmosphere. Some unique characteristics of the moon follow:

Orbital period is the same as its rotation period, which means we always see one side of the moon. The dark side has been photographed and mapped by unmanned and manned space vehicles. The orbit is not quite circular and is also not quite equatorial.

As bright as the moon seems to be, its reflectivity is fairly low. If it was much higher, we would have great difficulty seeing other sky objects during most of the moon's cycle. While the earth has dramatic color, the moon's surface colors are very subdued. So the combination of low reflectivity and subdued color yield enough reflected light on earth's surface to fulfill its primary purpose (night light) but not so much to mask the rest of the heavens.

The topography is very rough and characterized by past violence that yielded craters, lava filled areas, fissures, and scarps.

Postulations about the moon's origins by non-bible-believing people are many and varied, but none are adequate for the size, orbit, material, appearance, and precise effects on earth. And, where did the craters and rough terrain come from? We do not know for certain but most Bible-believing creationists think the moon was either bombarded with swarms of objects at the beginning of the Genesis Flood or at the Fall of man. Both events involved large changes to the universe and earth, as indicated from Scripture. [See creation.com for more information or download the Creation Study at the cwm4him.org site.]

Lunar landscape characteristics make observation fun and exciting. Every observation of a crater or sea or even whole moon is a little different due to sun position, earth position, and earth atmospheric effects, and how much of the moon is visible (its phase). Furthermore, many sketchers enjoy framing sketches of the moon with earth or sky objects, where details of either can be placed in a sketch. Using

the sketching practices in Lesson 5 as a basis, anyone can begin to sketch the moon immediately. Sometimes the scene seems too big or complicated to begin, but simple steps (listed below) and being fearless to try something are all that is needed to begin. Remember: during the sketching process you will be going back and forth from looking at the moon and the sketch. The repetitive observations during the recording process expand the detail that is observed. Some basic sketch steps for a drawing developed on white paper with a pencil follow:

1. Choose the area of the moon you want to sketch (whole moon, crescent, “sea”, crater, mountains, or a combination of features).
2. View the area several times and note light and dark areas, prominent features that you can recognize, high places (bright), low places or shadow (dark), different shades grey, sun direction, and shadow direction.
3. Select key features in the field of view that will act as reference points or anchors on your sketch. They should be far apart in the field of view that you have chosen and widely placed on your piece of paper. This helps you position other features accurately in relation to these large key features.
4. Outline large shapes. Outline shadow areas and label them if you need to with respect to their degree of darkness (black, grey, lighter grey, etc.). Outline white or bright areas. All outlines should be done with a light pencil line.
5. Fill in the dark shadow areas, then the lighter grey areas.
6. Add smaller features using the same techniques used for larger features but place them relative to the larger features that have already been located on the sketch. Lightly outline or mark their boundaries, fill in the dark shadow areas, fill in the grey areas; keep the lightest areas white by using white pencil or use an eraser to make those areas show the white paper.
7. If areas show a soft transition from light to dark (or the reverse), add pencil, use an eraser, or use a blending stick/finger/cotton swab to soften the light-dark transition. If white areas are too dark, use an eraser to remove the pencil marking. If dark areas need to be darkened, go over them
8. Review the overall drawing and re-emphasize both brightest and darkest areas. Add any sharp lines or make lines sharper if they need it.

Use Addendum 2, titled “Moon Observing” for helpful guidance and hints for teachers and observers who are learning how to follow the moon phases or identify where the moon will be during the lunar cycle. A review of this material will help lunar observing. It can also be used as a teaching guide for students. It is possible, because of the detail available on the moon and the value to studying light effects on the surface, to use the addendum and this chapter as an extended course on observing. This is especially valuable for observers in areas where clear night skies are rare or there is heavy light pollution, yet the moon is often available to observe.

THE OBSERVING SHEET

We have mentioned a sketch sheet or an observing sheet for night observations a few times. An observing sheet should be set up in its basic form if there is a planned observing period and a known

object to observe. If a sketch opportunity is unexpected and there is no time to set up a sheet, the observer must still record some notes following the recording session so they can be added to sketch of the object later. It is the combination of the sketch of the object and the applied notes that make an observing sheet.

If observing the heavens was pure art, then a sketch of an object with initials would be sufficient. Astronomical observing, however, is both an exercise in careful observation—dependent on critical factors that must be included—and an interpretation of a scene by using basic sketching techniques. Scientific or other professional observation methods are similar. They also require more information than just a sketch. They often contain notes, time, date, conditions of the observation, and author data. Therefore, for this course we will institute a common form for an observing sheet that includes these factors. Depending on local needs or teacher requirements, the place and arrangement of information might vary, but the elements are typically common. The minimum elements are described below.

--Name of the observer. For students, the class or level should be identified.

--Date and time of the observation. This can be local time but must be specified by time zone or the date/time can be converted to GMT, which is universally understood.

--Place of the observation. For lunar observation, this would be a local name of a sea, crater, or identifying geographic feature. For other sky objects, this would be the name of the object or its identifier in a common star atlas.

--Instruments used to help make the observation (unaided eye, or binoculars (list magnification and size aperture) or telescope (type, aperture size, mount, and eyepieces used)

--Local sky conditions (clear, haze, light clouds, etc.).

--Title (like a title of a book or simply the name of the object or region being sketched).

--A pertinent scripture with (if desired) a note or comment by the author. This can be added later after the observing is complete and the student has opportunity to consider what has been observed.

The last element is included because the course is Astronomical Observing with a Biblical view. It is the final touch by the author to indicate that the observer as stood back and looked at the observing time and the sketch, having considered them in light of one or more scripture references that deal with the heavens. An author comment is also encouraged but it is an optional element. While a comment may not seem important, others who look at the observing record usually enjoy the author's comment. A comment often indicates the author's interest, attitude, or personal emphasis, which makes the observing period unique.

An example of a completed observing sheet is shown on the next illustration, although a few elements are omitted for clarity. (Local time, the equipment used, and sky conditions are omitted.) A brief author comment is included, but some teachers and authors like to have comments placed on a separate page, or even made into a report. In real conditions of recording/observing, the observing sheet is usually


made up at the time. We will use the same basic form that you see below for the remainder of the lessons.

ASTRONOMICAL OBSERVING FORM
Example

Observer: New student Date/time: September 23, 2008 Place: Crozet, Virginia USA

Equipment: Unaided eye sketching from a poor resolution picture

Title and/or Object: Madler (a crater to the east of Theophilus)



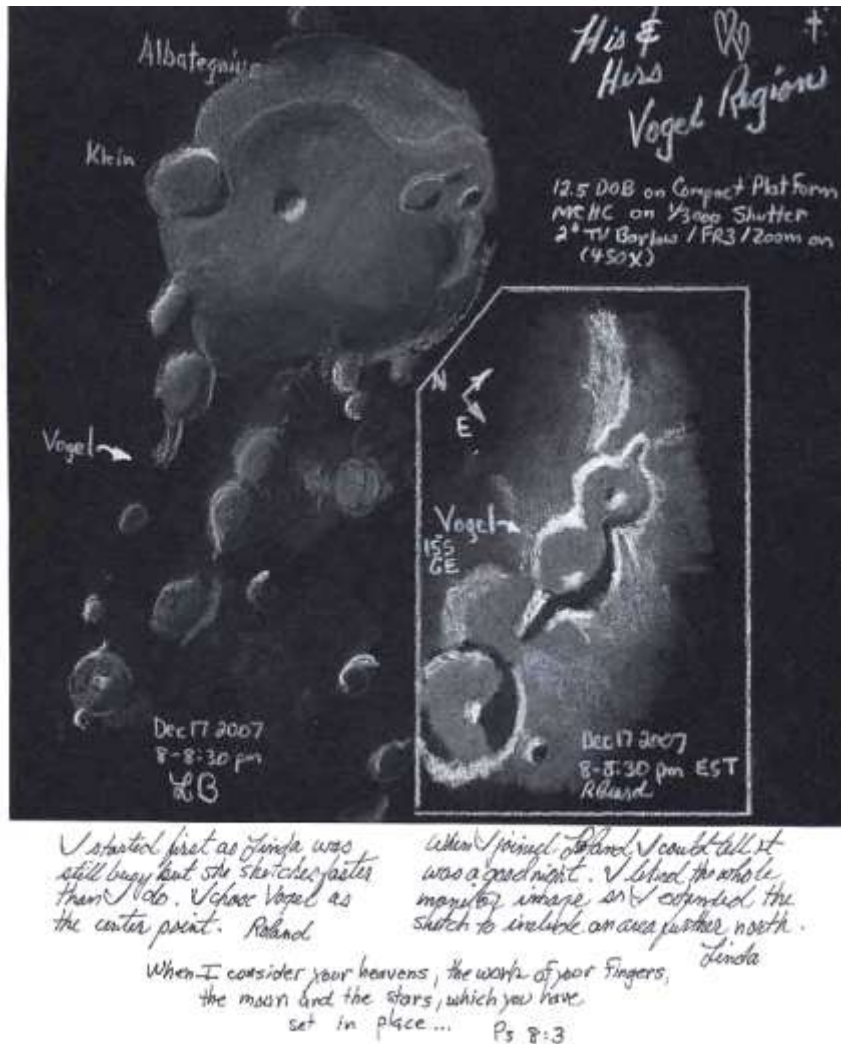
Scripture Reference and Author Note: Psalm 148:1,3a Praise the Lord.....Praise him sun and moon... These scriptures show the psalmist giving praise to God by making note of the things God has created, which includes the moon. In a sense, the things God has created point to himself, who is worthy of praise.

There is some helpful text information that can be added, such as compass directions (see the example below) and names of parts of objects/craters. In regard to compass directions, care must be taken to make sure that the directions are correct since the telescope optics can reverse the directions that are seen through the eyepiece. For moon observing, it is helpful to have a moon map handy during the observing period. There is a simple one in the Chandler Binocular Guide for sketches using binoculars or eyes alone. A more detailed map is helpful when a telescope is employed.

The example on the next page shows an observation report that has the required elements but they are not placed on a common form. You will note that it is a combined report, where two people have sketched the same object. Both sketches are shown and each sketch shows either a signature or initials. While the form is different, you will find most of the elements for an observing sheet are present. The illustration contains a title, date, time, equipment used, author notes, and a scripture. The only element that is missing is sky conditions during the observations. The sketchers have also labeled the moon craters on the sketches, which is a nice addition. Since both sketches are oriented the same, orientation is only shown on one sketch (the inset sketch).

Note for teachers: While an example observing sheet form is provided at the end of the course, it can easily be varied in terms of size, font, language, or arrangement of elements. In the end, the objective is to have students use a common layout and structure to help them remember important facts to record. As students become practiced, the form can easily be modified or not used at all if including the required elements is part of the student's memory task. An observing form can also be connected to a larger

report on the whole observing session. In this case, the observing form becomes the key attachment. **Use Addendum 4 for more detail and a sample form.**



Do not be surprised if abilities to observe and sketch the moon improve rapidly. Application of basic sketching skills (Lesson 5) and a little observing practice is all that is needed for lunar observations to improve quickly. These same methods have been taught to little children and the elderly successfully. We have seen it happen! You can do it!

Exercises have been completed that have introduced outlining, shading, and blending. These skills are the central part of sketching lunar terrain. Although examples are partially helpful (some have been provided), real progress in lunar observing skills is attained by doing it. It is common for a new observer to look through a binoculars or a scope at the moon and wonder how to start. Once the eye is trained to see detail, the amount of detail can seem overwhelming. The solution is practical: choose a limited target area or scene, make outlines of the prominent features you want to draw, and begin identifying light/dark areas. These are a summary of the same steps laid out earlier in the lesson. The principles for recording are the same whether an observer is sketching the whole moon or one crater.

As the sketch progresses, it is not uncommon to get disoriented, where an observer gets lost while trying to add details and features. This problem is lessened by identifying key or prominent landmarks in the scene and remembering them. As an observer goes back and forth from observing to the observing sheet, the landmarks will act as reference points. Then orientation (where you are) will be regained quickly if you get lost.

Another difficulty is not seeing the relief (or the highs and lows) on the sketch. A student may look in the binoculars or telescope and see the relief, but it does not seem to be developing on the sketch. Have the student hold to the procedures for developing a sketch (near the beginning of this lesson). The relief does become more obvious as the observing and sketching steps are followed.

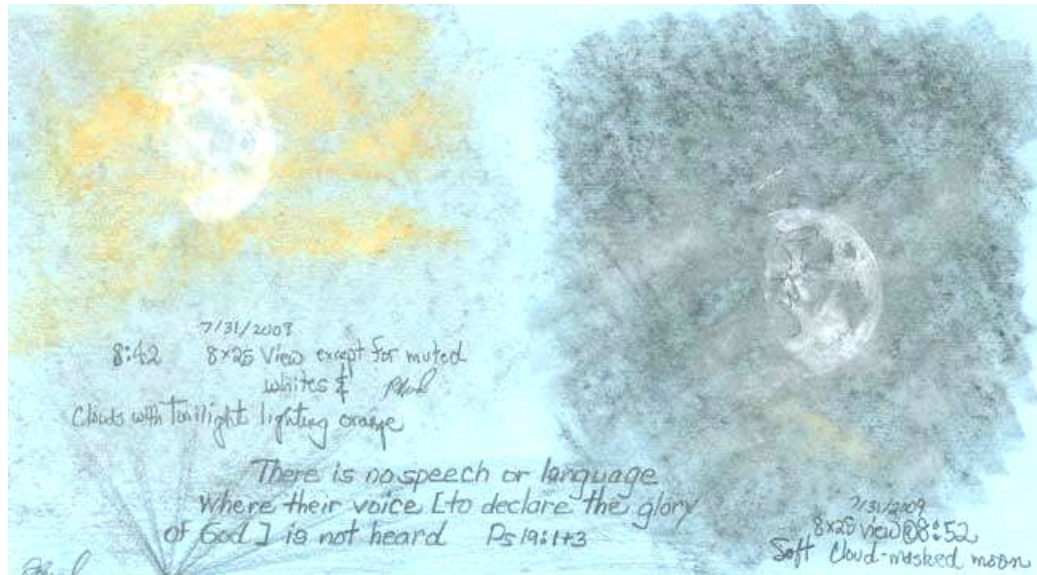
Do not be surprised that as a sketch progresses that more detail seems to appear. The discipline of sketching causes observing to get better. As you see more and draw more, more detail seems to appear. It is very common for non-sketchers to see an observer's sketch and wonder how that much detail can be seen. We encourage new observers to observe a object repeatedly because we know what they are able to see will continue to expand and improve.

Lunar observation and sketching in the daytime should not be underestimated. Several things make daytime observing profitable. First, you can see easily. Struggling to find the focus knob or paper or pencils does not occur in the daytime. Second, the moon is often framed by a late afternoon or early morning sky color that can be captured if you have colored pencils. Color is a completely different dimension that can be added to sketching a lunar scene. Third, the moon is also frequently framed by local landmarks, trees, flowers, or animal life that can also be sketched with the observation of the moon. There is one disadvantage to daytime sketching of the moon: contrast is low. So detail of craters or seas becomes much more difficult but there is still a wealth of observing that can be done under these conditions. If the sky is clear and the moon phase is right, daytime observing is highly recommended. Take care, however. DO NOT face the telescope or binocular toward the sun. This is very dangerous and can cause immediate and permanent eye damage in addition to destroying the optics of the instrument. For this reason, never leave the telescope or binoculars unattended around little children, who may not understand the danger.

The next page shows a daytime lunar observation to illustrate what can be done with binoculars or small telescope during the daytime. The original observations are in color and done with pastels but they could have easily been done and would be beautiful in black and white. God has provided every locale with terrestrial (earth) scenes that are significant, so a binocular view can permit inclusion of terrain, plants, flowers that might be in the field of view. Telescope views tend to have less contrast than the same views at night, but the scenes are still beautiful.

As a final note, when observing the moon the observer should note different types of terrain. Craters typically get attention, but there are also mountains, chasms, rifts, lines that look like ditches that are scraped over the lunar surface. As observing skills improve, different features will begin to become more

obvious. With a simple moon map many of these things can be identified and then sought during an observing session. Enjoy the discovery!



EXERCISES

9-D1 EXERCISE: OBSERVING SHEET EXERCISE

Using the lesson, the student should construct an observing sheet by using the sketch of a classroom object or object outside as a subject. Ensure all elements of an observation sheet are included. Writing should be neat and clear. Sketching can be a quick outline of an object with shading to show the light direction and effects.

9-D2 EXERCISE: A MOON CRATER EXERCISE

Using a moon crater picture or moon map as a reference, the student should choose a large crater as the subject. After a brief study of the crater, the student should reconstruct the crater with mud, clay, or plaster on a small piece of wood or ground. It does not have to be perfect; this is a learning exercise. Using the natural light in the early morning or late afternoon (when the sun angle is low) to sketch the homemade crater. Go through the same steps: outline the whole object, refine the outline for light and dark areas and label them lightly, shade the darker areas or shadowed areas, leave the brighter areas with lighter marks or no marks, etc. Put the sketch on an observing sheet that has been prepared for the exercise.

The same exercise is more effective in the dark. Once the model of the crater is made, take it to a darkened room. Use a candle or flashlight to go from one side of the crater to overhead to the other side of the crater. Note how the shadows change on the crater. Then fix the light in one position and draw the crater on an observing sheet. This is an excellent practical exercise to understand why changing sun position affects the appearance of things on the moon.

9-N1 EXERCISE: MOON CRATER EXERCISE AT NIGHT

The teacher will choose an object on the moon (major crater or “sea”) and ask the student to sketch it. Either a binocular or a telescope can be used. This is a sketching exercise but make an observing sheet so the sketch is placed on the observing sheet. If the weather is not good for observing the moon, the teacher can select a crater on a moon map for the students to model with clay or mud. Once the model is constructed, a light can be placed at some angle so the crater shows shadows. Sketch the crater using the proper steps.

9-N2 EXERCISE: OBSERVING SHEET FOR A CRATER

The teacher can select another lunar target to be sketched or the previous sketch can be used for this exercise. Place the chosen sketch on another observing sheet or add information to the top and bottom of the sketch to make a complete observing sheet. Make sure that all pertinent information is included. As a last step, the students can choose a pertinent scripture about the moon and include it at the bottom of the observing sheet. The student can also be encouraged to comment on the observing and sketching period. Be prepared to discuss students’ sketches at the next class.

AOBV Lesson 10: Observing Sky Objects and Using an Observing Sheet—Part I

Materials: paper and pencil Instruments: planisphere, small binoculars or telescope kit, red light

Reference: Hebrews 1:2-3

Sky Object: Moon by Day

REFERENCE SCRIPTURE

Hebrews 1:2-3 states that Jesus Christ is the author, creator, and sustainer of the heavens. The words and meaning are similar to several other scriptures. The two concepts of creating (in verse 2) and sustaining (in verse 3) are both essential. Creation may be more obvious since the act of God, as described in Genesis 1, brought things into being by His word. More than that, however, the universe is designed with a precision and balance: energy, forces and processes that appear to be permanent, yet they demand a sustaining. Some have described the universe as being “wound up” like a clock. Verse 3 could be summarized to say this, “While God created the heavens, their continued existence is not independent of His sustaining hand. If His sustaining hand was removed, they would vanish.”

As stated in Job, the heavens run or operate by a series of laws. Man’s understanding of those laws is very limited. A few have been characterized but many remain unfathomable. But the laws themselves are created and put in place well before our discovery of them. In a sense, this complex system makes discovery exciting as we and many other people seek to understand parts of the universe as well as the laws that are part of its operating system, but do not forget that the both the expanse of the universe and the laws that are apparent still require His sustaining hand.

Both verses also remind us that the universe is finite. It is what is called a “bounded system.” It has limits. While we cannot detect them, the scripture is clear: God is eternal and boundless—not the universe, which He created. The universe, in other words, is like a created masterpiece in which we are placed, but He is the Artist and holds it all in His hand. This makes observing interesting because we have opportunity to discover some of its detail, knowing that it also points to the One who made it.

SKY OBJECT

The moon by day is not a popular object in the sky for most amateur observers. However, observing in the day can be rewarding because the moon can still be studied but with the frame or context of a blue sky, clouds, and terrestrial objects. (This is mentioned near the end of the last lesson.) A good percentage of the authors’ observing and sketching of the moon have been done during daylight or near sunrise and sunset. If students and teachers read and understand AOBV Addendum 2: Moon Observing, it will make scheduling moon observing by day much easier, because you can understand more clearly when and where the moon is likely to be visible during daylight hours.

The next figure shows one part of a sketch and observing sheet that was done at midday. The observer sat under a “butterfly bush” that was in bloom as the moon was observed near midday. As the sketch



took shape, the contrail of a jet was seen and recorded. You can see that observing by day can be very interesting as the student can record actual terrestrial details and use color in the observation.

WHAT HAS BEEN LEARNED

At this point, the basic introduction of sky observing tools and methods of observation have been completed. The observing sheet has been introduced and practiced. The first sketch of the moon on an observing sheet should have been completed. Every class from this point is an observing session using the same tools and techniques that have been taught. The only

variation is the subject matter that will be chosen for observation. Each observing session, as mentioned earlier, is unique with respect to what can be seen, expected sky conditions, and the choice of optics (binoculars, telescopes, or eyes alone). Class exercises for this and the remaining lessons need to be held during night hours (at least an hour after sunset or an hour before sunrise).

WHERE WE ARE GOING

The remaining lessons are designed to give the student orientation recording observations on select types of deep sky targets that are viewable with a binocular or small telescope. As the targets are assigned and observed, the tasks of setting up equipment, using the equipment correctly, making a complete observing sheet, and disassembling equipment should become more habitual. As these procedures become practiced, the tools become less of an issue and observing the beauty of the heavens becomes the primary focus. But it is important not to be lax in procedures and use of equipment, because it is easy to break equipment or use it improperly. The result can be a ruined observing session. In essence, good disciplined observing makes the most of an opportunity to see the heavens, but an essential part of this process is care and proper use of equipment.

By the end of all the lessons, the new observer should be able to conduct a full observing session, which includes both the use of equipment and the observation of an object.

A NOTE ABOUT THE EXERCISES FOR THIS LESSON

This lesson's exercises are oriented to a big picture of a section of the sky. Knowing that the eyes are the most important tool for observing will be tested as the teacher will assign the new observer a section of the sky to study and map with eyes alone. With this accomplished, the observer could observe an object within that section of sky in confidence that the context around the object is identified.

Observing a section of sky is a key step in observing particular sky objects because an observer must find the object by recognizing the pattern of stars around it. While an observer might not record the constellation or local star field on the same night a particular object is observed, he will certainly have used that larger context of the local sky to find it.

NOTE TO TEACHERS

Scheduling observing, which requires some reasonable sky conditions, is frequently a challenge. There are alternatives if the weather is not suitable. First, a small picture of an object can be set in a dimly lit room at least 10 meters from the student observer. The lack of good light and the distance from the object are a reasonably replication of conditions at night. The light conditions should be such that the student must use a small red flashlight or very small light in order to see the paper upon which he will record what he can see of the object. For this alternative, the students can use their eyes alone or they can be assigned small set of binoculars to use, depending on the size of the picture and the type of object. While this kind of session has value, it is not a complete substitute for real night conditions under the stars.

Selecting targets is dependent on the month of the year and the latitude of the observer. Remember that the planisphere shows the dominant constellations for a selected time of darkness and a small star atlas will often show objects that are the brightest within the region of those constellations. For teachers who are relatively new to observing, test the selected object by observing it yourselves so you know it can be seen during the time period in the evening you expect students to observe. As you have learned, a time change for a couple hours does not make that much difference as long as the object that is selected is not too close to the horizon.

EXERCISES

10-D1 OBSERVING REVIEW

This exercise is small group or class exercise. The students tell each other and/or the teacher the procedures, general rules, and methods of observing. Describe an observing sheet. Describe the procedures for sketching a lunar object.

10-N1 SKY MAP SKETCH EXERCISE

The teacher can select an appropriate constellation or part of a constellation or an area around a major star to map. The objective is to have an observing sheet prepared, to use eyes, a binocular, or a telescope to study the area, and to sketch the major star field on the observing sheet. This is opportunity to practice identifying shapes among the stars to help identify their placement relative to each other. It is also opportunity for the observer to practice judging the differences in the apparent magnitude of the stars by changing the size of the 'dot' that is recorded on the observing sheet. Ensure that an appropriate scripture and comment is included on the observing sheet.

10-N2 SKY OBJECT SKETCH EXERCISE

The teacher should select a bright deep sky object to study. A sketch of the object with its immediate surrounding star field should be included on the observing sheet. It would be ideal for the object to be selected in the same area that the previous exercise was assigned, but it is not a requirement. A

binoculars or telescope should be used for this exercise. A complete observing sheet should be turned in at the conclusion of the observing period but allow enough time for the observer to consider what has been observed, select as appropriate scripture, and comment on the observing sheet. Comparing and discussing what the students have done will be helpful.

AOBV Lesson 11: Observing Sky Objects and Using and Observing Sheet—Part II

Materials: paper and pencil Instruments: planisphere, small binoculars or telescope kit, red light

Reference: 1 Corinthians 15:40-41

Sky Object: The Milky Way

REFERENCE SCRIPTURE

Each sky object has a splendor all its own. Observing objects tends to accent the splendor to the observer but the scripture speaks the same thing. The verse mentions that each of the following has their own designed and created splendor: the sun, moon, stars, and each star. New observers understandably get excited when they first see the differences among stars and objects. Studying and sketching is very fitting because the observer records the impressions of the objects in their natural splendor in the heavens. The verse echoes the same point made in dozens of references in other sections of the Bible. Together these references form an inseparable foundation that points to the wonder of our God, who created and sustains what we are observing.

SKY OBJECT

The Milky Way is our galaxy, which is a beautiful sight at night. We are unable to see the spiral arms very well from our interior vantage point because we are within the plane of the arms and about two thirds of the radius away from the region of the nucleus. Our view is nonetheless unique since we see objects very well in our own stellar “neighborhood.” Our view of the Milky Way is a large ribbon of denser stars.



The area also includes most of the sky objects that we can readily see with small instruments. The galactic center is an exciting area to observe because of the number of objects that we can see in that vicinity. Since the nucleus region is in the southern part of the celestial sphere, south latitude observers see the region very well and high in the sky. From Northern latitudes, other sections are more readily seen, although the galactic center area can be observed in the middle to late summer in the early evening.

The Milky Way is an easy but hard object to observe with eyes alone. It is easy because its width and length in our sky is noticeable on a reasonably dark night, unless light pollution from cities blocks the view. It is also hard, because the boundaries are not definite and it is so large. Telescopes

are of little use to see its expanse. The myriad of stars makes recording the Milky Way a daunting challenge for someone accustomed to precision observation. Nevertheless, it is a most beautiful object to observe. On the left is part of a sketch by Rick Angell [used with permission], who had never attempted a wide field sketch before. It is very good first-sketch for an observer. Notice that he captures

the Milky Way as it intersects the local terrain. The image will be difficult to see on a printed page but easier to see on a computer monitor.

The sketch just below [used with permission] is an example from a more experienced sketcher.

Aaron Weiss studied the Milky Way for several hours and nights to capture his detail. It is an excellent



sketch that shows good placement of stars, differences in star magnitude, and the boundaries of light from the Milky Way. It may be hard to see on a printed page because the low contrast, but he captures the boundaries and dense areas very well.

Each observer of the Milky Way usually shares a common goal: sketch some of the beauty of our galaxy, which comprises our stellar “neighborhood.” We encourage every student to observe and sketch the Milky Way on several occasions. In addition to recording a beautiful object, the practice also sharpens skills to see differences in star densities in sections of the sky and to see the boundaries of when star densities indicate the approximate edges of the galaxy.

One way in which people judge the conditions of the night sky (whether they are suitable for precision observing) is to see how the Milky Way appears. There are specific numerical criteria for sky conditions that are based on how well the Milky Way can be seen. If it cannot be seen on a clear night, it is often an indication of a lot of light pollution from cities or poor atmospheric conditions.

THE OBSERVING FOR THIS LESSON

The objective of the observing for this lesson is to observe a nebula and a cluster (either an open cluster or a globular cluster). The teacher will make the appropriate assignment based on location and the time of the expected observing period. An observing sheet will be used to sketch both types of objects. If no instruments are available, then sketching a portion of the Milky Way is a very good alternative.

EXERCISES

11-D1 REVIEW OF TYPES OF OBJECTS

Types of deep sky objects can be discussed in terms of their visual appearance. Make note in the discussion the difference between pictures of an object from big telescopes and what can be observed with small telescopes. Cover the following: constellations, major stars, double stars, open cluster, globular clusters, nebula, galaxies, planets, and the moon. Using your memory of pictures that were seen in class or pictures of any of these types of objects, make at least two quick sketches of two types of objects as if you were going to explain what they looked like to your teacher.

11-N1 FIND & SKETCH A NEBULA

Using the Star Atlas map that is appropriate for the time of year and location of the class, choose a nebula that is bright. For December through April M42 (the Orion Nebula) is an excellent choice. For June to September, the area of Sagittarius has a number of choices. The Lagoon Nebula (M8) is the brightest choice. A binocular or telescope will be needed.

11-N2 FIND & SKETCH A CLUSTER

Using a planisphere and Star Atlas, find a globular cluster that is bright and have the students find and sketch the cluster and the immediately surrounding star field. There are many choices, and they can be observed and sketched with binocular or a telescope.

AOBV Lesson 12: Complete Observing Period—A Review

Materials: paper and pencil Instruments: planisphere, small binoculars or telescope kit, red light

Reference: Job 41:11 & Acts 17:24

Sky Object: Earth

REFERENCE SCRIPTURE

These two scriptures, recorded centuries apart, point to the owner of the heavens: God. They both underline that the heavens are a created thing. They were never designed or intended as objects of worship, because they are created by God, who does not live in an object or a place as we understand a physical place. Rather, He is Spirit and we are His offspring. As unbelievable as it might be for someone to realize that God intended to create each of us, that is what He has done. His attention to each star (its creation, placement, and name--according to Psalm 147:4) is a picture of His individual attention.

The section in Acts is during a speech by a follower of God, Paul. He explains that God, who seems unknown to his audience, is not intending to be unknown. Rather, God wants them to seek him. Observing the stars is one way in which we can become acquainted with his works as we see and observe what He has created in its magnificent detail. But, one must remember, God's intention is for the stars to be a signpost to Him. As the verses explain, opportunity is given to each person to reach out to Him.

SKY OBJECT: EARTH

The fact that we can comfortably and relatively accurately make observations of the heavens from our privileged planet is nothing short of amazing. Students are encouraged to review some of the pictures of earth that have been taken during manned space travel flights. The pictures are well known, but are too often not considered more seriously. What do they show? Our incredible planet's most unique features like water and atmosphere are striking and dominate most of the images. The features underline God's intent that the planet be inhabited, and yet he points us to the heavens as well. Our protective atmosphere is also usually transparent, which permits observing of night skies.

REVIEW LESSON

This lesson will serve as a review. The instructor will review the principles and objectives of the lessons. Some student night observing is recommended following the classroom review, since it will reinforce the equipment and observing/sketching skills that have been learned. The review is opportunity to see what has been learned, what areas need strengthening, and to do any review exercises under controlled conditions (enough light and plenty of time).

As a practice for the exam the instructor can set up an observing session with small teams of students. If an actual observing session is not possible, the teacher can choose a picture of an object and students

will observe it—as if they were looking through a telescope. If the students help each other in a practice session like this, it will rapidly reinforce what they have learned.

This is a good time to review previous exercises if students are weak in some of their observing practices, or have students show and tell about equipment and observing aids they have learned to use.

There is a suggested grading criterion that is included in the FINAL EXAM file. It can also be used as a review tool.

EXERCISES

12-D1 DRY RUN EXAM

Using real equipment, make an observation sheet using the picture of an object at a distance in a reasonably dark room or, if outside, put the picture of the object in the shade at some distance away from the students. Observe the students set up equipment, set up an observing sheet and sketch the object, properly dismantle, and store the equipment. Exchange the observing sheets and have the student or the teams evaluate them for completeness and accuracy.

After or before the observing, have a group discussion to cover the following example questions as a review of the course:

What object in the sky should you never look at directly with your eyes? Why?

Review the major points found in Psalm 19:1-6, Genesis 1:14-19, and Hebrews 1:2-3

Define the following terms: zenith, horizon, cardinal directions, and elevation

What is a planisphere and demonstrate how to use it. Show how to find the major constellations and here they are using the planisphere set for January 15 at 8 pm.

Explain dark adaptation for your eyes. Explain averted vision.

Explain how to measure angles with your hands, arms, and fingers.

What is star hopping?

Explain how to use sticks and stones to show star patterns.

Explain the value of sketching an object. Demonstrate shading and outlining as sketching techniques.

Explain and demonstrate outlining a crater on the moon. How can you tell the direction of the sun by looking at the lunar surface?

Explain some of the major types of star objects.

FINAL EXAM GUIDANCE

NOTES FOR THE FINAL EXAM – AN INDEPENDENT OBSERVING SESSION

Materials: paper and pencil, planisphere, small binoculars or telescope kit, red light

Reference: to be chosen by the student and placed on the observing sheet

Sky Object: to be assigned to find, observe, and record by using an observing sheet

INTRODUCTION

This exam is modeled after a typical observing session that could occur anywhere in the world. The student is expected to have paper, pencil, be assigned a small binocular or telescope kit, and have either a Bible or a small set of scriptures that pertain to the heavens. In the case of a sky object being a constellation or in the case where equipment is not available, then a binocular or telescope will not be needed.

Once the student has the equipment kit, a sky object can be assigned by the teacher. A student or a small team of students should prepare or layout the observing area, properly set up equipment, set the planisphere, find the object, observe the object, complete observing sheets (written elements, sketch of the object, scripture, and comment), break down the equipment properly, and turn-in both the equipment set and the observing sheet to the teacher. Each student turns in an observing sheet. While the largest part of the evaluation will come from grading the observation sheet, other aspects are also important, since the students will demonstrate correct use of aids and equipment.

GRADING CRITERIA FOR IMPORTANT ITEMS TO CHECK

The table that is below is a guide for evaluating students during the observing period but also includes a few elements that the teacher can ask during the observing session.

TEACHER GRADING CRITERIA	DESCRIPTION OF ITEMS TO CHECK	COMMENT & PERCENTAGES
Using hands and eyes	-knows angle measurements with hands and fingers -can orient themselves as to cardinal directions and use hands/eyes to locate objects (especially major constellations) -understands how the eyes adapt to night conditions	5 demonstrate or question
Star hopping and references	-given major stars in the field of view, can measure angles between them -given a star and a direction, can find other stars or a constellation -should be able to identify the use of a planisphere and (if covered) a star atlas for the object assigned	10 demonstrate and question
Using binoculars	-demonstrates how to adjust and focus binoculars on a sky object	10

TEACHER GRADING CRITERIA	DESCRIPTION OF ITEMS TO CHECK	COMMENT & PERCENTAGES
	-knows how to find an object with binoculars	demonstrate
Using telescopes	-demonstrates knowledge of the telescope parts and their assembly -understands the effects of different eyepieces on field of view and magnification -knows how to find an object with the telescope and its star finder	15 demonstrate
Types of sky objects	-can identify significant sky objects: major stars and differences; star clusters, nebula, and planets -can explain moon appearance and as a general idea when the next lunar cycle starts; can explain the lunar cycle in terms of an observer	5 question and demonstrate
Observing sheet: (recording and sketching the assigned sky object)	-observation sheet shows basic star field or dominant moon features (if a moon subject is selected) such that the basic layout of the star field or moon features are represented properly (correct shape and magnitude in the field of view) -If nebula or a moon features are observed, basic outline and shading techniques should be reasonable for the experience and age of the observer. Significant features of the object are included in the sketch	25 demonstrate
Observing sheet (elements and layout)	-all elements of the observing sheet are included (name, class, place/time/weather conditions for observation, object name, scripture, author comment, and any other notes that the teacher requests -overall layout, clarity, and neatness	20 demonstrate
Safety rule #1 and important procedures	-observer should be able to identify the #1 rule: never look at the sun directly or look close to it -observer should be able to explain and demonstrate how to touch, use, focus, and move around a telescope to ensure that it is kept in good condition and not bumped or jarred	5 question rule#1; demonstrate and question remainder
Scripture principles	-observer has included a pertinent scripture that refers to the heavens and relates to the observation (one observing sheet) -observer has knowledge of at least 2 sections of scripture that explain the heavens. One of them should be Genesis 1:14-18 *	5 question and demonstrate

NOTES:

Students should be commended if the following things are observed:

Demonstrates ability to get around the sky or find objects and constellations without help but is also able to help others do the same thing.

Shows overall above average ability to handle equipment correctly but also is able to assist others develop the same practices. This includes making good decisions in regard to setting up an observing area and identifying celestial cardinal directions at the outset of a session.

Demonstrates an above average ability to layout star positions and magnitude with accuracy using eyes, a binocular, and a telescope. The evidence of this will be good observing sheets for different kinds of objects. And, is able to show or help other students who are having difficulty mastering the same techniques.

WHAT TO DO IF THE SKIES ARE NOT CLEAR:

If an observing session for the exam is scheduled and the skies are not clear, rescheduling is best. However, there are cases where rescheduling is not possible. An observing session can still be held. First, the students can still demonstrate the proper use of equipment and answer any of the categories listed in the table (above). Second, instead of viewing an object with eyes, a binocular, or a telescope, the teacher can post or hang a picture of a sky object on a wall. It is best to do this in a dimly lighted room with a small picture of the object at least 15 feet away from the students. The distance of the picture and the low lighting will cause the student observers to work at paying attention to detail in order to develop their observing sheet – as if they were using an instrument.

ORAL QUESTIONS and ANSWERS

Note: This is only a guide for trainers certifying other trainees but it can be used for a study guide. The questions and answers address most of the key points in AOBV, but many others could be asked. Other questions are also listed at the end of Lesson 12. We used the items below as a test guide when conducting verbal tests in the Philippines, where we trained teachers to teach the course to others. This part of the test acted as an introduction before we required trainees to demonstrate proper use of a binocular followed by the assembly of a refractor, alignment of a finder scope with the main telescope, and finding a sky object.

SHOW ME THE HAND AND FINGER POSITIONS FOR USE IN STAR HOPPING (TO MEASURE ANGLES IN THE SKY).

TELL ME THE NUMBER OF DEGREES EACH ONE OF THEM REPRESENTS IN THE SKY.

WHAT IS THE IMAGINARY CENTER LINE AROUND THE EARTH'S MIDDLE CALLED? Answer: equator

WHAT IS THAT SAME LINE CALLED WHEN IT IS EXTENDED TO OUTER SPACE? Answer: celestial equator

WHAT DOES "DEC" STAND FOR? Answer: declination

EXPLAIN AND SHOW "DECLINATION".

WHAT DOES RA STAND FOR? Answer: right ascension

EXPLAIN AND SHOW "RIGHT ASCENSION".

SHOW ME THE COMMON ANGLES YOU NEED TO KNOW TO TEACH THIS CLASS AND DEMONSTRATE WHAT THEY MEAN WITH ARM POSITIONS. Answer: demonstrate a circle, half circle, quarter circle, 1/8 circle or 360, 180, 90, and 45 degrees, respectively. Demonstrate 30, 60, and 90 degrees

WHAT DOES "APPARENT" MEAN IN THIS CLASS WITH RESPECT TO APPARENT MAGNITUDE OF STARS, IN CONTRAST TO TRUE MAGNITUDE OR SIZE.

TELL ME HOW TO USE A PLANISPHERE AND DEMONSTRATE AN EXAMPLE.

TELL ME HOW TO USE A STAR ATLAS?

DEMONSTRATE HOW THE PLANISPHERE AND THE STAR ATLAS WORK TOGETHER. USE AN EXAMPLE TO SHOW ME.

WHAT IS A CONSTELLATION?

WHAT IS THE ECLIPTIC? WHAT IS THE ZODIAC?

EXPLAIN HORIZON AND ZENITH.

EXPLAIN ALTITUDE AND ELEVATION

EXPLAIN AZIMUTH.

WHAT IS PERIPHERAL VISION?

WHAT IS AVERTED VISION?

WHAT IS A COMPASS ROSE?

EXPLAIN THE TWO LEGENDS ON THE RIGHT AND LEFT UPPER SIDES MAP PAGES IN THE CHANDLER STAR ATLAS. (The legends show types of sky objects by symbol and levels of magnitude by the size of the dots that represent major stars.)

ADDENDUM 1
TABLE SUMMARY OF KEY SCRIPTURES REGARDING THE HEAVENS
(books are in alphabetical order and abbreviated)

Book	Ch	Vs	Key Words	Summary
Acts	17	24-25	God, made	Paul states God made all; Lord of heaven and earth
Amos	5	8	Lord, Pleiades, Orion	Ref to God making night/day and constellations (Pleiades & Orion)
Col	1	15-17	God, created, Christ	Christ, the image of God--through whom all things created
Cor 1	15	40-41	moon, stars, splendor	Stars, moon, and heavenly bodies each have a splendor from God
Dt	4	19	sun, stars, worship	Worship of sun, moon, stars forbidden; they are given for the nations
Ez	32	7-8	heavens, stars, darken	God declares he will darken the heavens; judgment against Pharaoh/Egypt
Gen	1	1-2	created, heavens, earth	God's opening statement of creation
Gen	1	14-19	lights, stars	Foundation verses for creation of universe
Gen	2	1,4	heavens	God's reference to creation of the heavens
Heb	1	2-3	God, Son, created, sustain	God made the universe through the Son; the Son sustains all things
Heb	11	3	God, universe, formed	By faith we understand: universe formed by God's command
Is	13	9-10	stars, sun, light	Day of the Lord: when stars/sun will not give their light
Is	40	12,22	heavens starry host	God made and measured the heavens; named every star one by one
Is	40	26,28	heavenly host, name	Clear reference: God created heavens (stars), named each one; created earth
Is	42	5-9	heavens earth	Exact quote from God; created heavens and earth; gives breath and life to men
Is	44	24	heavens earth	Very similar to Is 40 quote
Is	45	7,12	heavens earth light darkness	God repeats what is said in Genesis; heavens, earth, light, darkness, men created
Jer	31	37	heavens, searched	Heavens are unsearchable in their extent; if they were, God would reject Is.
Jer	32	17	heavens, earth, made	God's greatness expressed in that he made the heavens and earth
Jer	33	3	earth created	Lord's opening address: He made, formed, established the earth
Jn	1	1-3	Beginning, Word	Jesus=Word; all things created through him
Job	9	8-9	He, heavens	Ref to God making heavens and ref to Bear, Orion, Pleiades, S constellations
Job	26	9	moon, clouds	God refers to ordering a cloud covering over the moon
Job	31	26-28	sun, moon	Ref to God's command by Job not to worship the sun or moon
Job	38	12-14	I, takes shape	God refers to ordering sun/earth motion and creating the earth
Job	38	32-33	sun, constellations	God's question: can you operate the heavens and know its laws
Job	38	37-38	earth	God refers to ordering rain/clouds and giving earth consistency
Job	41	11	heaven, belongs	Ownership: everything under heaven belongs to me (God)
Ki 2	19	15	heaven, earth, made	Hezekiah's proclamation: God made heavens and earth
Ki 2	23	4-5	sun, moon, stars	Removal and judgment against worshipping the heavens
Mt	24	35	pass away, heavens	Famous reference to heavens passing away but his word does not
Neh	9	6	starry, host, heavens	Worship the Lord who made all things
Pet 2	3	3-13	day Lord creation	Wonderful reference to day of the Lord, scoffers, how we should live
Pr	3	19-20	wisdom, earth, heaven	By wisdom God laid earth's foundations and set the heavens in place
Pr	8	22-31	beginning, world, heavens	Clear description of Wisdom (Christ) with God before and during creation
Ps	8	3-4	heavens, moon, stars	Considering God's work in the heavens, who are we that he cares for us?

Book	Ch	Vs	Key Words	Summary
Ps	19	1-6	heavens, glory, God	Heavens declare the glory of God to everyone at all times
Ps	33	8-9	Lord, earth	Let all earth fear Lord; he commanded & earth came to be/stood firm
Ps	50	4-6	heavens, earth, judgment	God, the judge, summons the heaven, earth, and his "consecrated" ones
Ps	74	16-17	sun, moon, earth	God's ownership of day, night, moon, earth, and seasons proclaimed
Ps	102	25-26	heavens, earth, God	Both are the work of his hands; they will perish/wear out but he does not
Ps	104	2,5,19-23	moon, sun, seasons	God is the author of planet/sun motion and night/day that marks time
Ps	146	5-6	Maker, heaven, earth	God is Maker of heaven/earth and all that is in them
Ps	147	4	stars, name	God determines the number of stars and calls them each by name
Ps	148	1-5	praise, sun, moon, stars	Emphatic statements: praise Him for sun, moon, stars, and heavens
Ps	150	1	praise, heavens	Praise him in his mighty heavens
Rom	1	20	creation, God, made	Since creation, God's qualities are revealed by what he has created
Zeph	1	4-5	starry, host, worship	Admonition to NOT worship the heavens

Notes:

1. The references are not exhaustive but do contain the majority of significant scriptures that relate to the physical universe: the stars, moon, earth (with respect to the heavens or creation), constellations, and sun. They also include direct and indirect references to precise placement and intended motion of earth/sun/moon.
2. Key words and the summaries are written by the authors as a handy reference tool; they are not infallible.
3. The references for the heavens are throughout scriptures, including the major/minor prophets, early books, and New Testament books. The common words and placement in a wide variety of locations make them unmistakably marked by the authority of God. They comprise a common thread—emphasizing God's handiwork in the universe's creation and continuance. The juxtaposition of key scriptures near statements about Jesus Christ and God's care or oversight in the affairs of mankind are not accidents; they strongly portray a theme: that we are responsible for our belief or disbelief that He has made and sustains all things.
4. A parallel set of scriptures about the earth is resident in another file that is obtainable on request. Since God's authority is the starting point for knowledge in a Biblical world view, details of his creation as referenced in the scripture can be a wonderful context for the study of water, the water cycle, weather, vegetation, animals, birds, and many other subjects that are often mentioned.

Addendum 2

Moon Observing (Day and Night) During the Lunar Cycle

Hints and Helps for Teachers

“God made two great lights—the greater light to govern the day and the lesser light [the moon] to govern the night.” Genesis 1:16

Moon or lunar observing can be done during daylight hours (sometimes during school time), early evening, or near dawn—times when most people are still active. To take advantage of this, a teacher needs to become familiar with the relative motion of the moon in the sky and the phases of the moon. Formal astronomy instruction is not a requirement as long as a person is observant of the appearance and motion of the moon. The guidelines that are described below provide enough detail to understand the lunar cycle, know how to set a schedule for likely times to observe, and observe successfully. (The AOBV curriculum provides the background for observing principles, which include recording observations with an observation sheet.) With a little practice, setting a schedule and teaching students to observe the moon is not hard. This addendum assumes the teacher is unfamiliar with the moon or lunar observing and may be briefly acquainted with the AOBV curriculum. The moon is a wonderful object to discover. We encourage you to start observing as you read through this material.

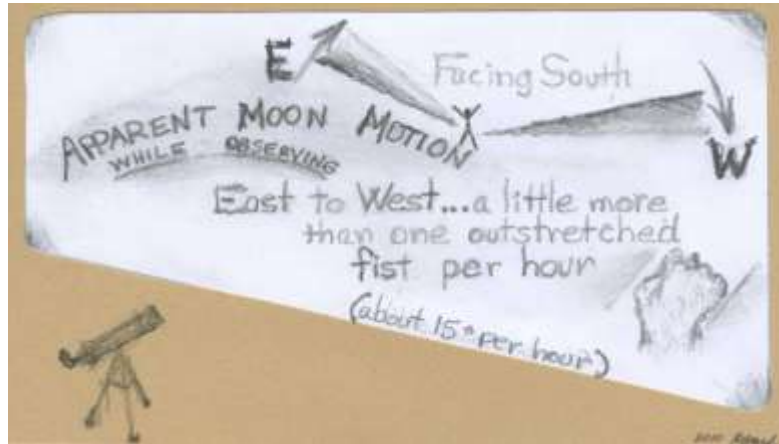
The Lunar Cycle and Measuring Moon Movement from Day to Day

Lunar motion and the moon’s appearance to an observer is a repeating cycle of 29.5 days (30 days if rounded off). It appears to rise in the east and set in the west. It is easiest for most people to remember when the moon is full, when the lunar disc is nearly a perfect circle. This occurs half way through the lunar cycle. From that day, count forward on a calendar 15 days. This will mark the approximate date of the next new moon, or the start of the next lunar cycle (Day 1). Because the lunar cycle is not precisely 30 days, the actual marking of new moon or full moon or any quarter may be slightly different on a calendar, but the suggested counting method is sufficient for teacher planning or setting up a personal or class observing schedule. All of our discussion is oriented toward this observable cycle.

Because of the relative motion of earth and moon, the moon changes position from one night to the next if one observes at the same time on both nights. The amount of the change is predictable and measurable in a simple way. For instance, if the moon is seen 40 degrees above the western horizon on Wednesday evening, Thursday evening at the same local time it will have moved eastward (a little higher). The distance is measured by angles (like other things in the heavens). The change from day to day is a little more than the width of one fist on an outstretched arm. In other words, the movement is a little more than 10 degrees. While not exact, this means that any teacher or student knows where the moon will be one or a few days in the future, which helps scheduling observing or choosing a spot to observe.

This angular change from one night to the next, assuming that both measurements are made at about the same local time, is also representative of the change the moon makes in one hour on a single night.

This can be understood quickly by direct observation, which is a good exercise for a student. If a person observes a full moon rise in the east at sunset, it can be seen setting in the west about dawn, having gone from east to west overnight. So, in one night, it moves about 180 degrees, or about 15 degrees per hour (see the figure below).

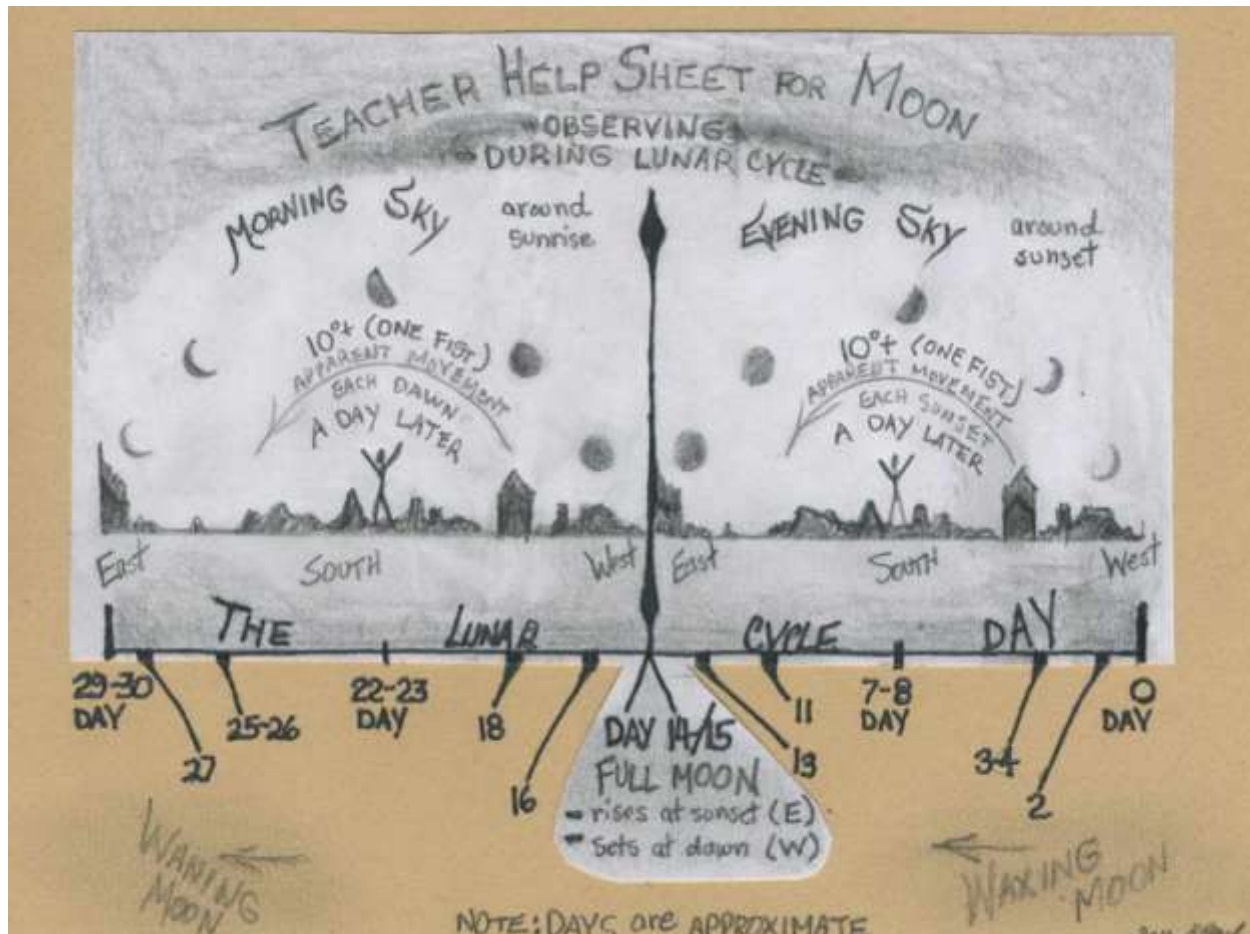


Estimating moon angular movement during an observing period is handy. For instance, if you see an early crescent moon about 30 degrees above the western horizon near sunset, then you know observing must occur within an hour or so before it gets too low in the sky to observe. A common reason for measuring moon movement is to help choose an observing spot that will not have interference from trees or buildings when you expect to observe. If obstacles are close, make sure the moon clears them to the west by a little over a “fist” to ensure you have about an hour to observe before having to move. Of course, as you teach the students you will have to remind them at first: it is not really the moon that moves, it is the earth’s rotation that causes the largest part of the change.

Moon Appearance and Quarters of the Lunar Cycle

Having a sense how the moon’s appearance changes during the lunar cycle is helpful when making a schedule for observing. There are two moon scenes that most people remember. The full moon is first, which we discussed as a way to predict the start of the next lunar cycle (15 days after full moon). An evening crescent moon is second, which looks like a thin sliver of light shortly after sunset and indicates an early part of the lunar cycle. A little less common scene for people, who are up early (around dawn) is a crescent moon in the east. Usually people are so busy in the morning they do not notice it. A morning crescent indicates the lunar cycle is near its end. While these scenes are notable, the day to day phase changes throughout the lunar cycle are fun to observe.

Let us look at the changes in moon appearance as represented in the figure below. The figure shows a time line (The Lunar Cycle Day) from Day 0 (on the right) to Day 29-30 (on the left). The figure always assumes an observer is facing south and it is divided into two sections. The right section is when the observer is looking south in the evening around sunset during the first half of the lunar cycle, when the moon is “waxing” or getting bigger. The left section is when the observer is looking south at sunrise (around dawn) during the second half of the lunar cycle, when the moon is “waning”, or getting smaller.



We already know that the moon always seems to move a little over 10° eastward from one day to the next. Let us start with the right part of the figure, which shows the first half of the lunar cycle. The observer is in the center. West would be on his right; east would be on his left. It shows the approximate shape of the moon and its angular position in the sky at sunset during five different days during the lunar cycle (they are labeled near the bottom: Day 2, 3-4, 7-8, 11, and 13). On Day 14/15, the observer would see full moon rise from the eastern horizon at local sunset. Let us assume the observer goes to bed after watching the moon rise in the east on Day 14/15.

Now shift attention to the left side of the figure. The same observer gets up just before dawn (almost time for sunrise) and goes to the same spot and looks south. The full moon is setting in the west after going from the eastern sky to the western sky while he was asleep the night before. Now the observer gets up every morning at dawn for the next two weeks. Each day the waning moon gets smaller; its position tracks eastward a little over “one outstretched fist” per day. The left side of the figure shows the approximate moon appearance for 5 particular days (Day 16, 18, 22-23, 25-26, and 27). Near the end of the lunar cycle the observer will be seeing a narrow crescent moon low in the eastern sky that that marks the coming end of the lunar cycle.

Note: when students are observing the moon and sketching what they see, it is not uncommon for them to face the crescent in the wrong direction. This is a good opportunity for teachers to explain the importance of being accurate but also an opportunity to explain how the sliver of the moon tells you the location of the sun. Of course, the outside curve of the crescent moon always faces the sun—the setting sun at the beginning of the lunar cycle and the rising sun at the end of the cycle as shown in the figure. If they are encouraged to think about this, they will understand moon appearance more quickly. Later, this will help them understand the importance of the direction of sunlight as it affects the lunar surface.

The following sections provide a brief description of observing opportunities in terms of the quarters of the lunar cycle. The comments are oriented toward teachers and students by presuming that most observing will be done during school hours, early evening, or in the morning before classes. Use the figure (above) for reference.

New Moon to 1st Quarter (Day 1 to 7-8)

The lunar cycle begins with the “new” moon on Day 1 but a new moon is rarely seen because it is a very thin crescent and is at the western horizon at sunset (very close to where the sun sets). Usually people start seeing the thin crescent on Day 2 or 3 when it is a little higher in the west a little thicker, and a little farther from the setting sun. The angle of the moon above the horizon (elevation) increases a little over 10 degrees every successive day and the crescent gets a little fatter each day. It is called a ‘waxing’ moon when the lighted disc gets larger. By day 7 or 8 the half disc of the moon (called a quarter moon for a quarter of the lunar cycle) is high overhead at sunset. From Day 2-3 to 7-8 the moon is easily observed around sunset. By late in the period (Day 7-8) it can also be observed in the late afternoon but also through the evening. The moon does not set until the middle of the night by the end of the period. Observing exercises as homework for early evening hours can easily be done for Day 4 and following since the moon is easily visible in the early evening hours.

For late afternoon observing, since the sun is above horizon, be sure to warn student observers not to look at the sun directly if it has not set since even a brief direct look at the sun can cause permanent eye damage. Looking at the sun through instruments is even more dangerous; damage is immediate and permanent.

1st Quarter to 2nd Quarter (Day 7-8 to 14-15 or Full Moon)

From Day 7-8 to Day 14-15 the waxing moon at sunset grows from one half of a lunar disc to a full moon, and it gets lower in the east each successive sunset. As full moon approaches, the moon gets lower in the east until full moon (Day 14-15), when it rises in the east as the sun sets in the west. Early evening observing is easy because the moon is bright and high at the beginning of the period. The full moon marks the point in the cycle when the moon is observable during the whole night.

Since the moon is rising in the east in the early afternoon about Day 8 and rises later each successive day, day time observing gets better as full moon gets closer. Day 11-13 are reasonable observing days as the angle of separation between the sun and moon are large and sun’s influence to brighten the sky

begins to lessen. On a clear and transparent day, the contrast between the sky and the moon can permit some nice observing of the near-full moon in the late afternoon.

2nd Quarter (Full Moon) to 3rd Quarter (Day 14-15 to 22-23)

From Day 14-15 (full moon) to Day 22-23 the moon is gradually getting smaller (waning) until $\frac{1}{2}$ of the disk is showing at the end of the period. The first few days of this period are often spectacular in two ways. First, the nearly-full moon rises in the eastern sky in the early evening hours (about an hour later each night). Mornings are equally beautiful as the moon is setting early in the morning at the beginning of the period and it gets higher in the west each successive sunrise.

Daytime viewing can be done in the mornings during the first part of the quarter since the moon is setting in the western sky—almost opposite the sun. However, it is difficult to see detail on the moon once the morning sun is higher than “3 fists” or a little over $30\text{--}40^\circ$ in elevation. This is because the bright sky reduces the contrast on the moon. Also, viewing must be done cautiously—taking care not to look at the sun directly since eye damage can occur. One way to take precautions for morning observing during this quarter is to observe on the west side of a building or line of trees, where the sun is blocked from view during the early to middle morning.

Night time viewing during this quarter is good but it requires being up late or before dawn since moon rise gets later and later each night.

Last Quarter

From Day 22-23 to the end of the cycle (Day 29-30) the moon is a crescent again and getting thinner. This period is very good for observing at or just before dawn. Care must be taken not to observe if any sun is showing since the angle between the sun and the moon is small. It is also a popular time to observe because Venus or occasionally other planets, especially if the moon is nearby. The moon is often not able to be observed near dawn during the last few days of the cycle because of its lack of brightness and closeness to the eastern horizon.

The Tools to Observe

Moon observing can be done with eyes alone, a binocular, or a telescope. Each method has advantages. When using optics (telescopes or binoculars), the area that receives the most attention is the boundary between lunar day (the bright part of the moon) and lunar night (the part that is also facing the earth but is not in sunlight). It is, in simple terms, the boundary of light and dark where the moon does not appear round. This border is called the terminator. The terminator region, which changes position each night on the lunar surface, has excellent contrast because of the low sun angle. The low sun angle highlights moon features. Eyes alone (no optical instrument) can detect the terminator region, but it takes a binocular or telescope to fully appreciate the improved contrast. On the other hand, the student can observe effectively with eyes alone, but the detail that is captured is different because the area viewed is much larger. Clouds in the sky or earth objects can be included in an observation using eyes alone. A binocular view falls between a wide view with the eyes and a very narrow view with a

telescope. We recommend that teachers not be hesitant to specify the method of observation you want students to use. Eventually have students try all three so they can discover the advantages and highlights of each one. Eyes can cover tens of degrees of a field of view; binoculars typically cover 4 to 6 degrees; telescopes cover less than a degree.

The moon is so bright during some nights that many observers use a moon filter to reduce some of the light. Daytime observing with polarized sunglasses or a polarizing filter on telescope or binocular optics can help darken the bright sky for the observer. Observers can use a single polarizing filter on a telescope to observe the planets and moon during the day when they are about 90 degrees east or west of the sun. For example, if it is noon, clear and transparent, if you take a single polarizing filter and face the east or west horizon and rotate it, you will be able to dramatically darken the blue sky. If you turn the filter on a rainbow you can make the rainbow disappear too. (Rainbows are invisible while wearing polarizing sunglasses.)

Background Knowledge for the Student

Background material presented with observing causes students to further appreciate the wonder of this created planetary body. God's purpose for the moon is primarily as a time piece (Genesis 1:14-16) in addition to light at night—both are discussed in AOBV. The precision of the moon's orbit, size, and mass all contribute to array of influences on earth that are fascinating to explore. Teachers can get students started by observing and fill in additional information as they observe. Examine geography texts that speak of ocean currents and tides to get an appreciation for the some of the more notable effects of the moon on earth. Examine the history of calendars or telling time to find how the moon plays a part in measuring time. Examine any basic astronomy reference to find discussions and pictures that explain sun, earth and moon relative motion that causes lunar and solar eclipses.

One thing to remember, which is frequently forgotten: observing is more than seeing something. Observing is seeing, interpreting, and recording what is seen with sketches and notes. It is easy to forget this premise by simply teaching the "seeing" part. AOBV teaches sketching what is seen as precisely as possible, using an observing form or sheet to record the scene. However, the observing sheet also includes a record of observing conditions, notes or comments by the observer, and a biblical reference to the moon with a comment. The aim is to have the student think about what has been observed.

It is important for teachers to have a measure of experience sketching an object and using an observing sheet themselves so students' work can be properly evaluated. In the excitement of sketching we have had many students turn in sketches with stars and make believe earth scenes around a moon sketch. While the students had good intentions and this might be acceptable for an art class, it is not observing accurately. So remember to promote accuracy: what is seen is what should be sketched. If it cannot be seen, it should not be sketched. Embellishing a sketch with borders or notes or comment is acceptable as long as the sky object (in this case, the moon) is rendered as accurately as possible. If part of the earth is in the field of view, it can also be recorded in the sketch. Whatever is seen should be recorded but not something imagined—to ensure the observation period is a reflection of what the student actually witnessed and interpreted with the sketch and notes. Once a teacher has some experience

observing, interpreting the accuracy of the student's observing sheet will not be difficult. For more detail on the recording process, see the AOBV curriculum.

Later, as the students learn the discipline of observing, teachers can encourage some lunar sketching to have more of an artistic flair. We can tell you from experience, however, if this done too soon the student will not learn to be accurate and precise with observing. Exercise caution in this regard. You want the observing sheets to be an accurate reflection of observing as the priority objective.

When sketch materials are not available or clouds cover the sky, consider using other methods for observing practice. Drawing from lunar pictures is often done as practice. Using a small amount of clay to make a crater, then using a light source to act as the sun works well to illustrate sun effects on the moon. Students can sketch the clay model. We have also seen pans with a rim used to represent a crater. There are many ways lunar observing skills can be practiced when the moon cannot be seen. The disciplines that a student uses are the same, and will help them later when actual observing is possible.

This brings the addendum on lunar observing to a close. Many people enjoy observing the moon for a lifetime, and there are a multitude of lunar targets and features to explore. Enjoy the discovery process. Be thankful for the placement of a planetary body so close to observe to easily. There is no substitute for the best way to learn!

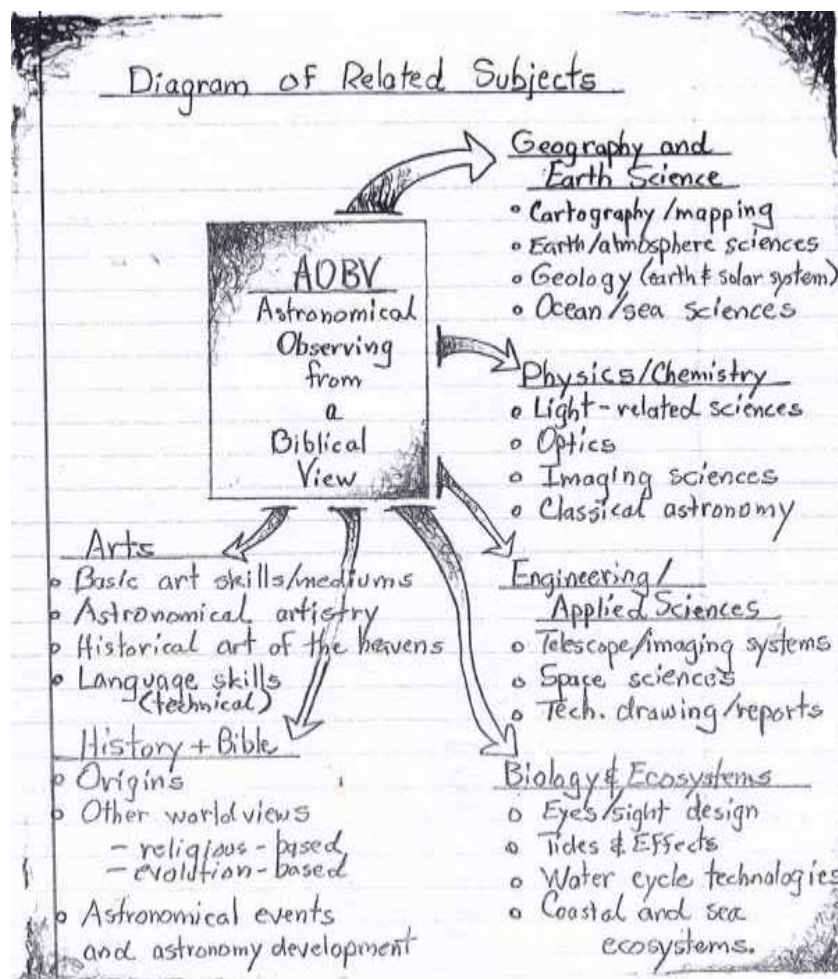
AOBV Addendum 3: Related Subjects and Applications

INTRODUCTION

AOBV teaches a variety of equipment and observing skills that are related to other subjects and applications. This addendum summarizes some of the subjects that may be of interest to teachers as they plan AOBV training. In addition, many functions of disciplined observing relate to practical skills in vocations and professions that students may eventually consider. This addendum explains two figures to illustrate these points.

RELATED SUBJECTS

The figure below shows a diagram summarizing a few categories of academic subjects that relate to AOBV if a teacher wants to introduce subject relationships in classes. Likewise, a teacher could dovetail AOBV while covering the subjects.



The information is limited to the experience of the authors, so there are many other subjects that could be introduced that are not included in the figure.

The AOBV central block in the figure has arrows pointing to different subject categories that are discussed below. The arrows could be reversed, where any of the subjects could be a launching point for AOBV. A brief explanation for subject categories follows.

GEOGRAPHY AND EARTH SCIENCE

AOBV covers the observer's orientation on earth but also addresses the celestial sphere (the heavens around the earth). One key AOBV objective is for the student to understand how God arranged and placed the heavens, which he begins to understand as the planisphere and star atlas are used. Mapping or cartography is a discipline applied to a number of earth-oriented disciplines but can be studied with respect to mapping the heavens.

Since the student observer is taught the value of observing from a privileged position on earth, where the atmosphere conditions protect him but also permit observing, earth/atmospheric sciences also become an interesting related subject. Many of the same observational techniques used to image parts of earth are used or were developed based on space sciences.

Now that several satellites have sent images or geologic information from other planets and/or their moons to earth, geology of earth has been expanded to include geology of the solar system. Similar analyses methods are used for both.

In view of earth's unique water properties and habitability characteristics that were specifically created, ocean/sea sciences are an excellent subject to be related to AOBV. There is an increased body of knowledge on planets and moons so comparing the privileged nature of earth to other planets is an obvious comparative subject for a student.

PHYSICS/CHEMISTRY

Learning to observe is learning to understand the effects of light, so any physics related to light properties and behavior is relatable to AOBV. Since the use of optics is a practical skill developed with AOBV, classical physics instruction on optics can have an immediate practical application.

In recent decades, imaging sciences have developed rapidly, providing a fascinating subject to explore but is also related to observing the heavens.

Classical astronomy, of course, is directly related to observing. If a student learns observing skills, he can expand that capability by studying classical astronomy.

ENGINEERING/APPLIED SCIENCES

There are many engineering and applied sciences related to practical observing—too many to mention in this addendum. We have included two obvious and one less obvious subject. The obvious subjects are telescope/imaging systems and space sciences that have direct relationships to observing. The concept of observing space is fascinating for children and adults, so it is easy to introduce space exploration, space vehicles, manned/unmanned space projects, rocket propulsion, and similar subjects. What young

or inexperienced teachers omit, however, is the number of engineering disciplines used to support space study. It is not confined to aerospace engineering but extends to many other engineering disciplines, such as materials, civil, mechanical, chemical, bio-medical, electrical, and systems.

A less obvious subject or function that is developed with AOBV but has similar application in a wide variety of professions is technical drawing and reporting. A key function for young students is learning to develop reports. Every engineering discipline (among many other professions) requires the generation of accurate and clear reporting, which includes text, graphics, measurements, presentations of data, development of test methods, and development of conclusions or results, and projections for applications. The equivalent exercise or function in AOBV is the development of an observing sheet, which includes observing site information along with observing conditions, observing instruments, a sketch of a sky object, a pertinent scripture, and notes or comments. Observing with an instrument is fun and rewarding, but it not complete without a good report that is legible, clear, and complete. Most professional companies, professionals in the field, government, and private institutions have requirements to develop reports in order to communicate status, ideas, evaluations, problems, and solutions.

BIOLOGY/ECO-SYSTEMS

It is fascinating to observe the heavens, but it is just as exciting and more tangible to study earth detail. One point that is repeatedly made by AOBV is the wonder of our privileged planet from which we observe, so it is easy to extend or apply AOBV observation principles to the earth, which God made to be habitable. Biology, eco-systems (both small and large), and a host of related subjects can be studied using the same methods used in AOBV. The binocular, one of the primary instruments used in AOBV, can be used for studying subjects in the field. When coupled with a microscope, observations and observing sheets can be developed by students on microscopic subjects.

Our eyes are essential for observing, so studying eyes or the function of sight among species is interesting.

AOBV observing methods are applicable to large eco-systems, which include tides and their effects, coastal eco-systems, and sea eco-systems—all heavily affected by the moon-earth complex.

There is no limit to types of biology-related subjects that can be explored as methods of observing and producing observing sheets are applied to plant and animal life. Processes can also be studied, such as the water cycle and photo synthesis that are essential for life on earth. Biological subjects are often mentioned by God in Job, the Psalms, and Genesis. God meant for them to be studied. Like the heavens, they point to Him.

ARTS

Because accurate sketching is a critical task in observing, the extending skills to different mediums and subjects is recommended as observers become more experienced. Basic art, while not a requirement for

AOBV, is a wonderful subject to explore. Astronomical art also has a history that can be researched and presented as AOBV is taught.

A less obvious topic related to AOBV is technical language skills. Many disciplines have a jargon and vocabulary that are unique; this is true for astronomy. As a novice observer gains experience, he becomes familiar with the terms and vocabulary that are universal within the discipline. The technical terms become an additional system of words but will show up in related disciplines.

HISTORY AND THE BIBLE

The last subject, but certainly not the least, is the subject of history. Contrary to the popular myth that the universe and life as we know it developed on its own with known scientific laws, origins or beginnings is a historical subject that cannot be tested with the scientific method. Believing scientists understand that hyper-extrapolation of existing processes to a creation event is a grand assumption by unbelievers. All scientists deal with the same evidence or data about earth features (tectonic plates, fossils in multiple strata worldwide, etc), but discerning or interpreting what it means is dependent on a person's world view. A worldwide flood (the Genesis flood) is a statement of historical fact in the scripture, so a Bible-believing person will interpret the fossil record accordingly, and will likely point to features of that evidence that support the world view. However, a non-believer has eliminated God from the consideration of the fossil record, so he must rely on beliefs in natural processes and an hyper-extended time line with those uniform processes.

A person's world view will dictate whether evidence from earth is interpreted as confirming the world event of a flood or hundreds of thousands of years of gradual processes produced the same results. Neither case can be proven; it is a matter of history that cannot be repeated. Believers simply state that the evidence fits the history of the event as revealed in scripture. Since the unbeliever does not have God in the equation, the evidence has to be interpreted some other way. In a similar way believing observers split with unbelieving observers regarding the formation of the heavens.

With this in view, AOBV presents the obvious opportunity to study origins and world views for students looking at the differences among them. The differences are profound. For high school students with a foundation in observing and Biblical beginnings, religious- and evolution-based worldviews can be examined to extend their knowledge to see what people believe about origins and how their worldview acts as the primary assumption that affects conclusions.

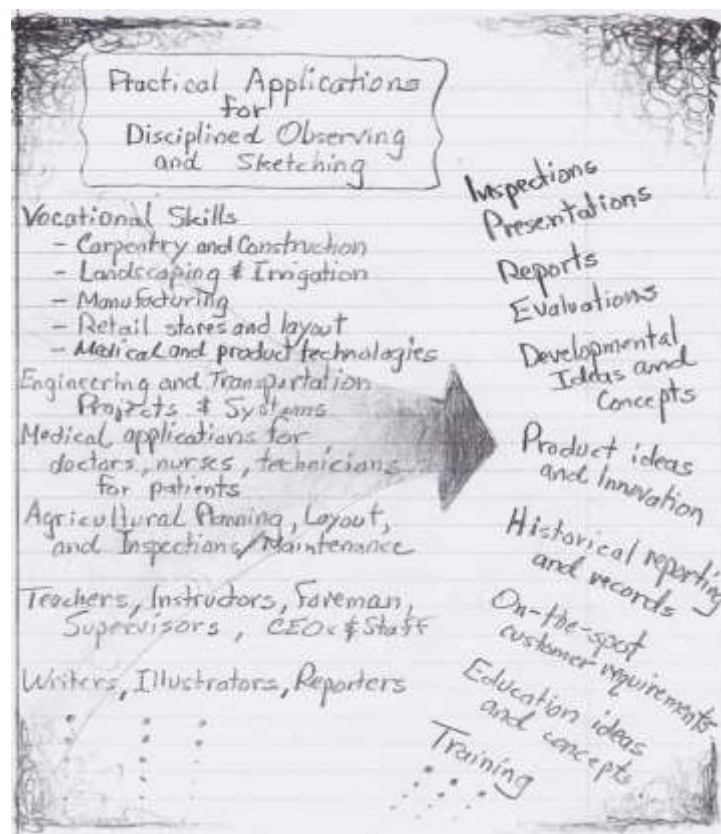
Because of the way in which God created the solar system and placed the heavens outside the solar system, they have been the subject of discovery and study for centuries. Astronomical events have often been recorded. The cycles of movement continue to be used to predict events but also to study past events. The result is a rich history of events and discoveries, including the equipment used to observe. Many key men and woman have contributed to astronomical history and technology development. AOBV is an excellent departure point to study these subjects and the people involved.

PRACTICAL APPLICATIONS OF DISCIPLINED OBSERVING

The functions of observing (seeing, recording information, sketching to record what is seen, and developing an observing sheet) are critical or have parallels in many professions or vocations. The set of functions on the right hand side of the figure begins with children learning to draw. But areas of the world that are depressed, poor, or undeveloped, children frequently do not develop these skills because of the effects of poverty or limited education. In these areas paper is hard to get, school books are in short supply, and crayons or pencils are a luxury so are not found in many homes. One effect is a limited ability to perceive or picture things or ideas, but also includes an ability to give or understand instructions with figures, notes and illustrations. We have been seen the effects first hand. Disciplined observing skills help fill the gap as children develop in poor areas.

For anyone, however, what jobs, projects, vocations, and professions will not benefit from a person who knows disciplined observing skills? Inspections require sketches, notes, and reports. Presentations require skills for developing pictures and illustrations that accent points to be made. Reports use graphics and figures to illustrate points. A disciplined observer has developed an appreciation for these functions.

The figure below is a partial summary of professions or vocations that use many of the observing functions that are part of disciplined observing skills used in AOBV.



The reader can go down the list of functions on the right side of the figure. All of these functions are more easily used or applied by people that have learned disciplined observing, because they can more quickly illustrate and articulate ideas and concepts in an organized manner. They also understand that careful observation is a skill that requires practice and discipline. It is a developed skill.

We (the authors) have known people that have worked in the vocations and professions listed on the left. The best performers are typically very effective and disciplined observers. This means they are able to see, understand, and record information with words and illustrations—functions that are the core of an observing sheet developed by a student of AOBV. In contrast, a person who is unable to develop these skills has some limitations. Think of good observation skills in terms of a job interview. If we want to hire someone for a task or project, job applicants who have mastered some type of disciplined observing have an advantage.

Addendum 4: Observing Sheet Guidelines for Observing Objects in the Heavens

While the addendum provides users of Astronomical Observing from a Biblical View (AOBV) course with a common observing sheet format, the same format can be used for earth (or terrestrial) observations.

The general elements of an observing sheet are described below. The notes by each element are descriptive so the user can decide how to apply the element in their specific application. Separate pages at the end of the addendum show example observing sheets and provide blank observing sheet that can be adapted for local needs. Some teachers want the observing sheet element to be part of the learning process, so they will provide a student with a blank sheet of paper and a pencil, since they expect the student to remember the key elements that are required for observing sheets. Other teachers want a full report developed from the observing sheet of a subject. The addendum is only a guide so any of these options can be exercised.

The size of the observing sheet can vary, but the objective is to have the student sketch and make notes of his assigned target or subject in the field. An observer will need a half sheet of paper for the observing sketch, so the elements and the sketch usually take a full sheet of paper. As observers become more practiced, some artistic license can be permitted. As long as the basic elements of the observing sheet are not forgotten, the student can be encouraged to make the sketch as excellent and artistic as he can, which can include some decorative flair as long as the additions do not alter or change the accuracy of the scene or object that was observed and sketched. Remember: this is observing – not fantasy or fiction.

Observing sheets can easily be adapted for small children. The teacher or parent can simply reduce the elements that are to be included, provide paper and medium appropriate for the age of the child, and be more specific about what is being observed.

Text elements of observing sheets are defined below:

Observer Information: The observer's name, grade, class, and school for school children should be listed at the top of the sheet. For most observers, your name is sufficient. For experienced observers, this information may be embedded in the sketch.

Date/time: Month, day, and year should be listed in the format commonly used for the observer's region. The time of the observation is listed for either the local or GMT time. Many observing sheets may be seen by people in other time zones, so the time zone must be listed. For some schools, where no time piece is available, the approximate time may have to be described relative to sunrise, midday (high sun), or sunset. Sometimes the author will also list a bracket of time, which indicates the time period for the sketch and observation were completed.

Location: This is the specific location of the observing site. The location should include the nearest local village, the province or state, and the country. For astronomy or terrestrial observations where the student's position is an important factor, details of the specific location can be included. For instance, the student may describe his observation on a playing field on the West side of the school like this:

“West side, school playing field, 100 m from Nyamabuga Village School, Nyamabuga, Uganda.” If the direction the observer is facing is important (which way he is looking to see the subject of his observation), then he can include a statement that specifies which direction he was facing during the observation.

Conditions: The conditions at the time of the observation are important to record. In astronomy terms, this means seeing conditions. These usually include comments or statements on the clarity of the sky, evidence of haze or clouds, moon position and its phase (because it masks faint stars), temperature, humidity, and wind. Many of the same elements are also important for terrestrial observations, since those conditions can affect what is observed.

Equipment for observation: This is a description so the reader or teacher knows that the student used only his eyes or also optics. If optics are used, they should be described. If the student has been taught how to compute or knows magnification, it should be listed. For astronomy or binocular or microscope observations, the information should be clear enough for the teacher to know exactly how the observation was made. If more than one method was used, then list each one.

Sketch medium: A typical astronomy or terrestrial observer will list the type of paper and the drawing/sketching media (pencils, pastels, etc.) that were used. For developing regions where supplies are hard to get, the listing may be as simple as “paper and pencil”. If anything else is used, the author should specify. If the observing sheet will be used for competition or a public showing, the type/grade of pencil and the type of paper should also be included.

Title or object of observation: The observer should provide a technically accurate title of the target of the observation. However, he may also choose to make a title that is more descriptive but still includes the specific target. In a wide field sky view, some will label specific targets in the sketch but provide a separate title. Whatever is done, the primary object needs to be identified so there is no ambiguity about what was observed.

Pertinent scripture: Observing from a biblical view, which is what CHRISTWORKS MINISTRIES teaches, requires that a pertinent scripture be included. For most new observers, this is usually a general scripture that related to the subject (whether an object in the heavens or on the earth). So an astronomy observation would have a heavens-related reference; a terrestrial observation would have an earth-related reference. If the scripture’s relationship to the sketch subject is not obvious, then the author must explain the relationship so the reader understands how it related to the observing period and/or subject of the sketch.

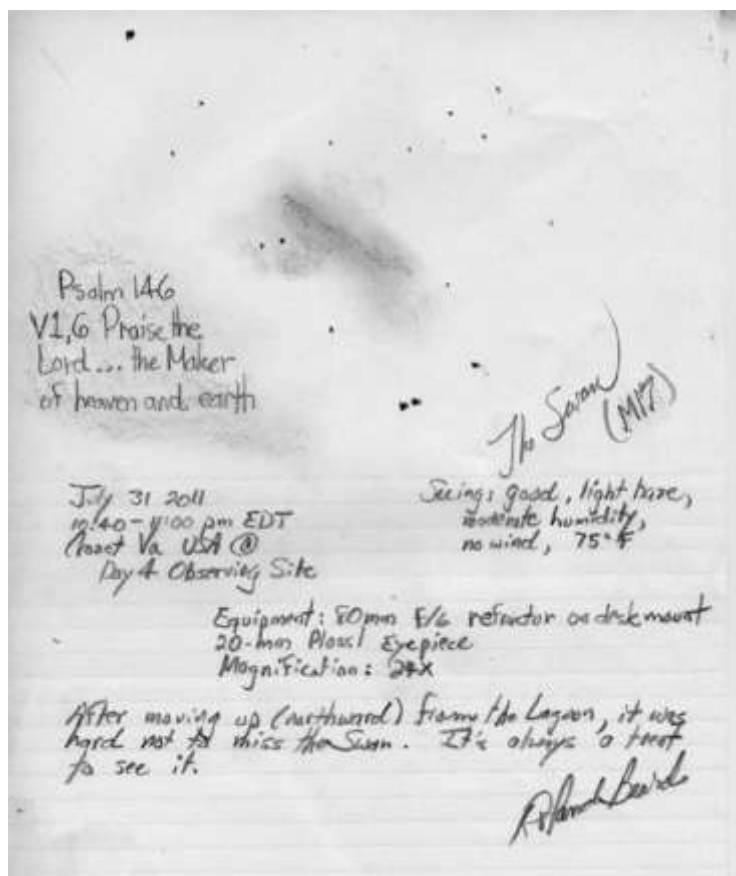
Author comment: As observers get more experienced, we expect authors to comment on their observation. While the comment need not be lengthy, the author’s feelings, lesson learned, or further descriptive comment is important—especially to readers who see the observing sheet later. We encourage comment that relates the scripture or the attributes of God to the observing opportunity.

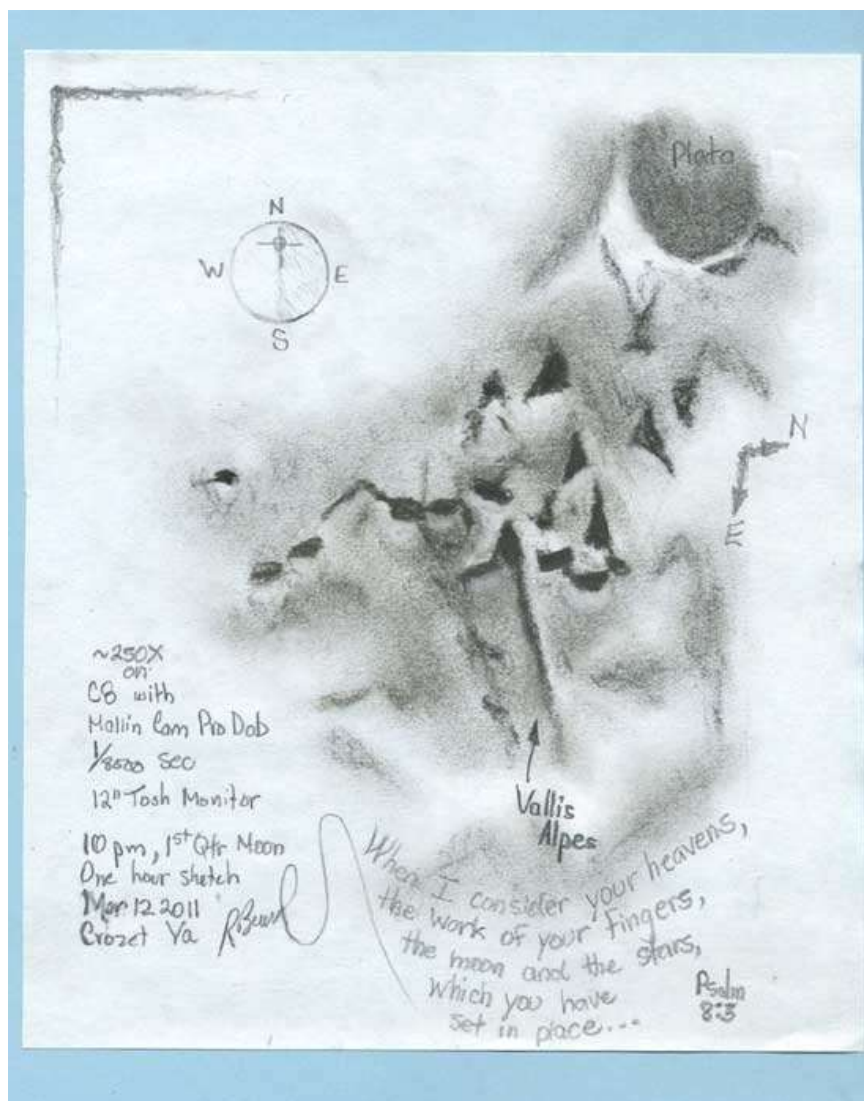
Note: A report may be required by the teacher if the observing period is part of a larger project. While this is not part of an observing sheet developed while observing, the observing sheet would become an

important attachment to a larger report. Or, the teacher may require a report for a series of observation sheets. This is not usually part of an individual observing period, but a teacher or parent could easily require a more developed report that uses the student's observing sheet.

The sketch of the object and its immediate environment: The sketch of the observed object is the central point of the observing sheet and will take up most of the page. Chapter 6 of AOBV teaches the basic skills that are needed. Even people who think they cannot sketch will improve rapidly with a little practice. The objective is not a pretty picture, although a pretty picture might be developed. The objective is the most accurate sketch observation of a subject that the author can develop. Notes on the sketch or inset diagrams are perfectly acceptable if they help the author describe what he is observing. A sketch is often developed immediately because the target is either moving or weather conditions demand quick work. In this case, text elements (described above) can be added later.

Two examples of observing sheets follow. There is a blank observing sheet at the end that can be used or adapted for students in most school situations.





Other examples, where observing sheets and stories or lessons are combined together, can be seen online by going to the Parables of the Sky (an inspirational blog at www.cwm4him.org or www.christworksministries.org. For class purposes, however, a basic format (simpler than these examples) is recommended. As observers become more experienced, latitude can be exercised to develop unique formats. Competitions in observing typically have strict formats.

An example format for an observing sheet that could be used by students is on the next page. Elements can easily be re-arranged to suit individual schools and needs.

Name, class, school grade level, school

Observing Location (details if needed)

Address (local observing site, village, state, country)

Weather Conditions (temperature, humidity, wind, cloud type and coverage, etc.)

Sky/Lighting Conditions (brightness of moon if showing, transparency or clarity of sky)

Equipment for Observation (eyes, binocular, telescope, etc.; when a telescope is listed, list the mount type, the eye piece used, and the magnification)

Sketch medium and paper

Object or title of observation

Sketch area is typically within this box area on a typical sheet of paper (at least half of a regular sheet of paper). Depending on the paper size and the text elements, this can be adjusted. For larger sketches, an observer can use the whole paper for one sketch and a second page for the text information.

We recommend that an author's signature be placed on the sketch, even if the observer's name is listed at the top of the page in the text elements.

The pertinent scripture and comment can be in the area surrounding the sketch, or these may be included outside the sketch area (usually near the bottom of the page as indicated).

Scripture: A scripture should be correctly quoted and have content that relates it to the heavens or something during the observing session.

Author comment: Normally this is relatively short. It can comment on the observation period, the object that was observed, or the Scripture that was selected. Some teachers want this made into a full report.

ADDENDUM 5

GUIDE FOR A BEGINNER'S OBSERVING KIT and HELPFUL REFERENCES

Author: Roland Beard

Date of information: 2014

INTRODUCTION

The excitement and passion to discover the created heavens is a primary reason why we developed this course. It has to stand alone in many places we go, because many people we visit have few resources. They usually have access to a Bible. This Reference alone, along with this course, a couple of binoculars, and maybe one small telescope are enough to begin discovering the heavens. However, we always get questions about references and others want guidelines for equipment. Hence, this addendum very briefly summarizes some key references and what someone might need for a beginner's observing kit. The information is brief, subject to our own experience and biases. Much more detailed information can be found online, but this is a start for those who might be using AOBV.

THE BEGINNERS KIT

We introduced some of this information in the lessons, but will repeat it here in summary form. Remember that we are biased toward a kit that is simple, relatively inexpensive, works for years, and permits the kinds of observations we incorporated in the lesson exercises. Further, the items we suggest have to be readily available from big companies, and shippable overseas. We have worked with the equipment we suggest.

Binocular. Get a 7 or 8 power (magnification) x 35 (minimum aperture diameter) binocular. The one we have used for 10 years and is still sold/available is the 7x35 Bushnell Falcon binocular. Amazon.com has had it in stock for years. The 2014 price is about \$30. If you want something a little better, try to get the same power but a little larger objective (40 to 50 mm instead of 35). Bushnell, Orion (telescope.com), and Celestron also have candidates for less than \$200. Do NOT get the following: off-brand, heavy binoculars advertising huge objectives. Do NOT get the tiny 25 mm objective binoculars, except for little children. We do NOT recommend zoom binoculars because they often compromise other features.

Telescope. Get a "short and fat" but small refractor that is well known or popular. In particular, this means something with at least an 80 mm objective diameter and a focal length between 5 and 7 times this number (400 to 560 mm). This equates to a wide-field small refractor, because it has a wide field of view that makes finding things easier. Do NOT get long skinny refractors like those found in almost every large retail store. You may pay less, but you or your children will struggle with it one year and then it will be parked. Don't bother. What we mean by getting a "well known" variety is candidates that are from many of the companies advertising in popular astronomy magazines. Most have an 80mm refractor candidate. Less aperture reduces the gathered light too much for our purposes and larger systems get expensive quickly. An 80-mm scope is what we use the most overseas. Keep in mind that one needs a few other pieces along with the main optical tube. Here are some suggestions for the whole small system that can be purchased:

Short tube refractor called the Orion Short Tube 80-A. It's tough, has not changed, the optics are decent, and it can be used on a larger telescope (if you ever get one) as a finder scope. It can be bought as a system, with a basic tripod mount and all the pieces you need for about \$300.

A desk-mount refractor 80mm of objective or a reflector with at least a 102mm diameter primary mirror. These are little less expensive than tripod mounted systems. As long as they are short (less than 20 inches or so) and have short focal lengths (5 to 7 times the aperture diameter), they will do fine for beginners. Again, pick from the popular companies that advertise in astronomy magazines or astronomy stores. These systems vary in cost, but you can get started with a desk mount system for about \$200 that has all the pieces and parts you need.

We would like people to avoid a few things, so we recommend NOT doing three things:

--Buying fancy sounding but usually cheap computerized scope that has less than 80mm objective or do not work well manually (without an onboard computer or power).

--Buying anything with poor customer ratings (less than 4 stars on a 5 star rating system).

--Buying a scope because it advertises outrageously high magnification capability. Most reasonable observations for small telescopes are seldom over 150 power.

Do you want a bigger system? Realize that prices go up quickly. However, you can get good systems (refractors, or Newtonian reflectors, or Dobsonians) from any of the major companies. The learning curve is longer. The prices vary dramatically, but you can get a very nice beginner's system for \$600-1000. They can cost many times that. BUT, do not start with a bigger system if you have significant doubts about your interest or the interest of your students. Another option is to buy a used system from a local astronomy observer or club. Online sales often work well, as long as you can go and see the system and you have judged the price to be competitive. Most owners of medium-sized scopes keep their systems in decent shape, so the used market does have real possibilities. Half of our systems that we own were bought on this market. If you can get a system with a clock drive or a platform (permitting the scope to negate the effects of earth's rotation), that is helpful. Beyond this, you need to do some research. Check out a local astronomy club and consult more experienced observers in your area.

As a point of reference, we started observing around 2000 with what is considered to be a classic medium-sized Schmidt-Cassegrain telescope (8 inches aperture with 2032 mm focal length). 15 years later we sent it to the Philippines and bought a previously-owned one to replace it. Later we got a 102mm refractor. We still use it. We have a 12.5 inch Dobsonian and still use it also. We have the little short tube 80-A (listed above) and sent similar systems overseas.

The scope that is best, as a wise observer told me once, is the one you keep using. We repeat that advice often. For each telescope we bought, we received advice from observers, did research ourselves, and made our choices. Please go through the same process. You might ask why we have more than one scope. We observe with scopes and binoculars over 50 times per year; each observing session lasts 1-5 hours; we have taught and trained with this course or parts of it in four countries with the rich to the

poorest of the poor. We use them often, travel with them, and each one has strong points as well as weak points for particular use. Our experience has taught us what works for the people we serve. If you buy wisely and learn the tools correctly, the equipment will outlive you. And, if you follow some of the general practical advice we give, you can replace pieces and parts or the whole scope if it breaks and not “break the bank.”

NIGHT OBSERVING ACCESSORIES

You need some basic things to make hunting for objects easier, but it is the same equipment we described in the lessons with a couple of additions. You WILL need these or an equivalent:

Planisphere. We use the Chandler Planisphere all the time. Get it for the correct band of latitude and the right hemisphere (N or S). (less than \$20)

Star Atlas. We use two. The first is the Chandler Atlas for Small Telescopes and Binoculars. The second is the Sky and Telescope Pocket Sky Atlas. (Each is less than \$20, but there are other candidates. Star atlases are very helpful when used in conjunction with the planispheres.)

A decent moon map. These are so helpful we have worn one completely out. There are a number of candidates. We use the large Sky and Telescope Moon Map, Laminated (less than \$10)

A red LED light. We use head band lights that have several options, but one is a red LED setting, which is essential for observing. We always have two lights on hand in case one goes dead. (less than \$20)

REFERENCES

We use a combination of books, online sites, and field references. The biblical creation view is important to us, but so is ease-of-use. Here are a few of our favorites that keep getting used during our observing and instruction (other than the Bible and its wonderful references about the heavens and creation):

Nightwatch by Terence Dickenson. It is practical and informative. We had it with us when using scopes and read the map sections in the dark to help us find popular constellations and objects for our first years of observing. It also has a nice analysis/comparison of types of telescopes. It has basic seasonal star charts and helpful hints for observing.

Finder charts. There are a number of possibilities, but finder charts are star and/or constellation maps that show bigger objects. They are helpful outside and for planning what to observe. There are plenty of computer-based and even phone-based versions, but we try to stay away from these because of bright light issues at night. Get a popular set.

Understanding the Origin of Earth's Nightlights, The Stars and Their Purpose by Werner Gitt. It is hard to find a biblically based but general astronomy reference on the stars and the Solar System. This is the one we chose to use in kits overseas and in local outreaches. If you find a real good one like this, please let us know.

Taking Back Astronomy by Jason Lisle. Dr Lisle is an astro-physicist who has written a very readable introduction-type of book about astronomy from a biblical creation viewpoint. Nice illustrations.

www.creation.com web site for **Creation Ministries, International**. We cannot recommend a better web site as an online reference tool for biblical creation or for astronomy articles related to biblical creation. The site is free to use and has hundreds of articles that are posted. Their search tool is excellent. We have heard many of their speakers, use many of their references, and support their work. They have good astronomy reference material for sale.

Creation Study. We needed but could not find a general, free, and electronically-transmitted Bible study on biblical creation that also included popular topics/questions from young people or parents. This study covers core parts of biblical creation, compares it with naturalism (evolution), and provides a comparison of these two worldviews with respect to major subject areas. The created heavens are touched on in several chapters. The first draft was reviewed by a small team of teachers and pastors in the Philippines. Dr. Carl Wieland of Creation Ministries assisted in a second edit and Ginny Kanter (a retired professional editor) assisted in a third edit. The published study is now available for free download at www.cwm4him.org. Go to the <Courses> menu to read more and <Download Courses> to download the English or Spanish version. While copyrighted, you can copy it and pass it as long as it is kept free and the copyright is carried along. It is for you. Please use it.

The Answers Book. This general biblical creation reference is available at creation.com for sale but is also downloadable for free chapter-by-chapter at the same site. We use this book in kits overseas as well as in the US.

The Creation Magazine. This is the most popular biblical-creation oriented magazine that is available internationally. We read it, use it, and give old copies to other ministries. It is well written and has a delightful children's section. Available at creation.com; published quarterly.