Lift Up Your Eyes on High

UNDERSTANDING THE STARS

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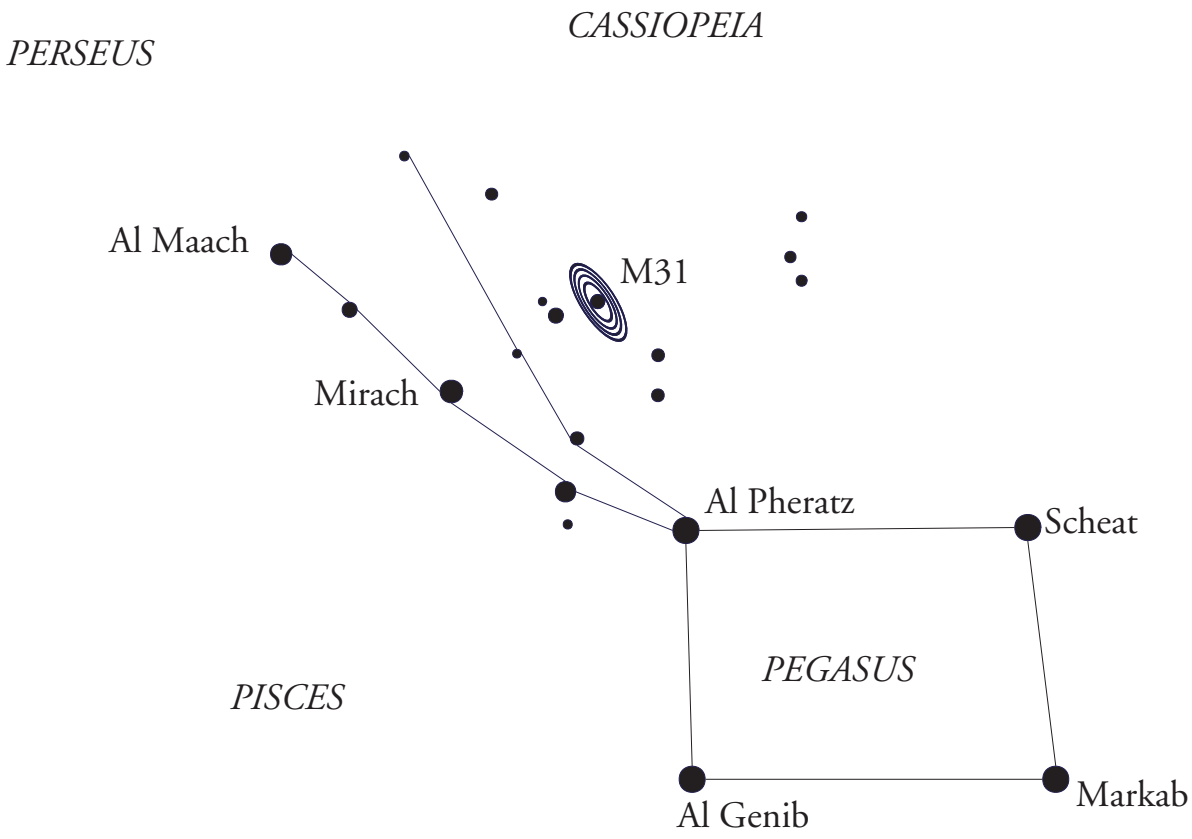

TEACHER'S MANUAL

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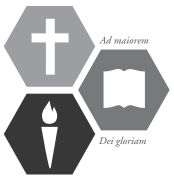

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INTRODUCTION

This guide assists a teacher or homeschool parent with ideas, solutions, resources, and learning activities for the book *Lift Up Your Eyes on High: Understanding the Stars*.

Grade 7–12 students should be able to understand the content and principles presented in the text. Mathematical principles have been kept to a minimum. The text appendices explore ideas that require some background in algebra, Euclidean geometry, and trigonometry. For more detailed mathematics, refer to the resources listed in the text's bibliography.

To make the material come alive for the student, nightly stargazing is a must:

- For star watching, all you need is the naked eye, a flashlight[1] (with a red lens cover or red cellophane tied on with a rubber band to stabilize night vision), a planisphere or star finder (store-bought or handmade), and warm clothing for cold nights. A reclining lawn chair or heavy ground cloth might also be helpful to prevent a sore neck.
- Plan nightly star parties throughout the entire school year.
- Try to get away from city lights for your stargazing activities.
- Let your eyes get accustomed to the dark (10 to 30 minutes) before you begin. This is called dark adaptation.
- Make sure that every student knows how to use the planisphere or star finder to find his or her way in the sky (they come with easy to understand instructions).
- A pair of 7x50 binoculars will help you zero in on galaxies and double stars. For deep sky objects (nebulae, star clusters, etc.), a quality telescope is a necessity. Buy your telescope from a reputable dealer in optics. Try to buy a 3-inch reflector. It is the least expensive and provides the light gathering power to see the rings of Saturn and the moons of Jupiter. It is great for close up views of the moon, too.

Purchase some astronomy computer software (I use SkyGlobe, a shareware product produced by KlassM Software[2]). Make sure that the software has the ability to "go backward and forward in time" and can trace the pathway of the planets and the moon. This tool will help the student understand precession, retrograde motion, and moon phases; and see what the night (or day) sky looked like at the time of Abraham, at the birth of Christ, or at the crucifixion of Christ.

[1] If you plan to show the stars and constellations to a group of people, use a bright, unfiltered spotlight-style flashlight. The beam will act as a pointer to the region of the sky you want to investigate.

[2] Originally produced by KlassM Software around 1989, this DOS program is now available as downloadable Shareware. Search the Web for "SG4WIN" (be sure the site also references SkyGlobe) if you wish to use it. Note, however, that it may not operate on Windows systems beyond Windows XP.

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Join your local astronomy club, if you have one. If not, start one! Mastering this material will open many doors for planting seeds of the Gospel. For example, I regularly take my children on backpacking trips in coordination with a local conservation society. Out in the mountains, the night sky takes on outstanding clarity. While we master techniques of terrestrial navigation (orienteering,[3] reading topographic maps, etc.), I casually mention the concept of celestial navigation. The result is that I am asked to give astronomy lectures at night!

A comment about the Questions for Review and Further Study: These questions range from basic definitions to full-fledged research projects. I hold a strong conviction about the necessity of requiring students to answer essay questions. Answering this type of question builds communication skills that will be used in real life. It also forces the student to put his thoughts together in a logical, coherent way. Because of these convictions, most of the assignment questions require essay answers. These are harder to correct than the simple definition questions. To guide you in grading, I will list principles that should be included in the answer. You, as a teacher, must master the material for yourself in order to evaluate the responses of your student. For the research project questions, I will list resource material that will help the student get started.[4]

A note on resource books: Every Christian school and home should be developing and budgeting for a library or have access to one. This guide will refer to books that are not listed in the text's bibliography. Some of these resources may be hard to find or out of print. You should be able to find most of these books using the Interlibrary Loan Service offered by your local public library. Internet searches may also help you locate these materials.

Many of the activity ideas used in this manual were modified and adapted from the following sources:

- *Astronomy for All Ages: Discovering the Universe Through Activities for Children and Adults*, second edition (The Globe Pequot Press, 2000), by Philip Harrington and Edward Pascuzzi.
- *New UNESCO Source Book for Science Teaching* (UNESCO, 1973).[5]

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[3] Orienteering is a sport in which competitors navigate unfamiliar terrain and locate checkpoints with the aid of a map and compass.

[4] Because a book is recommended as a resource does not mean that I necessarily agree with all its underlying presuppositions and interpretations.

[5] A free PDF copy of this product can be obtained from the UNESCO website at <http://unesdoc.unesco.org/images/0000/000056/005641E.pdf>.

A GUIDE FOR DAILY LESSON PLANS

For grade 7–10 students, allow three hours per week plus nightly star watching. You should be able to finish the book in about 10–12 weeks (30–36 classroom hours).

For grade 11–12, allow five hours per week (50–60 classroom hours) plus nightly star watching. You will need to add more material (e.g., mathematics) for students at these levels. You can assign one of the research projects and allow for one to two classroom hours per week for project work. Plan ahead and make sure that you can procure the required resource material for project work.

Review the chapter objectives, and quiz the student on these objectives after each chapter is completed. Photocopy and pass out the blank Star Charts (see Appendix B) at the end of this manual to help the student memorize key constellations and stars. Use these charts for pop quizzes. Make sure that each student knows how to use a star finder.

Follow this guideline for class work:

- **Day 1:** Introduce the course (provide the student with a copy of the Course Outline given on page *x* of this manual) and assign chapter reading as homework.[6]
- **Day 2:** Go over the assigned reading to make sure that the student understands the basic points. Assign homework (short sentence answers, short essay, and long essay) from the Questions for Review and Further Study based upon the assigned reading section. Do classroom activity or prepare for nightly stargazing. If you have astronomy software, use it to augment the lesson where appropriate.
- **Day 3:** Correct homework,[7] continue classroom activity, and assign the next reading selection.
- **Day 4:** Repeat day 2.
- **Day 5:** Repeat day 3.
- And so on …

For grade 11–12 students:

- Expect and demand more self-government; let the book be the primary teacher. You are there to guide and direct and to point the student toward resources that will answer his or her questions.

[6] For planning purposes, divide the number of pages of text by the number of classroom days and use this figure as a reading guideline. Take into account holidays and test days.

[7] Some of the long essay questions (that require research and extra reading) will take more time to discuss and correct. Encourage discussion at all times!

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- Follow the guideline for class work with one change: assign the reading and homework based upon the reading at the same time. Go over the homework in class the next day.
- Require each student to choose a project by the end of the second week. List all of the research projects from the text. You might also include other ideas, such as making a spectroscope, sundial, elementary telescope, etc.

TEST PREPARATION

As mentioned above, blank Star Charts are included in Appendix B for use as pop quizzes. A test packet (sold separately) is also available for this course. It contains seven tests; one for each chapter (tests six and seven are a comprehensive final exam).

Many (though not all) of the test questions come from the material presented in the Questions for Review and Further Study, so make sure your student completes all of the assignments in these sections.

Appendices referenced in a chapter, either directly in the text or through this manual, are considered part of that chapter. Therefore, any material in those appendices—including footnotes—should be studied. (NOTE: when studying the appendices, grade 11–12 students should also understand the mathematical principles involved in them.) Review of glossary terms will also be beneficial, as many of the definitions given in the glossary are more detailed than those appearing in the chapter itself.

If you are using this course with grade 7–10 students, we recommend that you scan the chapter test prior to beginning the unit to understand the kind of material the student will need to know. The goal here is not to "teach the test," but rather to ensure that you do not overlook a topic that you believe might only apply to grade 11–12 students. Some test questions assume the Research questions at the end of the chapter were completed. If these are overlooked, your student will not be fully prepared.

Finally, it should be noted that the final exam consists of two tests (six and seven) and is comprehensive, meaning that all material from the text, including all footnotes and appendices, is considered "fair game."

NOTES REGARDING THE TEXT

This text presumes the student will be using the material over the course of an entire calendar year, and includes activities for all four seasons. Depending on when you start this course, you may find it prudent to complete some star-viewing activities "out of order" so that you do not have to wait a calendar year for the appropriate season to return. However, the constellations should still be memorized in the order they appear in the chapter outlines.

Also, this text is written from a northern hemisphere perspective, meaning that terminology and images are, for the most part, from that vantage point (*some*

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southern hemisphere information has been provided, should you find yourself in that region of the world). If you are looking for a course written from the southern hemisphere perspective, see *The Heavens Declare: Understanding the Stars* by James Nickel (available from Light Educational Ministries, 200 Florey Drive, Charnwood ACT 2615, Australia; <http://lem.com.au>).

If you are using this text while traveling in the southern hemisphere, there are a few things to note:

- The seasons will be in reverse order. References to winter need to be changed to summer, spring changed to autumn, summer to winter, and autumn to spring.
- The constellations will all appear "upside down" because they are being viewed in reference to the South Circumpolar stars, instead of the North. This different perspective will engender other asterisms, such as "the saucepan" in the constellation Orion.
- When looking toward the south pole, the stars will rotate in a clockwise direction around the pole. This is opposite to the rotation around the north pole, where the stars rotate in a counter-clockwise direction.

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COURSE OUTLINE

Chapter One
- I. What is a star?
- II. How many stars?
- III. How far away are they?
- IV. Where did God place the stars?
- V. What are the purposes of the heavenly bodies?
  - A. Lights
  - B. Signs
  - C. Seasons
  - D. Days and Years
  - E. Governing the Day and the Night
- VI. How are the stars and earthly rulers connected?
- VII. Why study the stars?

Chapter Two
- I. Big and Little Dippers
  - A. Ursa Minor
  - B. Ursa Major
  - C. The Big Dipper Clock
- II. Two "Naked-eye" Galaxies
- III. The Milky Way
- IV. Facts and Faith
- V. Earth in Space by Design
- VI. More North Circumpolar Constellations
  - A. Cassiopeia
  - B. Draco
  - C. Cepheus
- VII. What is the message of these stars?

Chapter Three
- I. Geocentricity or Heliocentricity?
- II. The Celestial Sphere
  - A. Coordinates
  - B. Star Revolution
- III. Finding Directions from the Stars
  - A. Northern Hemisphere
  - B. Southern Hemisphere

Chapter Four
- I. The Winter Stars
  - A. Orion
  - B. The Great Winter Triangle
  - C. The Twins of Gemini
  - D. The Good Shepherd
  - E. Taurus, the Bull
- II. The Spring Stars
  - A. Leo
  - B. Virgo
  - C. Coma Berenices
  - D. Boötes
  - E. Corona Borealis
  - F. Corvus
- III. The Summer Stars
  - A. Scorpio
  - B. The Summer Triangle
- IV. The Autumn Stars
  - A. Piscis Australis
  - B. Pegasus
  - C. Andromeda

Chapter Five
- I. The Ecliptic
- II. Astrology
  - A. Cush, Son of Ham
  - B. Nimrod, Son of Cush
- III. The Federation of Twelve
- IV. The Federation and their Decans
- V. The Zodiac by Season
  - A. Winter
    1. Aries
    2. Taurus
    3. Gemini
  - B. Spring
    1. Cancer
    2. Leo
    3. Virgo
  - C. Summer
    1. Libra
    2. Scorpio
    3. Sagittarius
  - D. Autumn
    1. Capricorn
    2. Aquarius
    3. Pisces
- VI. Zodiac Summary
  - A. Aries – Christ, the Lamb of God
  - B. Taurus – Christ, the Good Shepherd
  - C. Gemini – Christ, the God-man
  - D. Cancer – Christ, the Refuge
  - E. Leo – Christ, the Lion of the Tribe of Judah
  - F. Virgo – Christ, the Branch of the Lord
  - G. Libra – Christ, the Propitiation for Man's Sin
  - H. Scorpio – Christ, the Victor over Satan
  - I. Sagittarius – Christ, the Archer of God's Judgments
  - J. Capricorn – Christ, the Goat of Atonement
  - K. Aquarius – Christ, the Water-bearer
  - L. Pisces – Christ, the Upholder of God's People
- VII. Responding to God's Glory

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CHAPTER 2 – NORTH CIRCUMPOLAR STARS

OBJECTIVES

- Survey the stars seen only by residents of the Northern Hemisphere
- Define the size and structure of the Milky Way galaxy
- Present an argument for a Designer from the design of the universe

OUTLINE OF CHAPTER

I. Big and Little Dippers
   A. Ursa Minor
   B. Ursa Major
   C. The Big Dipper Clock
II. Two "Naked-eye" Galaxies
III. The Milky Way
IV. Facts and Faith
V. Earth in Space by Design
VI. More North Circumpolar Constellations
   A. Cassiopeia
   B. Draco
   C. Cepheus
VII. What is the message of these stars?

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TEACHING IDEAS

The north circumpolar stars are visible year round to residents of the Northern Hemisphere looking north. You will want to take your students outside at night as soon as possible in order to let them become acquainted with this section of the night sky.

In the text, refer to Appendix One (The Greek Alphabet), Appendix Three (Apparent Visual Magnitudes of Celestial Objects), Appendix Four (Limiting Magnitudes for Various Instruments), and Appendix Five (The Twenty-Five Brightest Stars) when discussing magnitude.

When the color of a star is discussed, refer to Appendix Six (Types of Stars) in the text.

Refer to Appendix Eleven in the text for a discussion of precession.

Refer to Appendix Twelve in the text for a discussion of the mathematics of Cepheids.

LEARNING ACTIVITIES

Locating the constellations and bright stars of the north circumpolar sky

The student should be able to identify and locate the following in the night sky:

- Alpha Ursae Minoris (Polaris)
- Ursa Minor (Little Dipper)
- Ursa Major (Big Dipper)
- Alpha Ursa Majoris (Dubhe)
- Beta Ursa Majoris (Merak)
- Cassiopeia
- Draco
- Alpha Draconis (Thuban)
- Cepheus

Star brightness

Have each student make a star pattern for the following constellations:

- Spring (Leo)
- Summer (Cygnus)
- Autumn (Pegasus)
- Winter (Orion)

On a clear night, go outdoors and find the appropriate seasonal star pattern in the sky and study it with the naked eye. Rank the stars in this constellation in descending order according to their brightness. Mark the star in the pattern that is brightest with the number 1. Mark the next brightest star with the number 2, etc. Bring your results inside and check your answers either with a star atlas (Edmund's *Mag 5 Star Atlas* is good)[8] or from the text. Repeat with each season. The goal of this exercise is to train the eye at detecting brightness. Try it with other constellations.

Star brightness—apparent and absolute magnitude

This activity requires two flashlights, one brighter than the other, and three students. One flashlight will represent a bright star, and the other a dimmer star. Find a dark room or go outside at night. Give the flashlights to two students, and have them both walk about two yards away from the third student (the observer). The two students should shine their flashlights at the third student, who should be able to note

[8] A table of the 300 brightest stars can also be found at <www.atlasoftheuniverse.com/stars.html>. If you are looking for a detailed star atlas, the *Deep-Sky Hunter Star Atlas* is a free downloadable PDF that can be found at <www.deepskywatch.com>. Note, however, that the atlas contains much more information than you will need at this time and, as a result, may be difficult to use.

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the brighter flashlight and the dimmer flashlight. Now have the student holding the brighter flashlight walk backwards away from the observer, all the time aiming the brighter flashlight at the observer. As the distance between the observer and the bright "star" increases, what do you notice about its brightness? It gets dimmer. Soon its apparent brightness will equal that of the faint "star." Eventually, if space permits, the faint "star" will be brighter than the bright "star."

Use the following table as a guide in discussing the difference between apparent and absolute magnitude. Remember, the lower the number, the brighter the star, and that negative numbers are lower than positive numbers.

STAR	APPARENT MAGNITUDE	ABSOLUTE MAGNITUDE	DISTANCE (IN LIGHT-YEARS)
Al Tair	+0.77	+2.2	16
Arcturus	–0.6	+0.2	37
Betelgeuse	+0.7	–7.2	520
Deneb	+1.26	–7.2	1,600
Rigel	+0.14	–8.1	900
Sirius	–1.42	+1.4	8.7
Vega	–0.04	+0.6	27

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- Which star in this table appears the brightest in the sky? *Sirius*
- Which star appears the faintest in the sky? *Deneb*
- Which star has the greatest intrinsic brightness? *Rigel*
- Which star has the lowest intrinsic brightness? *Al Tair*

Note that the stars whose distances are greater than ten parsecs (32.6 light-years) have absolute magnitudes that are greater than their apparent magnitudes. Just the opposite is true for the stars closer than ten parsecs. Since Arcturus is close to ten parsecs away, the apparent magnitude of this star is about equal to its absolute magnitude.

To illustrate this point, use one flashlight. Have a student turn the flashlight on and hold it five yards away from the observer. Now instruct the student to move toward the observer to about two yards, keeping the light pointed at the observer. Note that the light's intensity increases as the distance decreases. Now instruct the student to move about ten yards away from the observer. Note that the light's intensity decreases as the distance increases.

A star's brightness (apparent magnitude) in the sky depends upon both its distance from the observer and its absolute magnitude.

Making a Star Clock

For this activity you will need cardboard, rubber cement or glue stick, a paper fastener, and scissors.

First, make your star clock by photocopying[9] Figures 1–1 (or 1–2)[10] and 1–3 in Appendix A of this manual. Glue the copies to stiff pieces of cardboard. After the glue has set, carefully cut out the circles in Figure 1–1 (or 1–2). Gently punch a small hole about the diameter of a pencil through the centers of both circles, as well as through the dot in the center of Figure 1–3. Note the center of the Northern Hemisphere "Time" circle marks the location of Polaris (Alpha Ursae Minoris). Place the Time circle on top of the larger circle, and attach them to Figure 1–3 using a two-pronged paper fastener.

Now, to use your star clock in the Northern Hemisphere, go out on a clear evening, look north, and locate the constellation Ursa Major. Once you have located this constellation, find Polaris. Hold the star clock up so that the "Pole" arrow points toward the northern horizon. Turn the outer dial with your thumb until the correct date lines up with the "Month" arrow. If you are in the middle of the month, point the arrow toward the dotted line separating the two solid lines. If you are near the first part of the month, point the arrow toward the solid line of the previous month. If you are near the last part of the month, point the arrow toward the solid line of the next month. Hold the outer dial with your thumb so that it does not move, and turn the inner dial until the orientation of Ursa Major in the sky matches the orientation of Ursa Major on the inner dial. Read the time using the "Time" arrow on the inner dial. It should be very close to the current time. If daylight-saving time is in effect, the star time will be one hour behind clock time.

If you are using the Southern Hemisphere clock, you would, of course, face the southern horizon and use the constellation Crux (Southern Cross).

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SOLUTIONS FOR QUESTIONS FOR REVIEW AND FURTHER STUDY

Short sentence answers

Define the following words:

1. **Circumpolar stars**—refers to stars that never set and therefore are always seen from a given location on Earth.
2. **Magnitude**—a logarithmic unit used to measure the optical brightness of celestial objects. The lower the magnitude, the brighter the object. Because it is based on logarithms, a five-fold difference in magnitude represents a 100-fold difference in brightness.
3. **Constellation**—a group of stars that form a picture in the night sky.

[9] Photocopying allows you to make a new one should yours become damaged or worn out.

[10] Use the figure that is applicable to your hemisphere.

4. **Binary star**—two stars linked by a gravitational attraction and revolving around a common center of mass.
5. **North Celestial Pole**—the point of intersection of Earth's north polar axis with the Celestial Sphere; the projection of Earth's north polar axis on the Celestial Sphere.
6. **Galaxy**—a gigantic gathering of stars, gas, and dust, all bound together by gravity.
7. **Ozone layer**—a layer about ten miles above the surface of Earth made up of a gas consisting of molecules of three oxygen atoms. It filters out deadly ultraviolet light from the sun.
8. **Supernova**—a cataclysmic explosion of a gigantic star.
9. **Cepheids**—supergiant stars that pulsate due to change in surface temperature over a period ranging from a few days to a few months.

Short essay

1. **Explain how Greek letters relate to star names.**

   The lowercase letters of the Greek alphabet are used to denote individual stars by constellation (e.g., Beta Centauri), usually in rough order of brightness—alpha signifying the brightest star in the particular constellation, beta the next brightest star, etc.

2. **Study and explain the difference between apparent and absolute magnitude.**

   Apparent magnitude is the brightness of a celestial object as seen from Earth. Absolute magnitude is the brightness that a celestial object would appear to have if viewed from a distance of ten parsecs from Earth. The student should explain what a parsec is (see Appendix Seven).

3. **Describe the pictures that are associated with the constellations Ursa Major and Ursa Minor.**

   The answer should include the meanings for the stars of Ursa Major and Ursa Minor, which suggest that these constellations symbolize the shelter and protection afforded to a flock of sheep.

Long essay

1. **Explain God's providence in association with Polaris.**

   The answer should include discussion of the following:

   - Polaris as a navigational aid for determining a ship's latitude
   - Reasoning that establishes a link between the development of astronomical techniques and instruments, and European exploration and missionary outreach from the fifteenth century through the nineteenth century

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2. **Define the size and structure of the Milky Way.**

   The answer should include discussion of the following:

   • How we see the Milky Way in the night sky

   • The approximate length and width, in light-years, of the Milky Way

   • The place of our Sun in the galaxy

   • Rotational aspects of the galaxy

3. **How would you respond to the following statement? "The chance, impersonal forces of evolution put Earth where it is now in space."**

   The answer should include discussion of the following:

   • How faith determines how facts are interpreted

   • The precise position of our Sun in the Milky Way

   • The placement of the stars in the Milky Way

   • The arrangement of the Solar System itself

   • The apparent size of the Sun and the Moon and its impact on astronomy

   • The inclination of the axis of Earth

   • Our amazing Earth and its unique life support system

   Emphasize that these facts do not show evolution to be false. The basic premise of evolution is that, given enough time, anything is possible. Both the biblical and evolutionary "view of the cosmos" require a miraculous mechanism. For the former, this mechanism is God Himself. For the latter, this mechanism is an equation: matter + time + chance = all that there is.

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Faith Comparisons

FAITH IN BIBLICAL REVELATION	FAITH IN MAN'S SPECULATIONS
Design Pre-existent personality imposing order on creation, giving meaning to life	**Accident** Cosmic gamble of Time + Chance + Matter = impersonal/materialistic man and universe
All creation a miracle designed by the infinite, personal, sovereign God to whom man is **totally** responsible	A theory that "performs" all the miracles of creation, but holds man to **no** account

Research

1. **Research and report on the different types (called classes) of galaxies.**

   The student should completely define and give examples for (1) ellipticals, (2) spirals, and (3) irregulars. See *Burnham's Celestial Handbook, Volume One: An Observer's Guide to the Universe Beyond the Solar System*, by Robert Burnham, Jr. (Dover Publications, 1978), pp. 91–95.[11]

2. **Do a research project on the science of spectroscopy.**

   Resources for this project include:

   - *Stars and Their Spectra: An Introduction to the Spectral Sequence*, second edition, by James B. Kaler (Cambridge University Press, 2011)
   - *Burnham's Celestial Handbook, Volume One*, by Robert Burnham, Jr. (Dover Publications, 1978), pp. 76–82
   - any physics or introductory astronomy textbook

   The project should include a discussion of the structure of the atom, the spectrum, and how the Doppler effect (redshift and blueshift) is measured. This project requires some advanced grade 10–12 mathematics.

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[11] If your library does not carry this text, you may be able to reference the pages mentioned in this teacher's manual through Google Books at <https://books.google.com/books?id=z3_CAgAAQBAJ>.