ATARI®

ATARI Planetarium™

Owner's Manual

ATARI Planetarium was developed by DELTRON Ltd., 155 Deer Hill Rd., Lebanon, NJ 08833.

ATARI Planetarium *Owner's Manual* was written by DELTRON Ltd.

Please Note: Every effort has been made to ensure the accuracy of the product documentation in this manual. However, because Atari Corp. is constantly improving and updating its computer hardware and software, we are unable to guarantee the accuracy of printed material after the date of publication and disclaim liability for changes, errors, and omissions.

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INTRODUCTION
YOUR WINDOW ON THE UNIVERSE

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WELCOME TO ATARI PLANETARIUM!

ATARI Planetarium makes it possible for you to have a planetarium-style model of the universe in your own home. Just press a few keys and your ATARI XE™ or ATARI XL™ Computer handles the complicated computations and enormous amounts of data quickly and accurately. ATARI Planetarium then displays the requested view of the universe on your screen in bright colors.

ATARI Planetarium is designed for anyone who looks at the sky and wonders what a particular object might be. If you're a novice astronomer, you'll find the program so easy to use that you'll return again and again to explore the splendors of the universe. Experts will appreciate the versatility of the program when researching particular subjects, as well as investigating new areas of interest. If you're a teacher, ATARI Planetarium can assist your students in their discovery of the celestial world, both with your help and independently.

ATARI Planetarium shows the regular cyclic positions of the major objects in our Solar System. It also displays the locations of more than 1200 stars, all 88 constellations, more than 300 deep-sky objects, and Halley's Comet during its 1985-86 appearance. A special HELP function in the program identifies displayed objects, and an accelerated time clock lets you view cosmic events as they unfold. The program also allows time travel of about 10,000 years, into both the past and the future. If you have a printer, you can print a permanent record of any screen display you create.

HOW TO USE THIS MANUAL

ATARI Planetarium is best learned by reading the manual thoroughly, practicing with the examples given in each chapter, and experimenting. The following outline summarizes the information in each chapter.

Chapter 1: *Starting Out* describes how to load the program and display a view of the sky from your current location and time. It then explains how to use the program to identify the celestial objects you see. At the end of the chapter, a **Command Key Table** summarizes how to use the special function keys.

Chapter 2: *A Guided Tour of ATARI Planetarium* explains how to operate the program. It describes the four screen modes available, details the uses of the special function keys in each mode, and summarizes all other command keys. The section on MAP mode introduces Mercator projections, time zones, latitude, and longitude. The chapter ends with program operating hints.

Chapter 3: *A Guided Tour of the Universe* gives you a look at the skies from many different perspectives. Seasons, including equinox and solstice, are explained in terms of Earth's relation to the sun. The four celestial coordinates (elevation, azimuth, right ascension, and declination) are defined. Stars, constellations, lunar phases, eclipses, and planetary movements are described and illustrated. Halley's Comet is a special feature of this chapter.

Chapter 4: *Chronology* presents past, current, and future astronomical events. It also chronicles the evolution of the calendar from ancient times to the present.

Chapter 5: *History/Archaeology* investigates interesting facts in the history of astronomy.

Chapter 6: *Navigation* is an overview of celestial and positional navigation.

Chapter 7: *Space Exploration* outlines past experiments in space travel and discusses the possibilities and limitations of future exploration. Special sections review astronomical distances in terms of light-years and the question of extraterrestrial life.

Tables and **Bibliography** are included for reference and further research.

Glossary and **Index** help you define or locate terms used in the manual.

CHAPTER 1
STARTING OUT

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You're about to start out on an exciting adventure with ATARI Planetarium. You'll get the most from this program by reading the manual thoroughly and going through all the examples. However, you can also do quite a few things right away just by knowing which keys to press.

This chapter tells you how to load the program and get a display of the sky from where you are right now. Then it explains how to use the program to identify the cosmic objects you see in the sky outside. A handy table summarizes how to use the various keys.

COMPUTER AND PERIPHERALS

- Computer: ATARI 800XL™, ATARI 65XE™, or ATARI 130XE™
- Disk Drive: ATARI 1050™
- Joystick (optional)
- Printer (optional): ATARI XMM801™ or EPSON FX-80™ with GRAFTRAX

LOADING ATARI PLANETARIUM

The ATARI Planetarium program is on one double-sided disk: the program (or front) side contains the program; the data (or back) side stores the data you'll need to get information when running the program. After turning on your disk drive, insert the disk, program side up, into the drive and turn the latch to the closed (vertical) position. Then turn on your computer. Loading the data and all the computer routines into your computer takes a few minutes. Once the loading process is completed, the ATARI Planetarium program automatically starts itself, calculates where all the stars and planets are, and draws a picture of the night sky for you.

When the disk is finished loading, the disk drive's Busy light will go off. Turn the latch on the disk drive to the open position, remove the disk, and flip it over. Insert it into the drive and turn the latch again to the closed position. This side of the disk contains the text files for the HELP function, which allows you to identify and obtain information about any celestial object shown on the screen.

Note: Be sure you always turn the computer off *first* before turning off the disk drive.

RUNNING ATARI PLANETARIUM: A SHORTCUT

Where Are You?

Because the program doesn't know where you live or even what day it is, it starts up in SKY mode with some defaults: January 1, 1985, in Washington, D.C. But, since it's not New Year's Day, 1985, and if you don't happen to live in Washington, D.C., you'll want to change the default-where-and-when to where and when you are right now. How do you do this? First, you need to tell the computer where you are. But do you know exactly where you are? If you know your latitude and longitude, you're all set. But if you don't, you'll need a map. Fortunately "Your Window on the Universe" has a built-in map to make it easy.

To view the map, press **[Select]** until you see the word MAP (for MAP mode) in reverse-field letters in the box in the lower right corner of the screen display. (If you press **[Select]** too many times and go past MAP, just keep pressing a few more times and it will reappear.) Now press **[Return]**. Your computer will paint a Mercator map of the world on your screen. When it's finished loading, you'll find a crosshair symbol—the cursor—over Washington, D.C.

Press one of the cursor keys ([↑], [↓], [→], [←]) or use your joystick. Note that the cursor moves on the screen and that some numbers in the data window at the right of the screen change. These numbers are the latitude and longitude of the cursor on the map. If you happen to know your latitude and longitude, you can move the cursor until the numbers in the data window match those for your location. If you don't know your latitude and longitude, just locate where you are on the map and move the cursor there. Now the computer knows where you are.

When Are You?

The computer by default is set for January 1, 1985, in the early hours of the morning. To tell the computer the actual date and time, you need to get into SET mode. Press **[Select]** again until the screen display says SET in reverse-field letters, then press **[Return]**. The map will stay on the screen, but the data window will change completely. It's now set up for accepting changes in the date and time. Make all changes with the cursor keys or with a joystick.

Note that the month is highlighted by being displayed in reverse-field letters. To change the month, press the Up/Down cursor keys or push the joystick up or down. (You can also use the [>]

and [<] keys.) When the month is correct, use the right cursor key or push the joystick to the right to highlight the first digit in the day. To change the number, use the Up/Down cursor keys or the joystick. When you get the correct digit, push the cursor one position to the right and fix the other number. You can change the year and the time in the same way, one digit at a time. Note that the program uses a 12-hour clock with a little "A" or "P" to the right of the time to indicate A.M. or P.M. You can change the "A" to a "P" and vice versa using the cursor keys.

Getting Back to the Sky

To return to SKY mode, go back to **[Select]** and press it until the display shows SKY in reverse-field letters; then press **[Return]**. The computer will now calculate where all the planets are on that date and which stars are visible. When all the computations are finished, the SKY display will reappear and it will be correct for where and when you are at the present moment.

Looking Around

You're now looking south and your window is 72° wide (by default). An easy way to look around is to use the **[N]**, **[S]**, **[E]**, and **[W]** keys. These simply direct your point of view to the north, south, east, or west and don't affect how high you're looking. Try pressing **[N]**. If you previously told the computer you were anywhere in the Northern Hemisphere, you're now looking at the familiar circumpolar constellations, including the Big Dipper, the Little Dipper (with the North Star at the end of the handle), and the sprawling "W" shape of Cassiopeia. Their positions in the sky depend on the season and what time of day it is.

Looking up or down is easy. Use the Up/Down cursor keys or your joystick to move the cursor. Note that you can move the cursor all over the field of view and as you move it the numbers in the data window at the right of the screen change. These numbers are the coordinates of your cursor in the sky. (You'll learn more about coordinates later.)

Move the cursor all the way to the top of the screen and continue pressing the Up cursor key. Note that the message "Slewing.." appears in the text window at the bottom of the display. In a few seconds, you'll get a new view of the sky, shifted in the direction in which you were moving the cursor and allowing you to see higher up in the sky.

You can continue to do this until the center of the screen is the point straight overhead (called the zenith). At this point, the program refuses to let you look farther in that direction, gives you the message "Looking straight overhead," and begins to rotate the display, exactly as it would appear to you if you looked up as high as you could and then turned your body around to see farther without falling down!

You are not limited to looking directly north, south, east, or west. You can also use the Left/Right cursor keys or the joystick to slew the field of view. Just move the cursor into the left or right margin of the screen until the message "Slewing.." appears in the text window; the field of view will shift in the direction you moved the cursor.

Identification

Let's say it's evening, the sun has just set, and you notice from your backyard that there's a brilliant "star" in the west, just above the horizon, easily seen in the twilight. What is it? ATARI Planetarium will tell you. If you're just starting up, follow the directions above, press **[W]**, and move the cursor down until you see the horizon. Compare the display with the sky, move the cursor to the object located where your UAO (unidentified astronomical object) is, then press **[Help]** or the fire button on the joystick. The computer will now display a message telling you the identity of the object, its distance from you, and other bits of information. (The message will scroll in from the right; use the cursor keys or the joystick to bring in the remainder of long messages.) When you've read the message, press **[Return]** or the fire button on the joystick to regain control of SKY mode.

For an enjoyable evening of stargazing, set up your ATARI Computer outside on a patio table, turn down the monitor brightness (to keep your eyes adjusted to the dark), and explore the sky, using your computer as a guide.

If you're mainly interested in recognizing the stars outside, the manual gives you some helpful tips, starting on page 31. For your convenience, the operation of all the command keys is tabulated on the following page.

For a full explanation of how to use the program, read on!

COMMAND KEY TABLE

COMMAND KEY TABLE

KEY	MAP	SET	SKY	CHART
[Select] SL(MODE) Select Program Modes	Select location on Earth. Input latitude and longitude.	Select date and time of observation. Select calendar.	Display sky in any direction.	Display sky as a north-is-up astronomical star map.
[Option] OP(OPTNS) Select Sky Display Options	None	None	Cycles through available options. **[Shift] [Option]** turns OPTION on or off. Available: LINES, NAMES, SYMBOLS, DEEP-SKY, TRACK, SOUND. Active in both SKY and CHART.	
[Start] ST(FIND) Find Major Sky Objects	None	None	Cycles through objects which can be located and brought to center of screen: moon, sun, planets, Halley's Comet, constellations. Active in both SKY and CHART.	
[Help]* HP(INFRM) Identify All Visible Sky Objects	None	None	Identifies all displayed objects with names and catalog numbers. Displays brief data on distance, size, and object classification. Active in both SKY and CHART.	
Up/Down* Cursor Keys	Move cursor north or south on MAP. Display latitude of cursor position.	Increase/decrease number under reverse-field cursor for change of date in data window.	Move cursor up or down. Display coordinates. Slew field when cursor hits edge.	Move cursor up or down. Display coordinates. No slewing.
Left/Right* Cursor Keys	Move cursor east or west on MAP. Display longitude of cursor position.	Advance cursor through month, day, year, hour, and A.M./P.M. positions in data window.	Move cursor left or right. Display coordinates. Slew field when cursor hits edge.	Move cursor left or right. Display coordinates. No slewing.
[>], [<] Keys	None	Increase/decrease number under reverse-field cursor in data window for data changes.*	Change RATE of automatic clock. 0X is stopped clock. Available: 64X, 32X, 16X, 8X, 4X, 2X, 1X, 0X, -1X, -2X, -4X, -8X, -16X, -32X, -64X. Active in both SKY and CHART.	
[Shift] [>], [<] Keys	None	None	Change VIEWing angle. Available viewing fields: 72°, 36°, 18°, 9°. Active in both SKY and CHART.	
[N], [S], [E], [W] Keys	None	None	Point field of view to north, south, east, west. Active in both SKY and CHART.	
[O] (letter key)	None	None	Points field of view exactly opposite to current direction. Active in both SKY and CHART.	
[Shift] [P], [Control] [P]	Print current video display if printer is connected. Active in all modes. Use **[Shift] [P]** for XMM801 Printer, **[Control] [P]** for Epson Printer.			

*Alternate joystick operation.

CHAPTER 2
A GUIDED TOUR OF
ATARI PLANETARIUM

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A great deal of flexibility has been built into the ATARI Planetarium program to make it both versatile and easy to use. This section explains how to operate the program and how to choose from among the many options to get the optimum output for your particular purpose.

If you're a novice, don't get discouraged by some of the astronomical drawings and explanations. All that's required to operate the program is to follow directions and press a few keys. You may bypass the descriptions of the various coordinate systems at a first reading and still be well rewarded by the uses you'll find for ATARI Planetarium.

If you're an expert, you'll appreciate the convenience of having your ATARI XE or ATARI XL Computer do preliminary calculations for you.

STARTING UP

With your computer off, follow the procedure for loading ATARI Planetarium (see **Loading ATARI Planetarium**, page 3). When using the program, you will be able to display the universe in any one of four screen modes: SKY, MAP, SET, or CHART. The mode you are in is displayed in illuminated letters in the data window to the right of your screen.

SKY mode is the normal display mode. In this mode you have a number of options to make the sky appear so it best suits your purpose.

MAP mode allows you to select your location on Earth.

SET mode lets you choose the month, day, year, and local time as determined by your earlier selection of location in MAP mode.

CHART mode lets you view sections of the celestial sphere without obstruction by the horizon, and with north always directed upwards for easy orientation. This mode is designed to be used with a printer for making permanent sky maps of stars and galaxies, and for plotting the locations or trajectories of celestial bodies during a given time period.

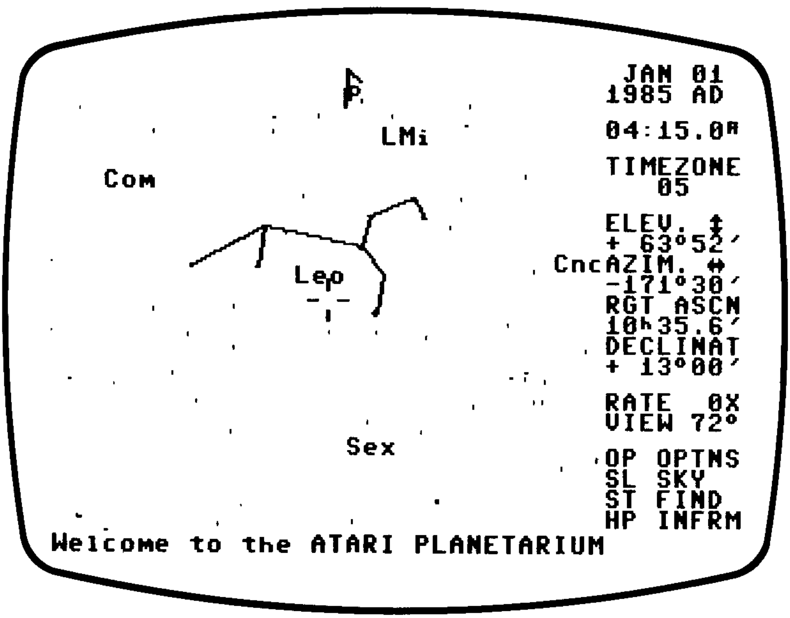
When ATARI Planetarium first starts up, it goes directly into SKY mode.

THE [SELECT] KEY

You can change modes by pressing **[Select]**. The new mode is shown in reverse-field letters in the data window. To activate the newly selected mode, press **[Return]**.

SKY Mode

ATARI Planetarium presents its first screen display in SKY mode.



Imagine you're looking out the window early in the morning on January 1, 1985, in Washington, D.C. You're looking straight south and, with the help of line diagrams and names magically painted in the sky, you immediately recognize the constellation Leo (the Lion). But your window is controlled by magic also! Use the Right cursor key to move the cursor from the center of the screen until it pushes on the right side of your window. Keep pushing until the textline underneath the window shows a "W" (west), then stop; you can now see the constellation Gemini (the Twins).

Continue pushing on the right side of the screen until the textline shows an "N" (north), then stop; you now see the Big Dipper, the Little Dipper, and, next to the North Pole (marked with a small cross), you see Polaris, the polestar. Then use the Down cursor to move the window downwards until you see the horizon come up; stop when the horizon is about a third of the way up the screen. You now recognize the "open-W" shape of Cassiopeia about to set below the horizon in the early morning hours.

Note that ATARI Planetarium has a translucent Earth: you can see through it! This means that stars and planets which have already set or which may be about to rise can actually be seen through Earth itself. This, incidentally, is also true of the sun and the moon. Now, use the Down cursor to push the window farther down; when the cursor no longer moves, you're looking straight down at your own feet!

Now, using the Up cursor, push the window upwards as far as it will go. When you get to the point where you're looking straight up, you cannot go farther without losing your balance. So instead, turn your head; as you turn, looking straight up, many of the constellations you saw before will reappear.

This example is an illustration of how to operate the basic SKY mode. There's a lot more you can do in this mode: you can change the VIEWing angle, use an automatic time clock, display deep-sky objects, identify and get information on all visible objects, and even replace the cursor with a space shuttle complete with sound effects. These operations will be covered in more detail under the description of the various command keys.

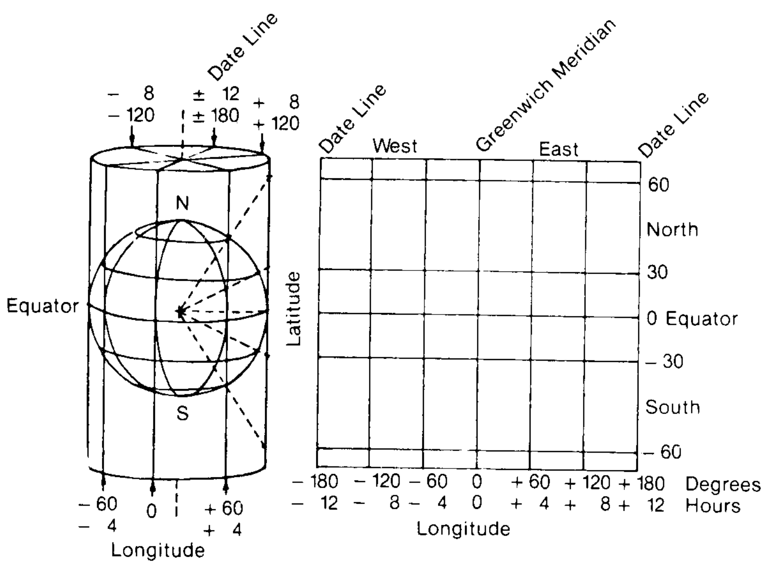
To prepare for the next SKY display, press **[Option]** until the message in the data window shows LINES; then hold down **[Shift]** and press **[Option]** again. The message now shows NO LINES in reverse-field letters. Continue pressing **[Option]** until the message shows NO SOUND; then hold down **[Shift]** and press **[Option]**, changing the message to SOUND. Finally, press **[Return]**.

MAP Mode

MAP mode enables you to change your location on Earth. Press **[Select]** until MAP shows in reverse-field letters in the data window, then press **[Return]**. The program now loads a map of the world onto your screen.

The map is a Mercator projection of Earth's surface, i.e., Earth's sphere is projected onto a cylinder which then is unrolled into a flat map. Each location on Earth is defined by two coordinates: latitude and longitude.

Mercator Projection



Latitude, measured in degrees from the Equator, goes from 0° at the Equator to 90° N (sometimes designated +90°) at the North Pole and to 90° S (sometimes designated −90°) at the South Pole. Note that on a Mercator map you cannot reach the poles; also, the map reproduces actual distances and areas faithfully only near the Equator but stretches everything more and more as you go near the poles. On the other hand, a Mercator projection is ideal for mapping time zones because lines of constant longitude are parallel lines on the map.

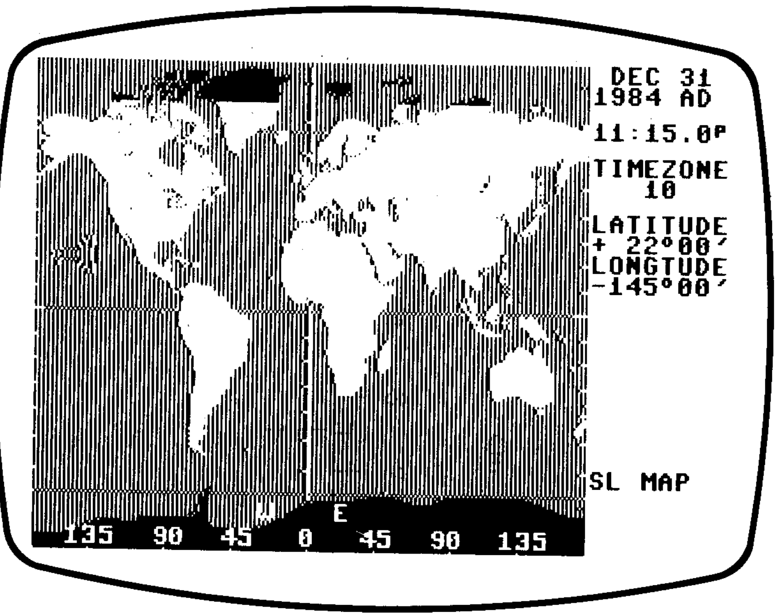
Longitude is measured in degrees (or hours) from the Greenwich meridian near London, England, and is counted positive eastward, negative westward. Each 15° corresponds to an hour of time difference (360°/24 hours = 15°/hour). In a Mercator projection, each hour zone is therefore a band 15° wide parallel to the Greenwich meridian, which goes through the middle of the Greenwich or zero time zone. At 180° E and 180° W, the eastern and western longitudes superpose as the date line.

Note that the astronomical time may differ from the official time in a given zone because actual time-zone boundaries are based on political decisions. The official time may also vary during the year due to daylight saving time.

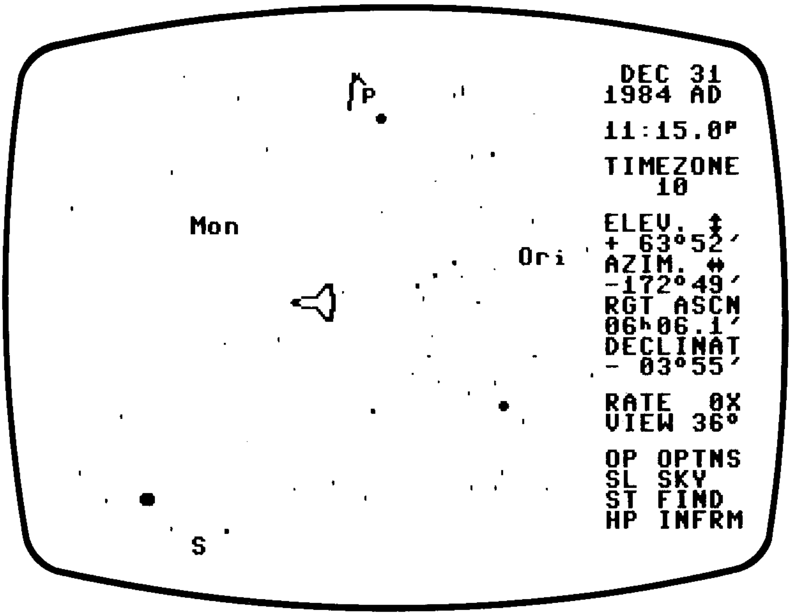
At start-up, the cursor was placed over Washington, D.C. You can change your location by using the Up/Down and Left/Right cursor keys or a joystick; the program will allow you to use either method for moving the cursor (this is true in SKY mode also). The data window at the right of your screen displays the latitude and longitude as well as the time zone of your cursor location. When greater accuracy is required in pinpointing a location, use this numerical display to fine-tune the cursor position. (The latitudes and longitudes of the major cities and islands are listed in a table on pages 89-94.)

Activating the SOUND option (as suggested on page 12) changed the MAP and SKY mode cursor into a space shuttle. In addition, cursor movement is now accompanied by a sound effect! This option is intended to help youngsters learn concepts such as time zones, date line, and star recognition while they're flying around the world. A continuation of the introductory example will illustrate this:

While you were looking out the window early New Year's morning in Washington, D.C., your friends were flying back from a vacation in Hawaii. If you haven't changed the settings from the last example, you can now easily move to their location. Since you're already in MAP mode, use the Up/Down and Left/Right cursor keys or your joystick to move the shuttle to latitude 22° N, longitude 145° W. Flying over the eastern Pacific (time zone 10), your friends are five hours behind Washington, D.C. (time zone 5) and are just getting ready to welcome the New Year. The data window shows that their local time is 11:15 P.M. on December 31, 1984.



Now, if you wish to see their view of the southern sky, press **[Select]** until SKY shows in the data window. Then press **[Return]**. You're now back in SKY mode. In order to reduce the VIEWing angle, hold down **[Shift]** while pressing [<], then press **[Return]**. After the 36° VIEWing angle has been computed and displayed, press **[S]** for a southern view. You should now recognize both the familiar constellation Orion (even without the help of a line diagram) next to the space shuttle (the cursor), and the brightest of all stars, Sirius, just to the lower left of Orion in the constellation Canis Major. This is your friends' view as they celebrate New Year's Eve.



SET Mode

"When longitude is east
Greenwich time is least
When longitude is west
Greenwich time is best"

SET mode allows you to select the time and date. As SET mode is displayed, a reverse-field cursor is shown over the month. Using the Up/Down cursor keys, you can change it to any month desired. To change the day and year, use the Left/Right cursor keys to move the cursor over any digit of the display; change it to the desired value, again using the Up/Down cursor keys. (Note that the Up/Down cursor keys change any digit one at a time and that years before 1 A.D. are automatically changed to B.C.)

You can now use the Left/Right cursor keys to move the reverse-field cursor to the hour/minute display. Again, use the Up/Down cursor keys to set the local time. Note that A.M. is indicated as an "A" and P.M. as a "P" to the right of the time display. If you wish to know the corresponding Greenwich mean time (GMT), add the number of hours (with the appropriate sign) shown under TIME ZONE to your local time. (You can use the little rhyme quoted above to remember this: Western time-zone numbers are positive, so when you add them to your local time, you get a later hour in GMT. In contrast, eastern time-zone numbers are negative so you will always get an earlier time for Greenwich than for local eastern times.)

CHART Mode

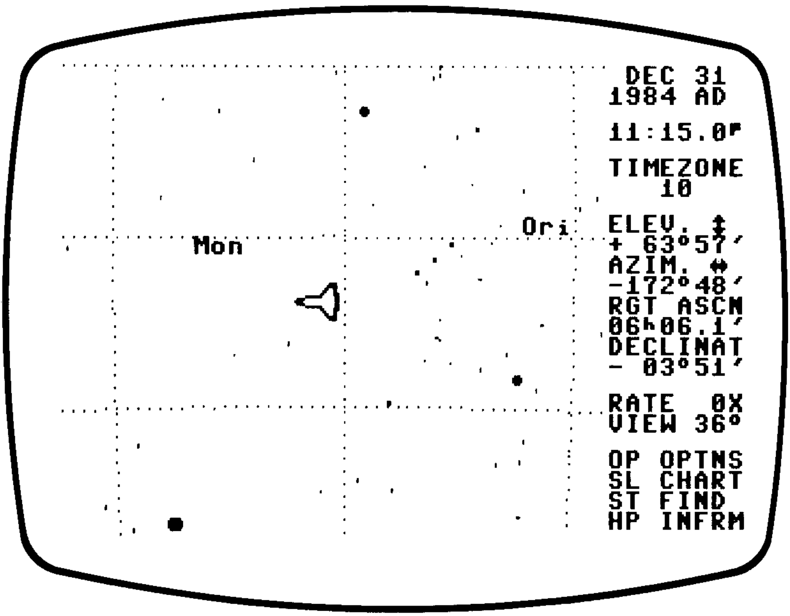
CHART mode allows you to view and print the section of the celestial sphere corresponding to the view of the sky you selected in SKY mode. In CHART mode, the horizon is removed and celestial coordinate lines for right ascension and declination (corresponding to longitude and latitude on Earth) are shown to make the chart easier to use for plotting. North is always "up" on the chart. CHART mode displays sky objects in reverse field, i.e., as dark spots on a light background. The printout of a CHART-mode screen uses black for the sky objects on a white background (to save your printer ribbon!).

You can use CHART mode to make sky maps for any date and location on Earth. The maps can then be used to locate planets and any deep-sky object of particular interest. In addition, the movement of the sun, moon, and planets for any desired time period can be plotted by hand on such a map. To do this, you'll need to read the location of these moving sky objects from the right ascension/declination values in the data window for a sequence of times or dates. This is most easily done with the TRACKing option (for details, see the description under **The [Option] Key**).

In general, all the options available in SKY Mode are also available in CHART mode, except that you can no longer use the cursor to move your window. To do that, you have to return to SKY mode, make the change, and then come back to CHART mode.

Again, remember that the celestial coordinates of the cursor position are displayed in the data window in both SKY and CHART modes. This enables you to label the right ascension/declination grid of your CHART display as well as of any object displayed. Furthermore, you can identify any object just by using the **[Help]** key (see **The [Help] Key**).

For illustration, press **[Select]** until the word CHART appears in reverse-field letters; then press **[Return]**. If you have a printer, connect it, then hold down the appropriate keys for your printer (see **The Print Keys**). If you've left the settings unchanged from the last example, you'll now get a CHART mode display or printout of your friends' New Year's Eve view on their flight back from Hawaii.



THE [OPTION] KEY

The **[Option]** key is active in both SKY and CHART modes and provides a number of choices. The selections which are currently active will appear in ordinary light-on-dark letters in the data window when you press **[Option]**. If you want to change any of them, hold down **[Shift]** and press **[Option]** again; the opposite choice is then shown in reverse-field letters. Make all the choices you want, then press **[Return]** to activate them.

LINES means constellation lines. Simplified line diagrams are available to help locate principal constellations, especially those that are useful for orienting yourself in the sky. NO LINES eliminates the diagrams.

NAMES displays three-letter abbreviations next to the constellations appearing on the screen. NO NAMES eliminates them. As with LINES, NAMES is helpful for general orientation but may be in the way if you're trying to identify individual objects.

SYMBOLS refers to the symbols commonly used to identify the planets:

Mercury ☿	Venus ♀	Mars ♂	Jupiter ♃
Saturn ♄	Uranus ♅	Neptune ♆	Pluto ♇

The SYMBOLS option is helpful since planets move around and sometimes are difficult to identify by inspection. When symbols are not needed or are in the way, NO SYMBOLS replaces them with regular starlike patterns.

DEEP SKY displays several hundred very interesting nebulae and galaxies and is essential when you want to study the distant universe. However, those objects do clutter up the more familiar star patterns and make it difficult to orient yourself, at least in the beginning. NO DEEP turns them off.

TRACK is used in special cases only in combination with **[Start]**. An object, such as the sun, moon, or Halley's Comet, which has been located under the cursor by means of the START function is kept there as long as TRACK is active. The principal use is to record over a period of time right ascension and declination values individually for two celestial objects, such as a planet and the moon, to determine their closest approach. This method is also useful in preparing star charts showing the location of planets over a time period for later observation outside. NO TRACK turns this option off and should be the normal setting.

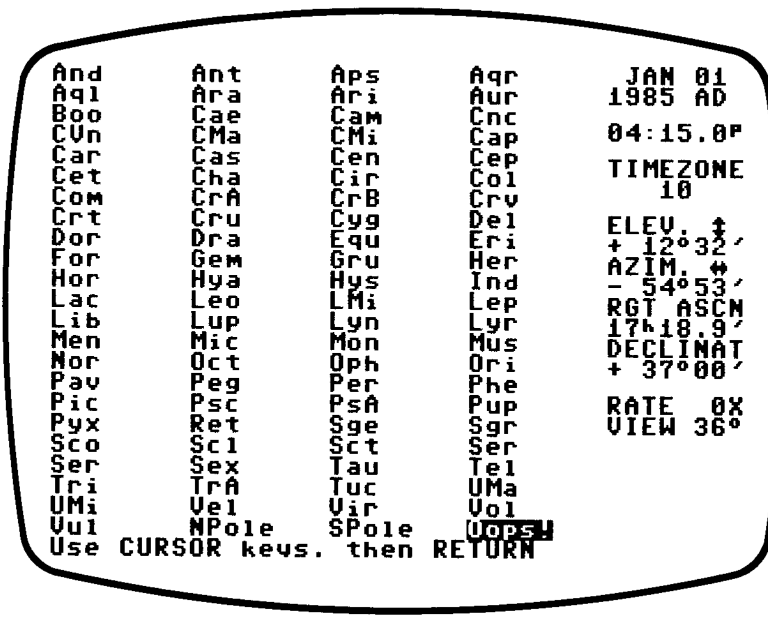
SOUND is intended to stimulate learning for the younger astronomer. In addition to providing sound effects when the cursor is being moved around, this option displays the cursor as a space shuttle in MAP, SKY, and CHART modes. NO SOUND turns these special effects off.

The default settings are LINES, NAMES, SYMBOLS, NO DEEP, NO TRACK, and NO SOUND.

THE [START] KEY

The **[Start]** key, active in SKY mode, enables you to position the sun, moon, any planet, any constellation, and Halley's Comet (in season) in the center of your screen. Instead of looking around the sky for a specific object, you can just press **[Start]** until the desired sky object is shown in the data window, then press **[Return]**.

If you want a particular constellation, the screen changes to a display of three-letter abbreviations for the 88 constellations. Move the cursor over the desired abbreviation and press **[Return]**. (If you don't remember the abbreviation, see the listing on page 96.) The constellation list also gives you the option to select either the North Pole or the South Pole (see bottom row of list display). It even gives you the option to get back gracefully if you change your mind and decide you don't want to see a constellation after all. The last "constellation" listed is Oops!; when you place the cursor on Oops! and press **[Return]**, you get back to where you were!



THE [HELP] KEY

The **[Help]** key is active in SKY mode and is intended to reduce the need for looking things up while you're using ATARI Planetarium. Descriptions of the 88 constellations, more than 1200 stars, and over 300 deep-sky objects are contained in text files on the data side of the disk. You can access these simply by placing the cursor over the particular sky object and then pressing **[Help]** or the fire button on the joystick. (In the case of constellations, place the cursor over the first letter of the abbreviated name.)

The information is displayed on the textline below the screen. You can scroll both forwards and backwards, so if you inadvertently pass over some pertinent information, you don't have to start all over again. When the HELP function is activated, the Left/Right cursor keys or the joystick control the scrolling.

The information identifies each star by its HD number and each deep-sky object by its NGC number. (The HD numbers refer to the Henry Draper Catalog; the NGC numbers to the New General Catalog.) In addition, the M numbers are given for deep-sky objects if they are included in Charles Messier's nonstellar catalog dating from 1781. These ID numbers will help you search the literature for additional information if you should wish to do so. The text also gives you pertinent astronomical data, including mass and/or dimensions as well as distance in light-years.

To get out of HELP, press **[Return]** or your joystick's fire button.

OTHER COMMAND KEYS

The Clock RATE

When you're in SKY mode, you can start a clock that will update the display so you can watch an event, such as a sunset or an eclipse, as it progresses. In the data window at the right of your screen, you'll see a line that says RATE 0X. This means that the clock is stopped. To activate the clock, press [>] or [<]. 1X is the approximate actual time, 2X is twice the regular time, and so forth. You can go up to 64X, which means that an hour of real time takes only about a minute on your computer. Pressing [<] reduces the speed of the clock until you reach 0X, i.e., the stopped clock. You can even go backwards in time by continuing to press [<] until you reach the rate of −64X.

It's always best to stop the clock before you change to another location or date. When your computer is computing, it tells you in the textline below the screen display. During these times, no new commands are accepted by the computer—it's "busy." The more information you request (the wider the window and the more stars and deep-sky objects you have on your screen) and the more you speed up the time factor, the busier the computer gets. In extreme cases, it becomes difficult for your computer to find a small time window to accept your change command. For example, if you are at 64X, keep [<] depressed until the clock RATE decreases. Once you're off the faster rates, it becomes easier to get the computer's attention!

The VIEWing Angle

When you're in SKY mode, you'll see a line with the word VIEW in the data window just below the RATE line. This is the angular section of the sky displayed on the screen, the maximum angle being 72°, the minimum angle 9°. To change the VIEWing angle, hold down **[Shift]** while pressing [>] or [<]. It's always a good idea to start out with the widest angle, making sure that the objects you're interested in are well centered on your screen before you reduce the angle; otherwise, you may lose your object outside the screen and not be able to orient yourself. For the same reason, it's easiest to decrease the angle in steps.

The Direction Keys

When you're in SKY mode and you want to look in a different direction, you can use the cursor to push the window to either side as well as up or down. But there's an easier way: you can use the keys **[N]** (for north), **[S]** (for south), **[E]** (for east), and **[W]** (for west).

There's still another direction key: the letter **[O]** (for opposition). This key points you in a direction exactly 180° from the direction you were looking in. You can use this key to see whether any planets are in direct opposition to the sun. Using **[Start]** (see **The [Start] Key**), center the sun on your screen; then press the letter [O].

The Print Keys

If you have a printer, you can make a permanent record of any visual screen display you create. You can use an ATARI XMM801 or an Epson Printer. Just plug it into the I/O port in the back of your ATARI Disk Drive. The printer is activated by holding down **[Shift]** while pressing **[P]** (for print) on the XMM801, or by holding down **[Control]** while pressing **[P]** for the Epson. You'll probably be using the printer mostly in connection with SKY and CHART modes. Therefore, carefully study the many choices you have for changing the screen display by means of the **[Option]** key.

PROGRAM OPERATING HINTS

Once you become familiar with ATARI Planetarium and begin using it on your own, you'll appreciate the many options the program provides. However, for general purposes, the following settings will work just fine (remember that the clock RATE, VIEWing angle, and optional changes are made in SKY mode):

- Clock RATE: 0X (stopped).
- VIEWing angle: 36° is a good choice.
- OPTION settings: LINES, NAMES, SYMBOLS, NO DEEP, NO TRACK, NO SOUND (these options are the default settings).

For the following purposes, make these changes:

- Star recognition: Go to a 72° VIEWing angle.
- Sunrise/sunset studies: Set the clock RATE at either 16X or 32X.
- Studies of galaxies: Reduce the VIEWing angle (in steps) and turn DEEP SKY on.
- Teaching youngsters: Turn SOUND on.
- Plotting trajectories on charts: Use TRACK.

For special purposes, consult the examples in this manual, and the technical notes at the end of the manual.

CHAPTER 3
A GUIDED TOUR OF THE UNIVERSE

□ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □

In this section, you'll take a tour of the universe from many different perspectives by way of ATARI Planetarium. Knowledge about the universe has affected human thinking through the ages, from religion and philosophy to simple tasks such as being able to tell how to get from one place to another! Understanding of the world we live in has increased perhaps as much in this generation as in all the generations that preceded us. Yet, the more we learn, the more amazing the universe becomes!

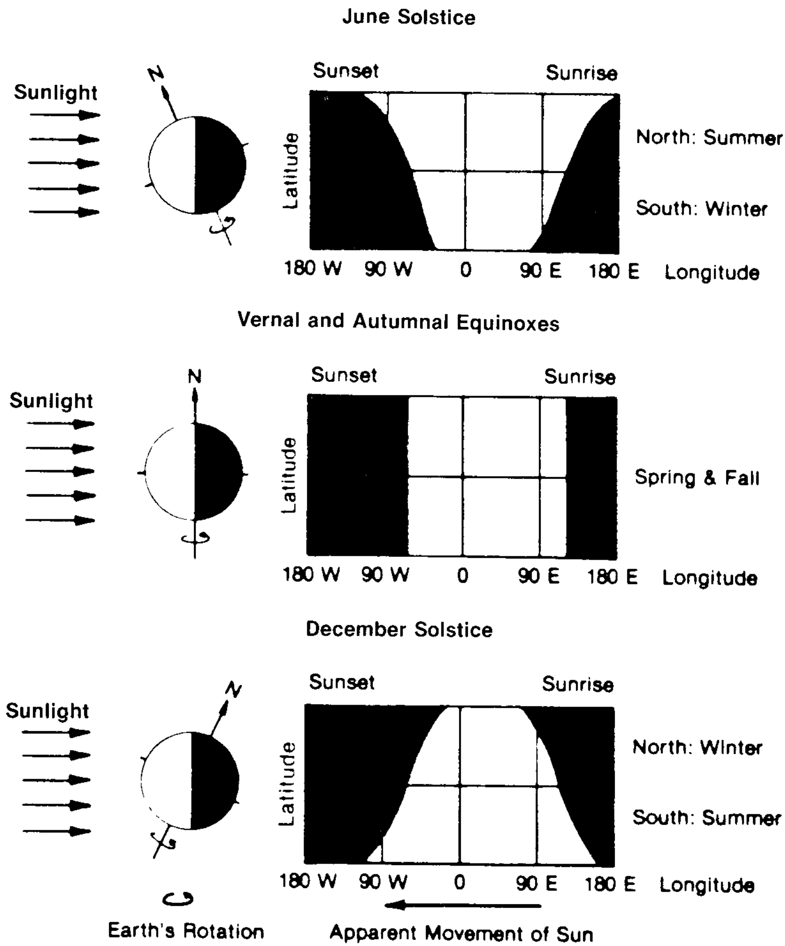
GEOGRAPHY

The first civilizations all emerged in the valleys of the great rivers: the Nile (Egypt), the Euphrates and the Tigris (Babylonia and Assyria), the Indus and the Ganges (India), and the Yangtze and the Yellow (China). The fertility of these regions provided a necessary condition for the creation of cities, since some people could be freed from laboring solely to provide food. On the other hand, as farming and the raising of animals developed, the new societies became more vulnerable to such vagaries of nature as flooding and droughts. It became essential to know when to plant, when to irrigate, and when to harvest. In short, it became necessary to understand the seasons.

Days, Years, and Seasons

> *"Time is the dimension that prevents everything from occurring simultaneously"*
>
> *Anonymous*

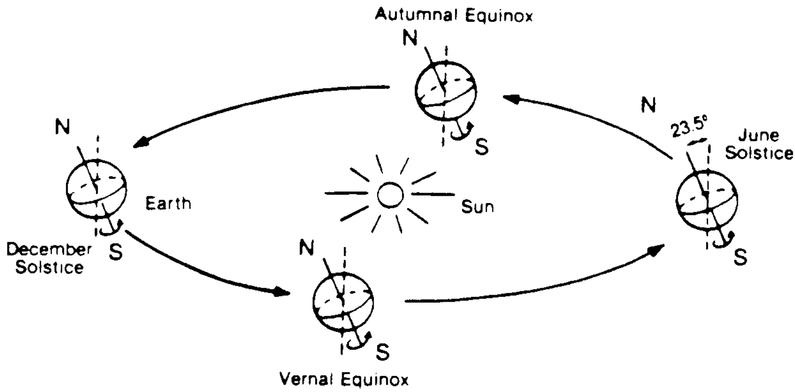
A solar day is the time it takes Earth to make one complete turn around its own axis with reference to the sun. When a given location is facing the sun, it's daytime there; when that location is no longer facing the sun, it's night. Earth's axis of rotation is tilted 23½° with respect to the plane of Earth's orbit. One result of this is that days and nights are not of equal length except at the Equator (all year) and at other locations twice a year (the vernal, or spring, and autumnal, or fall, equinoxes). This is explained by the illustration on page 24, showing both Earth's shadow on itself during its rotation and varying orbital positions around the sun as well as Earth's shadow shown on a Mercator map of Earth.



It takes Earth 365.2422 solar days to complete an orbit around the sun. This is the solar year on which our calendar is based. After that, the cyclic changes in daylight and in seasons are repeated. Like the variations in the length of the day during the year, the seasons are the result of the inclination of Earth's axis of rotation with respect to the plane of Earth's orbit. When the

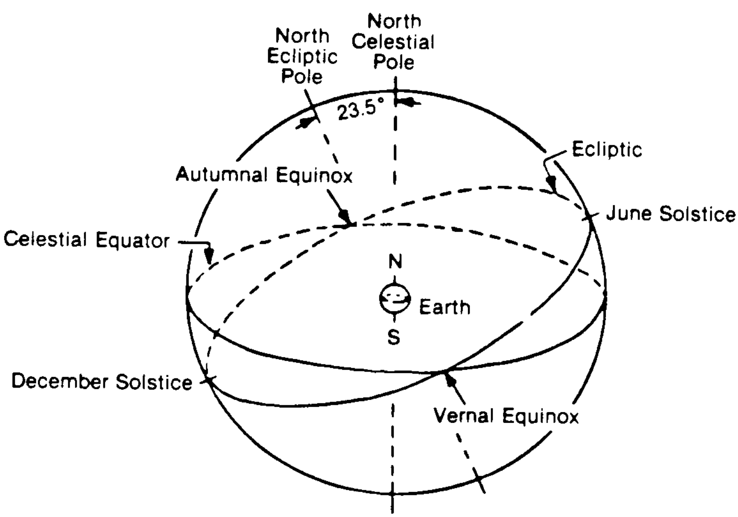
North Pole is tilted towards the sun, it's summer in the Northern Hemisphere. When the North Pole points away from the sun, it's winter. The seasons in the Southern Hemisphere are the opposite of those in the Northern Hemisphere.

Earth's Orbit Around the Sun



Translate these motions into the apparent movement of the sun on the celestial sphere, which is the way things actually appear to an observer on Earth.

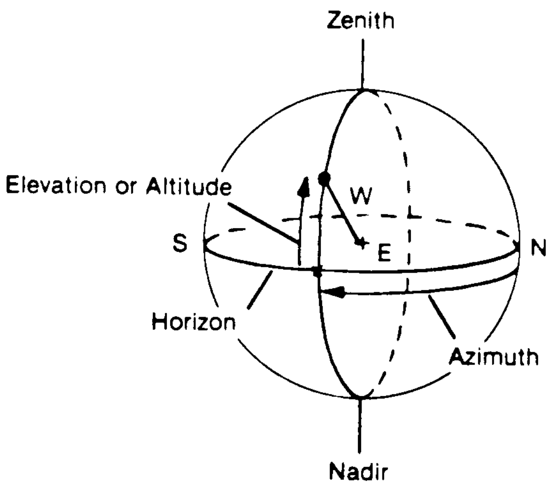
Celestial Sphere and Ecliptic



The sun appears to travel in a great circle, called the ecliptic, which is tilted 23½° with respect to the celestial Equator. This is the angle Earth's axis of rotation makes with Earth's orbit. Ancient astronomers knew the celestial sphere extremely well, including the precise location of the ecliptic. However, they didn't know the reason. They believed Earth was stationary (after all, you can't feel the rotation) and that it was the center of the universe. Nevertheless, even though we now know much more about the spacial geometry of the universe, the sky still appears to us the same way it did to our forefathers. Therefore, it's still useful to use this representation of the sky, and, in fact, it's the way it's displayed in a planetarium!

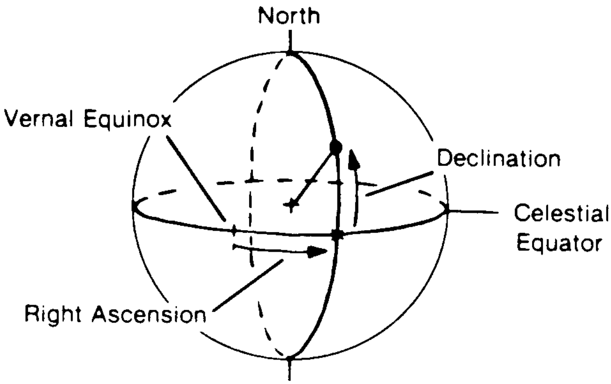
Before you look at some specific demonstrations, you'll want to learn the meaning of some of the numbers which appear in the data window at the right of the screen when you're in SKY mode. The numbers are the coordinates of the cursor. By placing the cursor over any visible sky object, you can directly read its coordinates. Elevation and azimuth are the direction coordinates to a point in the sky as seen by the observer with reference to the horizon and a meridian (great circle) through the zenith (the point directly overhead). These numbers are convenient to measure with but change constantly as Earth rotates.

Elevation and Azimuth



The other numbers, right ascension and declination, are the position coordinates on the celestial sphere corresponding to latitude and longitude on Earth. Maps for locating stars in the sky are often Mercator-style maps corresponding to the maps of Earth discussed on pages 12-13.

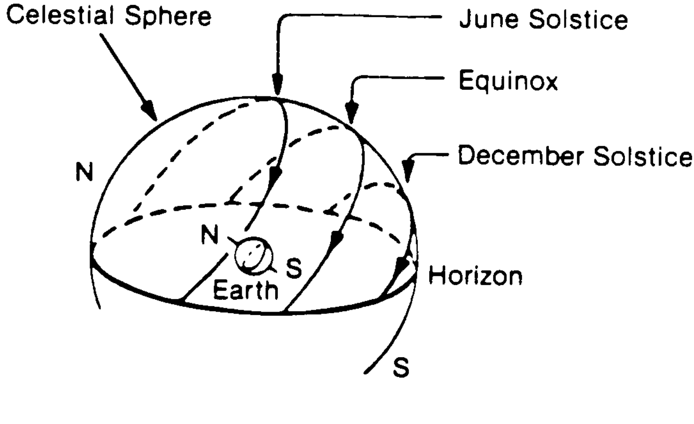
Celestial Sphere



Sunrise and Sunset over Washington, D.C.

ATARI Planetarium lets you observe and study the movements of the sun at different latitudes and times of year. The illustration below shows how Earth's tilted axis affects the elevation of the sun in the Northern Hemisphere during the year. This is, of course, quite familiar to people living in North America and Europe.

Apparent Movement of the Sun in the Northern Hemisphere



Now you're ready to use ATARI Planetarium to simulate a familiar sunrise:

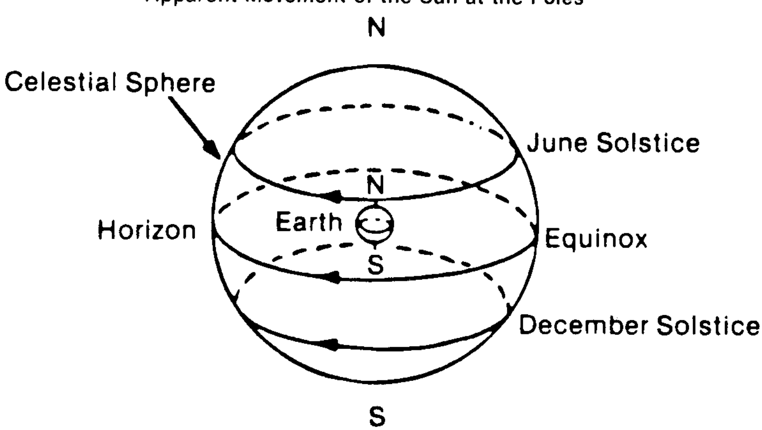
Press **[Select]** and go to MAP mode; press **[Return]**. Use the cursor keys to set the latitude to 38° 54′ N and the longitude to 77° W (Washington, D.C.). Press **[Select]** and go to SET mode; press **[Return]**. Use the cursor keys to set the date and time to July 4, 1986 A.D., at 2:45 A.M. Press **[Select]** and go to SKY mode; press **[Return]**. Use the default OPTION settings and a VIEWing angle of 72°. Press **[Start]** until the word MOON shows in the data window; then press **[Return]**. You now see that it's night in Washington with a new moon (dotted circle) just above the horizon. Now set the clock RATE to 32X by pressing the [>] key and watch the changing sky colors as the sun rises in the constellation Gemini. Mercury and Venus on this day rise after the sun; therefore, they won't be visible until shortly after sunset.

To confirm this, press **[Select]** and go to SET mode; press **[Return]**. Set the time to 5:00 P.M. Press **[Select]** again and go to SKY mode; press **[Return]**. Press **[Start]** until MOON shows in the data window; press **[Return]**. Check that the clock RATE is 32X and watch the setting sun. At about 6:00 P.M., the new moon is setting; at about 7:30 P.M., the sun sets as the sky turns blue, then darker blue, then purple. At this time, Mercury is setting below the horizon. As the sky turns gray and then black, Venus shines brightly in the constellation Leo before setting below the northwestern horizon.

The Sun at Equinox near the Poles

Near the poles, the sun moves parallel to the horizon. The sun is above the horizon all summer, below it all winter. At the equinox, it moves along the horizon. In the Northern Hemisphere, it moves to the right; in the Southern Hemisphere, it moves to the left.

Apparent Movement of the Sun at the Poles



Equinox near the North Pole

ATARI Planetarium can demonstrate the equinox near the North Pole, where the sun moves to the right:

> Press **[Select]** and go to MAP mode. Use the cursor keys to set the longitude to 0° (Greenwich meridian, GMT = local time) and move the cursor as far north as it will go. (Since this is a Mercator-style map, you cannot quite get to the North Pole.) Press **[Select]** and go to SET mode. Use the cursor keys to set the date and time to March 19, 1984 A.D., at 12:00 P.M. (GMT). Press **[Select]** and go to SKY mode, then press **[Start]** to locate the sun at the center of the screen. Next, push the sun to the left of the screen using the cursor (move the cursor to the right side of the screen until the sun is properly located). Then set the clock RATE to 32X, using the [>] and [<] keys. The sun now moves to the right along the horizon, neither setting nor rising.

Equinox near the South Pole

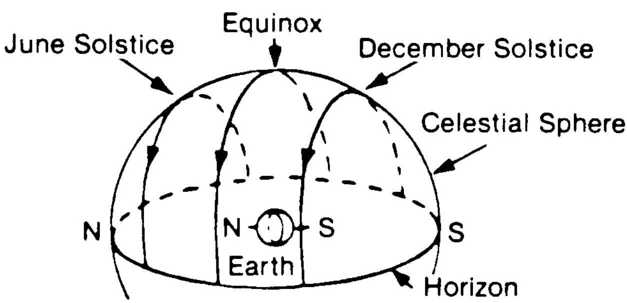
Follow the steps below to see the same phenomenon near the South Pole, except here the sun moves to the left:

> Set the clock RATE to 0X. Press **[Select]** and go back to MAP mode. Keep the longitude at 0° (Greenwich meridian, GMT = local time) and move the cursor as far as it will go towards the South Pole. Press **[Select]** and go to SET mode. Use the cursor keys to set the date and time to March 22, 1984 A.D., at 12:00 P.M. (GMT). Press **[Select]** again and go to SKY mode. Press **[Start]** to locate the sun at the center of the screen. Next, push the sun to the right of the screen using the cursor; then set the clock RATE to 32X, using the [>] and [<] keys. The sun now moves to the left along the horizon, again neither rising nor setting.

Sunrise and Sunset at the Equator

At the Equator, the North and South celestial Poles lie at the horizon. Both the sun and the stars rise straight up on the east side and settle straight down on the west side of the horizon.

Apparent Movement of the Sun at the Equator



Follow the instructions below to see both a sunrise and a sunset at the Equator:

> Set the clock RATE to 0X. Press **[Select]** and go to MAP mode. Set both the latitude and longitude to 0° (the Equator at the Greenwich meridian, GMT = local time). Press **[Select]** and go to SET mode. Set the date and time to December 21, 1983 A.D., at 5:00 A.M. Press **[Select]** again and go to SKY mode. Press **[Start]** to locate the sun at the center of the screen, then set the clock RATE to 32X. The sun now rises straight up from the horizon, as do the stars. To watch the sun set, change the clock RATE to 0X, then press **[Select]** and go to SET mode; change the time to 5:00 P.M., set the clock RATE to 32X as before, and watch the sun go straight down, followed by the same motion of the stars as the sky turns black.

ASTRONOMY

Each location on Earth is defined by two coordinates, latitude and longitude, so each location on the celestial sphere is defined by a similar pair of coordinates, declination and right ascension. (Three sky orientation maps are shown on page 32. You'll use them later to help you find your way around the sky.) Declination, measured in degrees from the celestial Equator, goes from 0° at the Equator to 90° N at the celestial North Pole and 90° S at the celestial South Pole.

Note that on a Mercator map you cannot reach the poles; also, the map faithfully reproduces stellar distances and shapes of constellations only near the Equator but stretches everything more and more as you move closer to the poles. On the other hand, a Mercator projection has the advantage that the circles of constant declination and right ascension, which intersect each other at right angles on the sphere, become sets of parallel lines, which still intersect each other at right angles on the Mercator projection.

Right ascension is measured in degrees (or hours) from the so-called vernal equinox (the location of the sun on the first day of spring when day and night are of equal length). As is the case for longitudes on Earth, each 15° corresponds to an hour of time difference (360°/24 hours = 15°/hour). The Mercator map displays line diagrams of prominent constellations; these are particularly useful when you're trying to orient yourself in the sky. A few geometrical star patterns commonly used by navigators are also shown. Since the polar regions cannot be shown on a Mercator map, yet are important regions of the sky, special projections of both the North and South Polar regions are also shown. All of these maps are discussed in more detail in following sections.

The data window on the right of your screen displays the right ascension and declination of your cursor location when you're in SKY and CHART modes. Therefore, if you know these coordinates for any given sky object, you can readily locate it on the map and on your screen. The right ascensions and declinations of the bright stars used in navigation, as well as of some other prominent name stars, are listed in a table on page 94.

Star Recognition/Constellations

"The Ram, the Bull, the Heavenly Twins
Next the Crab, and the Lion Shines
The Virgin and the Scales
The Scorpion, Archer and Seagoat
The Man that pours the water out
and the Fish with the Glittering Scales"

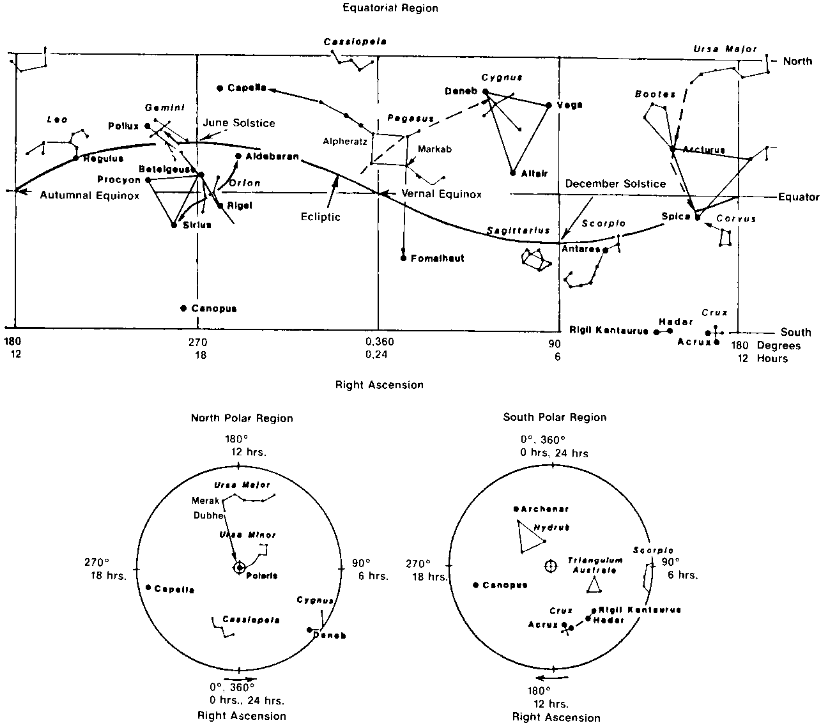
Old English Nursery Rhyme

During the last two millennia before the birth of Christ, astrologer-priests in the ancient Assyrian and Babylonian civilizations named particular star patterns after their gods, heroes, and animals. The Greeks later changed the names to those of their own gods and heroes, and the Romans, when they adopted the basic Greek mythology, gave most of the constellations the Latin names we still use today.

Constellations have no scientific meaning, yet some are still useful as signposts when you want to orient yourself in the sky. ATARI Planetarium displays simplified line diagrams of some of the more conspicuous constellations and gives an abbreviated name next to every constellation. When you no longer need these aids, or if you're already an expert star-finder, you may prefer to turn these options off. However, if you're a beginner, you may find these features helpful.

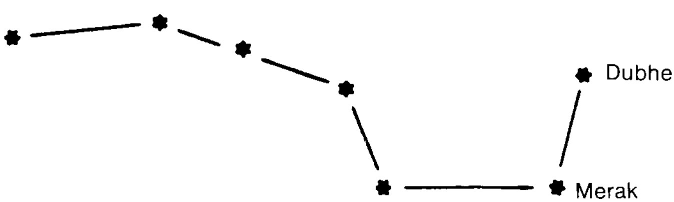
Look at the sky orientation maps on page 32. Note that certain stars are "pointer stars": by drawing imaginary lines through them, you can more easily locate other stars. The most useful instances are marked on the maps.

Sky Orientation Maps

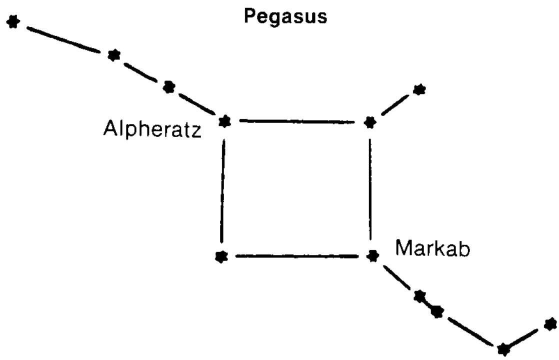


A well-known example is that of finding Polaris by means of the Big Dipper (Ursa Major), perhaps the most familiar constellation in the northern sky (see North Polar Region map). A line extended through the stars Merak and Dubhe in the Big Dipper leads directly to Polaris, the North Star. Polaris, in turn, is the last star in the handle of the constellation the Little Dipper (Ursa Minor). Note also that a curved line extended through the handle of the Big Dipper leads to Arcturus, the bright star at the point of the kite-shaped constellation Boötes, and farther down to the bright star Spica in the rather inconspicuous constellation Virgo (see Equatorial Region map).

Ursa Major



If you go through Polaris, almost directly opposite the Little Dipper you'll find the constellation Cassiopeia, easily recognized by the "open-W" shape. Farther away from Polaris in the same direction is the readily recognizable "Great Square" of Pegasus with the bright stars Alpheratz and Markab in opposite corners. A line from the latter through the former leads directly to Marfak in Perseus and to Capella in Auriga. A line through the opposite corners of the square leads to the constellation Cygnus (also called the Northern Cross because of its shape) and farther on to the bright star Vega.



Orion, one of the most beautiful constellations of the northern sky in winter, is another good starting point because of its prominence. A line through the corner stars Rigel and Betelgeuse leads directly to Castor and Pollux, the twin head stars in Gemini. Another line through the stars in Orion's belt leads on one side to Aldebaran in Taurus, and on the other side to Sirius, the brightest star in the sky, in the otherwise inconspicuous constellation Canis Major.

Other useful examples are the lines which can be drawn through two of the stars in the sail-shaped constellation Corvus leading to Spica, and between the Southern Cross (Crux) and the bright stars Rigil Kentaurus and Hadar.

Three conspicuous triangles, which are not constellations, are used by navigators because they contain very bright stars and are easy to locate. They are Procyon-Betelgeuse-Sirius, Deneb-Vega-Altair, and Arcturus-Denebola-Spica, where Denebola is the star at the tail of the constellation Leo.

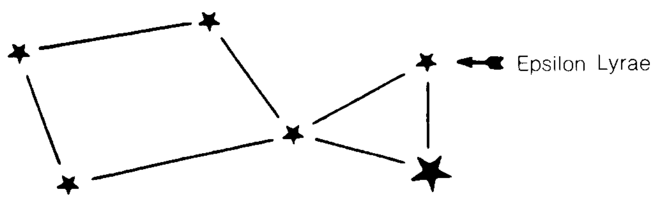
Signposts like these will help you locate many less conspicuous but nevertheless very interesting objects in the sky. Using the **[Help]** key, you can identify any visible object with ATARI Planetarium. As an exercise, press **[Help]** to identify the individual stars in the Big Dipper (Ursa Major).

Telescope/Stars and Galaxies

Many stars which appear as single stars to the naked eye are actually double stars visible even at relatively low magnification. ATARI Planetarium can be used as a low-power telescope so you can see this phenomenon. One example is Epsilon Lyrae.

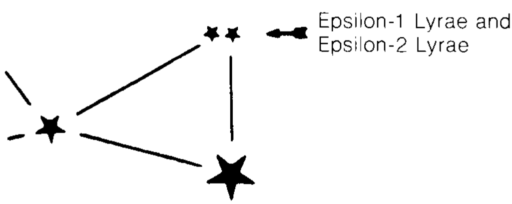
Press **[Select]** and go to MAP mode. Set the latitude to 39° 07′ N and the longitude to 94° 39′ W (Kansas City). Press **[Select]** and go to SET mode. Set the date and time to August 28, 1985 A.D. at 11:00 P.M. Press **[Select]** again and go to SKY mode, make sure OPTION is at NO DEEP, and set the clock RATE to 0X (stopped) and the VIEWing angle to 72°. Press **[Start]** to get the constellation list on the screen, then select Lyra. The characteristic connected diamond/triangle pattern with the bright star Vega is now in the center of the screen. Look at the rather faint star above Vega.

Lyra



At this magnification it looks perfectly normal. Now lower the VIEWing angle gradually to 36°, then to 18°, and finally to 9° while keeping Epsilon Lyrae in the field of view. It now resolves into two stars.

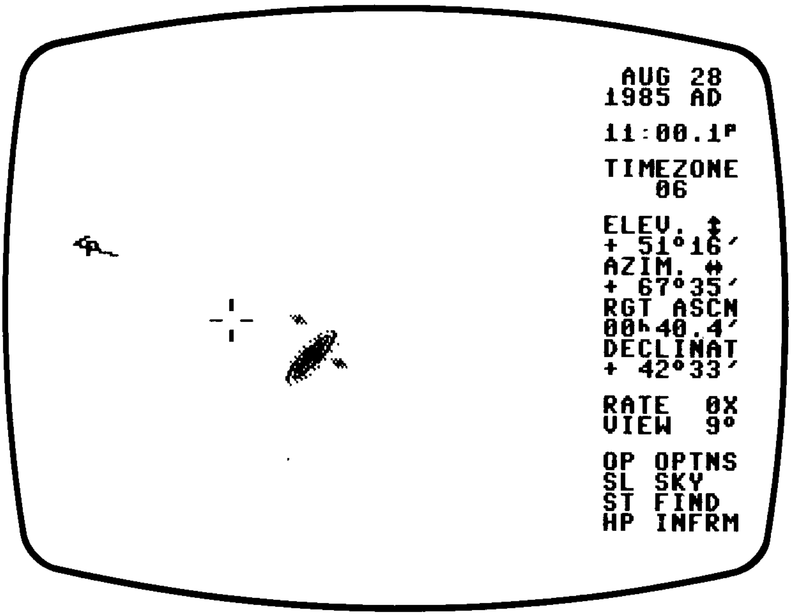
Close-Up of Lyra



Place the cursor in turn over each individual star and press **[Help]**. The stars are Epsilon-1 and Epsilon-2 Lyrae.

Here's how to resolve Andromeda into three separate galaxies:

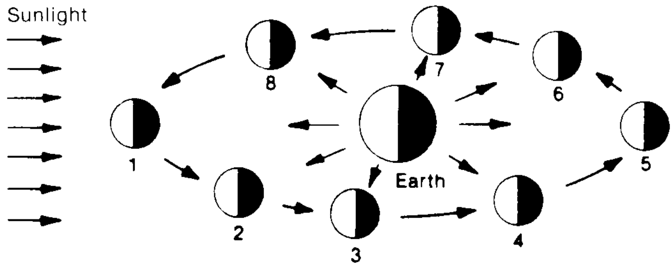
Stay in Kansas City, same day, same time. In SKY Mode, increase the VIEWing angle back to 72°, press **[Start]** to get the constellation map, and select Andromeda. Now press **[Option]** to install DEEP SKY. Use the cursor to place the conspicuous oval galaxy in the center of the screen, then gradually lower the VIEWing angle as before. You now see two small satellite galaxies next to the Andromeda Galaxy. As an exercise, press **[Help]** to identify all three.

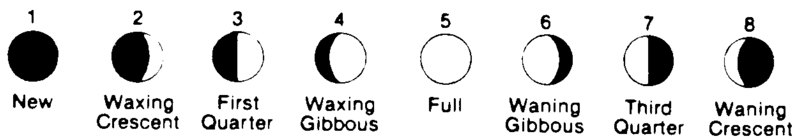


Phases of the Moon

The phases of the moon are caused by the position of the moon in relation to the sun, as seen from Earth. According to a Latin saying, the moon fools you ("Luna fallit"): when it looks like a "C" ("crescit" means *it increases*), it's actually decreasing; and when it looks like a "D" ("decrescit" means *it decreases*), it's actually increasing. The illustration shows why that's so.

Phases of the Moon





ATARI Planetarium calculates the moon's phases during regular updates of the moon's position in the sky. This is illustrated in the following example of the moon phases as seen from New York City during the month of December, 1983:

Day	NY Time	Moon Phase
Dec. 4	4:00 P.M.	New
Dec. 11	4:00 P.M.	1st Quarter
Dec. 21	7:00 P.M.	Full
Dec. 26	11:55 P.M.	3rd Quarter

Press **[Select]** and go to MAP mode. Set the latitude to 40° 43′ N and the longitude to 74° 01′ W (New York). Press **[Select]** and go to SET mode. Set the date and time to December 4, 1983 A.D., at 4:00 P.M. Press **[Select]** again and go to SKY mode. Press **[Start]** to locate the new moon. Now press **[Select]** and go back to SET mode. Set a new date—December 11, 1983, at 4:00 P.M. Again press **[Select]** to return to SKY mode. Press **[Start]** to locate the moon (1st quarter). Repeat with December 21, 1983, at 7:00 P.M. (full moon) and December 26, 1983, at 11:55 P.M. (3rd quarter).

Solar Eclipses

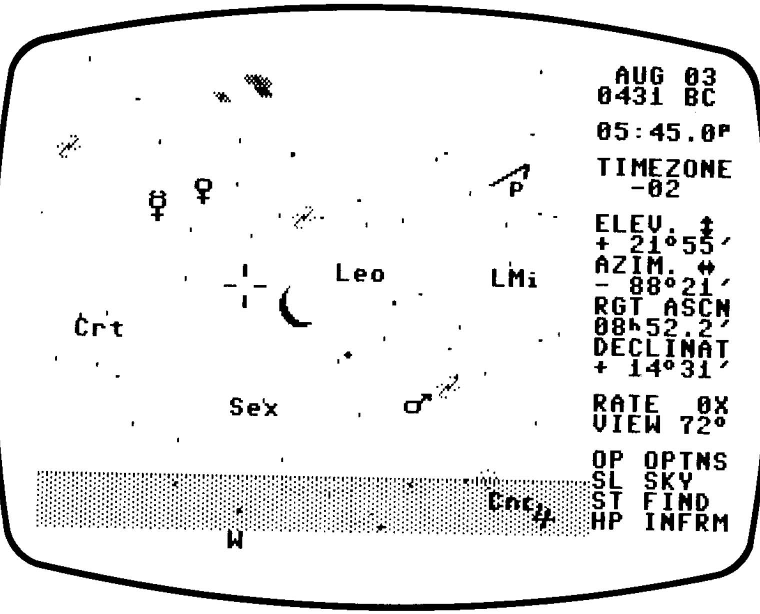
WARNING!
NEVER look directly at the SUN, even during a TOTAL eclipse!

A solar eclipse occurs when the moon blocks the sun's light at some location on Earth. Although the moon is much smaller than the sun, because the moon is much closer to Earth the apparent angular sizes are quite similar as seen from Earth. That's why when the moon almost completely covers the solar disk, we call the eclipse total.

One of the first reliable records of a solar eclipse dates from the Greek historian Thucydides. He reported an eclipse that occurred in the afternoon on August 3 in the year 431 B.C. The eclipse was not total, but enough of the sun was darkened to make some bright stars appear. The location of the observation was not mentioned, but since Thucydides was an Athenian, it's assumed to have been Athens.

Now you can look at that eclipse with ATARI Planetarium:

Press **[Select]** and go to MAP mode. Set the latitude to 37° 58′ N and the longitude to 23° 43′ E (Athens). Press **[Select]** again and go to SET mode. Set the date and time to August 3, 431 B.C., at 4:30 P.M. Press **[Select]** again and go to SKY mode. Press **[Start]** to center the sun on the screen. Next, use the cursor to push your window to the right until the sun is located on the left side of the screen. Now, change the clock RATE from 0X to 32X. The eclipse starts before 5:00 P.M. and is over by 7:00 P.M. The illustration below shows the screen at 5:45 P.M., local Athens time. Note the crescent sun and the planets Mercury, Venus, and Mars against a twilight sky, confirming Thucydides' report!



Next, you can try to confirm an eclipse predicted to occur in the future; for example, the one predicted for June 30, 1992:

> You have decided that the island of Tristan da Cunha might be a favorable place to observe and photograph this eclipse. So, press **[Select]** and go to MAP mode. Set the latitude to 37° 15′ S and the longitude to 12° 30′ W. Press **[Select]** and go to SET mode. Change the date and time to June 30, 1992 A.D., at 10:30 A.M. Then press **[Select]** again and go to SKY mode; if the VIEWing angle isn't already 36°, change to this angle. Now press **[Start]** to center the sun on your screen; then move the cursor to the left until the sun is on the right side of the screen. Next, set the clock RATE to 16X and you'll see an eclipse take place.
>
> Now, before you pack your bags for Tristan da Cunha, you realize that total solar eclipses are extremely location-dependent because of the small diameter of the moon's shadow, and, under optimum conditions, totality lasts only about five minutes. Obviously, you must be very careful if you want to experience totality. Therefore, stop the clock, go to SET mode, change the time back to 10:30 A.M., then return to SKY mode and get into TRACKing. To do this, press **[Option]** until NO TRACK appears in reverse-field letters in the data window; hold down **[Shift]** and again press **[Option]**. Now the data window shows TRACK.

Press **[Start]** until it shows SUN. Now, get pencil and paper ready, set the clock RATE to either 8X or 16X, and record for each time display the declination and right ascension of the sun as they're computed and displayed in the data window. When you've done this for the full time period of the eclipse, repeat the procedure for the moon. Next, plot the declination and right ascension numbers for the sun and the moon on a piece of graph paper. This method gives you a more systematic and accurate way of determining the closest approach than you can get solely by the visual display.

Actually, as you will find, the eclipse is not total at Tristan da Cunha, nor for that matter at St. Helena. But you could schedule your trip so that you'd be sailing from one island to the other and be at 25° latitude and at the longitude of Tristan da Cunha at around 11:00 A.M. local time. That way—weather permitting—you'd see a total eclipse!

Remember to get out of TRACK mode when you're finished. Otherwise, you might get some mysterious displays later on.

Note: For observations requiring pinpoint accuracy, such as determining the precise path of totality of a solar eclipse, you'll need specialized computer programs. Nevertheless, ATARI Planetarium gives a quick and rather accurate account of the main features of a wide range of celestial phenomena over very large time spans. A more detailed discussion of the structure and precision of the program appears in **Technical Notes** in this manual.

Lunar Eclipses

A lunar eclipse occurs when Earth blocks the line of sight between the sun and some location on the moon. If the shadow of Earth completely covers the moon's surface, the lunar eclipse is total. Therefore, though solar eclipses can occur only when the moon is approximately new, lunar eclipses can occur only when the moon is full. Total lunar eclipses are less frequent than solar eclipses, but they're much more common from any given location because lunar eclipses are always visible from about half the surface of Earth while solar eclipses are visible only from within the narrow path traced on Earth by the moon's small shadow. Examples of famous historical lunar eclipses appear on page 64.

Planetary Transits

The inferior planets, Mercury and Venus, are closer to the sun than Earth is. Therefore, when they block the line of sight between the sun and some position on Earth, a planetary transit occurs.

A planetary transit is similar to a solar eclipse, which is caused by the moon blocking the line of sight between the sun and some location on Earth. However, planetary transits are much more difficult to observe, in the case of Mercury because of the small apparent size of the planet and in the case of Venus because of the infrequency of the transits.

Early attempts to observe transits of Mercury, the smallest and innermost of the two planets, were unreliable due to confusion with sun spots. The first recorded Mercury transit was one predicted by Johannes Kepler to occur on November 7, 1631 A.D. Kepler himself died the year before, but an astronomer in Paris, Pierre Gassendi, observed and recorded the path of the planet across the surface of the sun. A second Mercury transit predicted to occur on May 3, 1661 A.D., was observed independently by the Polish astronomer Johann Hevelius from Gdansk, Poland, and by the Dutch scientist Christiaan Huygens from London.

Here's how you can verify these early recorded transits of Mercury:

> Press **[Select]** and go to MAP mode. Set the latitude to 48° 52′ N and the longitude to 02° 20′ E (Paris). Press **[Select]** and go to SET mode. Set the date and time to November 7, 1631 A.D., at 3:00 P.M. Press **[Select]** again and go to SKY mode. Press **[Option]** and set SYMBOLS and NO NAMES. Set the VIEWing angle to 36° and press **[Start]** to center the sun on your screen. Now press **[Start]** again to center Mercury on your screen. Set the clock RATE to 64X. Note that the symbol for Mercury is completely invisible because it's right in front of the illuminated solar disk. However, as the sun sets, the symbol starts emerging at the right side of the sun. This is the Mercury transit observed by Gassendi.
>
> Now stop the clock and go back to MAP mode. Change the latitude to 51° 30′ N and the longitude to 0° 10′ W (London). Then go to SET mode and change the date and time to May 3, 1661 A.D., at 4:30 A.M. Now go to SKY mode, keeping the same OPTION settings as before. Press **[Start]** to center the sun, then Mercury. Next, set the clock RATE again to 64X. The symbol for Mercury is

again invisible because it's right in front of the sun; but as the sun rises, it will appear at the left side of the solar disk. This is the Mercury transit observed by Huygens.

The first predicted transit of Venus was calculated from Kepler's laws to occur on December 7, 1631 A.D., but unfortunately the sun was below the horizon from Europe at the time so no observations were made. The next transit was predicted to occur on December 4, 1639 A.D., and was observed and recorded by the English astronomer and clergyman Jeremiah Horrocks. No Venus transits have occurred during the past 100 years, and the next transits will occur on June 8, 2004, and on June 5-6, 2012.

Follow the steps below to check both a past and a future Venus transit:

First, stop the clock. If you're continuing from the previous example, stay in London; otherwise, go there by the previous route designated in that example. Press **[Select]** and go to SET mode. Set the date and time to December 4, 1639 A.D., at 7:45 A.M. Press **[Select]** and go to SKY mode, leaving the same OPTION settings as before. Press **[Start]** to center the sun, then Venus. Increase the clock RATE to 64X. As the sun rises, the symbol for Venus will disappear against the background of the illuminated solar disk. This is the Venus transit observed by Horrocks.

Now stop the clock again. Press **[Select]** and go to MAP mode. Set the latitude to 41° 43′ N and the longitude to 74° 01′ W (New York City). Press **[Select]** and go to SET mode. Set the date and time to June 8, 2004 A.D., at 4:00 A.M. Press **[Select]** again and go to SKY mode. Press **[Start]** to center the sun, then Venus. Increase the clock RATE again to 64X. Note the sunrise and the symbol of Venus overlapping the solar disk. This is one of the Venus transits yet to come.

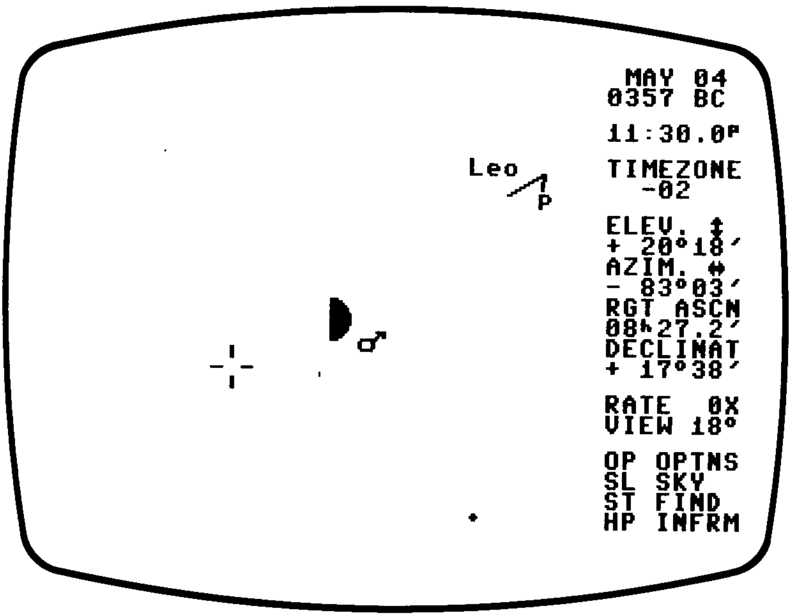
Planetary Occultations

Planetary occultations are eclipses of a planet by another planet or by the moon, as seen from Earth.

The Greek philosopher Aristotle observed and recorded an occultation of Mars by the half-moon on May 4, 357 B.C. He described how Mars disappeared behind the dark side of the moon and then reappeared on the bright side. Aristotle used this observation as conclusive proof that the moon is closer to Earth than Mars is, and commented that similar, earlier observations by the Egyptians and Babylonians had proven this to be the case also for the other then-known planets.

Here's how you can re-create this personal observation by Aristotle:

> Press **[Select]** and go to MAP mode. Set the latitude to 38° N and the longitude to 24° E (near Athens). Press **[Select]** and go to SET mode. Set the date and time to May 4, 357 B.C., at 6:00 P.M. Now press **[Select]** again and go to SKY mode. Press **[Start]** to center Mars on your screen. Set the VIEWing angle to 18°. Using the cursor, push Mars to the upper left of the screen; then set the clock RATE to 16X. Watch from 6:00 P.M. to about 2:00 A.M.; note how the sky changes color due to the sunset. Mars passes behind the dark side of the moon and reappears on the bright side, just as Aristotle observed.



As a young man in Tübingen, Germany, Johannes Kepler observed and recorded a rare occultation of Jupiter by Mars on January 19, 1591 A.D. Because of the distinct red color of Mars, Kepler was able to see that Mars covered Jupiter rather than the other way around. He therefore concluded—based on the Aristotelian argument previously explained—that Mars is closer to Earth than Jupiter is. Here's how you can see this event:

Press **[Select]** and go to MAP mode. Set the latitude to 48° 05′ N and the longitude to 07° 04′ E (Tübingen near Stuttgart, West Germany). Press **[Select]** and go to SET mode. Set the date and time to January 19, 1591 A.D., at 7:00 A.M. Press **[Select]** again and go to SKY mode. Press **[Start]** to center Jupiter on the screen. Also center Mars on the screen; note their close proximity. Set the clock RATE to 32X and watch the motion of the two planets. For a more accurate determination, use the TRACKing option separately for each planet, noting the right ascension and declination vs. the clock for each planet. Plot these values, recorded for the same times, on graph paper to see the time of the closest approach.

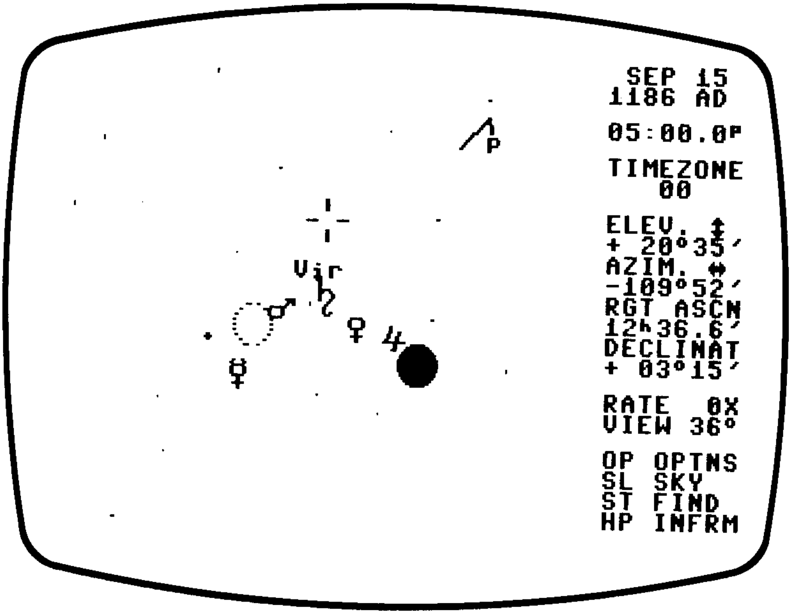
An occultation of Venus by the moon on July 17, 1974 A.D., is an example from recent times. The occultation took place in the early morning hours, and observations in the U.S. were particularly favorable from Florida. Using the method described above, set your ATARI Planetarium to the correct time and place and see this event for yourself on your screen.

Planetary Alignments and the "Jupiter Effect"

One of the most striking of astronomical spectacles occurs when several planets are visible within a narrow field of view. In ancient and medieval times, such spectacles were regarded as portents of great catastrophes. Even quite recently, predictions of natural disasters have been widely reported. Present-day fears are based on concerns that the combined gravitational pull of several planets might trigger major earthquakes and tidal waves on Earth.

On September 15, 1186 A.D., Mercury, Venus, Mars, Jupiter, Saturn, and the moon were all close to the sun and within a narrow viewing angle of 12°. This rare configuration of planets had been predicted several years before by the astrologer John of Toledo. It was taken as an omen of great calamities and earthquakes. Near panic ensued, and the location of the planetary clustering in the Libra sign of the zodiac was taken as a particularly ill omen for high winds. People sought refuge in cellars and caves. The windows of the Imperial Palace in Byzantium were boarded up, and the Archbishop of Canterbury ordered fasting. Finally, the month of September came and the predicted planetary configuration occurred without any of the feared consequences on Earth.

The following illustration represents this planetary alignment:



You can re-create this view as follows:

> Press **[Select]** and go to MAP mode. Set the latitude to 49° N and the longitude to 05° W (western Europe). Press **[Select]** and go to SET mode. Set the date and time to September 15, 1186 A.D., at 5:00 P.M. Press **[Select]** again and go to SKY mode. Set the clock RATE to 0X and the VIEWing angle to 36°. Press **[Start]** to locate Saturn, and you will get a display similar to the illustration above.

On February 5, 1524 A.D., another close planetary clustering was predicted, this time in the Aquarius sign of the zodiac. Another deluge was predicted, serious flooding was feared, and many people took refuge in boats. The year turned out to be an unusually dry one.

On March 10, 1982 A.D., the eight planets (excluding Earth) were within about one quadrant of the sky. The event, which scarcely qualified as an "alignment," was nevertheless forecast (by highly unscientific sources) to trigger a major earthquake in California and to result in enhanced solar activity. A so-called "Jupiter effect" was widely discussed in the news media. For the record, California did not break off at the San Andreas Fault and slide into the Pacific Ocean in 1982.

On February 26, 1953 B.C., the four planets Mercury, Venus, Jupiter, and Saturn were within a viewing angle of less than 4°. No historical record exists of this ancient planetary clustering.

You have an opportunity to practice on your ATARI Planetarium by demonstrating the planetary alignments described above. For each example, your location can be anywhere on Earth.

Planetary Retrogression

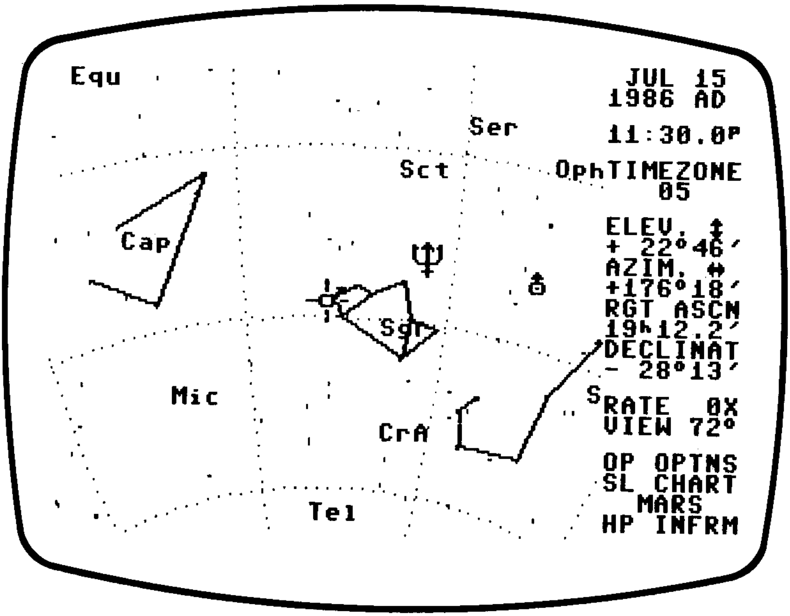
Since ancient times, the planets have been recognized as being different from the stars because they move relative to the background of fixed stars. This is reflected in the word "planet," which means *wanderer*. The superior, or outer, planets, which are more distant from the sun than Earth is, at times show a peculiar motion: they temporarily appear to move backwards. The astronomer-geographer Ptolemy of Alexandria in the 2nd century A.D. rationalized this observation by suggesting that a planet moves in a circle about a center, which itself orbits the sun.

The laws of planetary motion discovered by Johannes Kepler explain this phenomenon, which is now called "retrogression." Actually, planets don't move backwards when seen from the location of the sun. The reason that they appear to do so is that we observe the planets from Earth, which is itself a moving planet. The closer a planet is to the sun, the greater its orbital speed. Therefore, when a planet is near "opposition," that is, when it's located in the opposite direction of the sun as seen from Earth, the line of sight from Earth to the planet changes direction relative to the celestial sphere background simply as Earth catches up with and then overtakes the outer planet. Because the Earth and the planets are not in exactly the same orbital planes, a retrogression usually appears as a shallow loop.

The opposition of Mars in 1986 A.D. illustrates how CHART mode can be used for plotting planetary positions.

> First, you'll need to make a printout of an appropriate star chart. To do this, connect a printer to the computer as previously described. Then press **[Select]** and go to MAP mode. Set the latitude to 38° 54′ N and the longitude to 77° W (Washington, D.C.). Press **[Select]** and go to SET mode. Set the date and time to July 15, 1986 A.D., at 11:30 P.M. Press **[Select]** again and go to SKY mode. Press **[Option]** and install the following options: LINES, NAMES, SYMBOLS, NO DEEP, TRACK, and NO SOUND. Set the VIEWing angle to 72° and the clock RATE to 0X; then press **[Start]** for Mars.

You now see Mars centered on your screen near the constellation Sagittarius low in the night sky. Next press **[Select]** and go to CHART mode. After the CHART screen appears, press **[Shift] [P]** (or **[Control] [P]** for an Epson printer) and the printer will generate the background star chart shown below.



In order to plot the various locations of Mars on this chart, you must first identify and mark the right ascension and declination coordinates of the celestial chart grid by moving the cursor to the principal intersections on the chart and reading the cursor coordinates in the data window. Next, since you're tracking Mars, all you have to do is press **[Select]** to switch between SET and CHART (or SKY) modes, pressing **[Return]** in between. When you're in SET mode, input the desired date; when you're in CHART (or SKY) mode, read the right ascension and declination coordinates for Mars in the data window. Plot the coordinates and dates from March 15 through October 15, 1986, on the chart and connect the points; now you can clearly see the retrogression of Mars during the 1986 opposition.

Charts like this are convenient to take with you when you're studying the celestial phenomena of the real night sky.

Precession, Polestars, and Zodiac

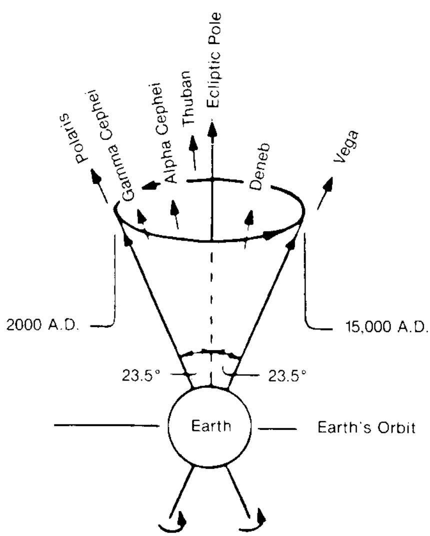
"This is the dawning of the age of Aquarius..."

from the Broadway musical **Hair**

Observers of the northern sky are familiar with the polestar (Polaris), also called the North Star. This star makes it particularly easy to determine the cardinal directions in the Northern Hemisphere at night. (There is no similarly easy method in the Southern Hemisphere because of the lack of a "South Star.") As was described on page 32, you can easily locate the North Star by extending a line through two pointer stars in the constellation the Big Dipper (Ursa Major). The North Star is formally known as Alpha Ursae Minoris, which means "the first star of Little Bear." Little Bear is another name for the Little Dipper. However, Alpha Ursae Minoris has not always been the North Star, nor will it always continue to be.

Ancient astronomers and navigators did not use Polaris as the North Star. In fact, the "North Star" at the time the Great Pyramids were built was the star Thuban in the constellation Draco (see page 67). The North Star today is about 1° from the true pole, and by the year 2102 A.D. it will reach its closest proximity to true north of about ½°. The next polestar will be the star Gamma Cephei in the year 4145 A.D., and the one after that will be the star Alpha Cephei in the year 7530 A.D. Both stars are in the constellation Cepheus.

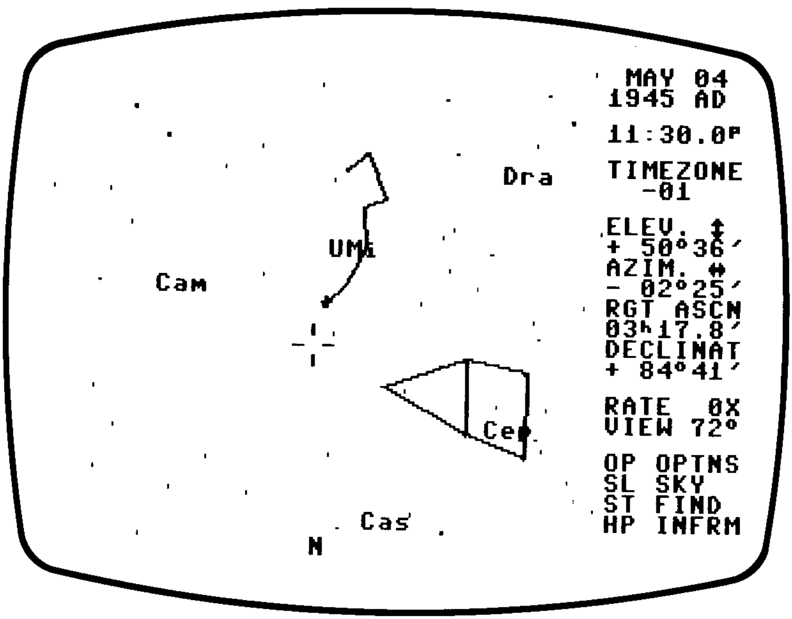
Precession Cone of Earth's Axis



The reason for the changing polestars is that Earth's axis wobbles like that of a spinning top. The wobbling, or precession, has a time cycle of 26,000 years, after which the sequence of polestars will repeat itself.

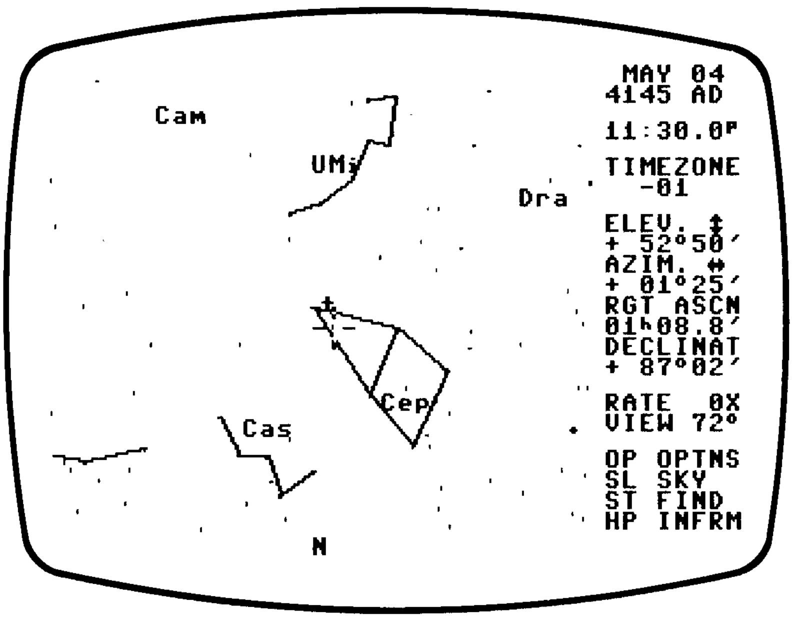
ATARI Planetarium takes Earth's precession into account, so you can demonstrate for yourself the past and future polestars mentioned above. The polestar in the distant past will be shown in a later example. Here you can see the appearance of the northern polar region far into the future:

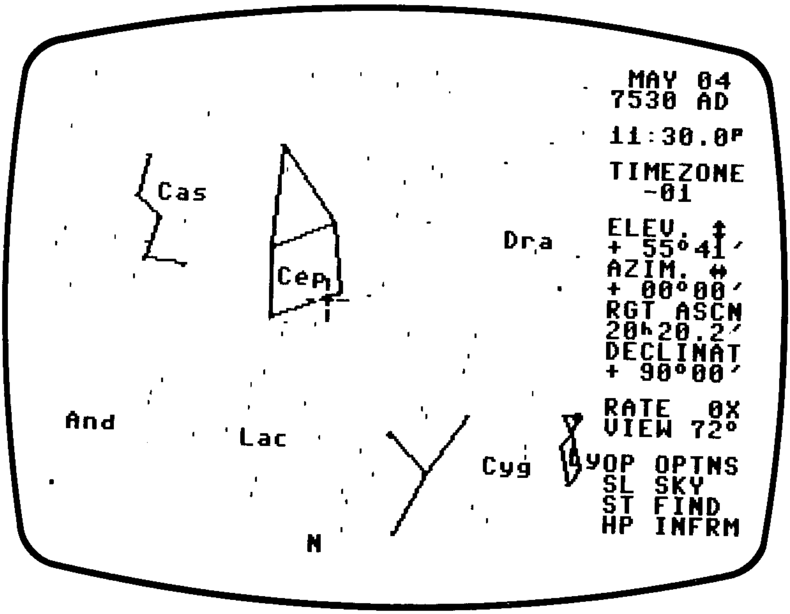
> Press **[Select]** and go to MAP mode. Set the latitude to 55° 41′ N and the longitude to 12° 41′ E (Copenhagen). Press **[Select]** and go to SET mode. Select any day and a time after sunset, for instance, May 4, 1945 A.D., at 11:30 P.M. Press **[Select]** again and go to SKY mode. Press **[Start]** to select CONSTELLATIONS; when the screen display appears, put the cursor on NPole and press **[Return]**. You now see the current polestar, Polaris, close to the North Pole. The pole is marked by a small cross, which you can best see if you move the cursor away from the center of the screen.



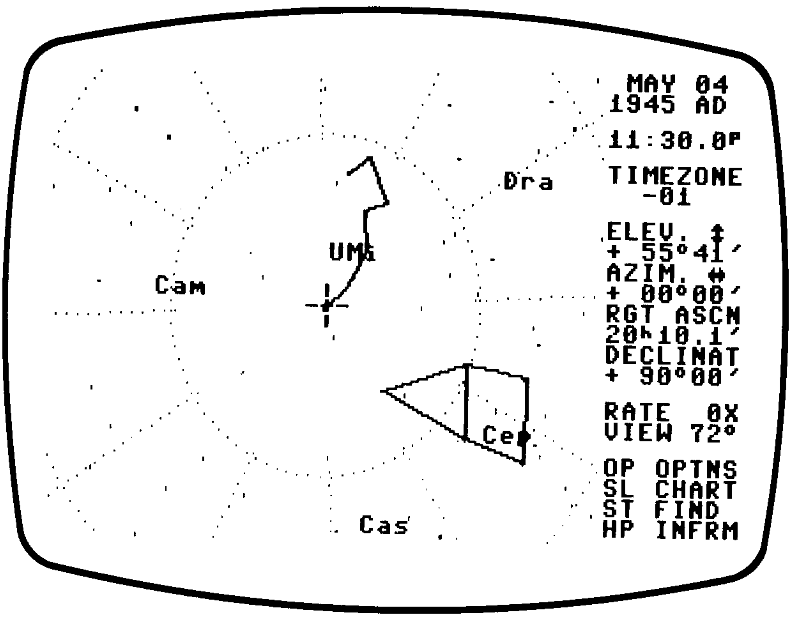
Next, press **[Select]** and go to SET mode. Change the year to 4145 A.D. Press **[Select]** again and return to SKY mode. Remember that major changes (more than 100 years) in year settings cause a delay in getting the screen display of the sky, since precession requires recalculation of all the star coordinates on the celestial sphere. While this is happening, the textline shows the message "Precessing.." Once the SKY screen reappears, notice the shift in positions of the stars near the North Pole. Specifically, the polestar is no longer Polaris but instead is Gamma Cephei. To confirm it, put the cursor on top of the new polestar and press **[Help]**.

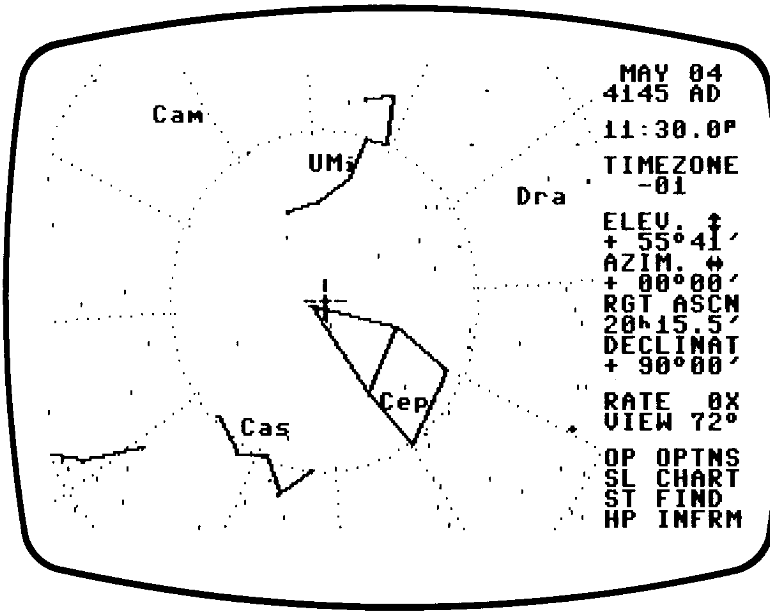
Now, repeat the procedure for the year 7530 A.D.





If you wish to get CHART mode versions of the SKY displays, press **[Select]** until the word CHART shows in the data window. CHART versions are shown below.





Another effect of precession is that the vernal equinox, the autumnal equinox, and both solstices change slowly during the same period of 26,000 years. You can see this by comparing the illustration on page 47, showing the wobbling of Earth's axis, with the illustration of the celestial sphere and ecliptic on page 25. The celestial Equator will turn in relation to the ecliptic when Earth's axis of rotation precesses. This is because both the celestial Equator and Earth's Equator are in the same plane.

One effect of this is that the star coordinates on the celestial sphere are not constant over long periods of time, as mentioned earlier. It may seem strange at first that astronomers would choose a moving origin for measuring right ascension when they could have chosen any immovable point on the celestial Equator and thus avoid that problem. Nevertheless, the advantage is that it keeps the sun's position independent of precession, and, for all inhabitants on Earth—including astronomers—the sun and the seasons are more important for everyday life than the stars.

The star background changes slowly with respect to the position of the sun. This is most obvious in relation to the zodiac constellations, located in a narrow band along the ecliptic. This is also the region in which all the planets move, because their orbital planes are tilted only moderately relative to Earth's orbit. This ecliptic band is thus the region of the sky where all the action is, and it is the region that captured the attention of the astrologer-priests in the Babylonian and Assyrian civilizations. They divided the ecliptic into twelve 30° intervals, or signs, and named them after the principal constellations located in those sections at the time. The Greeks later coined the name "zodiac" (meaning the circle of animals) for the ecliptic constellations. In the 2nd century A.D., Greek astronomer-geographer Ptolemy of Alexandria described and published illustrations of most of the constellations. Those illustrations are still in use today.

When the Babylonians made their observations around 2000 B.C., the vernal equinox was in the constellation Aries. At the birth of Christ, the vernal equinox was moving into Pisces; today, it's approaching Aquarius. In a sense, precession makes the ecliptic into a gigantic clock with a 26,000-year period for a single turn of the "hand," the vernal equinox. The circular motion of the celestial poles, causing changes in which star happens to be closest to the North Pole, is just another look at the same clock from a different direction.

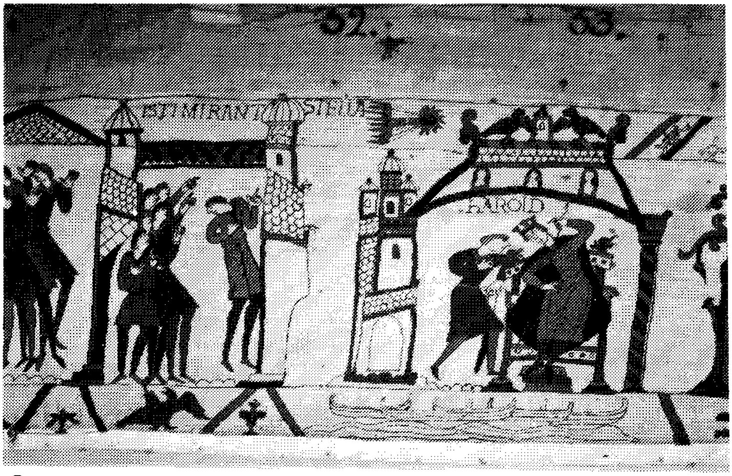
Halley's Comet

> *"Of all the comets in the sky*
> *There's none like comet Halley*
> *We see it with the naked eye*
> *and periodically"*
>
> *Harold Spencer Jones*

Comets are relatively small, frozen bodies that revolve around the sun. When a comet passes close to a large body, such as a large planet, its orbit is perturbed. For this reason, the trajectories of comets are changeable. Comet "tails" are vapor and dust clouds formed when the frozen "head" of the comet passes close to the sun and gets heated up. This process eventually depletes the comet. Since the tails of comets can be extremely large and spectacular, appearances of comets have been recorded since ancient times.

Halley's Comet was first observed and recorded in 240 B.C. Subsequent returns have been extensively recorded around the world. A particularly famous appearance is shown on the Bayeux tapestry, a two-foot-high, 239-foot-long weaving made in medieval times in Normandy depicting the Norman conquest of England. The comet appeared as William the Conqueror set sail for

England and was taken as an omen presaging the fate of King Harold, who later was defeated and slain at the Battle of Hastings in 1066 A.D.



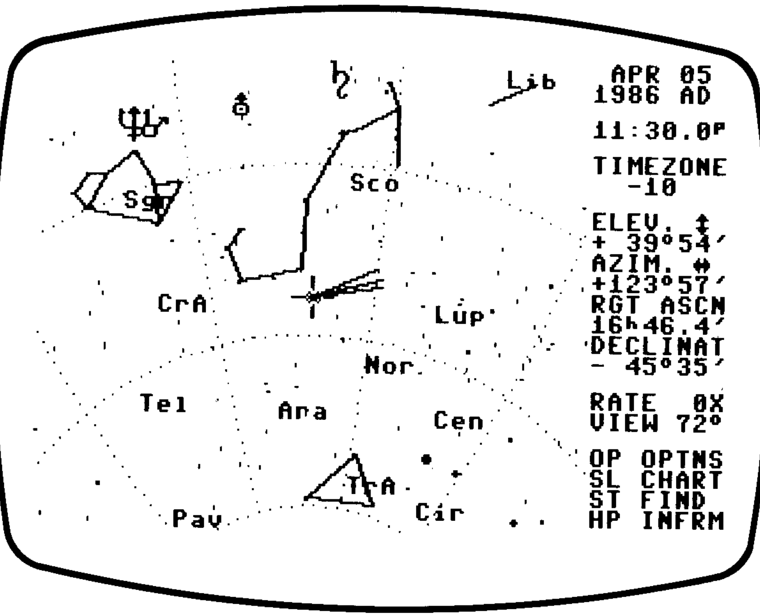
Courtesy: William the Conqueror Center, Bayeux, France

The Latin inscription on the tapestry means "men wondering about the star." Note the messenger bringing the bad news to King Harold and the invasion ships below the king.

The comet is named for the British astronomer Edmund Halley, who personally observed the "Great Comet" of 1682 A.D. Halley was a close friend of Isaac Newton and, in fact, was instrumental in getting Newton's theory of gravitation published. Working from Newton's ideas, Halley compared the appearance of the 1682 comet with the records of earlier ones and concluded that this was a periodic comet. He determined its orbit and correctly predicted subsequent appearances. In recognition of this accomplishment, the comet was later named for him. The comet appears about every 75 years; the apparition before the 1985-86 one was in 1910 A.D. Several space probes are being sent towards the comet to carry out scientific studies and to transmit close-up pictures back to Earth, making this visit a particularly spectacular and exciting event.

ATARI Planetarium can demonstrate the predicted trajectory for the 1985-86 passage of Halley's Comet. The closest approach to the sun (the perihelion) is early February, 1986. The best time for observation is from September through December, 1985 (especially in the Northern Hemisphere), and from March through July, 1986 (especially in the Southern Hemisphere). Since the comet's tail is formed by evaporation as its head passes close to the sun, a periodic comet is most spectacular on its return trip. Here, you can use CHART mode to plot the 1986 spring trajectory of Halley's Comet:

> Press **[Select]** and go to MAP mode. Set the latitude to 34° 04′ S and the longitude to 150° 08′ E (Wollongong, New South Wales, Australia). Press **[Select]** and go to SET mode. Set the date and time to April 5, 1986 A.D., at 11:30 P.M. Press **[Select]** again and go to SKY mode. Then press **[Option]** and set the following options: LINES, NAMES, SYMBOLS, NO DEEP, TRACK, and NO SOUND. Set the VIEWing angle to 72° and the clock RATE to 0X. Press **[Start]** until COMET is displayed in the data window. You now see Halley's Comet adjacent to the constellation Scorpio. Press **[Select]** again and go to CHART mode. Make a printout of this chart. Identify the right ascension and declination values of the coordinate lines by moving the cursor to the intersections of the coordinate grid and label the chart.
>
> In order to get the positions of Halley's Comet for the period from March 21 through April 20, 1986, press **[Select]** to switch between SET and CHART (or SKY) modes, pressing **[Return]** in between. When you're in SET mode, input the desired date; when you're in CHART mode, read the right ascension and declination coordinates for Halley's Comet in the data window. These coordinates are displayed because the computer is tracking the comet.



You'll also find it interesting to watch the comet in SKY mode during the same period. On the return trip from the sun, the direction of the tail and the comet's distance from Earth both change rapidly. Until the middle of March, the comet remains below the horizon in Wollongong, but it would have been rather inconspicuous anyway. However, from the end of March to early April, the comet is well above the horizon and a large tail is visible. By mid-April, the comet show is about over for observers without telescopes.

Southern Constellations

If you live in the Northern Hemisphere, you may be curious about the less familiar southern constellations. To learn more about them, place the cursor over a desired constellation abbreviation (left letter) or celestial object and press **[Help]**. The desired information now appears in the text window; use the cursor keys or your joystick to scroll the text through the window. The joystick fire button or **[Return]** will return the program to normal operation in SKY mode.

CHAPTER 4
CHRONOLOGY

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CALENDARS AND ASTRONOMICAL DATES

"Beware the Ides of March"

from Julius Caesar

ATARI Planetarium allows you to go backward or forward in time about 10,000 years. However, in checking astronomical events in the past, you'll need to be sure that the proper calendar date is used—often no easy task.

The calendar of western civilization dates back to the mythical founding of Rome in 753 B.C.* For many centuries, the Romans dated events by counting from this date and designated the years "ab urbe condita" (abbreviated as A.U.C.), which means "since the founding of the city." The Roman year originally had only ten months and began in the spring with the month of March. We still have a reminder of this in the names of the months September, October, November, and December, which from their Latin origin mean the seventh, eighth, ninth, and tenth months, respectively. Later on, the Romans added two more months, January and February, at the beginning of the year.

When the early calendar got too much out of step with the seasons, the Romans occasionally added an extra month. These adjustments, made under the jurisdiction of the priests, were often arbitrary and weren't always coordinated within different parts of the Roman Empire. Understandably, this became increasingly intolerable to the historians, scribes, and tax collectors, not to mention the taxpayers.

Change came in the introduction by Julius Caesar of the Julian calendar, based on a solar year of 365¼ days as determined by the Egyptians (a year is actually 365.2422 days long). The calendar has three years of 365 days and a fourth year (leap year) of 366 days. Leap years then, as now, were those evenly divisible by four. The Julian calendar was put into effect on January 1, 45 B.C. In order to offset errors accumulated beforehand,

*According to legend, there once was a forger who minted gold and silver coins in an attempt to pass them off as rare, ancient ones. The fraud was soon discovered, however: the years were marked B.C.!

corrections were made all at once in the year 46 B.C., which was made 445 days long and is generally referred to as the year of confusion!

The Gregorian calendar, the one currently in use, was formally introduced by Pope Gregory XIII in 1582 A.D. His main interest in an improved calendar was to ensure the proper timing of the holy days of Easter. The Julian calendar year was slightly too long. The Gregorian calendar corrected the error by requiring that only those centuries evenly divisible by 400 and all other years evenly divisible by four be leap years (366 days); other centuries would remain normal years (365 days). Errors which had accumulated since the establishment of the Julian calendar were again adjusted in one fell swoop by eliminating ten days in the year 1582: October 4 was followed immediately by October 15.

The Gregorian calendar was not universally adopted at the time. For example, England and the American colonies didn't adopt the calendar until 1752 A.D., at which time 11 days had to be eliminated: September 2 was followed that year immediately by September 14. One well-known historical consequence is George Washington's birthday. According to the Gregorian calendar in use today, he was born on February 22, 1732 A.D., but the calendar in use at his birth showed February 11. Russia didn't change to the Gregorian calendar until the Bolshevik Revolution (1917 A.D.), at which time 13 days had to be eliminated.

After the French Revolution, France's National Convention in 1795 A.D. legislated a "new" calendar, based in part on the decimal system. The year started in the fall at the autumnal equinox and consisted of 12 months, each with 30 days. A month was divided into three ten-day weeks, each day having ten hours, each hour 100 minutes, and each minute 100 seconds. To correct for the fact that a year is longer than 360 days, five or six specially named extra days were added at the end of each year. Actually, this revolutionary calendar was not new at all, but a rediscovery of an ancient calendar used in Egypt as early as 3000 B.C. Since no one liked the ten-day week, the attempt failed and the law was repealed in 1805 A.D.

Astronomical calculations are based on so-called Julian days, which have nothing to do with the Julian calendar. The system was created in 1583 A.D. by the French chronologist and mathematician J.J. Scaliger, who named his invention after his father. The Julian day system begins at Greenwich noon (GMT) on January 1, 4713 B.C., and a Julian date is simply the number of the day in a continuous count since that date. Dates before 4713 B.C. are counted as negative numbers. The Julian day system has three simple advantages: first, differences in days can be determined by simple subtraction; second, days of the week can be determined by dividing the Julian date number by seven, then using the remainder to define the day of the week (0 = Monday, 1 = Tuesday, etc.); and third, it provides an unambiguous reference standard for synchronizing dates among the multitude of ancient calendars.

The standard calendar mode is shown as AUTO in the data window. ATARI Planetarium converts all date entries to Julian day numbers before proceeding with the astronomical computations. It assumes that all dates before and including October 14, 1582 A.D., are in the Julian calendar as later modified so that the year count starts with the birth of Christ. On and after October 15, 1582 A.D., the program assumes that the date is in the Gregorian calendar. In accordance with convention, the Julian calendar has been extrapolated backwards before its inception to avoid the extremely cumbersome calendar systems used by the Romans and others during antiquity. The program has also been designed not to accept entries of nonexisting dates.

The following examples show how the calendar routines of ATARI Planetarium can be used for historical and chronological purposes:

> Press **[Select]** and go to SET mode. Set the year to 1984 A.D., then set the date to February 29. (Since 1984 is evenly divisible by four, it's a leap year and February 29 exists.) Now change the year to 1985; the date changes to March 1 since there is no February 29 in a nonleap year. Now change the year to 1900 A.D. and try to set the date to February 29; the program won't let you. Although the year 1900 A.D. is evenly divisible by four, it's a century not evenly divisible by 400, and, by the Gregorian calendar convention, such years are not leap years. In contrast, the century 2000 A.D. is evenly divisible by 400; hence, it's a leap year and February 29 exists.

> Press **[Select]** and go to SET mode. Set the year to 1582 A.D., then set the date to October 4. Next, advance the date one day at a time and watch the Julian day number: it also advances one day at a time until you reach October 15, when it goes back ten days to the same Julian day it was showing for October 5. Here you're seeing the disappearance of ten days ordered by Pope Gregory!

The program knows that those days do not exist in the Gregorian calendar, so anybody entering them must still be in the Julian calendar. However, on or after October 15, the program assumes that the date entry is Gregorian.

An example of how ATARI Planetarium can be used to determine historical dates with certainty is the rare planetary occultation of Jupiter by Mars presented earlier (page 42). The German astronomer Johannes Kepler reported that the event occurred on January 9, 1591 A.D.; yet, if you try to repeat the example on that date, you'll see that no occultation occurred. However, on January 19, 1591 A.D., the date given in our example, there was indeed an occultation. The explanation is unquestionably that in 1591—only nine years after Pope Gregory had introduced his calendar reform—Johannes Kepler in Germany was still using the Julian calendar.

Press **[Select]** and go to MAP mode. Set the longitude to 0° (Greenwich meridian). Press **[Select]** and go to SET mode. Local time is now Greenwich mean time (GMT). For any day, see that the Julian day number changes at noon rather than at midnight for the calendar day!

You can change the calendar setting from AUTO to JULIAN or GREGORIAN while in SET mode by the usual method of using the [>] and [<] keys. However, this is not recommended because the program no longer protects you from entering meaningless dates, such as Gregorian dates before Pope Gregory, Julian dates in modern times, etc. The option is included for users with a special need for frequent conversions but should be ignored by most people.

THE STAR OF BETHLEHEM

"Now when Jesus was born in Bethlehem...,
behold, wise men from the east came to Jerusalem
saying, 'Where is he who has been born king of the
Jews? For we have seen his star in the east,
and have come to worship him.'"

Matthew 2, 1-2

The Julian calendar was used for many centuries with the year count beginning at the founding of Rome (A.U.C.). However, in the 6th century A.D. (by our present calendar), the monk and scholar Exiguus suggested that the count start instead at the birth of Christ, which he calculated to have occurred in the year 754 A.U.C. The proposal was accepted only gradually. For example, in the 9th century, Charlemagne ordered this change in the calendar within his empire. Even so, the custom of counting the years from the birth of Christ did not become common practice in Europe until the 11th century.

There is considerable uncertainty as to the accuracy of Exiguus' calculations. Although Christmas is celebrated on December 25 by convention, both the day and year of Christ's birth are uncertain. For example, based on what is believed to be reliable historical sources, Herod the Great died in 4 B.C., which conflicts with the statements in both Luke and Matthew that Christ was born during his reign.

Because astronomical events have often proven to be a means of accurately dating historical events, the brief description of the "star of Bethlehem" in Matthew might provide a valuable clue. Many attempts were made for centuries to identify the nature of the "star" which brought the three Magi to Bethlehem at the birth of Christ. It's been suggested, for example, that the "star" might have been a supernova, but such an event would most likely have been observed and recorded elsewhere, and besides, no supernova remnant has ever been found.

Another suggestion was that it might have been a comet. For example, the early Renaissance painter Giotto depicted the star as a comet in a well-known 1300 A.D. fresco of the nativity scene in the Arena Chapel in Padua, Italy. Indeed, later studies have shown that Halley's Comet did appear during October in the year 12 B.C. However, the historical records of the reign of King Herod make this apparition too early to be the plausible explanation, although a comet certainly would have alerted astrologers from the east to look for further signs in the sky.

More recently, it has been suggested that the "star" was actually a conjunction of the planets Jupiter and Saturn. These planets were in close alignment in the year 7 B.C. in the constellation Pisces (the Fish). The conjunction of these particular planets in Pisces at a time when the vernal equinox was moving from the sign of Aries into the sign of Pisces might well have had a special meaning to Magi from the Mesopotamian region who were well versed in Babylonian astrology. Note also that the fish was used as a secret sign by the early Christians long before the use of the Cross. Assuming that this suggestion is correct, the most probable date for the birth of Christ has been calculated to be September 15, 7 B.C.

ATARI Planetarium allows you to observe the alignment of Jupiter and Saturn on that night nearly 2000 years ago:

> Press **[Select]** and go to MAP mode. Set the latitude to 32° 29′ N and the longitude to 34° 01′ E (Bethlehem). Press **[Select]** and go to SET mode. Set the date and time to September 15, 7 B.C., at 11:55 P.M. Press **[Select]** again and go to SKY mode. Make sure the clock RATE is stopped. Press **[Option]** to select the following: SYMBOLS and NAMES. Set the VIEWing angle to 72°. Press **[Start]** to find Saturn. You are now looking at the midnight sky over Bethlehem; Saturn and Jupiter are so close that the symbols actually are superposed. Next, press **[Option]** to eliminate SYMBOLS.

ATARI Planetarium has now re-created the "star of Bethlehem" as it may have appeared to the Magi and the shepherds on the night Christ was born.

CHAPTER 5
HISTORY/ARCHAEOLOGY

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WARNING!
NEVER look directly at the sun,
even during a TOTAL eclipse!

SOLAR ECLIPSES IN ANTIQUITY

In ancient times, total solar eclipses, which turned day into night, were believed to be frightful signs of displeasure by the gods. In many instances, primitive responses to eclipses influenced human history.

Eclipses are important to historians for another reason. Because they were widely considered to be warnings of great misfortunes and calamities, they were often recorded if they preceded major historical events. Since present-day calculations can determine the precise date of an eclipse for a given location, such records have proven extremely valuable for synchronizing early calendars and correlating the histories of ancient societies.

The Roman statesman Cicero recorded a solar eclipse that occurred on June 21, 400 B.C. This eclipse attracted special attention since it occurred near Rome a few minutes after sunset and was very nearly total. The sudden, complete darkening of the twilight sky followed by the reappearance of twilight was poetically described at the time as "on the nones of June, the sun was covered by the moon and night." This particular event is an example of an eclipse that has helped historians solve some problems with the very cumbersome early Roman calendar.

With ATARI Planetarium, you can re-create this famous solar eclipse:

> Press **[Select]** and go to MAP mode. Set the latitude to 42° N and the longitude to 14° E (near Rome). Press **[Select]** and go to SET mode. Set the date and time to June 21, 400 B.C., at 6:30 P.M. Press **[Select]** again and go to SKY mode. Press **[Start]** to center the sun. Next, increase the clock RATE to 16X and watch the sunset until about 8:00 P.M.; note the sky changing from twilight to darkness, with the stars appearing, then the stars fading as twilight reappears, followed shortly afterwards by the blackening of the sky as the sun sets—all in agreement with Cicero's report.

LUNAR ECLIPSES IN ANTIQUITY

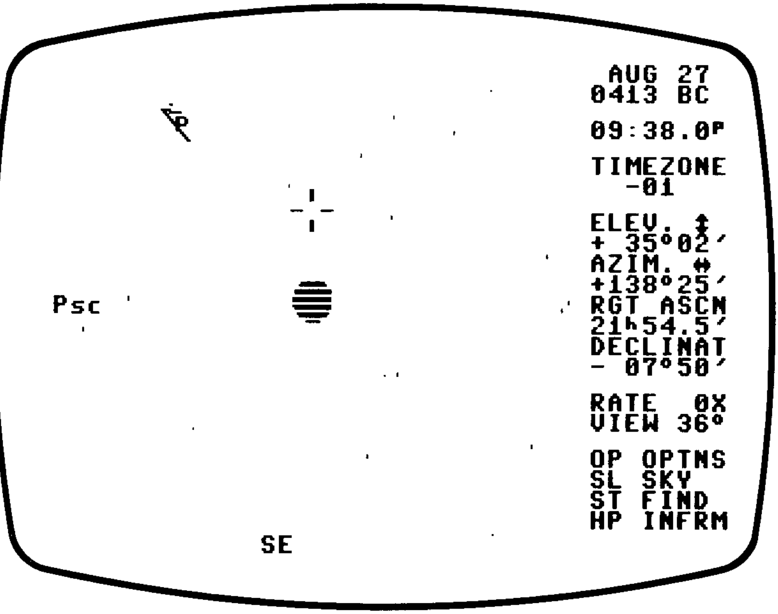
Although the loss of the moon's light was less frightening to people in antiquity than the loss of the sun's light, a lunar eclipse was nevertheless considered an important omen.

The Greek historian Thucydides reported on a famous lunar eclipse during the Peloponnesian war. It occurred on August 27, 413 B.C., the day the Athenian commanders had planned to leave Syracuse. The eclipse so frightened the Athenian soldiers and sailors that on the advice of the astrologer-priests, the departure was delayed 27 days. This delay gave the people of Syracuse the opportunity to regroup, and they destroyed or captured the entire Athenian force.

Cicero and Livy reported on a lunar eclipse that occurred on June 21, 168 B.C., during a war between Rome and Macedonia. The Roman soothsayers astutely construed the eclipse as a sign that the reign of the Macedonian king was nearing its end. The eclipse—and the priests—were thus given credit for having contributed to the Roman victory at the famous battle of Pydna, which marked the end of the Macedonian Empire founded by Alexander the Great.

To see these historical lunar eclipses for yourself, follow the steps below:

> Press **[Select]** and go to MAP mode. Set the latitude to 37° 30′ N and the longitude to 15° E (Syracuse, Sicily). Press **[Select]** and go to SET mode. Set the date and time to August 27, 413 B.C., at 8:00 P.M. Press **[Select]** again and go to SKY mode. Set the VIEWing angle to 36° and the clock RATE to 32X. Press **[Start]** to center the moon on the screen. Earth's shadow is represented by a circular disk of raster lines on the same (enlarged) scale as the moon. The rasters become visible as the moon enters into Earth's shadow. The eclipse becomes total around 9:40 P.M. and is over by about 11:00 P.M.



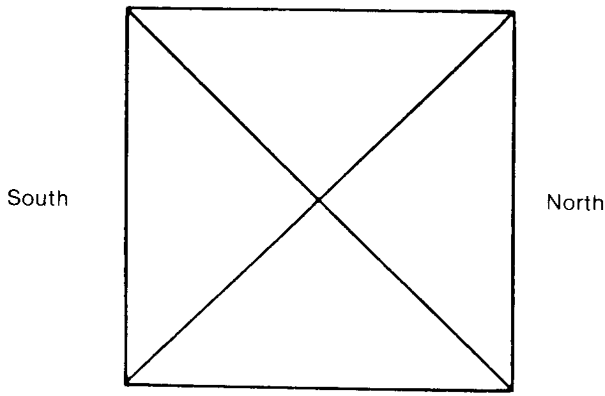
For the second example, first stop the clock. Press **[Select]** and return to MAP mode. Set the latitude to 40° 03′ N and the longitude to 22° 06′ E (ancient city of Pydna near Mt. Olympus in Greece). Press **[Select]** and go to SET mode. Set the date and time to June 21, 168 B.C., at 7:00 P.M. Press **[Select]** and go to SKY mode. Press **[Start]** to find the moon, set the clock RATE to 36X, and watch the moon rise, totally eclipsed. By about 9:00 P.M., the eclipse is over.

THE GREAT PYRAMID AT GIZA

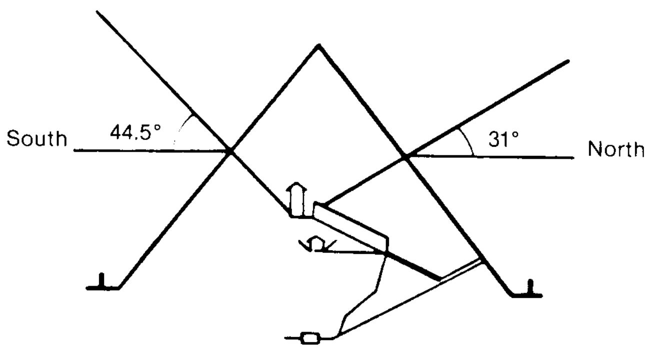
The Great Pyramid at Giza, near Cairo, was built during the reign of Cheops (Khufu), a Pharaoh of the 4th dynasty. The dimensions of this, the greatest of the pyramids, are truly impressive: the base is a square measuring 756 feet on each side and covers over 13 acres; the original height was 482 feet. Even more impressive is the precision of this large monument: the maximum deviation from a true square is less than eight inches, and the base is aligned in the four cardinal directions, north, south, east, and west, with a maximum deviation of less than 1/10°. This is testimony to the skill of the early Egyptians as master builders and surveyors.

The pyramid is a solid building containing over two million limestone blocks, each weighing an average of two and one-half tons. Originally faced with smooth, well-fitted white limestone, the pyramid was capped with a golden "pyramidion." The Greek historian Herodotus, who visited Giza in the 5th century B.C., reported that Cheops, during his 50-year reign, exchanged 100,000 men every three months to toil at the construction site.

Cheops' Pyramid



Top View



Cross Section

The interior of the pyramid is accessible through a single entrance, originally covered, on the north face about 55 feet above ground level. From here, a narrow corridor descends at a 26° angle for 355 feet to an unfinished subterranean chamber. About 100 feet from the entrance, another corridor, originally blocked off, ascends at a 26° slope from the ceiling of the descending corridor. The ascending corridor ends in a long, tall, narrow chamber called the Great Gallery. The gallery is connected to an upper burial chamber, the King's Chamber, and through a separate corridor (also originally blocked off) to a lower burial chamber, the Queen's Chamber. The purpose of the complicated network of corridors was no doubt to mislead potential grave robbers.

Of special interest are two narrow (nine-inch square), precisely aligned shafts, one leading from the upper end of the gallery and ending on the northern face of the pyramid, the other leading from the King's Chamber and ending on the southern face. The purpose of these shafts has been the subject of speculation for centuries. An early suggestion that they were intended for ventilation is implausible: the construction of these shafts at precise angles through many courses of limestone blocks must have been such an arduous task that a much more commanding reason must be sought. Considering the importance to the ancient Egyptians of celestial mythology, it's much more likely that the astrologer-priests oriented the shafts towards carefully selected regions of the sky.

Early estimates placed the 4th dynasty, the period of the "Great Pyramid Kings," at about 4000-3000 B.C. However, at that time, the northern shaft would have pointed towards a segment of the sky without any bright stars. In contrast, from 3000-2500 B.C., the bright star Thuban in the constellation Draco was perfectly aligned with the northern shaft. Based on this and other evidence, the time of the building of Cheops' pyramid is now believed to be about 2800-2600 B.C. The question then is what did the southern shaft point towards at that time? Recent studies show that only three bright stars qualify, namely the three stars in what we now call Orion's belt.

It's not likely that the shafts were intended for astronomical observation. First, the shafts were originally covered by the facing stones on the pyramid; second, a slight bend at both ends of the shafts, presumably designed to prevent accumulation of sand and debris, would have prevented direct sighting. It's therefore more likely that the purpose was a religious one.

In ancient Egypt, the circumpolar stars, which neither set nor rose, were called imperishable stars and represented immortal gods. Pharaoh's soul was believed to ascend to these eternal stars to take its place among the gods in the sky. Thuban, then the polestar, would have been the ultimate eternal star. The stars of Orion, in turn, were representative of Osiris, the Egyptian god of transformation and resurrection. The shafts in the pyramid were therefore most likely intended as passage ways for Cheops' soul towards its ultimate destination in the sky.

The "Pyramid Kings" of the 4th dynasty left no written records and no pictorial descriptions on the walls of their tombs. Yet, in the precise alignment of their pyramids, they revealed insights into astronomy that have allowed later generations to determine their age.

ATARI Planetarium lets you re-create the appearance of the ancient sky over Giza as it appeared at the time of the construction of Cheops' pyramid. By setting the elevation and azimuth of the cursor to correspond to those of the northern and southern shafts, respectively, you can see the transits of Thuban and the belt stars of Orion, respectively, as Pharaoh's astrologer-priests planned it more than 4500 years ago.

> Press **[Select]** and go to MAP mode. Set the latitude to 29° 59′ N and the longitude to 31° E (Giza). Press **[Select]** and go to SET mode. Set the date and time to January 1, 2700 B.C., at 8:00 P.M. Press **[Select]** again and go to SKY mode. Stop the clock, then press **[Start]** until it shows CONSTELLATIONS. When the constellation listing appears on the screen, place the cursor over NPole and press **[Return]**. Now, press the Up/Down cursor keys to adjust the cursor as close as possible to 31° N, using the numerical elevation display in the data window to the right of the screen. The view within the crosshair cursor now corresponds to the view through the northern shaft of Cheops' pyramid at the time of its construction. Place the cursor on the polestar and press **[Help]** to verify that the star really is Thuban. Then set the clock RATE to 64X and watch the stars rotate around Thuban as they did at the time of Cheops.
>
> Now change the setting to show the original view through the southern shaft. Stay in SKY mode but stop the clock; then press **[S]** (for south). Use the Up/Down cursor keys to place the cursor as close as possible to an elevation of 44° 30′, using the numerical display in the data window. Next, set the clock RATE to 64X and watch the belt stars in Orion pass through the crosshair cursor.

Cheops' pyramid was admired even in antiquity as one of the seven wonders of the world; in fact, it's the only one still standing. However, in terms of its principal function, namely to guarantee the Pharaoh a peaceful resting place surrounded by his vestiges of power and wealth and protected from grave robbers, it was

Greek inscriptions identify the three large stars above the lion as the planets Mars, Mercury, and Jupiter. The star pattern is recognizable as the constellation Leo. The prominent star on the lion's chest is no doubt Regulus, also known as Cor Leonis, or the heart of the lion. The star nearest the tail must be Denebola, which means "tail of the lion." The angles in the constellation are a bit distorted, but this can be ascribed to artistic license on the part of the unknown sculptor.

This stone lion is the first known Greek horoscope, and the unusual configuration of the moon, planets, and stars has been extensively studied in an attempt to determine the exact date represented by the horoscope. These studies show that the only dates on which a crescent moon and three planets were observable in the sign of Leo during the life of King Antioch were July 6 and 7, 62 B.C. These dates are in agreement with the arrival in the region of the Roman consul Pompeius after he had defeated Mithradates VI, finally consolidating the Roman protectorates in Asia Minor. The kingdom of Commagene was a buffer state between the Roman and Parthian empires, and it has been suggested that King Antioch may have shown his gratitude for the defeat of the treacherous Mithradates by erecting this temple and perhaps even by counting his own reign from this date.

With ATARI Planetarium, you can compare the appearance of the sky over Commagene on the above dates with the planetary configuration and crescent moon depicted on the stone lion:

> Press **[Select]** and go to MAP mode. Set the latitude to 37° 05′ N and the longitude to 38° 07′ E (Samosata, ancient capital of Commagene, now the village of Samsat in Turkey). Press **[Select]** and go to SET mode. Set the date and time to July 7, 62 B.C., at 8:05 P.M. Press **[Select]** again and go to SKY mode. Set the VIEWing angle to 72°. Press **[Start]** until the moon is shown in reverse field, then press **[Return]**. Note that the three planets and the crescent moon are indeed clustered in the constellation Leo. Actually, the only time they were all visible was shortly after sunset, and then only for a brief period. If you check the previous day, you'll see that the moon was still new, so July 7 appears to be the only one fitting the horoscope.

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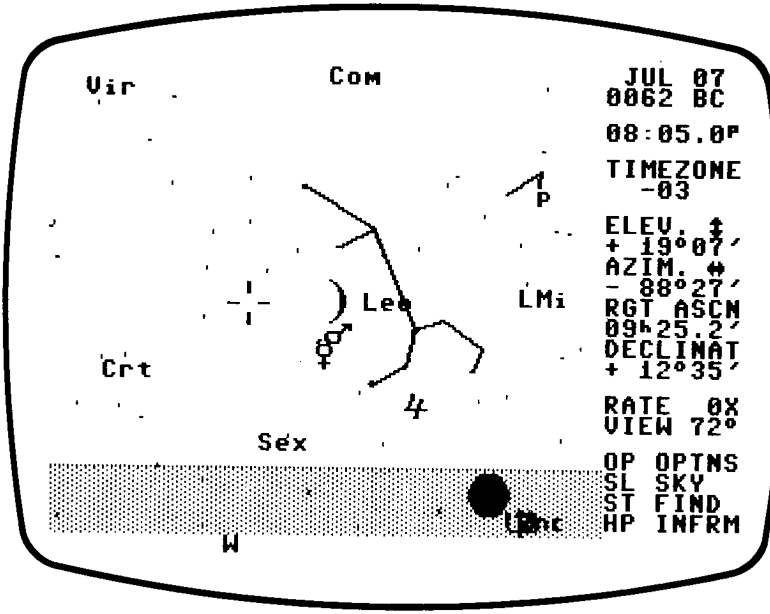
> Press **[Select]** and go to MAP mode. Set the latitude to 37° 05′ N and the longitude to 38° 07′ E (Samosata, ancient capital of Commagene, now the village of Samsat in Turkey). Press **[Select]** and go to SET mode. Set the date and time to July 7, 62 B.C., at 8:05 P.M. Press **[Select]** again and go to SKY mode. Set the VIEWing angle to 72°. Press **[Start]** until the moon is shown in reverse field, then press **[Return]**. Note that the three planets and the crescent moon are indeed clustered in the constellation Leo. Actually, the only time they were all visible was shortly after sunset, and then only for a brief period. If you check the previous day, you'll see that the moon was still new, so July 7 appears to be the only one fitting the horoscope.

Greek inscriptions identify the three large stars above the lion as the planets Mars, Mercury, and Jupiter. The star pattern is recognizable as the constellation Leo. The prominent star on the lion's chest is no doubt Regulus, also known as Cor Leonis, or the heart of the lion. The star nearest the tail must be Denebola, which means "tail of the lion." The angles in the constellation are a bit distorted, but this can be ascribed to artistic license on the part of the unknown sculptor.

This stone lion is the first known Greek horoscope, and the unusual configuration of the moon, planets, and stars has been extensively studied in an attempt to determine the exact date represented by the horoscope. These studies show that the only dates on which a crescent moon and three planets were observable in the sign of Leo during the life of King Antioch were July 6 and 7, 62 B.C. These dates are in agreement with the arrival in the region of the Roman consul Pompeius after he had defeated Mithradates VI, finally consolidating the Roman protectorates in Asia Minor. The kingdom of Commagene was a buffer state between the Roman and Parthian empires, and it has been suggested that King Antioch may have shown his gratitude for the defeat of the treacherous Mithradates by erecting this temple and perhaps even by counting his own reign from this date.

With ATARI Planetarium, you can compare the appearance of the sky over Commagene on the above dates with the planetary configuration and crescent moon depicted on the stone lion:

> Press **[Select]** and go to MAP mode. Set the latitude to 37° 05′ N and the longitude to 38° 07′ E (Samosata, ancient capital of Commagene, now the village of Samsat in Turkey). Press **[Select]** and go to SET mode. Set the date and time to July 7, 62 B.C., at 8:05 P.M. Press **[Select]** again and go to SKY mode. Set the VIEWing angle to 72°. Press **[Start]** until the moon is shown in reverse field, then press **[Return]**. Note that the three planets and the crescent moon are indeed clustered in the constellation Leo. Actually, the only time they were all visible was shortly after sunset, and then only for a brief period. If you check the previous day, you'll see that the moon was still new, so July 7 appears to be the only one fitting the horoscope.


Vir
Com
JUL 07
0062 BC
08:05.0P
TIMEZONE
-03
ELEV.
+ 19°07'
AZIM.
- 88°27'
RGT ASCN
09h25.2'
DECLINAT
+ 12°35'
RATE 0X
VIEW 72°
OP OPTNS
SL SKY
ST FIND
HP INFRM
P
Leo
LMi
Crt
Sex
W

CHAPTER 6
NAVIGATION

□ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □

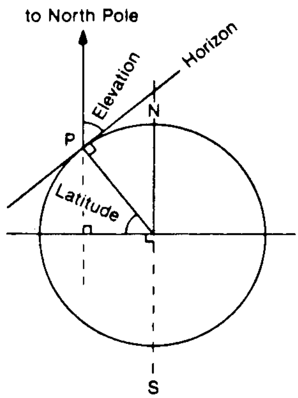
The art of navigating by the sun and the stars was developed by ancient mariners. The earliest primitive form of navigation consisted merely of determining the "bearing," i.e., the direction in which you were sailing.

In order to know your position, it's necessary to determine both your latitude and longitude. Latitude can be determined solely from celestial observations; longitude requires knowledge of both local time and the time at some reference longitude, i.e., the time difference from a known longitude. Although it's always possible to determine local time, it wasn't until the invention of a reliable, portable chronometer by the British clockmaker John Harrison in 1735 A.D. that it became possible to know a reference time aboard ships. The standard reference time and longitude was and still is that of Greenwich.

LATITUDE FROM POLARIS

At any point (P) on the Northern Hemisphere, the latitude equals the elevation above the horizon of the North Pole (see the illustration below). Since stars are so far away that sightings are parallel no matter where on Earth they are made, the north-south line of Earth and the sighting line from P are parallel. It follows that the angle of P's latitude equals the angle of elevation of the North Pole as sighted from P:

Latitude and Elevation of the Pole



Since Polaris is within 1° of the North Pole, you can get an immediate, approximate reading of your latitude simply by measuring the elevation of the polestar, as long as you're in the Northern Hemisphere.

> Imagine you're a merit-badge counselor in astronomy for the Boy Scouts. Your young scouts want to know whether astronomy "can be used for anything," so you give them a little problem to figure out. You tell them they're on a small boat in the Caribbean, there's been a storm, their two-way radio doesn't work, and they're lost. However, they have a small sextant, a wristwatch, a little transistor radio, and a map. The sea is now calm and the boat is dead in the water with no current. Just before dawn, a break in the clouds allows them to read the elevation of Polaris as 15.5°. Around noon, they sight the sun at its highest elevation and find that their watch shows 12:15 P.M. Shortly afterwards, they hear a radio broadcast from Miami stating that it's 12:30 P.M. (EST). When they check their wristwatch, it shows 12:37 P.M. Where are they?
>
> First, their latitude is approximately the same as the altitude of Polaris, i.e., 15.5° N. Second, the broadcast tells them that their watch is seven minutes fast, meaning that the sun was at its zenith at their location at 12:08 P.M. (EST). Third, since eastern standard time is time zone 5, the sun would be at its zenith at 12:00 noon (EST) in the middle of time zone 5, which is five times 15° or 75° west of Greenwich (five for the number of time zones away from time zone 0 and 15° per time zone). Thus, the boys conclude that they are eight minutes or 2° ($8 \times 15/60° = 2°$) farther west than the middle of time zone 5. Accordingly, their longitude must be 75° + 2° or 77° W. Looking at their map, the boys see that they're about 2.5° (150 nautical miles) directly south of Kingston, Jamaica. By setting a course due north, they cannot miss this large island, where they'll be able to get their equipment repaired.
>
> Using ATARI Planetarium, you can go to MAP mode, position the cursor at the boys' latitude and longitude, go to SET and SKY modes, and show the boys that the elevation of Polaris and the local time of noon were as they reported!

POSITIONAL NAVIGATION

You can determine your position on Earth in terms of both degrees and distance. Since the circumference of Earth is 40,000 km along any great circle (e.g., the Equator), 1° of arc corresponds to 111 km (69 miles or 60 nautical miles; 40,000 km/360° = 111 km/1°). One minute of arc is 1.9 km (1.2 miles or 1 nautical mile) and one second of arc is 31 m (116 feet). So, if for instance you want to know your location to within 200 m or 1/10 of a mile, your position in terms of degrees must be determined to within $1/10$ of a minute of arc. For this reason, a number of corrections are required to ensure that observations of celestial objects are sufficiently accurate.

Consider also the accuracy needed in a chronometer for determining longitude. In 1714, the British Government posted an award of 20,000 pounds for anyone who could design a clock which could be used to determine a ship's longitude within 30 miles after a six-week voyage. This translates into an accuracy of better than three seconds per day—much better than even a pendulum clock on land was able to do at that time! John Harrison won the award, and by the end of the 18th century chronometers were in common use aboard ships.

After the invention of the radio by Marconi in 1920, it became very easy to know the Greenwich time anywhere on Earth, so longitude became as simple to determine as latitude. Today, pulsed radio and radar signals from Earth stations and satellites, combined with on-board computers, have speeded up navigation computations to match the needs of jet airplanes and spacecraft. Still, in case of equipment or power failures, the chronometer method is a stand-by technique, especially on small ocean-going craft. Navigation by the stars is, of course, a special subject in the case of space exploration.

The ATARI Planetarium program cannot cover the actual techniques used in nautical and air navigation. Due to the accuracy of measurement required, a number of corrections must be made to the direct readings (for example, for altitude over the horizon or for refraction by air). Nevertheless, ATARI Planetarium can replace a Nautical Almanac for instructional purposes since the program can calculate the position of the sun, the moon, and the navigational stars at any time from any location on Earth. This means you can use the program as a self-contained system for training without the need for sextants, astronomical tables, or even clear weather!

CHAPTER 7
SPACE EXPLORATION

□ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □

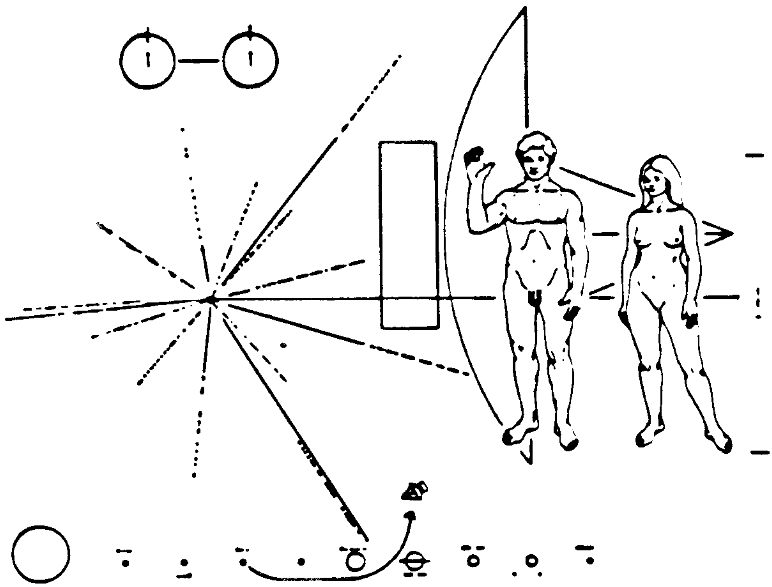
"...it would be surprising if
life were not abundant in the galaxy.
Our problem is to find it."

George O. Abell

In July, 1969 A.D., American astronauts landed on the moon. They were the first human beings ever to set foot on a celestial body other than Earth. The astronauts left a plaque with a message in English, with the reasonable expectation that other human expeditions to the moon will occur before English—and perhaps humankind—become extinct.

Towards the end of 1973 A.D., the spacecraft *Pioneer 10* passed Jupiter on its way towards the constellations Taurus and Orion, the first human-made object to leave our Solar System. This mission also carried a plaque, but since other intelligent beings in the universe would be unfamiliar with any human language, the message was written in the language of science:

Pioneer 10 Plaque



In order to introduce ourselves to extraterrestrials who may have developed along lines very different from us, male and female humans are shown to the same scale as a drawing of the spacecraft. The symbol at the top of the plaque refers to hydrogen, the most abundant element in the universe. To identify the launch site, *Pioneer 10* is shown leaving Earth and passing out of our Solar System between Saturn and Jupiter. And in order to allow a decoding of the time of the launching, a diagram shows the directions to 14 pulsars as presently seen from our Solar System. In a sense, this plaque is a 20th-century counterpart of the stone lion of Nimrud Dagh.

This space experiment has been compared to throwing a bottle with a note into the sea. However, such a comparison is charitable: the ocean of the universe is vast and even though *Pioneer 10* travels at seven miles per second, it will not reach a potential planetary system for ten billion years!

The space program has encouraged laymen, scientists, and science fiction writers alike to speculate on future human exploration in space and on the possibility of finding intelligent life forms somewhere else in the universe. ATARI Planetarium, through its HELP function, provides general information about all the celestial bodies and galaxies visible on your screen as well as their distances, if they're known. With this information, you'll be better able to appreciate both the possibilities and the limitations of interplanetary and interstellar exploration, and to make your own judgments regarding reports you will see or hear in the news media in the future.

ASTRONAUTICS

The space program has resulted in a general realization of just how unique Earth really is, and how inhospitable the rest of even our own Solar System is. This doesn't mean that colonization of space is impossible, but it does mean that it will be difficult—and probably quite some time in coming. Aside from artificial space stations, the most likely bases for space colonies in our Solar System are the moon and perhaps the asteroids between Mars and Jupiter. These asteroids are relatively small, solid bodies ranging from about one to 500 miles in diameter; their advantage is that they are already in orbit. Some day such space stations might well serve as bases for deeper space probes.

The following procedure details the nature (size, temperature, composition) of the moon and the planets and lists the distances within our Solar System:

Press **[Select]** and go to SKY mode. Press **[Start]** to find each planet and the moon, then press **[Help]** sequentially for each. Since the fastest existing spacecraft travels at speeds no more than about 1/10,000 the speed of light, you can calculate present travel times from the distances given. For example, to calculate travel time to a planet, multiply the number of light-minutes by 10,000 and convert the minutes to years, months, and days.

For human space travel outside the Solar System, the problems are literally astronomical. The distance to the nearest bright star (Rigil Kentaurus) is 4.3 light-years, which corresponds to a travel time of 43,000 years!

Of course, it's possible that the speed of future spacecraft may be increased dramatically. It's also possible that astronauts could be brought to a state of hibernation to increase their life span or that later generations born and raised on board might eventually make it to distant places in the universe. Nevertheless, even if they do, this is not exploration in the sense that Earth was explored or that may be possible within our Solar System itself: there would be no return tickets for the astronauts! Should they or their descendants ever return to Earth, it would be to a different place. If humankind were still to exist, the difference might be even greater than that between the Stone Age and our own age.

To develop an appreciation of the enormity of the universe and the distances even to the closest stars and galaxies outside our Solar System, use the star and constellation tables in the back of this manual. For example, compare the distance from Earth to Sirius in Canis Major to the distance from Earth to Deneb in Cygnus. To locate the selected stars and deep-sky objects, press **[Start]** for the corresponding constellation, then press **[Help]** for the object. If you don't recognize the star, rather than resorting to trial and error, use the declination/right ascension values in the star tables to place the cursor directly on the star (the coordinates for the cursor are shown in the data window to the right of the screen).

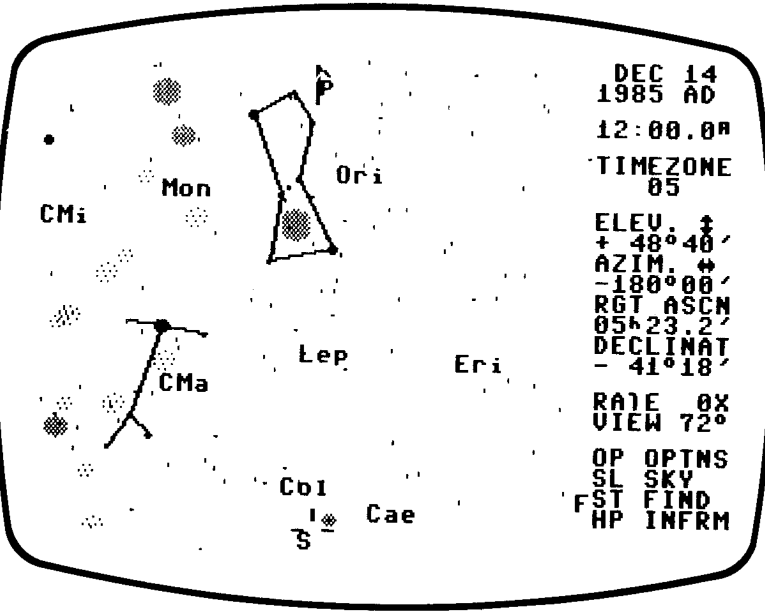
The DEEP-SKY option of ATARI Planetarium lets you study the distant universe on your computer. Here are a few examples:

Our galaxy, the Milky Way, is 100,000 light-years across. Our sun is about 30,000 light-years from the center of the galaxy. If you look toward Sagittarius, you're looking in the direction of the center of the Milky Way.

Press [Select] and go to MAP mode. Set the latitude to 0° N and the longitude to 77° W. Press [Select] and go to SET mode. Set the date and time to June 14, 1985 A.D., at 12:00 A.M. Tap [Select] again and go to SKY mode. Press [Option] and choose the following: LINES, NAMES, DEEP, NO TRACK, and NO SOUND. Set the VIEWing angle to 72° and the clock RATE to 0X. Press [S] for a southern view. You now have a typical summer night's view with a section of the Milky Way stretching diagonally across the screen. Note the many star clusters in this section.

Take a look now at the Milky Way in the direction of Orion and Canis Major. For a good view, you must go to the winter season:

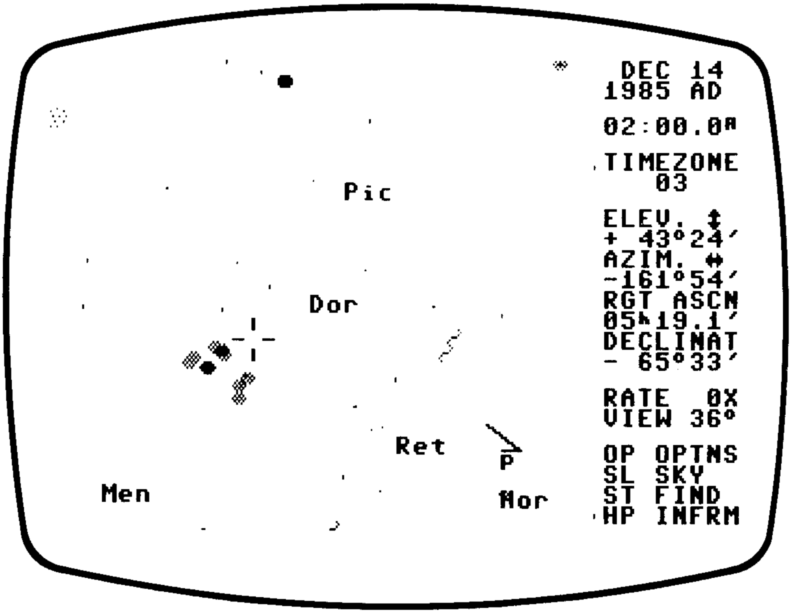
Keep the above settings, except for the month. Go to SET mode and change the month to December. Go to SKY mode and proceed as before. Here you see a section of the Milky Way which covers the whole left half of your screen. Note particularly M42, the Great Nebula below the belt stars in Orion.



The closest galaxies to the Milky Way are the Small and the Large Magellanic Clouds, named after the Portuguese explorer and discoverer of the Magellan Strait, who observed these "clouds" in the southern sky. Satellite galaxies of the Milky Way, the Magellanic Clouds are 160,000 to 180,000 light-years away. In order to observe them, you'll need to go to the Southern Hemisphere:

Keep the date and time from the previous example, but go to MAP mode and change the latitude to 24° S and the longitude to 49° W.

Now go to SKY mode. Press **[Start]** to call the list of the constellations onto your screen. The easiest way to locate the Large Magellanic Cloud is to view the constellation Dorado, using a 36° VIEWing angle. Press **[Help]** to verify that you are indeed looking at the Large Magellanic Cloud.



Now use the cursor to push at the edge of your screen until you have the Magellanic Clouds well centered; then reduce your VIEWing angle in steps (so you don't lose the clouds outside your screen frame). At an 18° VIEWing angle, the first magnification step, you can already see the clouds being resolved into individual star clusters.

Earlier, you observed the Andromeda Galaxy, the most distant object in the sky which can still be seen with the naked eye. This galaxy is 2.2 million light-years away. The known universe is 40 billion light-years across.

EXTRATERRESTRIAL LIFE

"No signs of intelligent life,
Scotty. Beam us up. Kirk out!"

from the TV series Star Trek

The question of the possible existence of life beyond Earth is really a question on two levels: first, is there *any* form of life; and second, are there any *intelligent* life forms? As to the first question, the *Viking* spacecraft to Mars tried to determine whether the Martian soil contained any form of living organisms which with the addition of water and nutrients would show a typical biological reaction. Unfortunately, the results were inconclusive: the soil did respond, but in such a manner that chemical reactions alone might explain the observations. Thus, there is still no proof of life, even in primitive form, beyond Earth.

The conditions that enable life, especially higher life forms, to exist appear to occur very rarely in the universe. On the other hand, the universe is incredibly huge. In trying to estimate the probability that intelligent life forms exist somewhere in the universe, we have to multiply a very small number by a very large one, both of which we have little basis for estimating. The result of such a calculation is basically a guess.

If we ask whether any advanced extraterrestrial beings might exist close enough to make possible some form of contact, such as the reception of radio signals, the answer is a definite "maybe." But the contact would hardly be a traditional conversation: by the time the answer got back, the "civilization" might well have ceased to exist! Certainly, the civilization on Earth, assuming that one still existed, would be very different from the one that sent the signals.

When a source of extremely regular radio pulses from deep space was observed for the first time in 1967 A.D., the discoverers initially referred to the deep-sky object as LGM-1 (LGM standing for "little green men"). Similar objects have since been detected and are now called pulsars. The types of radio signals emitted have been shown to be those expected from a rapidly rotating neutron star.

We may not be alone, but we do not seem to have any close neighbors!

TECHNICAL NOTES

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The technical details that follow are of particular interest to astronomers and advanced students.

Stellar Positions

A 2000 A.D.-epoch star catalog is used as the basis for all stellar positions. Calculations for other epochs take into account Earth's precession but not the proper motion of the stars. With the exception of a few of the closest stars which have large proper motions, stellar positions are accurate to within one minute of arc over the time span from 9999 B.C. to 9999 A.D.

Planetary Positions

The planetary ephemerides used in the program are based on the method of T. Van Flandern and K.F. Pulkkinen (*The Astrophysical Journal*, Supplement Series, Vol. 41, Nov. 1979: 391-411). Planetary perturbation effects are included. For the period 1700 A.D.-2300 A.D., planetary position calculations are accurate to within a few minutes of arc. An exception is Pluto, whose orbit is not known accurately enough for position calculations better than about 15 minutes of arc. The utility of the planetary ephemerides has been considerably extended into the past by correcting for the difference between universal time (related to Earth's rotation) and ephemeris time (related to an absolute atomic clock standard). Calculations for the distant future are less reliable due to the lack of an accurate physical model for the long-term variations in the rate of rotation of Earth.

Solar and Lunar Positions

In addition to the planetary perturbations, this program allows for the long-term decelerations of the orbital motions of Earth and the moon (due to tidal effects). For modern times (1900-2000 A.D.), the solar and lunar positions are accurate to within one minute of arc. For dates earlier than 1000 A.D., time differences of 30 minutes to two hours may be expected due to uncertainties in the difference between ephemeris time and universal time. These differences are the result of changes in the distribution of mass on Earth (such as formation and melting of ice caps, continental drifts, and convection in the mantle) and may cause corresponding errors in lunar positions ranging from 15 minutes of arc to 1°. In cases where there's suitable historical data to verify events, the accuracy has been well within these limits.

Computer Updating

When the SKY display is driven by the automatic clock, the display is updated automatically according to the following schedule:

Clock RATE	Display Time Interval Minutes	Real Time Interval Seconds
1X	0.7	42
2X	1.4	42
4X	2.8	42
8X	5.6	42
16X	5.6	21
32X	5.6	10.5
64X	5.6	5.3

The planets are updated at the following intervals:

Planet	Updating Interval
Mercury	1 hr.
Venus	2.5 hrs.
Mars	8 hrs.
Jupiter	2 days
Saturn	5 days
Uranus	15 days
Neptune	45 days
Pluto	61 days

The sun is updated every two hours and the moon every 23 minutes except when an eclipse is in progress, at which time both are updated at five-minute intervals. Because of this, it's possible to miss a brief period of totality. In the case of total eclipses, therefore, some precautions are necessary to ensure accurate visual displays. The recommended procedures are discussed in **Eclipses, Transits, and Occultations** on page 87.

The position of Halley's Comet during the 1985-86 apparition is updated every 22 minutes. The anticipated accuracy of the computed trajectory is about 20 minutes of arc.

Automatic updating due to precession occurs every 100 years.

Color Monitor Display

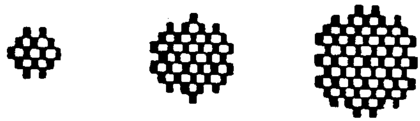
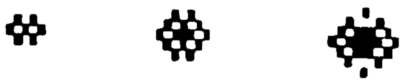
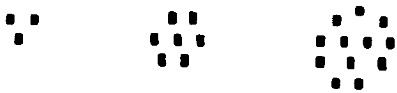
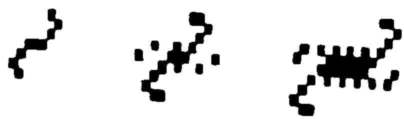
In order to achieve a pleasing display, the size of the tokens used to represent the sun and the moon is greatly exaggerated. Since the token size is constant, the size exaggeration factor for both the sun and the moon varies with the VIEWing angle, as shown in the table below:

VIEWing Angle	Size Factor
72°	13.5X
36°	6.8X
18°	3.4X
9°	1.7X

Similarly, enlarged tokens are used for the stars and planets to give an impression of their brightness. The pixel patterns are shown in the following table:

Magnitude	Number of Pixels	Pattern
-2 to -1	26	
-1 to 0	16	
0 to 1	8	
1 to 2	4	
2 to 3	2	
3 to 4	2	
4 to 5	1	

The deep-sky objects are also represented by enlarged tokens with pixel patterns as shown below:

Deep-Sky Object	Pixel Pattern
Planetary Nebulae	
Diffuse Nebulae and Star Cluster within Nebulosity	
Globular Star Cluster	
Open Galactic Star Cluster	
Elliptical Galaxy	
Spiral Galaxy (Normal, Barred, or Irregular)	

The Andromeda Galaxy (M31) has its own token.

In addition to esthetic considerations, oversized tokens were chosen to help the user differentiate visually between the various celestial objects shown on the monitor. Actual angular sizes are greatly exaggerated by the displays, so the tokens do not portray the actual apparent sizes of the objects they represent. Nor were they intended to; they're meant solely as schematic aids for displaying the various celestial objects and for showing their positions.

The number of objects that can be displayed on a screen is limited to 256. This does not allow the display of all the stars and deep-sky objects present in certain highly populated regions of the sky when both are requested and the widest VIEWing angle is selected. In such cases, the program omits the faintest stars and the dimmest deep-sky objects. If the VIEWing angle is reduced, these objects will reappear.

Eclipses, Transits, and Occultations

Oversized tokens and finite intervals of position updating can lead to misinterpretation of certain displays unless the following precautions are taken:

First, an overlap of the tokens for the sun (an illuminated disk) and for the new moon (a dotted circle) in SKY mode is not necessarily evidence of an eclipse. To overcome this difficulty, the program calculates eclipse graphics based on actual angular sizes rather than on the displayed token sizes. When an eclipse actually occurs, the program plots a token for the partially eclipsed solar disk that has the correct relative size of the obscuring dark disk of the moon. This allows the various phases of a solar eclipse, from first contact through totality to last contact, to be displayed as they would appear in the sky, including the associated sky-darkening effects.

Second, although the five-minute interval between position updates is adequate for displaying partial eclipses, it's possible to overshoot totality because it's of such short duration unless one of the displays is deliberately timed to occur near the midpoint of the eclipse.

The most accurate way of timing an eclipse display is to plot on graph paper the declination and right ascension values individually through the same time period for both the sun and the moon. The intersection or closest proximity of the lines drawn for the sun and the moon determines the time of the midpoint of the eclipse. This time can then be entered in SET mode before going to SKY mode and activating the clock. It's convenient to set the clock first in the backtracking mode to determine the time of first contact. Note that the TRACKing option makes the tabulation of solar and lunar coordinates relatively easy to do (use the procedure previously described for plotting a trajectory of Halley's Comet, page 54, and a Mars retrogression, page 46). This method is clearly indicated when you need the best display possible, such as for demonstrating a particular eclipse on an overhead projector.

A quicker but less precise method is outlined below:

- Scan through the eclipse at a clock RATE of 8X or 16X and estimate the time (using the data window) of maximum obscuration of the sun and darkening of the sky (eclipse midpoint).
- Write down the time of the last update prior to the estimated time (this occurs just after the textline shows "Computing Sun").
- Stop the clock. Call the difference between the estimated eclipse midpoint and the last update "delta."
- Go to SET mode and readjust the clock setting backwards by ten minus "delta" minutes; go back to SKY mode and restart the clock.

The computer, recognizing that it's more than five minutes away from its last update, will choose the new time as the starting point for the usual sequence of five-minute interval updates, and one update will now occur near the midpoint of the eclipse.

In studies of other phenomena, such as transits and occultations, similar techniques can be used for optimizing SKY and CHART mode displays.

TABLES

LATITUDE AND LONGITUDE

North American Cities

Name	Latitude Deg	Latitude Min	Latitude NS	Longitude Deg	Longitude Min	Longitude EW	State/Country
Albuquerque	35	05	N	106	40	W	New Mexico, USA
Anchorage	61	10	N	150	00	E	Alaska, USA
Atlanta	33	45	N	84	23	W	Georgia, USA
Baltimore	39	17	N	76	37	W	Maryland, USA
Bangor	44	49	N	68	47	W	Maine, USA
Boise	43	37	N	116	13	W	Idaho, USA
Boston	42	21	N	71	04	W	Massachusetts, USA
Calgary	51	03	N	114	04	W	Alberta, Canada
Chicago	41	53	N	87	38	W	Illinois, USA
Cincinnati	39	06	N	84	31	W	Ohio, USA
Cleveland	41	30	N	81	41	W	Ohio, USA
Dallas	32	47	N	96	48	W	Texas, USA
Denver	39	43	N	105	01	W	Colorado, USA
Des Moines	41	35	N	93	37	W	Iowa, USA
Detroit	42	20	N	83	03	W	Michigan, USA
Edmonton	53	33	N	113	28	W	Alberta, Canada
El Paso	31	45	N	106	29	W	Texas, USA
Fairbanks	64	51	N	147	43	W	Alaska, USA
Godthaab	64	11	N	51	44	W	Greenland
Halifax	44	38	N	63	35	W	Nova Scotia, Canada
Havana	23	07	N	82	25	W	Cuba
Honolulu	21	19	N	157	52	W	Hawaii, USA
Houston	29	46	N	95	22	W	Texas, USA
Indianapolis	39	46	N	86	09	W	Indiana, USA
Jacksonville	30	20	N	81	40	W	Florida, USA
Kansas City	39	07	N	94	39	W	Kansas/Missouri, USA
Las Vegas	36	11	N	115	08	W	Nevada, USA
Los Angeles	34	03	N	118	15	W	California, USA
Madison	43	05	N	89	22	W	Wisconsin, USA
Mexico City	19	24	N	99	09	W	Mexico
Miami	25	46	N	80	12	W	Florida, USA

Name	Latitude Deg	Min	NS	Longitude Deg	Min	EW	State/Country
Milwaukee	43	02	N	87	55	W	Wisconsin, USA
Minneapolis	45	00	N	93	15	W	Minnesota, USA
Montreal	45	31	N	73	34	W	Quebec, Canada
New Orleans	29	58	N	90	07	W	Louisiana, USA
New York	40	43	N	74	01	W	New York, USA
Nome	64	30	N	165	24	W	Alaska, USA
Oklahoma City	35	28	N	97	32	W	Oklahoma, USA
Omaha	41	16	N	95	57	W	Nebraska, USA
Ottawa	45	25	N	75	42	W	Ontario, Canada
Philadelphia	39	57	N	75	07	W	Pennsylvania, USA
Phoenix	33	27	N	112	05	W	Arizona, USA
Pittsburgh	40	26	N	80	00	W	Pennsylvania, USA
Quebec	46	49	N	71	14	W	Quebec, Canada
Salt Lake City	40	46	N	111	53	W	Utah, USA
San Francisco	37	48	N	122	24	W	California, USA
San Juan	18	28	N	66	07	W	Puerto Rico, USA
Seattle	47	36	N	122	20	W	Washington, USA
St. John's	47	34	N	52	43	W	Newfoundland, Canada
St. Louis	38	38	N	90	11	W	Missouri, USA
Thule	70	30	N	69	29	W	Greenland
Toronto	43	39	N	79	23	W	Ontario, Canada
Vancouver	49	16	N	123	07	W	British Columbia, Canada
Washington D.C.	38	54	N	77	00	W	USA
Winnipeg	49	53	N	97	09	W	Manitoba, Canada

Cities Outside North America

Name	Latitude Deg	Min	NS	Longitude Deg	Min	EW	Country/Continent
Accra	05	33	N	00	13	W	Ghana, Africa
Addis Ababa	09	00	N	38	50	E	Ethiopia, Africa
Algiers	36	42	N	03	08	E	Algeria, Africa
Amsterdam	52	22	N	04	54	E	Holland, Europe
Anadyr	64	55	N	176	05	E	USSR, Asia
Ankara	39	56	N	32	52	E	Turkey, Asia
Asuncion	25	16	S	57	40	W	Paraguay, S. America
Athens	37	58	N	23	43	E	Greece, Europe

Name	Latitude Deg	Latitude Min	Latitude NS	Longitude Deg	Longitude Min	Longitude EW	Country/ Continent
Baghdad	33	21	N	44	25	E	Iraq, Asia
Bangkok	13	44	N	100	30	E	Thailand, Asia
Beirut	33	53	N	35	30	E	Lebanon, Asia
Belgrade	44	50	N	20	30	E	Yugoslavia, Europe
Benghazi	32	07	N	20	04	E	Libya, Africa
Berlin	52	32	N	13	25	E	West Germany, Europe
Berne	46	57	N	07	27	E	Switzerland, Europe
Bogota	04	36	N	74	05	W	Columbia, S. America
Bombay	18	58	N	72	50	E	India, Asia
Bonn	50	44	N	07	05	E	West Germany, Europe
Brasilia	15	47	S	47	55	W	Brazil, S. America
Brussels	50	50	N	04	20	E	Belgium, Europe
Bucharest	44	25	N	26	07	E	Romania, Europe
Budapest	47	30	N	19	05	E	Hungary, Europe
Buenos Aires	34	36	S	58	27	W	Argentina, S. America
Cairo	30	03	N	31	15	E	Egypt, Africa
Calcutta	22	32	N	88	22	E	India, Asia
Cape Town	33	55	S	18	22	E	South Africa, Africa
Caracas	10	30	N	66	56	W	Venezuela, S. America
Casablanca	33	39	N	07	35	W	Morocco, Africa
Colombo	06	56	N	79	51	E	Ceylon-Sri Lanka, Asia
Copenhagen	55	41	N	12	34	E	Denmark, Europe
Dacca	23	43	N	90	25	E	Bangladesh, Asia
Dakar	14	40	N	17	26	W	Senegal, Africa
Dublin	53	20	N	06	15	W	Ireland, Europe
Hanoi	21	02	N	105	51	E	Vietnam, Asia
Helsinki	60	10	N	24	58	E	Finland, Europe
Hiroshima	34	24	N	132	27	E	Japan, Asia
Hong Kong	22	15	N	114	10	E	China, Asia
Istanbul	41	01	N	28	58	E	Turkey, Asia
Jakarta	06	10	S	106	48	E	Indonesia, Asia
Jerusalem	31	47	N	35	13	E	Israel, Asia
Johannesburg	26	15	S	28	00	E	South Africa, Africa

Name	Latitude Deg	Min	NS	Longitude Deg	Min	EW	Country/ Continent
Kabul	34	31	N	69	12	E	Afghanistan, Asia
Karachi	24	52	N	67	03	E	Pakistan, Asia
Khartoum	15	36	N	32	32	E	Sudan, Africa
Kiev	50	26	N	30	31	E	USSR, Europe
Kinshasa	04	18	S	15	18	E	Zaire, Africa
Kyoto	35	00	N	135	45	E	Japan, Asia
Lagos	06	27	N	03	24	E	Nigeria, Africa
La Paz	16	30	S	68	09	W	Bolivia, S. America
Leningrad	59	55	N	30	15	E	USSR, Europe
Lima	12	03	S	77	03	W	Peru, S. America
Lisbon	38	43	N	09	08	W	Portugal, Europe
London	51	30	N	00	10	W	England, Europe
Longyearbyen	78	12	N	15	40	E	Norway, Europe
Madrid	40	24	N	03	41	W	Spain, Europe
Magadan	59	34	N	150	48	E	USSR, Asia
Manila	14	35	N	121	00	E	Philippines, Asia
Marrakech	31	38	N	08	00	W	Morocco, Africa
Mecca	21	27	N	39	49	E	Saudi Arabia, Asia
Melbourne	37	49	S	144	58	E	Australia, Australasia
Montevideo	34	53	S	56	11	W	Uruguay, S. America
Moscow	55	45	N	37	35	E	USSR, Europe
Murmansk	68	58	N	33	05	E	USSR, Europe
Nagasaki	32	48	N	129	55	E	Japan, Asia
Nairobi	01	17	S	36	49	E	Kenya, Africa
New Delhi	28	36	N	77	12	E	India, Asia
Novosibirsk	55	02	N	82	55	E	USSR, Asia
Omsk	55	00	N	73	24	E	USSR, Asia
Oslo	59	55	N	10	45	E	Norway, Europe
Paris	48	52	N	02	20	E	France, Europe
Peking	39	55	N	116	25	E	China, Asia
Perth	31	56	S	115	50	E	Australia, Australasia
Prague	50	05	N	14	26	E	Czechoslovakia, Europe
Quito	00	13	S	78	30	W	Ecuador, S. America
Rangoon	16	47	N	96	10	E	Burma, Asia
Reykjavik	64	09	N	21	51	W	Iceland, Europe
Rio de Janeiro	22	54	S	43	14	W	Brazil, S. America
Riyadh	24	39	N	46	46	E	Saudi Arabia, Asia
Rome	41	54	N	12	29	E	Italy, Europe

Name	Latitude Deg	Min	NS	Longitude Deg	Min	EW	Country/ Continent
Saigon	10	46	N	106	43	E	Vietnam, Asia
Santiago	33	27	S	70	40	W	Chile, S. America
Sao Paulo	23	32	S	46	37	W	Brazil, S. America
Seoul	37	33	N	126	58	E	Korea, Asia
Shanghai	31	14	N	121	28	E	China, Asia
Singapore	01	17	N	103	51	E	Singapore, Asia
Sofia	42	41	N	23	19	E	Bulgaria, Europe
Stockholm	59	20	N	18	03	E	Sweden, Europe
Sydney	33	52	S	151	13	E	Australia, Australasia
Taipei	25	03	N	121	30	E	Taiwan, Asia
Tananarive	18	52	S	47	30	E	Madagascar, Africa
Tashkent	41	20	N	69	18	E	USSR, Asia
Teheran	35	40	N	51	26	E	Iran, Asia
Tel Aviv	32	04	N	34	46	E	Israel, Asia
Timbuktu	16	46	N	03	01	W	Mali, Africa
Tokyo	35	42	N	139	46	E	Japan, Asia
Tomsk	56	30	N	84	58	E	USSR, Asia
Tripoli	32	54	N	13	11	E	Libya, Africa
Tunis	36	48	N	10	11	E	Tunisia, Africa
Vienna	48	13	N	16	20	E	Austria, Europe
Vladivostok	43	10	N	131	56	E	USSR, Asia
Warsaw	52	15	N	21	00	E	Poland, Europe
Wellington	41	18	S	174	47	E	New Zealand, Australasia
Yakutsk	62	13	N	129	49	E	USSR, Asia
Zanzibar	06	10	S	39	11	E	Tanzania, Africa

Islands

Name	Latitude Deg	Min	NS	Longitude Deg	Min	EW	Ocean
Ascension	07	57	S	14	22	W	Atlantic
Azores	38	30	N	28	00	W	Atlantic
Baker	55	20	N	133	36	W	Pacific
Bermuda	32	20	N	64	45	W	Atlantic
Bouvet	54	26	S	03	24	E	Atlantic
Canary	28	00	N	15	30	W	Atlantic
Cape Verde	16	00	N	24	00	W	Atlantic
Christmas	02	00	N	157	20	W	Pacific
Christmas	10	30	S	105	40	E	Indian
Cocos	13	14	N	144	39	E	Pacific
Cook	20	00	S	160	00	W	Pacific
Easter	27	07	S	109	22	W	Pacific

Name	Latitude Deg	Min	NS	Longitude Deg	Min	EW	Ocean
Falkland	51	45	S	59	00	W	Atlantic
Fiji	18	00	S	175	00	E	Pacific
Galapagos	00	30	S	90	30	W	Pacific
Gilbert	00	30	S	174	00	E	Pacific
Gough	40	20	S	10	00	W	Atlantic
Guam	13	28	N	144	47	E	Pacific
Jan Mayen	71	00	N	08	20	W	Arctic
Kerguelen	49	15	S	69	10	E	Antarctic
Marshall	09	00	N	168	00	E	Pacific
Palmyra	05	52	N	168	05	W	Pacific
Pitcairn	25	04	S	130	05	W	Pacific
St. Helena	15	57	S	05	54	W	Atlantic
Samoa	14	00	S	171	00	W	Pacific
Seychelles	04	35	S	55	40	E	Indian
South Georgia	54	15	S	36	45	W	Antarctic
South Orkney	60	35	S	45	30	W	Antarctic
Tahiti	17	70	S	149	27	W	Pacific
Tonga	21	10	S	175	10	W	Pacific
Tristan da Cunha	37	15	S	12	30	W	Atlantic
Wake	19	17	N	166	36	E	Pacific

NAME STARS AND NAVIGATIONAL STARS

Name	Declination Deg	Min	NS	Rt.Asc Degree	Constellation	Comments
Acamar	40	30	S	316	Eridanus	
Achernar	57	29	S	336	Eridanus	
Acrux	63	06	S	174	Crux	
Adhara	28	54	S	256	Canis Major	
Albireo	27	51	N	68	Cygnus	Blue/yellow double star*
Aldebaran	16	25	N	292	Taurus	
Algenib	14	54	N	310	Pegasus	
Algol	40	46	N	314	Perseus	3-day cycle double star
Alioth	56	14	N	167	Ursa Major	
Alkaid	49	34	N	153	Ursa Major	
Alnilam	01	14	S	276	Orion	
Alphard	08	26	S	219	Hydra	
Alphecca	26	53	N	127	Corona Borealis	
Alpheratz	28	49	N	358	Andromeda	
Altair	08	44	N	63	Aquila	
Ankaa	43	18	S	354	Phoenix	

Name	Declination Deg	Min	NS	Rt.Asc Degree	Constellation	Comments
Antares	26	19	S	113	Scorpio	
Arcturus	19	27	N	147	Boötes	
Atria	69	02	S	109	Triangulum Australe	
Avior	59	31	S	235	Carina	
Bellatrix	06	18	N	279	Orion	
Betelgeuse	07	24	N	272	Orion	
Canopus	52	50	S	264	Carina	Second brightest star
Capella	45	57	N	282	Auriga	
Caph	58	52	N	08	Cassiopeia	
Castor	32	00	N	247	Gemini	
Deneb	45	06	N	50	Cygnus	
Deneb Kaitos	18	16	S	350	Cetus	
Denebola	14	51	N	183	Leo	
Diphda	18	16	S	350	Cetus	
Dubhe	62	01	N	195	Ursa Major	
Elnath	28	36	N	279	Taurus	
Eltanin	51	29	N	91	Draco	
Enif	09	39	N	34	Pegasus	
Fomalhaut	29	53	S	16	Pisces Austrinus	
Gacrux	57	07	S	173	Crux	
Gienah	17	32	S	177	Corvus	
Hadar	60	22	S	150	Centaurus	
Hamal	23	14	N	329	Aries	
Kaus Australis	34	25	S	85	Sagittarius	
Kochab	74	22	N	137	Ursa Minor	
Marfak	49	41	N	310	Perseus	
Markab	14	56	N	14	Pegasus	
Menkar	03	54	N	315	Cetus	
Menkent	36	22	S	149	Centaurus	
Merope	23	48	N	304	Taurus	
Miaplacidus	69	31	S	222	Carina	
Mira	03	12	S	326	Cetus	"Disappearing" star, varies during year from very bright to invisible to naked eye
Mizar	55	11	N	160	Ursa Major	Double star, visible to naked eye**
Nunki	26	22	S	77	Sagittarius	

Name	Declination Deg	Min	NS	Rt.Asc Degree	Constellation	Comments
Peacock	56	44	S	54	Pavo	
Polaris	89	02	N	332	Ursa Minor	Polestar, also called North Star
Pollux	28	09	N	244	Gemini	
Praesepe	19	52	N	231	Cancer	
Procyon	05	21	N	246	Canis Minor	
Ras Elhague	12	36	N	97	Ophiuchus	
Regulus	12	13	N	208	Leo	
Rigel	08	15	S	282	Orion	
Rigil Kentaurus	60	50	S	141	Centaurus	Third brightest star; closest to Earth (4.3 light-years away)
Sabik	15	40	S	103	Ophiuchus	
Saiph	09	41	S	274	Orion	
Schedar	56	16	N	350	Cassiopeia	
Shaula	37	04	S	97	Scorpio	
Sirius	16	39	S	259	Canis Major	Brightest star
Spica	10	54	S	159	Virgo	
Suhail	43	00	S	223	Vela	
Vega	38	44	N	81	Lyra	Has recently discovered solar system in formative state
Zuben Elgenubi	15	50	S	138	Libra	

*30X-40X telescope needed.
**In ancient times, the Arabs used the star Mizar in the Big Dipper for testing vision. If you could see two stars, your eyesight was perfect! Mizar's companion star is Alcor.

CONSTELLATIONS

Abr.	Latin Name	English Name	Comments
And	Andromeda	Andromeda	Great Spiral Galaxy (M31); most distant object visible to naked eye (two million light-years)
Ant	+Antlia	Air Pump	
Aps	+Apus	Bird of Paradise	
Aql	Aquila	Eagle	
Aqr	‡Aquarius	Water Carrier	
Ara	Ara	Altar	
Ari	‡Aries	Ram	
Aur	Auriga	Charioteer	

Abr.	Latin Name	English Name	Comments
Boo	#Boötes	Herdsman	
Cae	+Caelum	Graving Tool	
Cam	+Camelopardalis	Giraffe	
Cap	‡Capricorn	Sea Goat	
Car	+Carina	Keel	
Cas	#Cassiopeia	Cassiopeia	
Cen	Centaurus	Centaur	Rigil Kentaurus, or Alpha Centauri; closest star (4.3 light-years)
Cep	Cepheus	Cepheus	
Cet	Cetus	Whale	
Cha	+Chamaeleon	Chameleon	
Cir	+Circinus	Compass	
CMa	Canis Major	Big Dog	
CMi	Canis Minor	Little Dog	
Cnc	‡Cancer	Crab	Beehive, or Praesepe, Cluster (M44)
Col	+Columba	Dove	
Com	+Coma Berenices	Berenice's Hair	
CrA	Corona Australis	Southern Crown	
CrB	Corona Borealis	Northern Crown	
Crt	Crater	Cup	
Cru	+Crux	Southern Cross	
Crv	#Corvus	Crow	Cutter's Mainsail
CVn	+Canis Venaciti	Hunting Dogs	
Cyg	#Cygnus	Swan	Northern Cross; CygX-1 may be "Black Hole"
Del	Delphinus	Dolphin	
Dor	+Dorado	Goldfish	
Dra	Draco	Dragon	
Equ	Equuleus	Little Horse	
Eri	Eridanus	River	
For	+Fornax	Furnace	
Gem	‡#Gemini	Twins	
Gru	+Grus	Crane	
Her	Hercules	Hercules	Great Cluster (M13)
Hor	+Horologium	Clock	
Hya	Hydra	Sea Serpent	
Hys	+#Hydrus	Water Monster	
Ind	+Indus	Indian	
Lac	+Lacerta	Lizard	
Leo	‡#Leo	Lion	
Lep	Lepus	Hare	
Lib	‡Libra	Scales	
LMi	+Leo Minor	Little Lion	

Abr.	Latin Name	English Name	Comments
Lup	Lupus	Wolf	
Lyn	+Lynx	Lynx	
Lyr	Lyra	Lyre	Vega (see star table); Ring Nebula (M57)
Men.	+Mensa	Table Mountain	
Mic	+Microscopium	Microscope	
Mon	+Monoceros	Unicorn	
Mus	+Musca	Fly	
Nor	+Norma	Level	
Oct	+Octans	Octant	
Oph	Ophiuchus	Serpent Holder	
Ori	#Orion	Orion	Great Nebula (M42)
Pav	+Pavo	Peacock	
Peg	#Pegasus	Pegasus	
Per	Perseus	Perseus	
Phe	+Phoenix	Phoenix	
Pic	+Pictor	Easel	
PsA	Piscis Austrinus	Southern Fish	
Psc	‡Pisces	Fish	
Pup	+Puppis	Stern	
Pyx	+Pyxis	Mariner's Compass	
Ret	+Reticulum	Net	
Scl	+Sculptor	Sculptor	
Sco	‡#Scorpius	Scorpion	
Sct	+Scutum	Shield	
Ser	Serpens Caput	Serpent	
Ser	Serpens Cauda	Serpent	
Sex	+Sextans	Sextant	
Sge	Sagitta	Arrow	
Sgr	‡#Sagittarius	Archer	Tea Pot; center of our galaxy (Milky Way)
Tau	‡Taurus	Bull	Crab Nebula (M1) with pulsar, remnant of 1054 A.D. supernova; Hyades and Pleiades Clusters
Tel	+Telescopium	Telescope	
TrA	#+Triangulum Australe	Southern Triangle	
Tri	Triangulum	Triangle	
Tuc	+Tucana	Toucan	
UMa	#Ursa Major	Big Bear	Big Dipper; Exploding Galaxy (M82)
UMi	#Ursa Minor	Little Bear	Little Dipper; Polaris

Abr.	Latin Name	English Name	Comments
Vel	+Vela	Sail	
Vir	‡Virgo	Virgin	
Vol	+Volans	Flying Fish	
Vul	+Vulpecula	Little Fox	

‡ Constellations belonging to zodiac
# Constellations with line diagrams in ATARI Planetarium
+ Constellations after Ptolemy (c. 150 A.D.)

FUTURE ASTRONOMICAL EVENTS

Total Solar Eclipses

WARNING!
NEVER look directly at the SUN, even during a TOTAL eclipse!

Year	Date	Duration (Min)	Location
1987	Mar. 29	0.3	Equatorial Africa, Atlantic Ocean
1988	Mar. 18	4.0	Philippines, Indonesia, Indian and Pacific Oceans
1990	July 22	2.6	Finland, North Atlantic Ocean
1991	July 11	7.1	Hawaii, Brazil, Central America, Pacific Ocean
1992	June 30	5.4	South Atlantic Ocean
1994	Nov. 3	4.6	South America, Pacific Ocean
1995	Oct. 24	2.4	South Asia, Pacific and Indian Oceans
1997	Mar. 9	2.8	Siberia, Arctic Ocean
1998	Feb. 26	4.4	Central America, Pacific and Atlantic Oceans
1999	Aug. 11	2.6	Central and southern Europe, Central Asia

Planetary Transits

Transits by Venus	Transits by Mercury*
2004 June 8	1986 Nov. 13
2012 June 5-6	1993 Nov. 6
	1999 Nov. 15

*Telescope needed.

Halley's Comet

Best time of observation: Northern Hemisphere, Sept.-Dec., 1985
Southern Hemisphere: Mar.-July, 1986

Perihelion: early Feb., 1986

MATHEMATICAL CONVERSIONS
Distance

$$\text{velocity} = \frac{\text{distance}}{\text{time}}$$

velocity of light

$$= \frac{186{,}282 \text{ miles}}{1 \text{ second}} = \frac{299{,}793 \text{ km}}{1 \text{ second}}$$

$$\text{distance} = \text{velocity} \times \text{time}$$

1 light-second

$= 186{,}282$ miles/second $\times$ 1 second $= 186{,}282$ miles
$= 299{,}793$ km/second $\times$ 1 second $= 299{,}793$ km

1 light-minute

$= 186{,}282$ miles/sec $\times$ 1 min $\times$ 60 sec/min $= 11{,}176{,}945$ miles
$= 299{,}793$ km/sec $\times$ 1 min $\times$ 60 sec/min $= 17{,}987{,}550$ km

1 light-hour

$= 186{,}282$ miles/sec $\times$ 1 hr $\times$ 60 min/hr $\times$ 60 sec/min
$= 670{,}616{,}721$ miles

$= 299{,}793$ km/sec $\times$ 1 hr $\times$ 60 min/hr $\times$ 60 sec/min
$= 1{,}079{,}253{,}000$ km

1 light-year

$= 186{,}282$ miles/sec $\times$ 1 yr $\times$ 365.25 days/yr $\times$ 24 hr/day $\times$
60 min/hr $\times$ 60 sec/min $= 5{,}878{,}626{,}175{,}000$ miles

$= 299{,}793$ km/sec $\times$ 1 yr $\times$ 365.25 days/yr $\times$ 24 hr/day $\times$
60 min/hr $\times$ 60 sec/min $= 9{,}460{,}731{,}798{,}000$ km

Another unit of distance is the parsec, the distance from which the orbit of Earth has an apparent radius of 1 second of arc. Since the average radius of Earth's orbit is 149,500,000 km, this distance is

$$\frac{149{,}500{,}000 \text{ km}}{1 \text{ second of arc in radians}} = 3.083659 \times 10^{13} \text{ km}$$

$$= 3.25943 \text{ light-years}$$

where the denominator is $\left(\dfrac{2\pi \text{ radians}/360°}{3600 \text{ second/degree}}\right)$

Conversely, 1 light-year is 0.306802 parsecs.

Hours and Degrees

Hours	↔	Degrees
24 hrs	=	360°

hours to degrees

e.g., converting 7 hours, 12 minutes, 27 seconds to degrees:

$$
\begin{aligned}
7 \text{ hrs} \times 360°/24 \text{ hrs} &= 105.0000° \\
12 \text{ min} \times 1 \text{ hr}/60 \text{ min} \times 360°/24 \text{ hrs} &= 3.0000° \\
27 \text{ sec} \times 1 \text{ hr}/3600 \text{ sec} \times 360°/24 \text{ hrs} &= \underline{0.1125°} \\
& 108.1125°
\end{aligned}
$$

degrees to hours

e.g., converting 108.1125° to hours, minutes, and seconds:

$$
\begin{aligned}
108.1125° \times 24 \text{ hrs}/360° &= 7.2075 \text{ hrs} \\
0.2075 \text{ hrs} \times 60 \text{ min/hr} &= 12.450 \text{ min} \\
0.450 \text{ min} \times 60 \text{ sec/min} &= 27.00 \text{ sec}
\end{aligned}
$$

or 7 hours, 12 minutes, 27 seconds

BIBLIOGRAPHY

Abell, George O. *Exploration of the Universe*. 3rd ed. New York: Holt, Rinehart and Winston, 1975.

Abell, George O. "The Search for Life Beyond Earth: A Scientific Update." In *The First Encounter*, James L. Christian. Buffalo: Prometheus Books, 1976.

Albers, Steven C. "Mutual Occultations of Planets: 1557 to 2230." *Sky and Telescope* (March 1979): 220-222.

Archaeoastronomy. Center for Archaeoastronomy, University of Maryland, College Park, Maryland.

Ashbrook, Joseph. "Astronomical Scrapbook: Some Bunchings of Planets." *Sky and Telescope* (November 1973): 300 & 305.

Asimov, Isaac. *Asimov on Astronomy*. New York: Doubleday, 1975.

Asimov, Isaac. *Exploring the Earth and the Cosmos*. New York: Crown Publishers, 1982.

Astronomy. Astro Media Corporation, Milwaukee, Wisconsin.

Astronomy (Merit Badge Library #3303). Boy Scouts of America, New York City.

Banks, Arthur. *A World Atlas of Military History*. New York: Hippocrene Books Inc., 1973.

Barraclough, G., ed. *The Times Atlas of World History*. Maplewood, N.J.: Hammond Inc., 1979.

Beatty, J. Kelly, et al., ed. *The New Solar System*. 2nd ed. Cambridge: Cambridge Univ. Press.

Bergamini, David, et al. *The Universe*. New York/Chicago: Time Inc., 1962.

Breed, Joseph B. *Stars for the Space Age*. New York: World Publishing/Times Mirror, 1971.

Calder, Nigel. *The Comet is Coming*. New York: Viking Press, 1980.

Clarke, Arthur C. *The Exploration of Space*. Rev. ed. 1979.

The Earth and Man. New York: Rand McNally & Company, 1972.

Ernst, B., T.J. E. De Vries. *Atlas of the Universe*. London-New York: Thomas Nelson and Sons Ltd., 1961.

Friedman, H. *The Amazing Universe*. Washington, D.C.: National Geographic Society, 1975.

Gardner, Martin. *The Relativity Explosion: A Lucid Account of Why Quasars, Pulsars, Black Holes and the New Atomic Clocks Are Vindicating Einstein's Revolutionary Theory*. Random House, 1976.

Gingerich, Owen. "Astronomical Scrapbook: How Astronomers Finally Captured Mercury." *Sky and Telescope* (September 1983): 203-205.

Goell, Theresa. "Throne Above the Euphrates." National Geographic (March 1961): 381-405.

Gore, Rick. "The Once and Future Universe." *National Geographic* (June 1983): 704-749.

Hart, M.R. *How to Navigate Today.* Cambridge: Cornell Maritime Press, 1970.

Hirschfeld, Alan, Roger Sinnott, ed. *Catalogue 2000.0, Vol. 1: Stars to Magnitude 8.0.* Cambridge: Cambridge Univ. Press, 1982.

Hughes, David. *The Star of Bethlehem: An Astronomer's Confirmation.* Walker & Co., 1979.

Krupp, E.C. *Echoes of the Ancient Skies.* New York: Harper & Row, 1983.

Lindsay, Jack. *Origins of Astrology.* New York: Barnes & Noble, 1971.

Markowitz, W. "Polar Motion: History and Recent Results." *Sky and Telescope* (August 1976): 99-103 & 108.

Mercury. Astronomical Society of the Pacific, San Francisco, California.

Michener, James. *Space.* New York: Fawcett, 1983.

Moyer, G. "The Origin of the Julian Day System." *Sky and Telescope* (April 1981): 311-313.

Neugebauer, Otto. *A History of Ancient Mathematical Astronomy.* 3 vols. Berlin: Springer, 1975.

Neugebauer, Otto, H. B. Van Hoesen. "Greek Horoscopes." *Memoirs of the American Philosophical Society,* Vol 48. Philadelphia, 1959.

Newton, Robert R. *Ancient Astronomical Observations and the Accelerations of the Earth and Moon.* Baltimore-London: Johns Hopkins Press, 1970.

Norville, Warren. Celestial Navigation Step by Step. New York: Association Press, 1973.

Pournelle, Jerry, ed. *Black Holes.* New York. Fawcett, 1979.

Rey, H.A. *The Stars—A New Way To See Them.* Boston: Houghton Mifflin Co., 1967.

Sagan, Carl. *The Cosmic Connection: An Extraterrestrial Perspective.* New York: Doubleday, 1980.

Sagan, Carl. *Cosmos.* New York: Random House, 1980.

Sato, Kuniji. "Glimpses of Ancient Japanese Astronomy." *Sky and Telescope* (August 1979): 108-109.

Scientific American. Scientific American, New York, New York.

*"Scientific Reports on Viking Missions (Mars)." *Science* 193 (no. 4255): 759-815; 194 (no. 4260): 57-110; 194 (no. 4271): 1274-1353.

*"Scientific Reports on Voyager Missions (Jupiter)." *Science* 204 (no. 4396): 945-1008; 206 (no. 4421): 925-996.

Sky and Telescope. Sky Publishing Corporation, Harvard College Observatory, Cambridge, Massachusetts.

Space Exploration (Merit Badge Library #3354), Boy Scouts of America, New York City.

Stephenson, F. Richard, David H. Clark. "Ancient Astronomical Records from the Orient." *Sky and Telescope* (February 1977): 84-91.

Stephenson, F. Richard, David H. Clark. *Application of Early Historical Records*. New York: Oxford Univ. Press, 1978.

Thompson, L.G. "On the Trail of the 'Jupiter Effect.'" *Sky and Telescope* (September 1981): 220-221.

The Times Atlas of the World. 5th ed. New York: Quadrangle/The New York Times Book Co., 1975.

Trimble, V. "Astronomical Investigation Concerning the So-Called Air-Shafts of Cheops' Pyramid." *Mitteilungen des Instituts fuer Orientforschung*, Vol. 10: 183-187. Berlin: Deutsche Akademie der Wissenschaften, 1964.

Van Flandern, T., K. F. Pulkkinen. *The Astrophysical Journal*, Supplement Series, Vol. 41 (November 1979): 391-411.

Vehrenberg, Hans. *Atlas of Deep-Sky Wonders*. 4th ed. Cambridge: Cambridge Univ. Press.

Warner, L. *Astronomy for the Southern Hemisphere*. Wellington, New Zealand: A.H. & A.W. Reed, 1975.

* = Multiauthored

GLOSSARY

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Altitude Elevation; a position coordinate for a point in the sky, measured in degrees above the horizon along a great circle perpendicular to the horizon (see illustration on page 26).

Asteroid A celestial body, smaller than a planet, that orbits the sun.

Astronomy The science that studies the universe beyond Earth.

Azimuth A position coordinate for a point in the sky, measured in degrees in an easterly direction along the horizon from due north to the meridian passing through the point (see illustration on page 26).

Cardinal directions North, south, east, and west.

Celestial poles The projection of Earth's poles onto the celestial sphere.

Celestial sphere An imaginary sphere surrounding Earth on which all celestial bodies are projected.

Chronology The science of time-keeping, which includes the sequential ordering of events.

Chronometer An instrument used for keeping time precisely.

Circumpolar stars Stars which remain above the horizon at a given latitude.

Clusters Groupings of stars or galaxies.

Comet A celestial body composed of frozen gases and dust that revolves around the sun. When a comet approaches the sun, a large vapor and dust cloud may form around it, often appearing as a long "tail."

Conjunction The apparent meeting or passing of two celestial bodies that have the same right ascension.

Constellations Eighty-eight star groupings named after animals, objects, and mythological gods and heroes. By convention, the celestial sphere is divided into sections named after the constellations.

Date line The longitude opposite prime meridian, where 180° E and 180° W superpose.

Declination A position coordinate measuring the angular north/south distance of a point from the celestial Equator along a meridian passing through the point (see illustration on page 27).

Deep-sky objects Distant nebulae, galaxies, and clusters outside our own galaxy.

Double stars Stars which appear very close to each other when viewed from Earth. Some double stars are pairs revolving around each other.

Eclipse, lunar Complete or partial darkening of the moon as it passes through Earth's shadow.

Eclipse, solar Complete or partial darkening of the sun when the moon passes in front of it, as seen from Earth.

Ecliptic The apparent path of the sun on the celestial sphere (see illustration on page 25).

Ephemeris A tabulation or mathematical model of the positions of celestial bodies during a given period of time.

Equator A great circle on Earth located 90° from both the North and South Poles. The celestial Equator is its projection onto the celestial sphere.

Equinox Twice a year, in spring and autumn, when day and night are of equal length in all latitudes.

Galaxy A huge grouping of stars, dust, and gases.

Great circle A circle formed by intersecting a sphere with a plane through its center.

Greenwich mean time (GMT) The time at the prime meridian in Greenwich, England; standard by which time zones around the world are established.

Gregorian calendar The calendar introduced in 1582 A.D. by Pope Gregory XIII and in use at present.

HD numbers Star identification numbers from the Henry Draper catalog.

Horizon A great circle on earth, 90° from both the zenith and nadir of the observer. The celestial horizon is its projection onto the celestial sphere.

Horoscope A chart showing the position of celestial bodies at a particular time and location.

Inferior planet A planet closer to the sun than Earth is; also called an inner planet.

Julian calendar The solar calendar introduced by Julius Caesar in 45 B.C., replacing the Roman lunar calendar.

Julian day system A chronological day count used for astronomical calculations.

Jupiter effect A pseudo-scientific theory on the gravitational effect of Jupiter on Earth.

Latitude The distance of a point north or south of the Equator, measured in degrees along a meridian passing through the point.

Light-year The distance light travels in a year (5,878,626,175,000 miles or 9,460,731,798,000 km).

Longitude The distance of a point east or west of the prime meridian, measured in degrees or hours along a meridian passing through the point.

M numbers Identification numbers for celestial objects (usually the more prominent deep-sky objects) which are not stars, planets, or comets; tabulated in 1781 A.D. by Messier.

Magellanic Clouds The two galaxies closest to our own, visible only from the Southern Hemisphere.

Magnitude The apparent brightness of a celestial object.

Mercator projection A method of projecting the surface of a sphere onto a planar map where lines of latitude and longitude are straight and intersect at right angles.

Meridian A great circle that passes through the North and South Poles and any given point; also half that circle.

Meteor A small, solid object that revolves around the sun and is visible when it enters Earth's atmosphere.

Milky Way The galaxy to which our Solar System belongs.

Moon phases The changing appearance of the moon as it orbits, ranging from new to full, as seen from Earth.

Nadir The point on the celestial sphere directly underfoot.

Navigation The art and science of determining your location and direction of travel.

Nebula A faintly glowing cloud of dust and gases; sometimes also a distant galaxy.

NGC numbers Identification numbers for deep-sky objects from the New General Catalog, a listing started by Herschel and later revised by Dreyer.

North Star The star (presently Polaris) closest to the celestial North Pole; the polestar.

Occultation Eclipse of one celestial body by another, for example, the eclipse of a planet or star by Earth's moon.

Opposition The situation of one celestial body relative to another when the right ascension of one differs by 180° from the other, such as when a planet is in the opposite direction from the sun, as seen from Earth.

Planetary alignment When planets appear together within a narrow viewing angle.

Planetary retrogression The apparent backwards movement of an outer planet relative to the star background.

Planetary transit The passage of a small planet across the sun or a larger planet.

Precession The wobbling motion of Earth's axis of rotation.

Prime meridian The meridian that passes through Greenwich, England.

Proper motion The angular change in the position of stars relative to each other.

Pulsar Deep-sky object of small angular size emitting very regular radio pulses.

Right ascension A position coordinate measuring the east/west location of a point on the celestial Equator from the vernal equinox eastward to the meridian passing through the point (see illustration on page 27).

Slewing Turning about a fixed point.

Solar day The time interval (24 hours) from one midnight to the next at a given location.

Solar year The time interval (365 days, 5 hours, 48 minutes, and 46 seconds) from one vernal (spring) equinox to the next at a given location.

Solstice The time of year with the longest (summer solstice) or shortest (winter solstice) number of daylight hours.

Superior planet A planet more distant from the sun than Earth is; also called an outer planet.

Zenith The point on the celestial sphere directly overhead.

Zodiac The narrow path in which the sun and planets move in the heavens, divided into 12 parts, or signs, each named after a constellation.

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