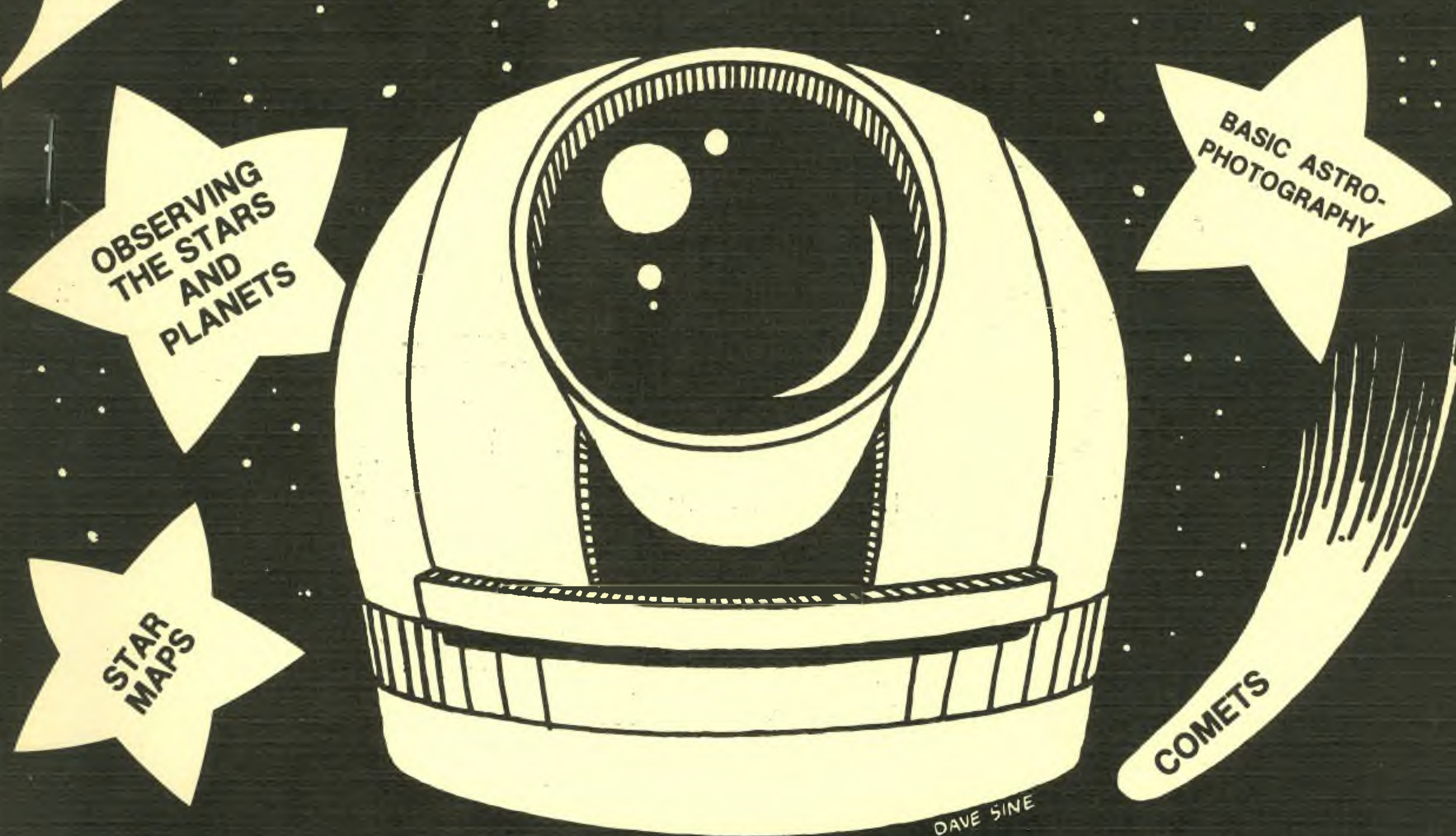
ASTRONOMY

A HOBBY OF MANY COLORS



A BEGINNERS GUIDE TO GENERAL ASTRONOMY

WINNIPEG CENTRE - ROYAL ASTRONOMICAL SOCIETY OF CANADA

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Contributing Editors	Index	Page

Dedicated to the younger generation in the hope of finding a pathway to the stars.

F O R E W O R D

by

David H. Levy

A UNIVERSE FOR CHILDREN

Have you ever really looked up at the stars? Tried to count them, make shapes out of them, or even try to see if they are all of the same colour? Have you tried to see if the stars always stay in the same place, or do some of those points of light appear to move? Have you ever looked up at the stars, and wondered?

If you have never done this, then you are in store for a treat that is extra special and unique. Your first night out could be a voyage on a magic carpet that takes you to distant places and times, from the nearby planets who live in the family of the sun, to the distant stars that are so far away that their light takes years to reach us.

Have you ever wondered about how far you can see, without a telescope? Your unaided eyes are actually capable of seeing over three million light years (that's about 18 quintillion miles.) And all from your own back yard, assuming that the sky is dark enough. What is the name of this ethereal thing so far away? It's called Messier #33, and is named after a Frenchman, who more than 200 years ago, enjoyed staying up at night with his telescope, searching for new comets. Although his search was successful, he was more often disappointed by the many fuzzy patches in the sky that looked like comets but which turned out to be distant gas clouds, custers of stars, and galaxies. Today his dozen comets are all gone into the depths of space, lost forever, but all those fuzzy objects are easily visible to us as reminders of the careful search of a great observer.

The sky belongs to you. And before you learn about all the constellations that have been made up by a thousand centuries of humans, try to make up some of your own. Can you see your favourite cat in the sky, a figure of stars joined by the lines of your imagination? After that you can try to understand the constellations that were invented by earlier people who share your sense of adventure. You'll see the warriors like Orion, the hunter, Sagittarius the archer, and Hercules; the Queens and Kings like Cassiopeia and Cepheus, the birds like Cygnus the swan and Corvus the crow, and the musical instruments like Lyra the harp.

But this presents only one narrow side of the stars. What we see each clear night is something that offers clues to how we got here and what we are made of. We can ask questions about them: are they all white or do some show the faintest hints of colour, bluish or reddish hues that might tell us something of their nature? Are some parts of the sky more crowded than others? And do certain bright "stars" shine with a steadier light than the shimmer of the rest? These same "stars" also appear to move from week to week, and were once known as the wandering stars. Today both telescopes and spacecraft are aimed at these fascinating sisters and brothers of the earth.

Look up at the sky thoughtfully tonight, for you may find something familiar up there in the vastness of space and time. There is evidence that some five billion years ago, a large red star exploded, sending carbon through space to the young planet earth. We may be made of that star, and when we look at its descendants, in a special sense, we look at ourselves.

Have you ever looked at the stars and wondered? Read the pages that follow, and begin a happy voyage that, if you put your mind to it, will last the rest of your life.

HOW THE SUN PRODUCES ITS ENERGY

by D. Kerr

Our sun, which is a star like many other stars, is something we usually take for granted. However, if we take the trouble to examine it closely and then ask the right questions, it becomes a fascinating and complex object. The sun is an enormous ball of gas nearly one and half million kilometres in diameter, or roughly a hundred times the size of our planet Earth. It consists mostly of the lightest gases, hydrogen and helium - about 75 percent hydrogen and 25 percent helium with other elements present in only very small quantities. The sun produces an immense amount of energy which we receive as light and heat, and it has been producing this energy at a steady rate for almost 5 billion years.

About one hundred years ago astronomers and other scientists began serious considering the very important question: How has the sun produced such a large amount of energy for such a long time? Early astronomers thought the sun must be burning in the same way wood or coal would burn. They soon realized, however, than an ordinary fire would not give off enough energy for long enough. Many other more or less ordinary methods for producing energy were considered but none could account properly for the energy we receive from the sun. It was only after Einstein wrote his famous equation, $E = mc^2$, that scientists began to realize that a very special and powerful process might be responsible for the sun's energy production. What Einstein's equation says, simply is that a very small amount of matter can be changed into a fantastically large amount of energy under certain conditions.

To understand how the sun produces its energy, we must imagine travelling from the surface of the sun deep into its interior. At the surface, the temperature is high - about $6000^{o}C$ - and as we move deeper into the sun, the temperature gets even higher, eventually reaching at least 10 million ^{o}C. At this extremely high temperature the hydrogen atoms are moving with such great speed that, if two atoms collide, they can stick together or fuse. (More accurately, it is the nucleus or central part of the atom that collides and fuses with another nucleus.)

This is the process of nuclear fusion. The complete process involves fusing four hydrogen atoms to make a helium atom. We find, however, that something unusualy has happened in this fusion process. The helium atom weighs less than the four hydrogen atoms that fused to produce it. In other words, some of the matter apparently has disappeared but, of course, nothing can simply disappear without a trace. What is heppening here is explained by Einstein's equation - the matter that has been lost has been converted into energy.

What has been described is the fusion process producing a single helium atom. Inside the sun this process is repeated countless times each second so that, in fact, during each second 600 million tons of hydrogen are converted into 596 million tons of helium. The missing four million tons of matter have been converted into an enormous amount of energy which appears initially, in the core of the sun, as dangerous gamma rays. As these gamma rays move outward toward the sun's surface, they are involved in many collisions with individual atoms, eventually being changed enough so that the energy which finally emerges at the surface is mostly in the familiar form of visible light.

It may appear from the rate at which our star is using its hydrogen - 600 million tons per second - that it must soon run out of fuel for the fusion process. However, the sun contains such a high supply of hydrogen that we expect it to continue producing energy at the same rate as today for another five billion years. At that time, in the distant future, with its hydrogen fuel supply exhausted, the sun will enter a new stage of its life and become a very much enlarged red giant star, bringing to an end our solar system as we know it today.

Total Solar Eclipse.

Prominence erupting from the surface of the sun. Some of the matter will escape [illegible]

Loop prominence. This distinctive shape is a result of strong magnetic fields.

ASTROPHOTOGRAPHY FOR BEGINNERS

G.N. Patterson, D.F.M., C.D., B.E.

Astrophotography is, literally, the taking of photographs of astral or sky objects such as the Sun, Moon, Planets, Stars and Deep Sky Objects. It has also come to mean the taking of photographs of atmospheric phenomena such as Aurora, Meteor Showers, Parahelia, etc. A good astrophotograph is the result of experience, knowledge of the equipment to be used, and an element of good luck. The good luck element can be largely, but not totally eliminated by a good understanding of the various factors involved, and the use of proper techniques. The object here is to summarize many of the techniques, some of which are unique, used in astrophotography.

Astrophotography differs from normal routine photography in that:

a. The object to be photographed is usually very distant.

b. With the exception of the Sun, most objects are so poorly illuminated that a normal 'built-in' light meter, or an external light meter are of no value in determining the exposure times required.

c. Focusing in a TTL (Through The Lens) camera is very difficult due to the poor illumination and size of the object, so special techniques are required to obtain a precise focus; the normal ground-glass screen built into a camera requires too much light to give a sharp image at focus.

d. Due to the small size of the object, some pre-magnification is usually needed ahead of the film plane, resulting in a long exposure time.

e. Long exposure times can only be obtained by accurate tracking of the object being photographed. This requires special ancillary equipment.

f. Long exposure times can result in film fogging. This can be minimized by correct selection of film and the proper use of filters.

g. Long exposure times result in low-intensity reciprocity failure. Proper techniques can minimize the effect of this failure but cannot nullify it completely. With color film, only the use of a cold camera (below freezing point) can produce satisfactory results.

h. Absolute precision in polar alignment and mounting rigidity are mandatory due to the extremely long focal lengths used. Even the slap of the focusing mirror can introduce unacceptable vibrations.

i. Atmospheric refraction, and air and light pollution cause special problems. The newer nebular filters can minimize some of the effect of light pollution, but the other forms must be tolerated and worked around.

The above lists some, but not all of the problems encountered by the budding astrophotographer. Don't lose hope and give up. Most can be minimized using proper techniques coupled with experience, and experience can only be gained by the use of patience couped with trial-and-error methods. What may work ideally for one individual does not necessarily produce the same results with someone else. Experience is gained by making mistakes - do not discard the data that gave an unacceptable picture; store it away so that you know what not to do the next time. This is what experience is all about. Further, do not be ashamed to use someone else's ideas. An experience shared is another form of learning, and it will all add up to your own fund of experience in this fascinating hobby.

LOCATION

One of the primary conditions for good astrophotography is the location of the telescope. While good photographs can be taken of some of the brighter astronomical objects in built-up urban areas, (usually with special filters), the preferred location is one well away from urban areas and their resultant air and light pollution problems. A dark area will permit longer exposures without film fogging, and is practically mandatory when photographing Deep Sky Objects. Other aspects should also be taken into account such as:

a. Accessibility, particularly in wintertime. It is no good having the perfect site if you cannot get to it when you need it. Also covered under this heading is the distance that has to be travelled to get to the site. If you have to travel several hours to get to the site, this is so much time taken away from useful photographing time.

b. Shelter availability. This is most important during winter, even a mild breeze at -20^{o}C can be insufferable. This, of course is why so many private observatories get built.

c. Freedom from vandalism - in this day and age, a site that is quite free from wanderers in summertime may be inundated with powered recreation vehicles in wintertime. It is often preferable to relax on some of the other requirements to ensure this criteria is met - usually an obliging farmer can be found who will provide some safeguards against unauthorized entry and vandalism.

THE TELESCOPE

An accurately tracking, equatorial-mounted telescope, fitted with a variable frequency drive, rigidly mounted and accurately oriented for correct latitude and true north, is essential for long exposure photographs. If a refracting-type telescope is used, it should normally not be faster than f/15 to minimize achromatic abberation. For a reflector-type telescope, speed should normally not exceed f/8, although excellent photographs have been taken with reflectors with faster speeds than this, i.e. f/4.5. The main reason for this is to minimize coma. Special type astro-cameras, such as the Schmidt Camera can have speeds as fast as f/0.5. Provision has to be made for visually 'tracking' a nearby star during the exposure time. This is best provided by an ancillary telescope that is accurately collimated with the main telescope, and is equipped with a reticule using lighted crosshairs. Further a wind-proof shelter around the telescope is almost essential both from the point of view of the photographer's comfort, and to prevent wind vibration of the telescope.

RECORDING

A very essential feature to successful astrophotography is the keeping of accurate records of all photos taking, including all dates and times, exposure times, films used, seeing conditions, objects photographed, etc. These data will provide the novice and experienced astrophotographer with a fund of information that will act as a 'yardstick' for future photographs. A simple method that the author has used on occasion is to use a small battery operated cassette recorder while at the telescope, and transcribing the information later to the back of the finished print, or a proper log sheet, for a permanent record. Further, transcribing this basic information on to prints used for display of competitive purposes gives everyone a chance to see how it was 'done' and provides a 'share-the-wealth' concept with new and budding astrophotographers.

Art by Bruce Bond

ASTROPHOTOGRAPHY: IN THE BEGINNING - EQUIPMENT

L. Gamache

CAMERA: Of prime importance is a camera with a shutter capable of staying open. This enables faint starlight to build up an image on the film over a period of time. Some exposures require a few second, others a few hours.

CABLE RELEASE: This device screws into the shutter release button and locks it down keeping the shutter open.

LENSES: A standard 50 mm or 28 mm wide angle lens is fine for photographing constellations, northern lights, meteors, comets and star trails.

TRIPOD: This is almost an essential piece of equipment. Handheld photos are out of the question at night. In a pinch anything that will hold the camera in position without any vibrations will do.

FILMS: There are many "fast" films on the market that are excellent for astrophotography. Black and white film is not expensive and hence great to experiment with. 400 ASA (150 metric) is highly recommended for a beginner. Fast colour print film is very grainy, but colour slide film is super. After you have a film developed you'll probably have to order prints made or specific negatives. Most photo labs can't understand why in the world you would want a print made from a "blank" negative.

STAR TRAILS: Because the earth rotates on its axis, starlight falling onto photographic film will appear as a trail. Set up the camera towards whatever piece of sky you fancy. Set the focus at infinity, and the exposure time to "bulb". The F stop should be kept at its lowest number i.e. wide open, to allow the maximum amount of light to strike the film. Depress the cable release and wait for about four minutes. Unlock the cable release and try again in another part of the sky. If you centre your photo on Polaris you'll notice concentric circular star trails. As you examine your photos check for any regularly spaced broken lines. This is usually an aircraft of some kind. Tumbling satellites also exhibit this pattern but are normally very faint. A streak of light which is not consistent with the star trails could be a satellite or a meteor. The light trail from a meteor varies in intensity, sometimes flaring up during its run.

CONSTELLATIONS: This can be accomplished with a tripod and a sky chart or planisphere. The part of the tripod that vibrates the most is the neck which holds the camera platform. Try to keep it low, that is, close to the legs. Exposure times from 5 to 15 seconds should capture the brightest stars of most constellations with little or no trailing.

AURORA: After following the standard set up procedures, expose the film for ten to thirty seconds. The brightness of the Aurora changes rapidly and only experience will allow you to determine reasonably accurate exposure times. Colour slide film will yield superb results.

CAUTION: No experimentation is going to be useful unless you record your location, exposure time, sky conditions, type of lens, area of the sky, F stop, etc. - anything that will help you to analyze your photographs.

City light and bright moon bathe the sky with unwanted light. Any extraneous light should be avoided when exposing the film. It takes dark country skies to make a great astrophotograph.

WHAT ARE THEY UP TO? Some members of the Winnipeg Center R.A.S.C. are deeply involved with Astrophotography. They combined telescopes, cameras, photographic techniques and an excellent knowledge of the night sky to produce award winning photographs. They are always delighted to assist newcomers and welcome anyone who is interested in this small but important part of amateur astronomy.

This information package only scratches the surface of the available know-how that our members will be happy to share with you. Get involved with the Royal Astronomical Society of Canada and have fun.

PHOTOGRAPHING THE AURORA

by L. Gamache

The clouds, moon and aurora almost wiped out deep sky photography in 1981. A very active sun was responsible for the intense aurora. Naked eye sunspots were easily visible through Mylar filters and occasionally before sunset through the smoke generated by the numerous forest fires. At night, the Northern Lights, powered by huge solar flares were very spectacular. There's nothing quite like the sensation you get while staring wided-eyed at a fabulous aurora. A photograph brings back those memories and helps you to share a bit of that evening with friends. Because I had taken hundreds of auroral shots last year, someone suggested that I should share my experience with others.

You will need in the way of equipment:
Any camera that allows you to keep the shutter open manually will do. The most popular type of camera with this capability is the 35 mm SLR (single lens reflect). This type of astrophotography does not require a telescope or any of its many accessories, so the camera will be the most expensive item. Most SLR's have a B setting which allows the shutter to remain open as long as the shutter release button is held down. There are two types of shutter cables which will perform this task for you, so you don't have to touch the camera. I prefer a rubber, air pressure release because its long enough to rest on the ground. The short metal coil cables can transmit vibrations. These vibrations are a major cause of blurred photographs.

Although a tripod is not a necessity, it can make one's life a lot easier when an exact positioning of the camera is needed. Look for a tripod that's sturdy with cost being the limiting factor.

Most 35 mm SLR's have interchangeable lenses. A standard 50 mm will accept the Big Dipper but the aurora usually covers a larger area of the sky.

Photo: G. Westcott

It's not practical to buy a fisheye lens, that will give you most if not all of the sky, because they're costly, very slow (f/4.5), and distort the image. A wide angle lens is preferable. I use a 28mm f/2.8, it's fast, inexpensive and also ideal for group photos. This lens can fit in the whole Summer Triangle very nicely.

There are many excellent brands of film on the market. Black and white is less expensive, but a color shot is much more exciting. Color film also brings out the faint hues of green and red that can't always be seen with the naked eye. A fast film is necessary to freeze the sharp edges on the bottom of the auroral curtain and the well defined ray structure which often accompanies it. The grain of a fast print film is very coarse but fast slide film gives good results. 400 ASA film will give you a hard, sharp photograph. 200 ASA will pleasantly soften the aurora but you'll have to double the exposure time. Finer grain films can produce better enlargements but cannot record crisp images because of their slower speeds. I've taken photos using a 64 ASA slide film. This resulted in the aurora coming out as a soft green blur, and the exposure took about 8 times longer than using a 400 ASA film.

Different brands of film and even different speed ratings have a variety of color balances. Some will pick up more red while others more green or blue. It's a good idea to try a few and pick the one that most pleases you.

Although I might try gas hypersensitized film in the future, I still haven't used any for auroral photography. Once the film is removed from the forming gas it immediately begins to desensitize. This film is much more effective for long exposure deep sky work. The aurora is already a variable light source, hence it's best to use a film which gives consistent results.

Getting out of the city is a must but it's not necessary to travel hundreds of kilometers. If the aurora is really intense it will show up well above the city from the southern perimeter.

When I show my photographs to my friends and relatives, their reactions are usually "that's nice." Then they come to a picture which has a tree or a view of the horizon, then I get "Wow! That's a beautiful shot." People need familiar objects of scenery to give them a sense of perspective. I've moved my tripod many times just to get a better photo. Setting up on sod will allow any vibrations to dampen out more quickly then if rested on concrete or wood. The shakiest part of a tripod is not the legs, but the shaft that holds the camera platform and allows it to be raised and lowered. Keep the platform as low as possible and you'll be able to photograph the aurora from a comfortable sitting position.

The trickiest part of auroral photography is the exposure time for the film. The table below will give you a starting point that should yield you good results. Because the aurora varies in brightness so rapidly your experience will be the determining factor in achieving excellent photographs. It's wonderful to combine the two hobbies of astronomy and photography but please don't let celestial photography become a chore and dampen your enthusiasm for astronomy.

Photo: G. Westcott.

EXPOSURE TIMES

F STOP OF LENS	A.S.A. 400	A.S.A. 200
f/1.2	2 seconds	3 seconds
f/1.4	3 seconds	5 seconds
f/2	4 seconds	7 seconds
f/2.8	10 seconds	20 seconds
f/3.5	20 seconds	40 seconds

As you halve the A.S.A. you should double the exposure time.

COMPUTERS IN ASTRONOMY

by B.L. Belkin

In recent years, computers have become widely available in the home market. What used to take up a large room, was composed of thousands of tubes, enough wire to circle the Earth, and cost millions of dollars, now occupies the space of a typewriter, is composed of silicon chips the size of your thumbnail and costs $500. More and more, amateur astronomers are taking advantage of the computer's powerful calculating ability in order to help out with the daily problem solving that is so tediously done by hand. Before we explore some of the particular uses of computers in amateur astronomy, let's familiarize ourselves with some common computer terminology.

When we speak of a computer, we are referring to a box that has a keyboard similar to a typewriter whose insides consist of an organized row of boards and wires, which make up the electronic "brain" of the computer. This circuitry is what performs calculations near the speed of light. It is this speed that is behind all of the "magic" attributed to computers. The box and all of the computer's associated electronics is usually called HARDWARE.

Have you ever wondered how the computer knows what to do when we ask it to do something for us? Well, the computer can be visualized as a machine that plays "Simon Says" -- and we humans are Simon of course. We humans tell the computer what to do by giving the computer a set of instructions called a computer PROGRAM. Programs are simply the instructions that tell the computer what we want it to do. In the computer business, computer programs are often referred to as the SOFTWARE of a computer system. Software is usually stored (another word is recorded) on magnetic tape cassettes similar to those we record music on. Software may also be recorded on magnetic tape inside soft packages called FLOPPY DISCS. The floppy disc is a flat, square board that is very much like a regular recording tape, but is much preferred to cassettes because retrieving and storing information on discs is much faster.

The computer is usually hooked up to a television set or MONITOR, in order to see what you or the computer is doing.

COMPUTER APPLICATIONS IN ASTRONOMY

Have you ever wondered how weathermen on the news or your local paper know just when the sun and moon will rise and set? Sunrise, sunset, moonrise and moonset times are conventionally calculated by astronomers who use information obtained from making careful observations of the sun, moon and stars. The information they obtain is published in books called Astronomical Almanacs and Ephemeri. Calculating rising and setting times of the moon, sun and planets, and predicting the locations of these and other astronomical objects is very complicated and time-consuming. Wouldn't it be nice to be able to do these calculations quickly with a home computer? I've consulted my computer many times when I wanted to know when the moon was to rise, where I could find the planet Mars in the sky and on which day of the week Canada Day fell. Computers are very often used to plot the positions of the planets, moon and constellations for any given date. It would take you and I hours to do these calculations by hand or even with a pocket calculator. It takes the computer only seconds!

Speaking of constellations. Maybe you thought you'd never be able to learn their names and where to find them. In fact, many programs have been written as an educational tool to teach you the names and locations of the constellations and stars. The programs are designed to display the constellations as seen from any date and location on Earth!

As you have read in Len Gamach's review of one of the most popular and enjoyable parts of amateur astronomy - astrophotography, finding the best camera exposure time for a celestial object may be difficult. Often the best photographs are a result of trial and error. I believe that trial and error astrophotography is not necessary -- especially since computers can help. Mathematical formulae have been developed in film manufacturing and physics laboratories that relate the best exposure to the brightness of an astronomical object, the camera aperture (lens opening), and the film speed. We can program the computer to calculate for us this best exposure time for the astronomical object we're interested in photographing.

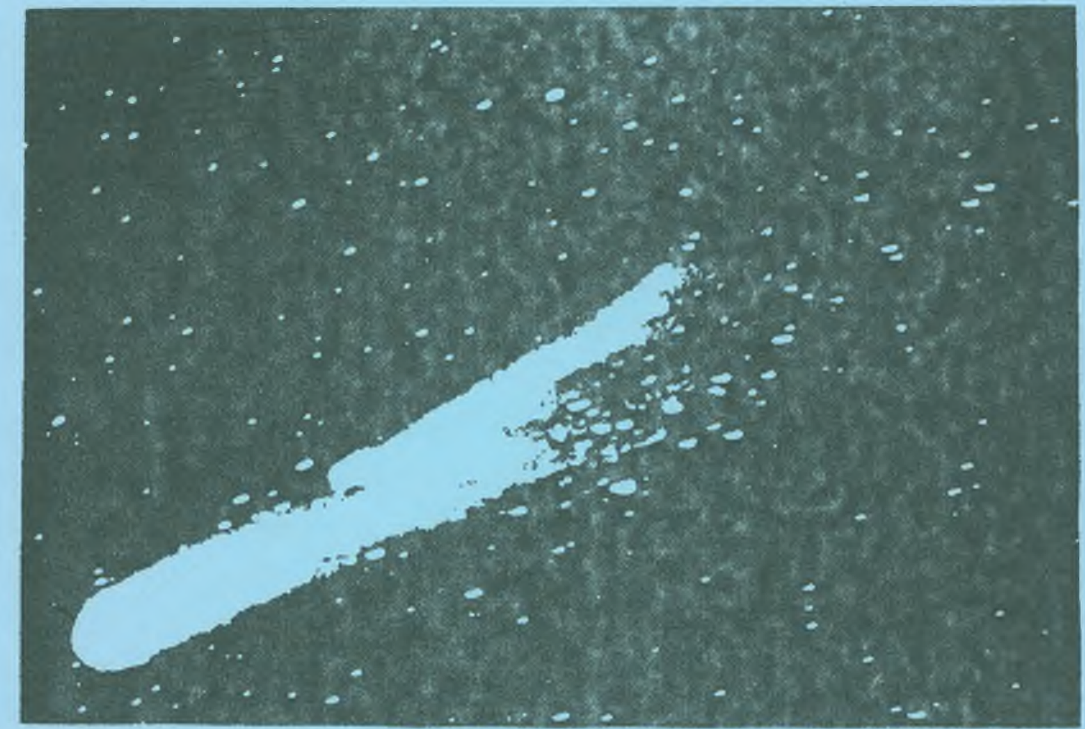
You simply tell the computer what kind of camera equipment you will use and what object you'll be photographing be it planet, galaxy, moon or whatever. Et Voila! The computer recommends the proper exposure time for that object! It's that simple. As a matter of fact, I wrote a computer program that told me what exposures to use for photographing the July 1982 total lunar eclipse. My pictures turned out near perfect. I just looked up the recommended exposure time in a computerized table. There's no guessing involved and think of the film and time you can save by not ruining photographs using the trial and error method.

With a computer, you can store large amounts of information on the planets, moon, galaxies and other objects. Retrieving this information from the computer is easier and quicker than looking through your library trying to find the information you're interested in. Were you ever curious as to when the next solar or lunar eclipse would occur in any part of the world? Computer programs have been written to do just that too. One of the future applications of computers in amateur astronomy is hooked up ("interfacing" in computer lingo) the telescope to the computer. During an observing session for example, the amateur could instruct the computer to turn his telescope onto a certain object given the object's celestial coordinates in the sky. The computer would activate the telescope's motor and control its movement to the exact position of the object. The amateur astronomer would have then have the object centered in his eyepiece! The FORTH computer language is currently used for telescope control in professional astronomy. The FORTH language was developed by astronomers for this purpose.

Of course the astronomy applications I have mentioned are only a small portion of what can be done with a small home computer. In fact, the applications in astronomy and other interests is only limited by the imagination of the programmer. Many people are worried about the prospect that computers may very well one day run people's lives. We must understand that people write the instructions for c o m p u t e r s to follow -- not the other way around. As a matter of fact, if several people are asked to write a program to perform a particular task, the chances are excellent that no two people will write exactly the same program. This evidence suggests that writing computer programs is one of the more c r e a t i v e and h u m a n sciences ever developed.

Indeed computers have added an important dimension to amateur astronomy. Amateurs will now be able to contribute professionally formatted, accurate and readily usable information to professional astronomy. On the lighter side -- amateurs have never had so much fun!!

MR. HALLEY'S HAIRY STAR



HALLEY'S COMET - THE COMET RETURNS

INTRODUCTION

by P DELANEY

Astronomy is one of the few sciences that everyone can enjoy, regardless of their education or professional training. The only requirements are a clear sky and an appreciation of beauty - and perhaps a hearty constitution for those cold Winnipeg winter nights. Star watching can be performed with large, expensive telescopes, or simple binoculars and, in both instances, awe-inspiring sights can be glimpsed. Even observations with the naked eye can be most satisfying as any meteor watcher or solar eclipse chaser will testify. Few other sciences can claim such wide-ranging appeal to all ages, and yet no two people see a given object in the same way. Such is the beauty of astronomy.

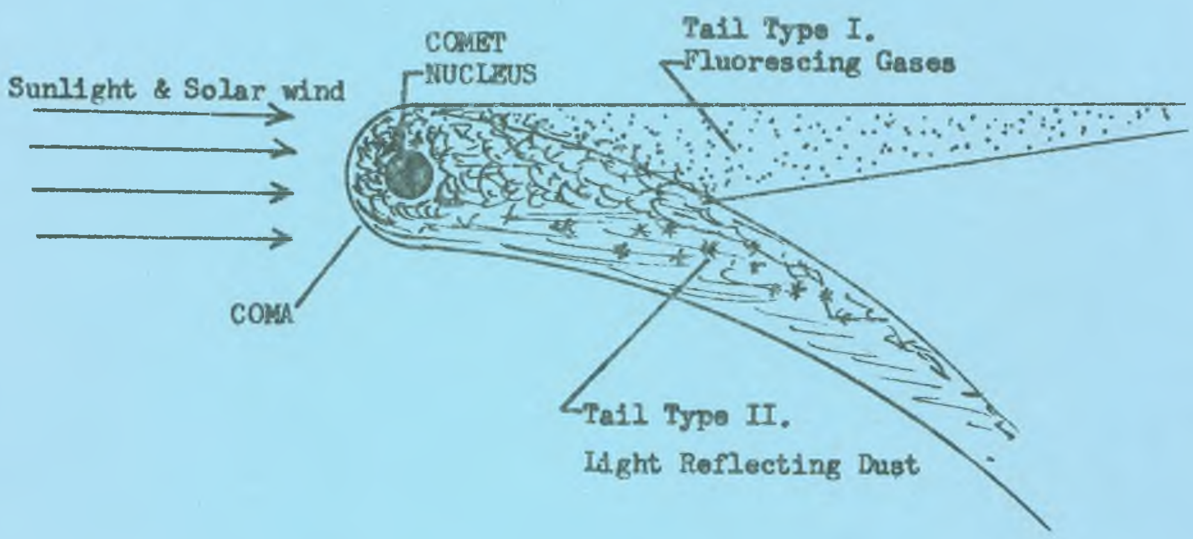
To the uninitiated, the night sky contains a myriad of coloured fixed points, both bright and faint, and a series of brighter, wandering points. The latter lights are the planets of our solar system and in the course of a year will march relentlessly through one constellation and then another, to pass from evening to morning skies, while varying their brightness significantly. By contrast, the stars form the familiar constellations in the sky: the signs of the Zodiac, the Big Dipper, and so on. Everyone has grown up with these patterns of stars and used them as directional indicators for their terrestrial travels. Further, while gazing at the sky, it is most likely that a flash of light will be seen, i.e., a shooting star. These "stars" represent the disintegration of chunks of rock that have been caught by the earth's gravitational field and dragged to their doom in the atmosphere. The light is the fiery, frictional death of a meteor.

Another celestial traveller that appears randomly is the comet. This object, unlike any other, has stirred the imagination of countless generations all over the world. Although a total solar eclipse rivals a comets splendour, it lasts only a few minutes, whereas a comet may dominate the sky for weeks. And the most famous of all comets, Comet Halley, is rapidly approaching our sun. Be prepared for the comet's return!

COMETS IN GENERAL

Before Comet Halley is discussed, the general features of a comet should be considered. As can be seen in Figure 1, a comet is made up of several distinct parts. The 'head' of a comet comprises the coma and the nucleus. The nucleus is the solid, star-like point of the head, several kilometres in diameter and best described as a dirty snowball. The coma, which is a diffuse glow surrounding the nucleus, is caused by the boiling of the nucleus and the consequent release of gas as the comet nears the sun. Streaming away from the comet head, and pointing away from the sun is the tail, a broad luminous stroke in the sky, often easily seen from the earth. There are two types of tail, sometimes distinct, sometimes not. Type I comprises ionized gases, while Type II tails contain solid, dusty materials.

(Figure 1)



Although no space probes have yet visited a comet, a great deal has been discovered about their composition. As long ago as 1868, the English astronomer William Huggins used the science of spectroscopy to determine that part of a comet's light arise from luminous carbon vapour. Modern spectroscopes have identified many neutral atoms and molecules such as C (carbon), CH, CN, Na (sodium) and ions as well, like CH^+, OH^+, N_2^+, CO^+, and CO_2^+. All this material, however, is only contain millions of comet nuclei, some of which are gravitationally perturbed enough to fall inwards to the sun, sometimes to be captured by the sun and kept within the confines of the planetary system. If this happens, the comet becomes a periodic visitor to the inner solar system, carving out a long eliptical orbit that can be mathematically determined, and thus the comet's return can be predicted. Such a period comet is Comet Halley.

As to the formation of the comets four and one-half billion years ago, many theories exist. The most widely accepted on states that comet nuclei formed as planetesimals from the pre-solar nebula and are made of methane, ammonia, water and silicate particles. These smaller bodies would have been strongly effected by the larger planets of the solar system and flung outwards to form the Oort Cloud.

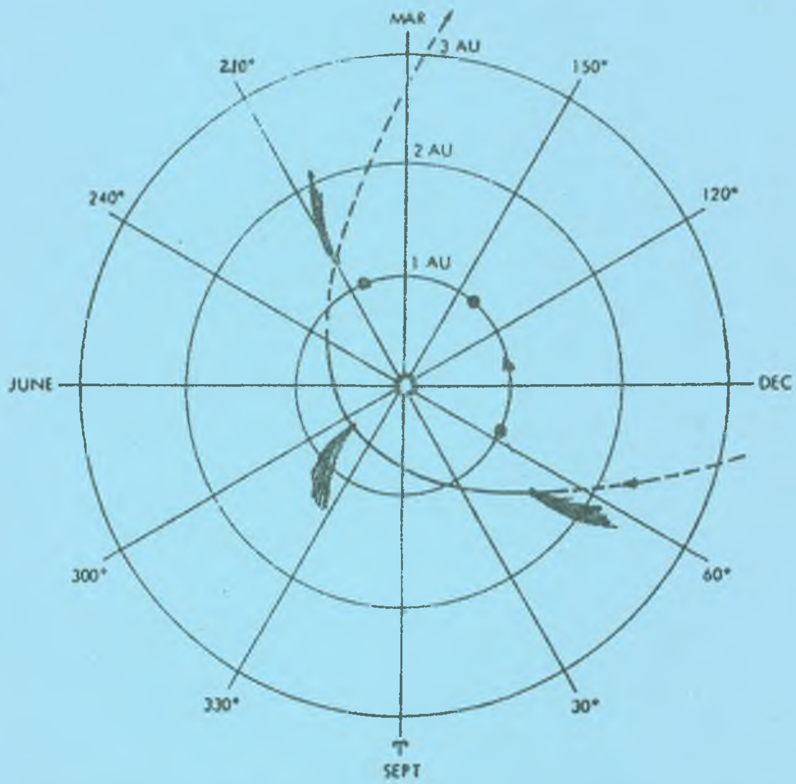
When a comet approaches the sun and its nucleus begins to evaporate, the effect is to erode the solid core of the comet. After numerous returns to the sun, the comet can become burnt out, leaving a small innocuous body orbiting the sun. Such objects have been observed. Further, these orbits coincide with prominent meteor showers, through which the earth periodically passes. In other words, the debris from a comet's tail orbiting about the sun behind a spent comet corresponds to the meteor shower material. This link between meteor showers, comets and small, dark bodies orbiting the sun has been well established in recent years.

HALLEY'S COMET

In 1756, the English astronomer Edmund Halley correctly predicted the return of a bright periodic comet for 1758, based on a series of cometry observations dating back to 1456. Every 76 years, since 1456, a comet with the same orbital elements (trajectory) had been seen. In fact, historial records indicate that Comet Halley was observed as far back as 240 B.C. The most recent appearance was in 1910-11 and the next will be in 1985-86. The questions, of course, are where should one look and when, and what will the comet look like this time, etc. Let us take these questions one at a time.

visible when a comet draws near to the sun, such that the frozen nucleus is heated sufficiently to drive gases from its surface. This transition of a comet from the dormant to active phase, occurs at a distance of about three astronomical units (A.U.) from the sun (279 million miles or 446 million kilometres). As may be expected from a body of ice, the nucleus is a very fragile object. Many have broken up as they approach the sun because of the tidal forces pulling at their surfaces and the continual evaporation of the surface. Lastly, a comet's tail is always pointing away from the sun, regardless of the comet's position relative to the sun (see Figure 2). This is because the charged particles in the solar wind push on the ions in the comet's Type I tail and the radiation pressure presses on the dust in the Type II tail. The tail can be several thousand kilometres in length and varies with the comet's distance from the sun. The size of the dust particles is a few microns (0.000002 metres).

(Figure 2)

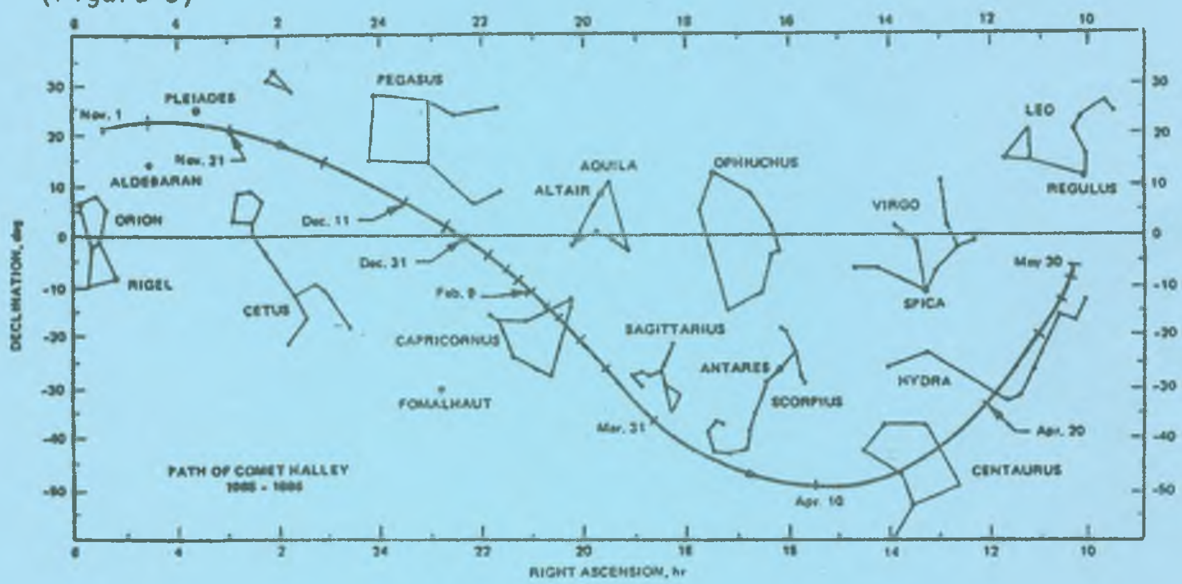


These wanderers are believed to be true members of the solar system (not interstellar transients), formed at the same time as the planets. In the early 1950s, the astronomer James Oort concluded that comets existed in an extensive spherical volume surrounding the solar system, some 50,000 A.U. from the sun. This is the Oort Cloud and is thought to

Comet Halley will reach perihelion (closest approach to the sun) on February 9, 1986 [at about 4:00 p.m. (ET)] and will be at a distance of 0.587 A.U. from the sun. It will be travelling at a speed of 54.55 km/s at that time. The pre- and post-perihelion close approaches of the comet to the earth will occur on November 27, 1985 and April 11, 1986, the distances being 0.62 and 0.42 A.U., respectively.

Where the comet will be throughout this period is best seen in Figure 3. After perihelion passage, the comet's tail will be very apparent and will be best seen from the Southern Hemisphere. This is because of the comet's large, southerly declination. Northern observers will have to be content to view the comet at low elevations at that time.

(Figure 3)

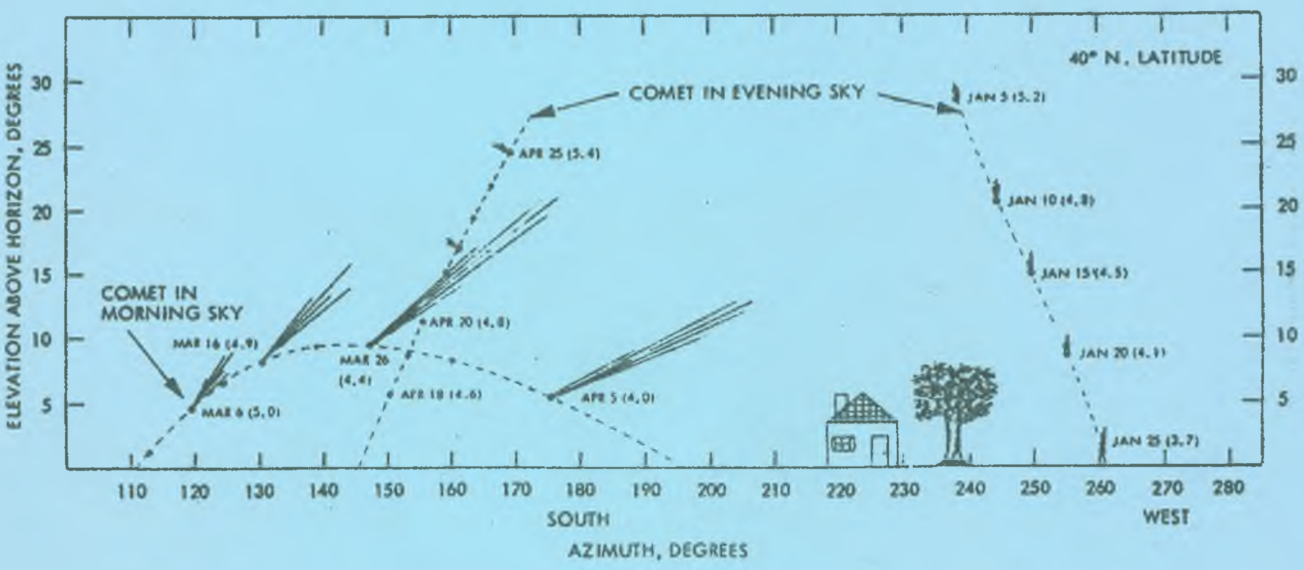


Path of Comet Halley on the Celestial Sphere During November 1985-May 1986

Positional facts about Comet Halley are well know, but its appearance is not. Many people will remember the brightness estimates publicized for comet Kohoutek in December 1973 and how wrong they were! However, in the case of Comet Halley, we have history as a guide as well as modern theory. The comet is predicted to reach an apparent magnitude of +3 in early February and will be north of the constellation Capricornius. Although the brightness of the comet will not rival the brighter stars of the night sky, its appearance should be unmistakable. The comet's coma will be some 1000,000 km across and will appear as a fuzzy disc about one-third the size of the moon. Trailing behind the coma, perhaps for several degrees of arc, will be the tail. Most notably, the comet will move considerably from night to night, and, depending on the observing conditions, its appearance will change appreciably. As for most faint astronomical objects, the best views of the comet will be found away from the lighted city areas. A trip to the country will be most rewarding, as the sky will be very dark, thus enhancing the contrast of faint objects.

For those who may have difficulty in finding various constellations, see Figure 4. As was mentioned, the comet's large southerly delination results in low elevations for observers in Winnipeg.

(Figure 4)



Comet Halley Observing Conditions in 1986 for Observers Located at 40° North Latitude. Comet Positions are Given for Beginning of Morning Astronomical Twilight or End of Evening Astronomical Twilight. Approximate Total Visual Magnitudes are Given in Parentheses Following Dates. Viewing with Binoculars and Ideal Observing Conditions are Assumed.

In January, Comet Halley should be visible for an hour or so in the evening sky, south of west, some 20° above the horizon. The tail will be small but the comet's movement across the sky will be rapid. Following perihelion, the comet will emerge in the morning sky.

In early April, it will be very low in the morning sky, almost due south, rising nearly an hour before the sun. For morning observations, a better time would be around the vernal equinox, March 21. The tail should be most pronounced at this time. If you prefer the evening for observations, then you will again see the comet after sunset, in the south, later in April, climbing higher in the sky night after night, but dimming with time.

In summary then, viewing Halley's Comet from Winnipeg should be a remarkable sight indeed, but the splendor of this celestial visitor will be enhanced as you travel south. In fact, a trip to Australia in late March 1986 may be the best way to view Comet Halley! As 1986 draws nearer, telescopic observations of the comet will become more numerous and the predictions as to the size and brightness of the comet should improve. The Royal Astronomical Society will have this information and be ready to pass it on to you.

Happy viewing!

COMET HALLEY: HISTORICAL AND PHYSICAL DATA

Historical Data

Earliest probable recorded apparition	240 B.C.
Number of recorded apparitions From 240 B.C. to 1910 A.D., only the 164 B.C. apparition was not recorded.	28
Shortest period between returns to perihelion	74.42 years (1835-1910)
Longest period between returns to perihelion	79.25 years (451-530)
Closest approach to the Earth	0.04 AU (April 11, 837)
Longest angular tail length recorded	93° (mid-April 837)
Brightest apparent magnitude recorded (approximate)	-3.5 (April 11, 837)

Physical Characteristics

Estimated diameter of nucleus	5 km
Estimated density of nucleus	1 g/cm^3
Estimated rotation period[A-1]	10.3 hours, direct
Observed spectra in 1910[A-2]	CH, CN, C_2, C_3, Na D, Co^+, N_2^+
Observed tails	Type I ion and Type II dust
Associated meteor streams	η Aquarid (Early May) and Orionid (late October)

A-1. Whipple, F.L., private communication, March 1, 1980

A-2. Bobrovnikoff, N.T. (1931), Publications of the Lick Observatory, v.17, part II.

OBSERVING THE PLANETS

by C. Rutkowski.

Although many millions of kilometres distant, the planets make very good objects for observation due to their brightness with respect to the dark sky background.

The discs of planets can usually be resolved even with a small telescope, or even binoculars for the nearer ones. It is often possible to discern details on the nearer planets. As well, Jupiter's moons are readily visible and their study can show their revolution around the gas giant.

It is a pleasure to explore the solar system by yourself and learn first-hand of the marvellous universe we live in.

MERCURY

Mercury is the innermost planet to the Sun, and is difficult to observe. Its most favorable dates of observation are called its greatest elongations and it will rise only an hour or so before sunrise and set only an hour or so after sunset. It is never high in the sky. Because it is relatively near to Earth and it passes between us and the Sun, Mercury will appear to go through phases, just like the Moon. The best time to see Mercury is during the morning in the fall, and in the evening in the spring.

VENUS

Venus is the brightest planet. It has been called both the morning and the evening star because of its relative brightness. Like Mercury, it will appear to go through phases; from full to crescent, new, then crescent and full again as it travels around the Sun. A pair of binoculars easily resolves its shape. Because it has a thick atmosphere of featureless clouds, no markings can be seen on its disc.

MARS

Mars is perhaps the most interesting planet to observe. Its rapid movement can be traced among the stars in less than a week. It varies greatly in brightness and can outshine Jupiter to rank second only to Venus. Mars appears red-orange due to the rust-colored dust which covers the planet. At its closest approaches to Earth, some features such as its polar icecaps and its infamous canals can be seen with a small telescope.

JUPITER

Jupiter is the largest planet in the Solar System. Its large, cloud-covered disk makes it also one of the brightest objects in the sky, since nearly half of the Sun's radiation falling on it is reflected back. In a telescope, Jupiter appears as a ball, flattened at its top and bottom, due to its rotation. Its surface shows dark streaks (cloud belts) and bright lines (zones). Often the Great Red Spot, a huge local storm is visible on the disc's face. Jupiter's moons revolve around it just like Earth's Moon. Four of the largest moons: Io, Europa, Ganymede and Callisto, are easily observed in a telescope. Watching their changing position is a fascinating exercise.

SATURN

Saturn is the second-largest planet in the Solar System, and it is circled by easily-observable rings. These rings consists of billions and billions of particles of varying sizes. Even through a large telescope, however, only three major rings can be seen. The rings take on different orientations as the planet revolves around the Sun. Saturn has belts of cloud like Jupiter, although they are much harder to see. Five of Saturn's moons can also be seen with a fair-sized telescope. Saturn appears a yellow-white color in a telescope, and is even more like a flattened ball in shape.

URANUS

Uranus is just visible to the naked eye on a dark night, but only if you know exactly where to look. Even in a telescope, Uranus appears only as a very small, greenish ball.

NEPTUNE

Neptune is not visible without a telescope, and even then is an extremely small green-blue ball with no markings.

PLUTO

Practically the only way to detect the planet Pluto is by taking a photograph and carefully comparing each star until one stands out unaccounted. Its slow movement means that even this method often fails to find its target.

An interesting project might be to try and observe all the planets over the course of a summer. Surprisingly few people can actually claim to have "seen" all the planets in the Solar System. If you are successful, consider yourself among a special, select group!

EXPLORING THE PLANETS

by G. Westcott

Despite their efforts to peer across the vast distances of space through an obscuring atmosphere, scientists of the past had only one planet which they could study closely, the Earth. But during the past twenty years planetary space flight has given a new definition to earth sciences like geology, meteorology, and has spawned an entirely new science called comparative planetology. By studying and comparing similarities and differences between planets and moons we learn more about the origin and history of the worlds and solar system as a whole. Weather effects all of us here on earth. If it were extreme, weather could threaten human kind, long term climatic changes on earth would be catastrophic. It is important that we understand our planet's complex ecology and weather machine. Other planets have weather too. By studying their weather and comparing it to Earth's we may better understand our own climate. Geology and weather are just two areas of science that benefit from planetary exploration. Perhaps some day geologists will get their chance to compare the only life forms we have ever known, that is on our Earth, to living creatures of another world.

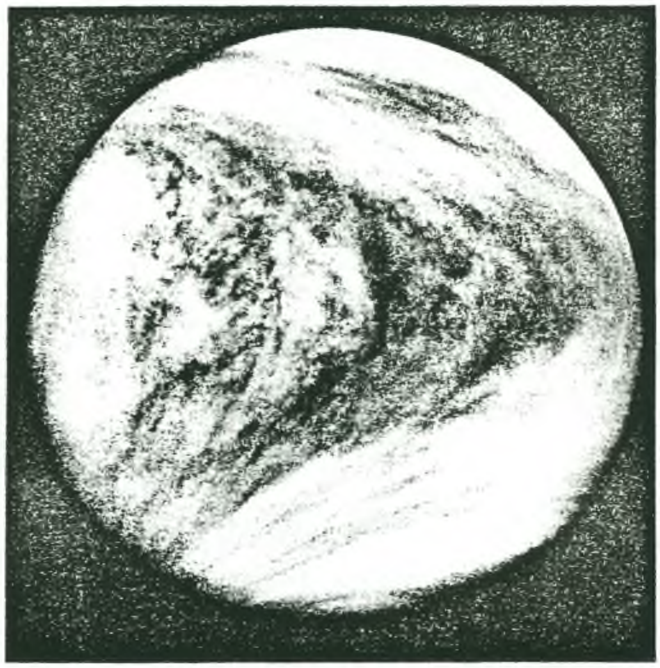
MERCURY. In November 1973, Mariner 10 was launched on its way to Mercury. By March 29, 1974 the space craft was swinging past Mercury at a distance of 500 miles. The photographs radioed back to Earth revealed an uneven, heavily cratered surface, much like our own Moon. Huge cliffs cross-crossed the planet's surface. These were created apparently when the interior of Mercury cooled and shrank, compressing the planets crust. The cliffs appeared to be as much as 1-2 miles high and as long as 1,000 miles in some cases. Instruments on board Mariner discovered Mercury's weak magnetic field and a slight trace of atmosphere - a trillionth of the density of Earth's-composed chiefly of argon, neon and helium. Temperatures ranged from 510^{O}C. on Mercury's sunlit side to -210^{O}C on the dark side. The days and nights on Mercury are long. It takes 59 Earth days to make a single rotation; its rate of spin is about 6 miles per hour, measured at the Equator as compared to Earth's spin rate of about 1,000 miles per hour at the Equator.

Mercury appears to have a crust of light silicate rock and a heavy iron rich core which makes up about half of its volume. Even past telescopic views from Earth show Mercury as an indistinguishable object lacking in surface detail. The planet is so close to the Sun that it is easily lost in the Sun's glare. When it is visible on Earth's horizon, after sunset or just before dawn, it is obscured by the dust and haze of our atmosphere. Only radio telescopes gave any hint of Mercury's surface conditions.

The Moon-like surface of Mercury is revealed in this photograph taken by the approaching Mariner 10 spacecraft.

VENUS. Veiled by dense cloud cover, Earth's sister planet, Venus, was the earliest spot of interplanetary exploration. Exploration of Venus by American and Russian space probes started in earnest on December 14, 1962. Instruments on the spacecraft measured magnetic field, ionosphere, radiation belts and temperature. Ultra violet pictures showing cloud circulation patterns, were beamed back to Earth. A few days later five separate components making up a second spacecraft entered the Venusian atmosphere to radio back more data about the atmosphere during their descent towards the surface. Approximately 97% of Venus' atmosphere is carbon dioxide. Venus' atmosphere acts like a greenhouse, permitting solar radiation in to reach the surface of the planet but not allowing any radiated heat from the surface to travel back out into space. As a result surface temperatures can reach up to 248^{o}C. Radar on board the spacecraft orbiting Venus pierced the dense cloud cover and plotted many surface features over much of the planet. Among the features are two highland areas. There is evidence of two major active volcanic areas with a mountain higher than Mr. Everest, and concentration of lightning over these two regions suggests frequent volcanic activity at both places. Venus' predominant weather pattern is a high speed circulation of clouds made up almost entirely of sulphuric acid.

The speeds of these clouds reach as high as 225 miles per hour. The circulation is the same direction East-West, as Venus' slow backward (retrograde) rotation. Venus rotates once on its axis every 243 days.



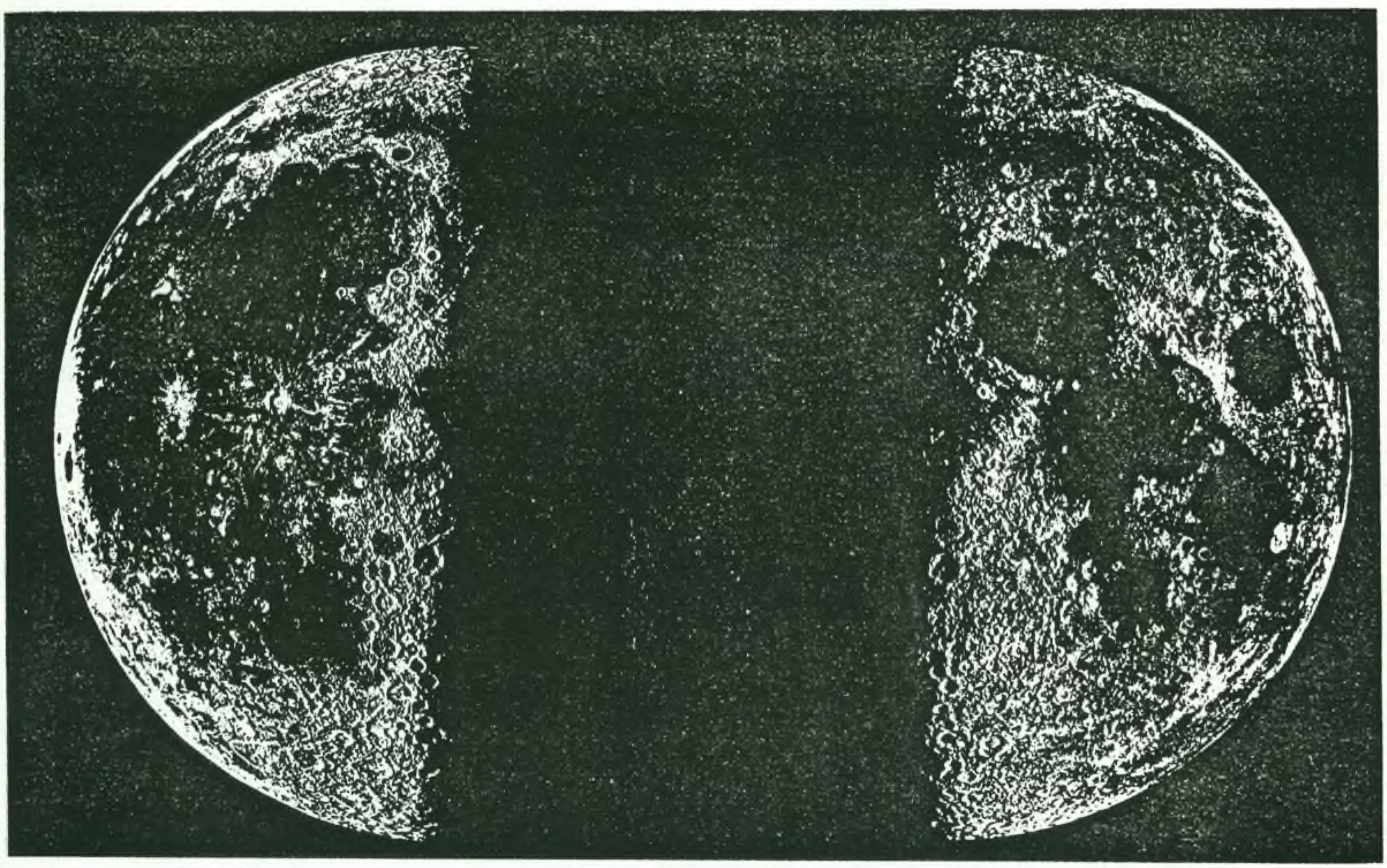
An enhanced photo taken by the Pioneer Venus Orbiter shows the circulation of the dense Venusian atmosphere.

The solar system's only known oasis of life, our planet Earth, is photographed by the Apollo 17 astronauts.

EARTH AND MOON. From our journeys into space we have learned much about our home planet Earth. We have discovered intense radiation zones, called the Van Allen radiation belts encircling the Earth. Satellite exploration has revealed large mineral deposits, crop growing seasons and diseased crops, and weather patterns. We have discovered that our Earth's magnetic field is distorted into a teardrop shape by the solar wind - a stream of charged particles continuously thrown out by the Sun. Earth's magnetic field does not fade off into space but has definite boundaries and our thin upper atmosphere seethes with activity, swelling in the day time and shrinking at night. It is this solar activity that changes our weather and climate on Earth. Earth's atmosphere consists of 78% nitrogen, 21% oxygen and 1% rare gas. The planet is the only one in our solar system known to harbour life. Circulating the sun at an average distance of 93 million miles and turning on its axis once every 24 hours, Earth is the third planet from the Sun and the fifth largest in the solar system.

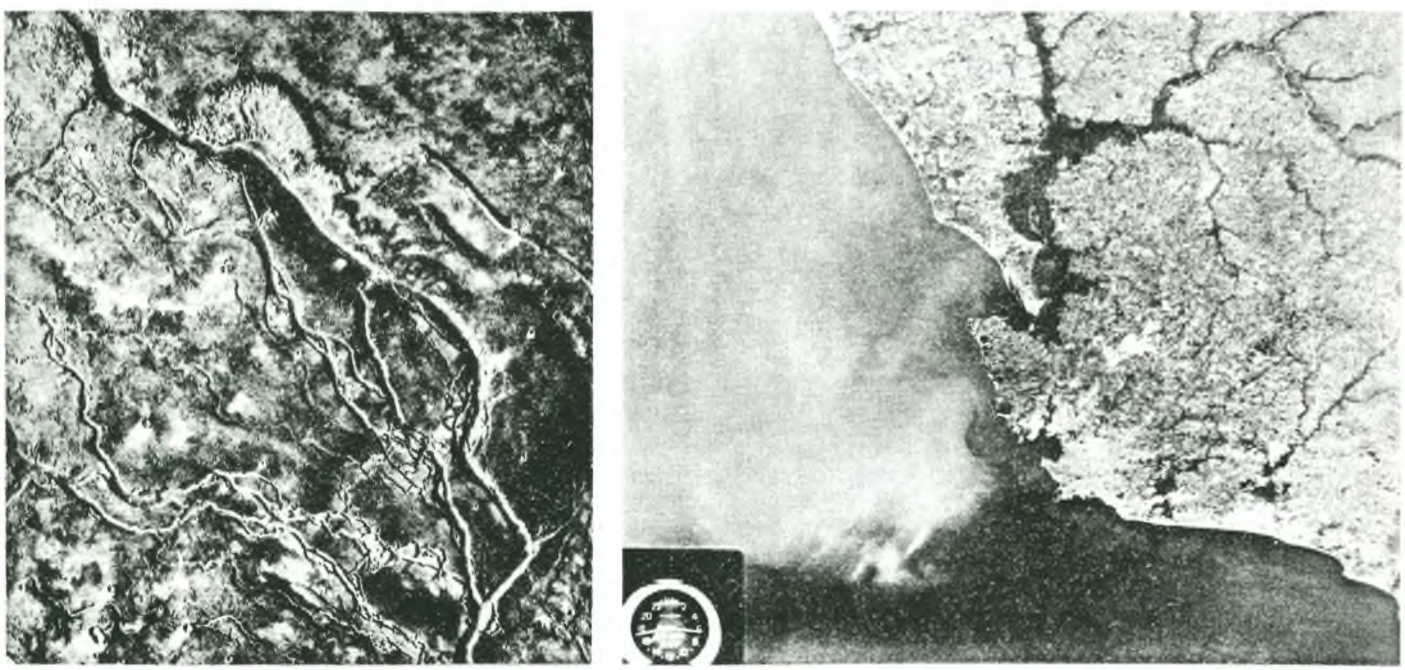
It's rapid spin and molten nickel iron core give rise to an extensive magnetic field which, coupled with our atmosphere, shields us from nearly all harmful radiation coming from the Sun and other stars. The Earth has a single natural satellite, the Moon.

From Lunar materials returned to Earth during the Apollo missions, scientists have constructed a history of Lunar data back to its infancy. Rocks from the lunar highlands were dated to about 4-4.3 billion years old. It is believe that the solar system was formed about 4.6 billion years ago. The first few million years of the Moon's existence was so violent that few traces of this period remain. As its molten outer layer slowly cooled and solidified into different kinds of rock, the Moon became a target for huge asteroids and smaller meteoric objects. Their clashes with the Moon created huge basins hundreds of miles across. This bombardment died away about 4 billion years ago leaving the lunar highlands covered with huge overlapping craters and a deep layers of shattered, broken rock. Slowly the centre of the Moon began to melt, then about 3.8 to 3.1 billion years ago great tides of lava flooded out from inside the Moon pouring over its surface and filling in the large impact basins to form the dark areas we see today which are called maria or seas. Exploration shows that there has been no significant volanic activity for more than 3 billion years. Since then the lunar surface has been hit only by rare impacts of large meteorites.



One question about the moon that remains unanswered is "Where did it come from?" The three theories attempting to explain its existence are: (a) that it formed near the Earth as a separate body; (b) that it separated from the Earth when still in a semi-molten state; and (c) that it was formed somewhere else and then captured by the Earth's gravitational field. The notion that the Moon may have once been part of the Earth now appears less likely than the other suggestions because of the difference between the two bodies in chemical composition, such as the absence of water, free or chemically combined in the lunar rocks. The other two theories are fairly evenly matched. The origin of the Moon still remains a mystery.

MARS. Of all the planets Mars has long been considered the solar system's prime candidate for harbouring extra terrestrial life. Astronomers observing the red planel through their telescopes saw what appeared to be straight lines crisscrossing its surface. This observation - later determined to be optical illusions (astronauts on the Moon have seen the same features on the Earth) - led to the popular notion that intelligent beings had constructed a worldwide system of irrigation canals on the planet.



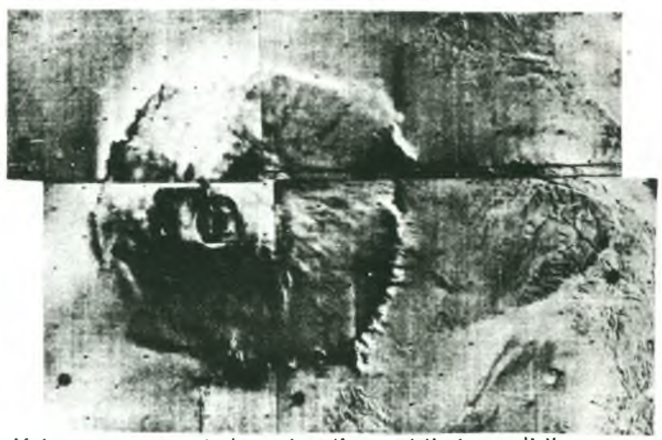
Large Martian channels (left) start near the volcano Elysium Mons and wind their way to the northwest for several hundred kilometers. Their origin is controversial: Did they form from lava flows or water released from the melting of ground ice during volcanic eruptions? Compare the Martian channels with the Skylab photograph of the Rio de la Plata river in Uruguay (right).

Another reason for scientists to expect life on Mars arose from the apparent seasonally colour changes on the planet's surface. This led to speculation that conditions might support a bloom of vegetation during the warmer months and cause plant life to become dormant during the colder months. Results sent back by two unmanned laboratories which soft-landed on the planet were very inconclusive. Small samples of soil were specially treated by experiments designed to detect biological processes. While some of the tests indicated biological activity was occurring, the same results could be explained by the planet's soil chemistry. There was a notable absence of organic molecules existing on Mars. By satellite many previously unknown Martian features were revealed, rivers and possibly seas, could have once existed on the planet. A huge chain of Martian volcanos stood out distinctly as the satellites approached the planet. From Mars, Lander probe photographs showing a panorama of bleak red, rusty landscape were returned to the Earth. Other pictures show a gently rolling plain littered with rocks and graced by rippled sand dunes. Fine red dust from the soil gives the Martian sky a pinkish hue. The highest temperature recorded on Mars was -21^{O}Centigrade and the lowest -124^{O} Celsius. Wind speeds near hurricane force were measured at the two Martian Lander sites. Light patches of frost, probably water ice were photographed during the second winter on the planet.

Jack Frost lives on Mars too. Light patches of frost on the Plains of Utopia (above) were observed during the Martian winter. The Viking landers became our first weather stations on another planet and scientists on Earth continue to get weekly updates from the Viking 1 site. Had Viking 1's first weather report been aired on the 6 p.m. news, it would have gone something like this: "Light winds from the east in the late afternoon, changing to light winds from the southeast after midnight. Maximum winds were 15 miles per hour. Temperatures ranged from minus 122 degrees Fahrenheit just after dawn to minus 22 degrees in midafternoon. Atmospheric pressure 7.70 milibars." (On Earth that same day, the lowest recorded temperature was minus 100 degrees Fahrenheit at the Soviet Vostok Research Station in the Antarctic.)

The Martian atmosphere, like that of Venus, is primarily carbon-dioxide. Present in small percentages are nitrogen, oxygen and argon, with trace amounts of krypton and xenon. Martian air contains only about one thousandth as much water as Earth's. Local patches of early morning fog could be seen forming in the valleys and high cirius clouds, riding high in the atmosphere or swirling around the slopes of the outer Martian volcanoes. Mars has two small irregular shaped moons, Phobos and Deimos with ancient cratered surfaces.

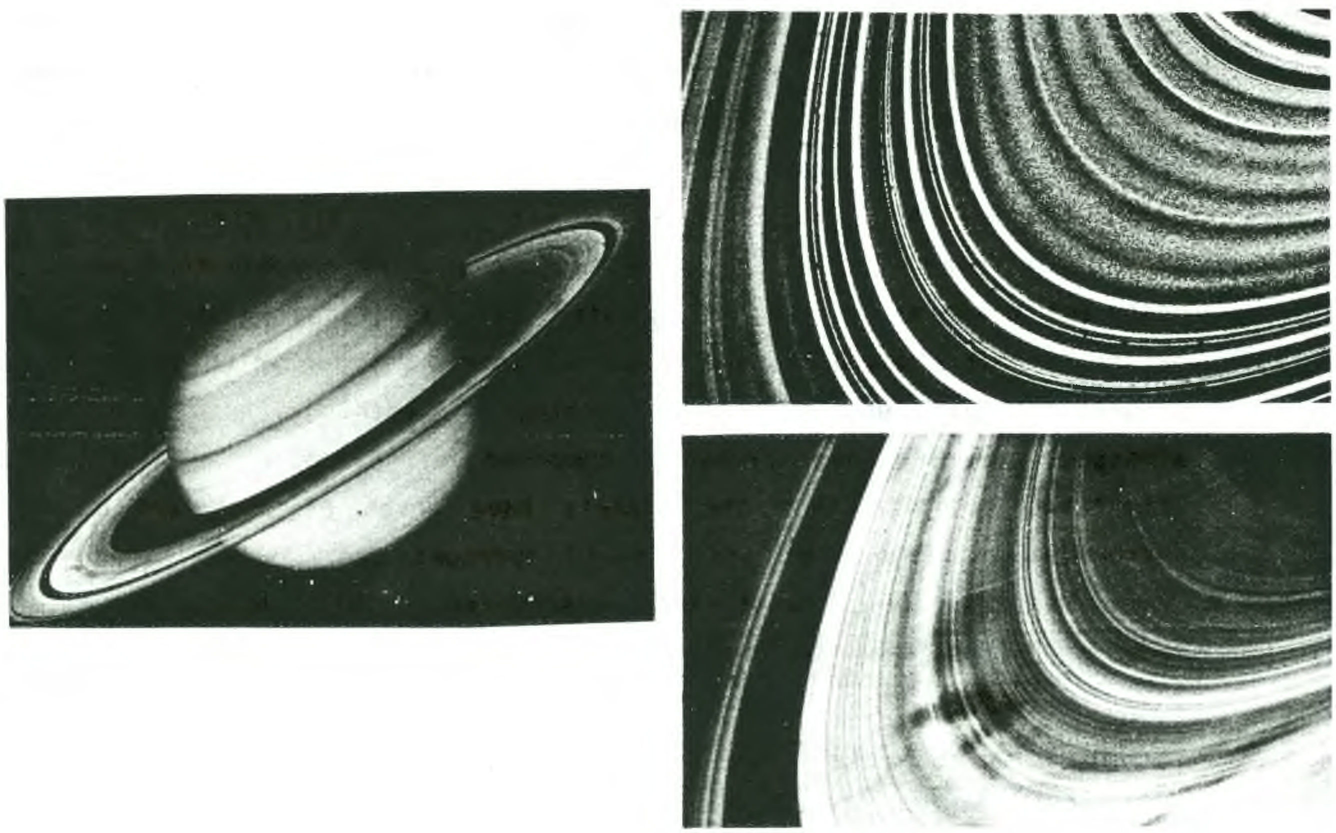
Jupiter looms ahead of the Voyager 1 spacecraft. The Great Red Spot is visible at the lower left. Slightly above the feature, and to the right, is the volcanically active moon Io.



Volcanoes are vents in a planet's crust that permit the escape of internal heat. The geologically active Earth has hundreds of volcanoes, like this one in New Zealand (top). Compare it to one of the large shield-type volcanoes on Mars (center).

<u>JUPITER</u>. Outward from Mars and beyond the asteroid belt lie the giants of our solar system. Jupiter is a large, whirling ball of liquid hydrogen, topped with a uniquely coloured atmosphere of hydrogen and helium. Jupiter's clouds form vast belts of different colours, swirling around the planets girth. The great red spot has been observed for centuries through earth-based telescopes, it is a tremendous atmospheric storm similar to an Earth hurricane, which rotates counter clockwise

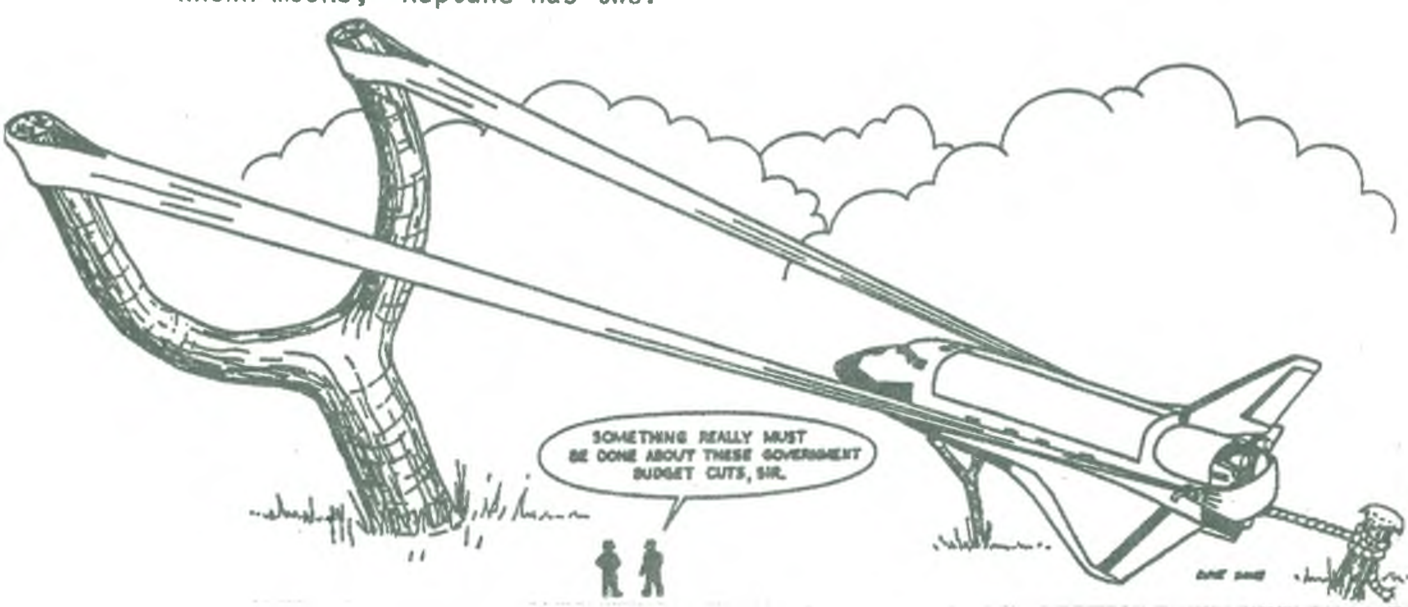
around the planet. Lightning and auroral emissions have been detected in Jupiter's upper atmosphere near the polar regions. Saturn, thought at one time to be the only planet with rings, now has Jupiter for a companion. A narrow ring, too fine to be seen by Earth-based telescopes was discovered by Voyager 2. Jupiter, the largest planet in the solar system rotates once every 9 hours 55 minutes. It takes almost 12 Earth years to complete a journey around the Sun. The planet is somewhat of a mini solar system with 16 known moons orbiting above its clouds. One of Jupiter's moons, Io, was discovered to have active volcanoes. It was the first time that volanic erruptions had ever been observed on any world other than the Earth. Spacecraft cameras identified at least eight active volancoes, sending plumes of sulphur-rich materials up to 155 miles above its surface.



Voyager 2 photographs of the Saturn ring system during its August 1981 approach. The shadow of the planet's exquisite ring system can be clearly seen in the equatorial region.

SATURN. No planet in the solar system is quite adorned like Saturn. It's beautiful ring system is unrivalled. Like Jupiter, Saturn is mostly hydrogen. But in contrast to the vivid colours and wild turbulence in Jupiter's clouds, Saturn has a more subtle, butterscotch hue and it's marks are often muted by high altitude haze. Recent discoveries have shown that Saturn's rocks are actually thousands of ringlets composed of countless low density particles, orbiting individually around the Equator at progressing distances from the planet's cloud tops. Analysis of the rings has shown that the particles varied widely in size, from dust to boulders, mostly the material is ice and frozen rock. Scientists believe that the rings result from a moon or passing body which ventured too close to Saturn and was torn apart by great tidal forces , another theory is that clashes with larger objects slowly broke one or more moons up into dust. This dust was kept from forming into a moon by the gravitational forces of Saturn and its other satellites. Saturn rotates once every 10 hours 39 minutes and it takes 29.4 Earth years for one orbit around the Sun.

URANUS AND NEPTUNE. These two bluish-green giants are scheduled for a visit from Voyager 2 in 1986. The two planets are roughly the same in mass and diameter. They are greater and significantly denser than Saturn. Their atmospheres are known to contain methane which gives both planets their unusual green colour. Both planets possess atmospheres which are probably composed of hydrogen and helium. Scientists theorize that the planets have cores of rock and metal surrounded by layers of ice, liquid hydrogen and gaseous hydrogen. Uranus has a system of faint rings, discovered in 1977. Uranus has five known moons; Neptune has two.



PLUTO. Pluto is an oddity of the solar system. It has nothing in common with the gas giants. It travels farther from the Sun than any of the rest, yet the eccentricity of its orbit periodically carries it inside of Neptune's orbit. Pluto's orbit is highly inclined; that is, it is well above and below the plain of the other planet's orbit. It was discovered in 1930 after years of searching by astronomers looking for a predicted ninth planet. Pluto appears to be little more than a celestial snowball. Observations of Pluto calculate it's diameter between 1,864 to 2,175 miles, which is the same size or somewhat smaller than our Moon. Earth based observations indicate Pluto's surface is covered with Methane ice. Small as it is, Pluto does have a satellite, this moon was discovered in 1978 and named Charon. Of the nine planets Pluto will be the only one not visited this century by a automated spacecraft.

There may still be undiscovered planets that orbit the Sun. Some scientists believe there is evidence for a tenth planet beyond the orbit of Pluto. The search for new worlds in our solar system continues with earth based telescopes. Man waits with baited breath the transporting into space in the mid 1980's of the space-telescope, the new orbiting observatory - unimpaired by Earth's image-distorting atmosphere the telescope will enable astronomers to peer much further into space and view objects much dimmer than they ever could with Earth-based telescopes. Scientists may be able to spot planets orbiting nearby stars, proving what most researchers already believe - that the formation of star orbiting planets occurs commonly throughout our universe. As we study new worlds and expand the infant science known as planetology we gradually piece together age old puzzles into a complete picture of life throughout the universe.

HOSERS IN SPACE

WRITTEN BY CHRIS RUTKOWSKI, ILLUSTRATED BY DAVE SINE

CONSTELLATIONS IN THE NORTH CIRCUMPOLAR SKY

Ursa Major: (The Great Bear, The Big Dipper, The Plough)
Through all ages Ursa Major has been known under various names. It is linked with the nymph Kallisto, the Daughter of Lycaon, a King of Arcadia in Greek Mythology. The second star from the end of the handle is called Mizar.
- Can you locate Mizar's faint companion: Alcor.

Ursa Minor: (The Lesser Bear, The Little Dipper)
The origin of this group is uncertain and in some ages has been referred to as the Little Dog belonging to Kallisto.

Cassiopeia: (The Queen, The Chair or The Throne)
Cassiopeia is one of the oldest and best known of our constellations. The Chair or Throne is quite familiar to most observers. It is also known as the celestial W when below the Pole and the celestial M when above it. In mythology Cassiopeia was the wife of Cepheus, King of Ethiopia, and the mother of Andromeda.
- Can you identify in the sky the six major stars making up "Cassiopeia's Chair?"

Cepheus: (The King, The Church Steeple)
According to Greek mythology Cepheus was the King of Ethiopia, husband of Cassiopeia and father of the beautiful Andromeda.

Draco: (The Dragon)
Mythologists have suggested that Draco was the snake snatched by Minerva from the giants and whirled to the sky: or the monster killed by Cadmus at the foot of Mars, whose teeth he sowed for a crop of armed men.
-Can you identify the head and trace out the coils of the dragon extending to a point between the Pointers and Polaris?

ASTRONOMICAL PHENOMENA

May to December 1984

A typical Sky Sheet can be used for more than one month. The map shows the sky around 10:30 p.m. at the middle of the month, or 8:30 p.m. a month later. This also applies to the text. April Sky (1984) featured Leo. This constellation is on the map from February (low in the east) to July (low in the west). Information about planets and the moon, however, can only be used for the specified month and year. A summary of this information for 1984 follows. File your sky sheets as most of the information can be used year after year.

MAY

d	h	(Universal Time)
1	04	New Moon
4	07	η Aquarid Meteors
8	12	First Quarter
14	08	Saturn 0°.5 N. of Moon
15	05	Full Moon; Eclipse of Moon
18	17	Jupiter 3° N. of Moon
19	11	Mars closest approach to Earth (79,500,000 km)
22	18	Last Quarter Moon
30	17	New Moon; Eclipse of Sun

JUNE

d	h	(Universal Time)
6	17	First Quarter Moon
10	13	Saturn 0°.2 N. of Moon
10	14	Mars 4° S. of Moon
13	15	Full Moon; Eclipse of Moon
14	22	Jupiter 3° N. of Moon
21	05	Summer Solstice; Summer begins
29	03	New Moon

JULY

d	h	(Universal Time)
3	07	Earth at aphelion
5	21	First Quarter Moon
7	17	Saturn 0°.1 N. of Moon
11	23	Jupiter 3° N. of Moon
13	03	Full Moon
21	04	Last Quarter Moon
28	10	South δ Aquarid Meteors
28	12	New Moon

AUGUST

d	h	(Universal Time)
4	00	Saturn 0°.3 N. of Moon
4	03	First Quarter Moon
4	22	Mars 3° S. of Moon
8	01	Jupiter 2° N. of Moon
11	16	Full Moon
12	01	Perseid Meteors
19	20	Last Quarter Moon
26	19	New Moon
31	09	Saturn 0°.5 N. of Moon

SEPTEMBER

d	h	(Universal Time)
2	07	Mars 1°.7 S. of Moon
2	11	First Quarter Moon
3	03	Mars 2° N. of Antares
4	05	Jupiter 3° N. of Moon
10	07	Full Moon; Harvest Moon
18	10	Last Quarter Moon
19	15	Venus 3° N. of Spica
22	21	Autumnal Equinox; Autumn begins
25	03	New Moon
27	00	Venus 2° S. of Moon
27	22	Saturn 0°.9 N. of Moon

OCTOBER

d	h	(Universal Time)
1	00	Mars 0°.3 N. of Moon
1	14	Jupiter 3° N. of Moon
1	22	First Quarter Moon
8	17	Venus 3° S. of Saturn
9	24	Full Moon; Hunters' Moon
13	23	Mars 1°.9 S. of Jupiter
17	21	Last Quarter Moon
21	05	Orionid Meteors
24	12	New Moon
27	00	Venus 0°.3 S. of Moon
27	16	Venus 3° N. of Moon
29	05	Jupiter 3° N. of Moon
29	21	Mars 2° N. of Moon
31	13	First Quarter Moon

To convert from Universal Time, subtract the appropriate number of hours for your Time Zone: (Standard Time)

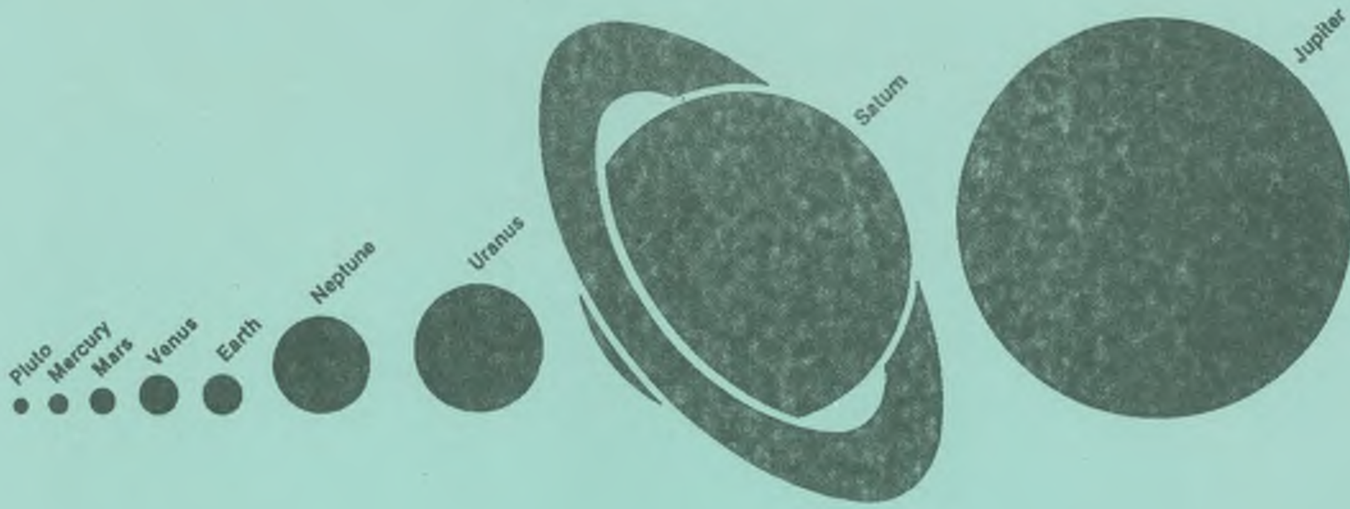
NST 3^h30^m AST 4^h EST 5^h
CST 6^h MST 7^h PST 8^h

NOVEMBER

d	h	(Universal Time)
3		South Taurid Meteors
8	18	Full Moon; Eclipse of Moon
16	07	Last Quarter Moon
17	12	Leonid Meteors
22	23	New Moon; Eclipse of Sun
24	21	Venus 2° S. of Moon
25	23	Jupiter 4° N. of Moon
26	01	Venus 1°.6 N. of Moon
27	21	Mars 4° N. of Moon
30	08	First Quarter Moon

DECEMBER

d	h	(Universal Time)
8	11	Full Moon
14	00	Geminid Meteors
19	21	Saturn 1°.8 N. of Moon
21	16	Winter Solstice; Winter begins
22	06	Ursid Meteors
22	12	New Moon
23	20	Jupiter 4° N. of Moon
26	02	Venus 3° N. of Moon
27	00	Mars 4° N. of Moon
30	06	First Quarter Moon



	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Mean Distance From Sun (Millions of Kilometers)	57.9	108.2	149.6	228.0	778.4	1,427.0	2,869.6	4,496.6	5,965.2
Period of Revolution	88.0 Days	224.7 Days	365.26 Days	1.88 Years	11.86 Years	29.46 Years	84.01 Years	164.1 Years	247.7 Years
Rotation Period	58.65 Days	243.02 Days Retrograde	23 Hours 56 Minutes 4 Seconds	24 Hours 37 Minutes 23 Seconds	9 Hours 56 Minutes 30 Seconds	10 Hours 39 Minutes 24 Seconds	23.9 Hours Retrograde	20 Hours or Less	6 Days, 9 Hours 18 Minutes Retrograde
Inclination of Axis	Near 0°	3°	$23^\circ 27'$	$25^\circ 12'$	$3^\circ 5'$	$26^\circ 44'$	$97^\circ 55'$	$28^\circ 48'$	?
Inclination of Orbit To Ecliptic	7.0°	3.4°	0°	1.9°	1.3°	2.5°	0.8°	1.8°	17.2°
Eccentricity of Orbit	.206	.007	.017	.093	.048	.056	.047	.009	.254
Equatorial Diameter (Kilometers)	4,880	12,104	12,756	6,794	142,800	120,400	51,800	49,500	4,000?
Atmosphere (Main Components)	Virtually None	Carbon Dioxide	Nitrogen Oxygen	Carbon Dioxide	Hydrogen, Helium	Hydrogen, Helium	Helium, Hydrogen, Methane	Hydrogen, Helium, Methane	None Detected
Satellites	0	0	1	2	16	21	5	2	1
Rings	0	0	0	0	1	1,000 ?	9	?	?

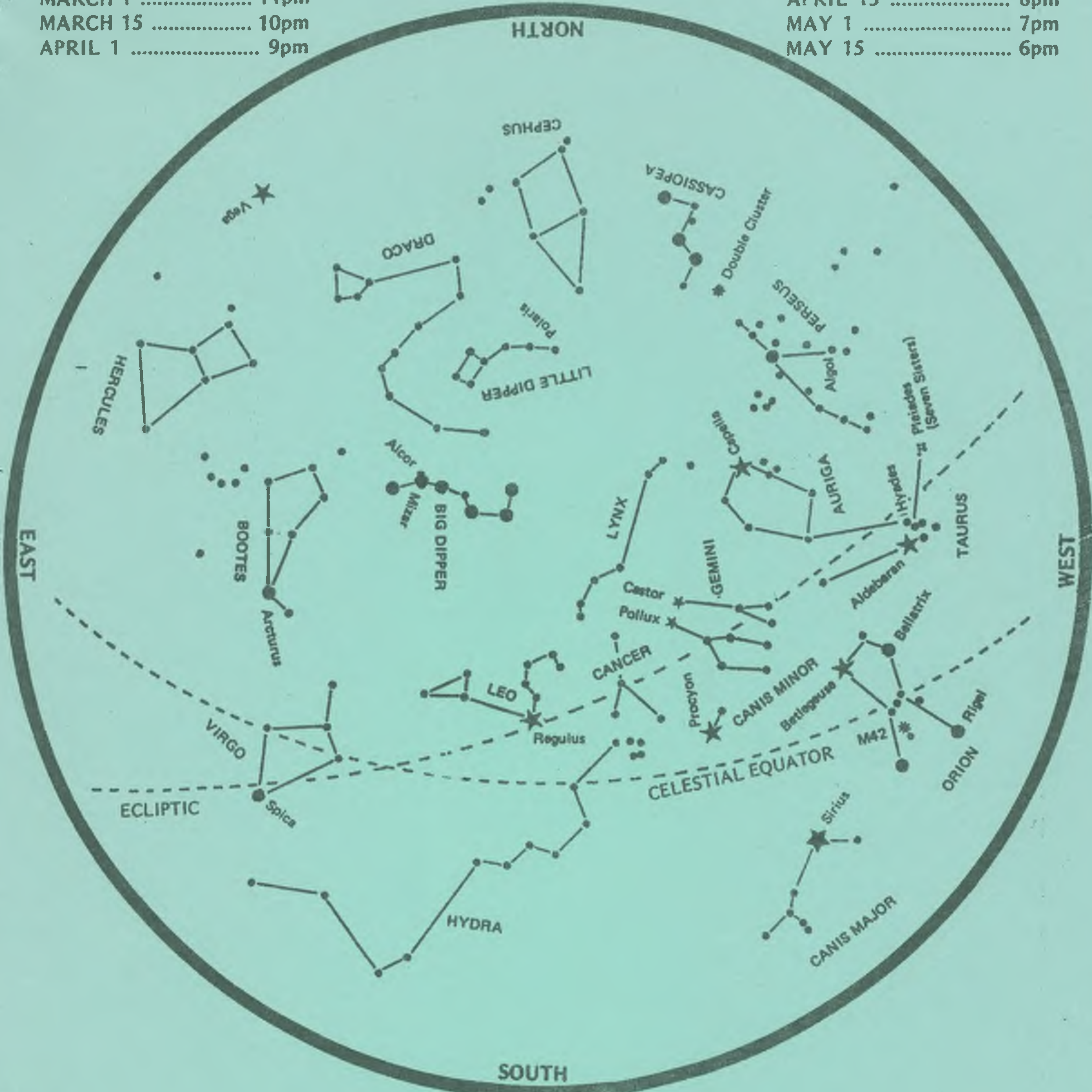
STAR MAPS

On the following five pages you will find star maps for your night sky at certain times of the year. There are two spring maps, one summer, one autumn and one winter. These maps work best at the times stated at the top of the page. To use the map hold it overhead and turn it so that the directions marked around the map's circular horizon match the true directions on your horizon. Try and find the brightest stars and constellations first. Then look for the fainter ones. If any planets are visible they will look like bright stars. Planets are always found close to the ecliptic. Some objects are marked with large stars, i.e. M13 and M42. These objects are Messier objects, such as galaxies, nebulae or star clusters. Under a dark sky most of these can be observed with the eye alone but they are best observed with binoculars or a telescope. There is a complete Messier object list and explanation after the star maps.

SPRING STARS

THIS STAR MAP WILL WORK BEST AT THESE TIMES:

MARCH 1 .... 11pm	APRIL 15 .... 8pm
MARCH 15 .... 10pm	MAY 1 .... 7pm
APRIL 1 .... 9pm	MAY 15 .... 6pm

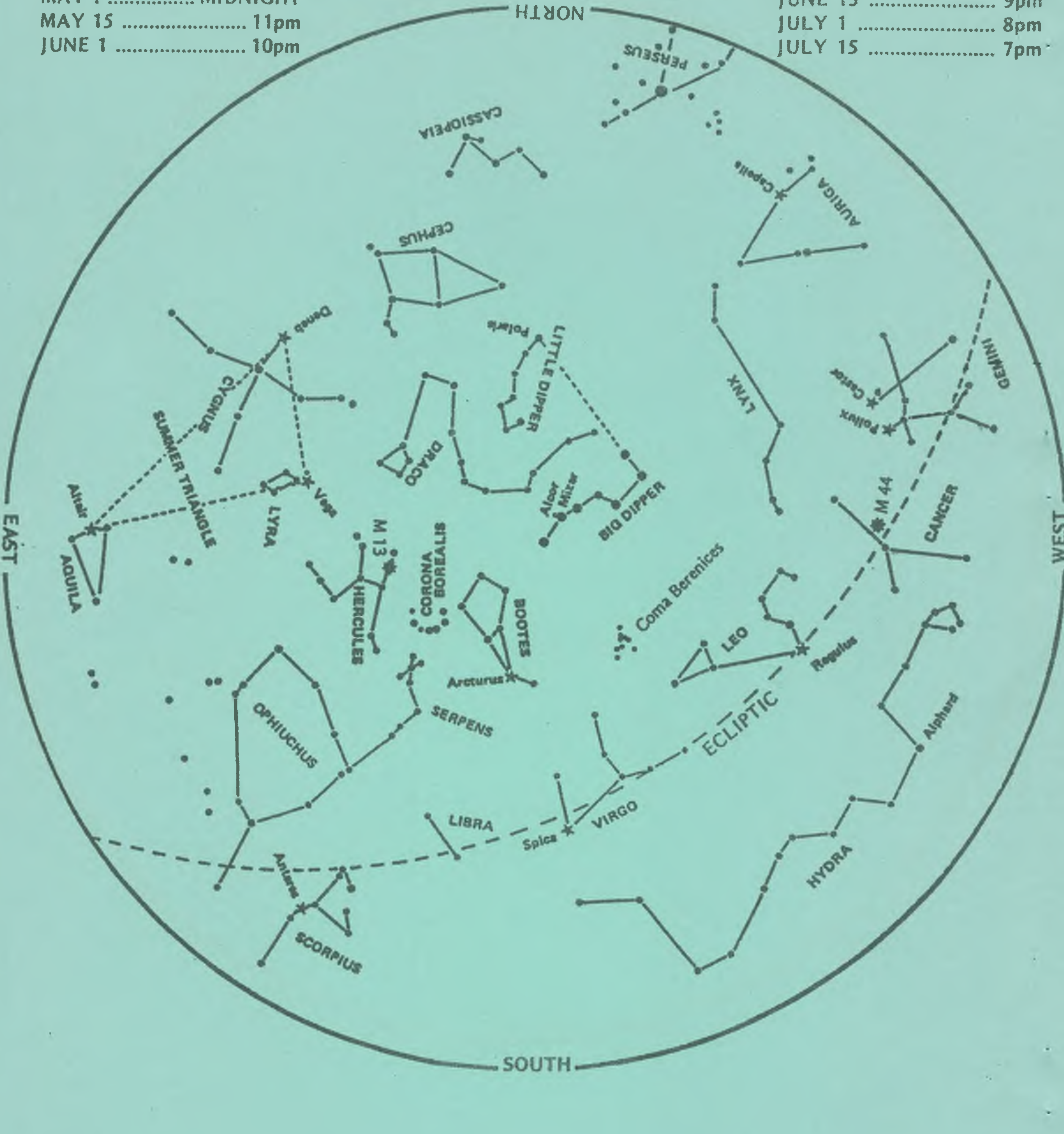


SPRING STARS

THIS STAR MAP WILL WORK BEST AT THESE TIMES:

MAY 1 .... MIDNIGHT
MAY 15 .... 11pm
JUNE 1 .... 10pm

JUNE 15 .... 9pm
JULY 1 .... 8pm
JULY 15 .... 7pm

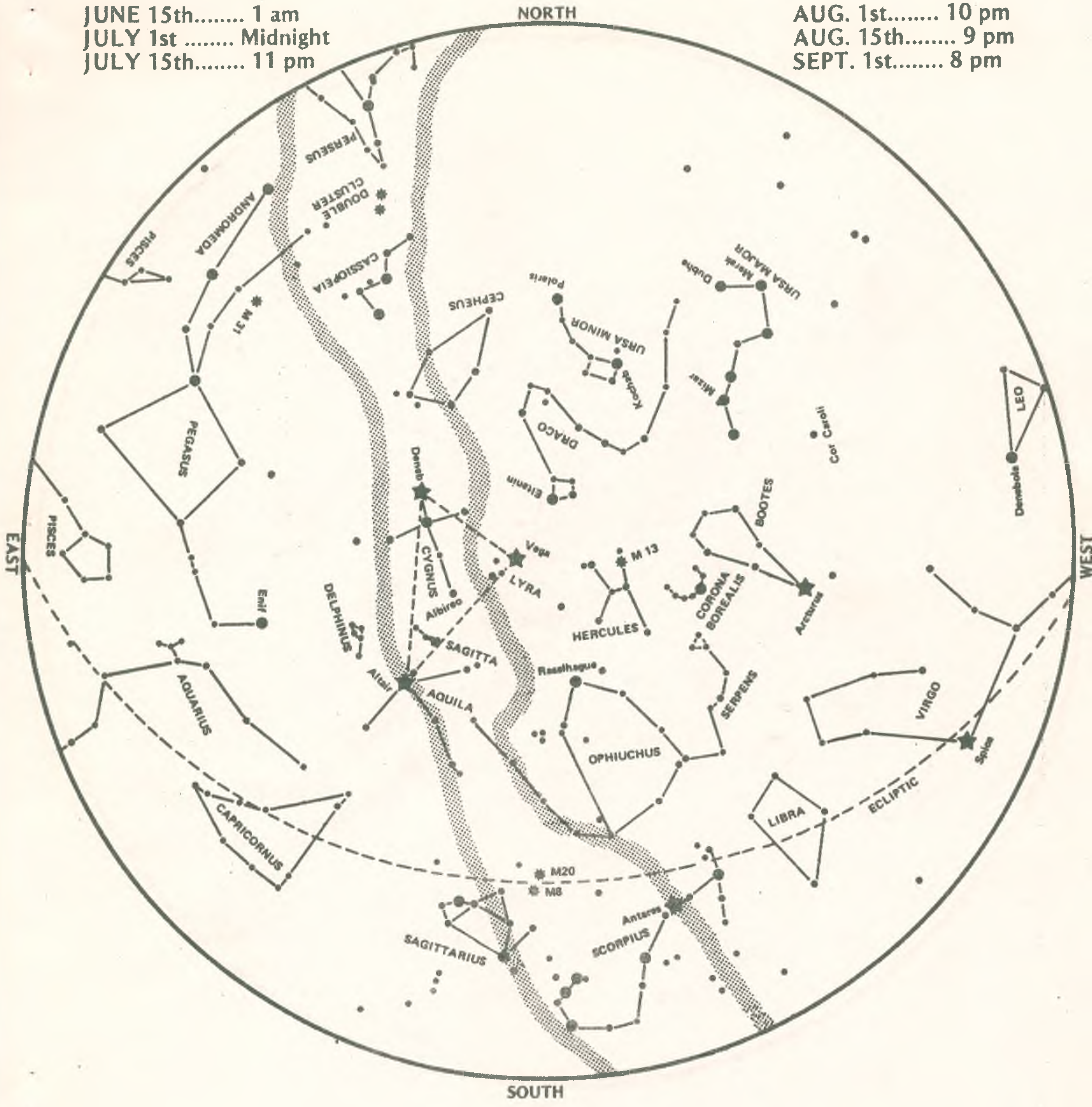


SUMMER STARS

This star map will work best at these times:

JUNE 15th........ 1 am
JULY 1st .... Midnight
JULY 15th........ 11 pm

AUG. 1st........ 10 pm
AUG. 15th........ 9 pm
SEPT. 1st........ 8 pm

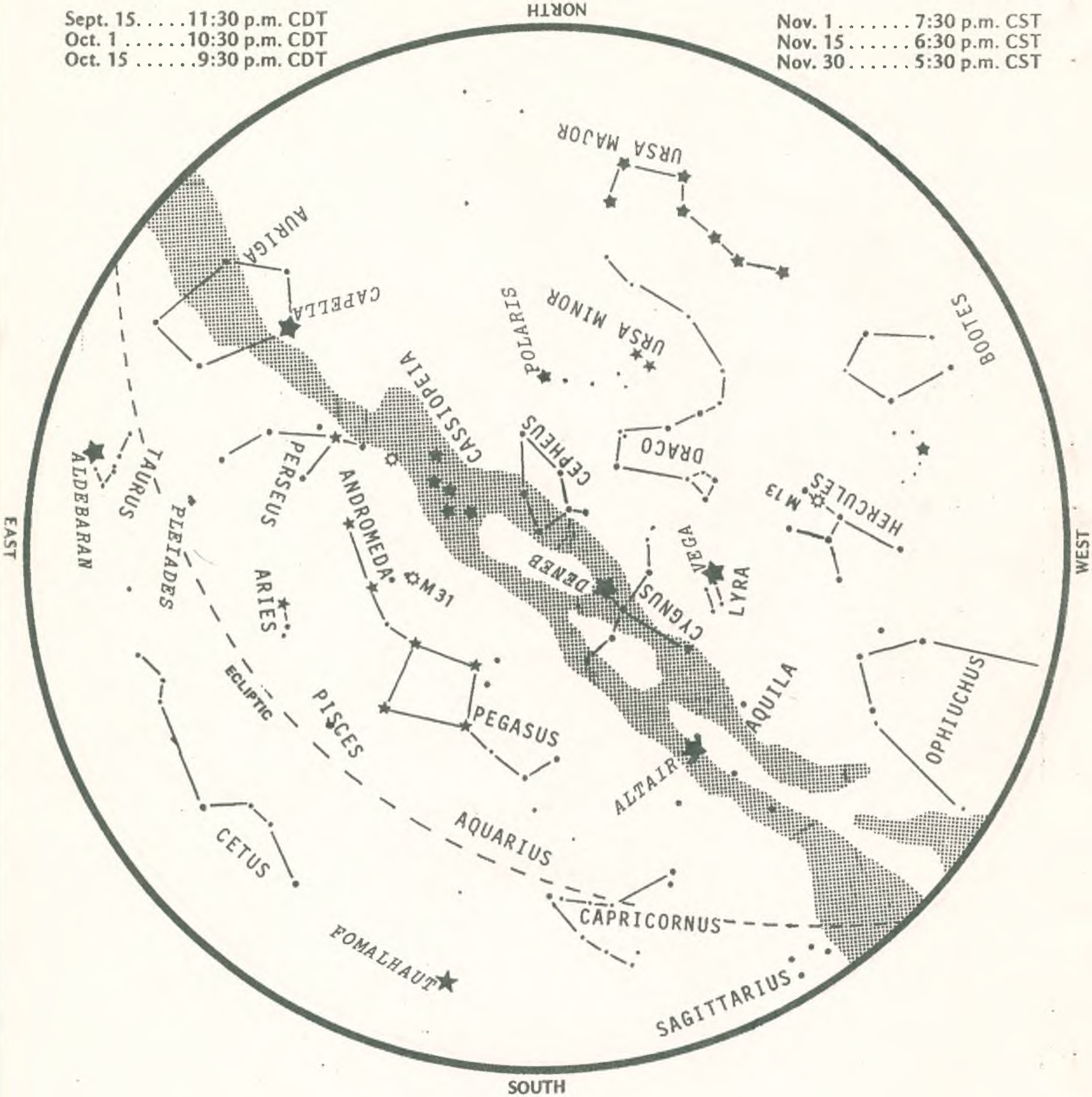


AUTUMN STARS

THIS STAR MAP WILL WORK BEST AT THESE TIMES:

Sept. 15. . . . .11:30 p.m. CDT
Oct. 1 . . . . . .10:30 p.m. CDT
Oct. 15 . . . . . .9:30 p.m. CDT

Nov. 1 . . . . 7:30 p.m. CST
Nov. 15 . . . . . . 6:30 p.m. CST
Nov. 30 . . . . . . 5:30 p.m. CST

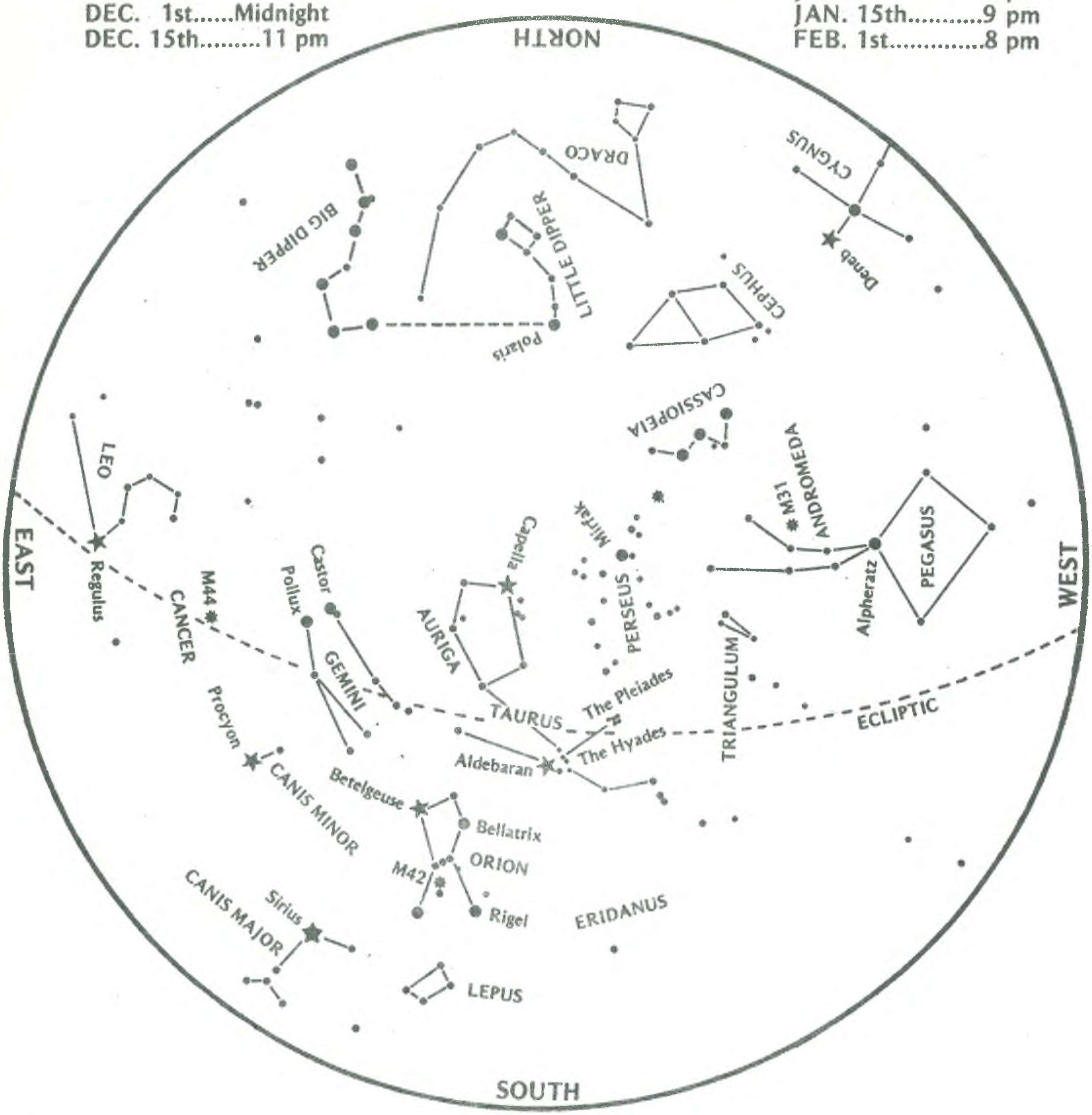


WINTER STARS

THIS STAR MAP WILL WORK BEST AT THESE TIMES:

NOV. 15th..........1 am
DEC. 1st......Midnight
DEC. 15th.........11 pm

JAN. 1st............10 pm
JAN. 15th...........9 pm
FEB. 1st..............8 pm



THE MESSIER MAP

Constellations and star names have been omitted from this map for simplicity. The key is at the lower right hand corner of the map. The Messier objects range in declination from 70^{o} North to 35^{o} South. At least a score can be seen at any time of the year. Galaxies are placed best in the spring skies, globular clusters in the summer, and galactic clusters in the fall and winter skies of the northern hemisphere. Most of the galaxies are rather inconspicuous, and a dark night is needed for successful viewing. Diffuse and planetary nebulae have details that can be seen through amateur telescopes.

SOME COMMON NAMES OF MESSIER OBJECTS.

M1 - Crab Nebula;
M8 - Lagoon Nebula;
M13 - Hercules Cluster;
M17 - Omega or Horseshoe Nebula;
M20 - Trifid Nebula;
M27 - Dumbbell Nebula;
M31 - Andromeda Nebula (Anromeda Galaxy);
M42 - Great Nebula in Orion;
M43 - (Northeast wing of Great Nebula);
M44 - Praesepe or Beehive Nebula;
M45 - Pleiades or Seven Sisters;
M51 - Whirlpool Nebula (Whirlpool Galaxy);
M57 - Ring Nebula;
M64 - Blackeye Nebula;
M97 - Owl Nebula;
M104 - Sombrero Nebula (Sombrero Galaxy);

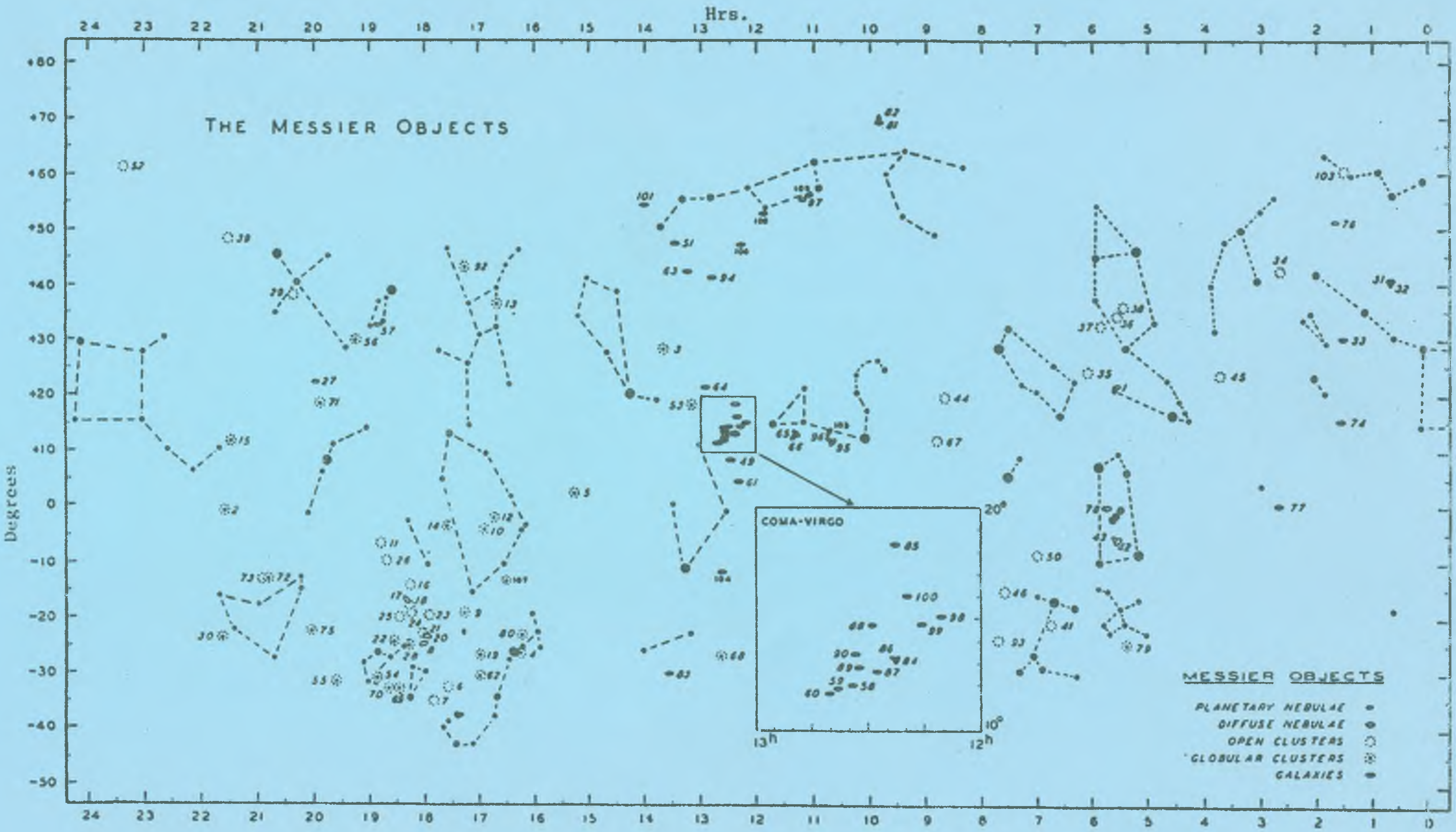
THE MESSIER CATALOGUE

Charles Messier's catalogue came from his comet searching nearly 200 years ago. Clusters and nebulae new to him would be plotted on his atlas, and eventually lists of them were published.

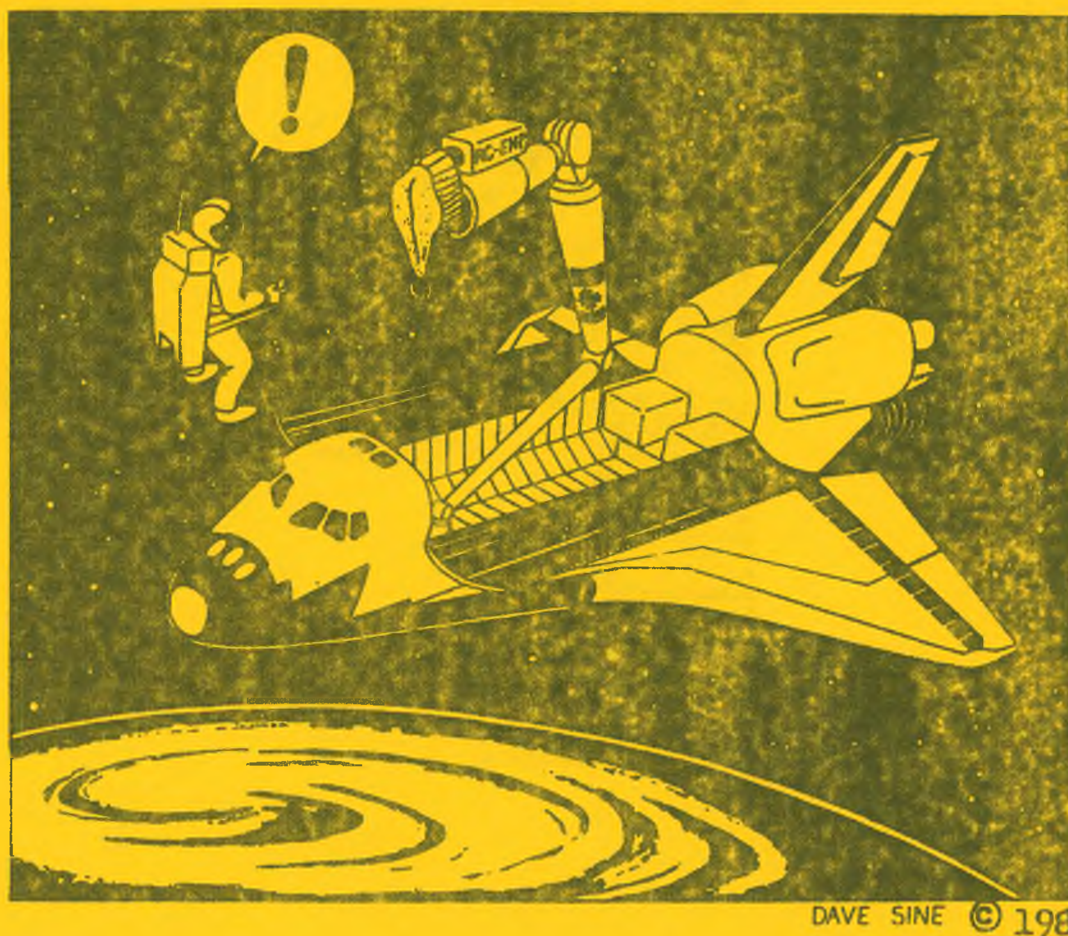
Five of the 109 objects (keyed by asterisks) do not exist, being mistakes by Messier. Owen Gingerich has given explanations of these in the October, 1960 issue of SKY AND TELESCOPE. M73 is only four stars.

Most of the remaining 104 nebulae, clusters, and galaxies can be seen easily in a 3-inch refractor, and many of the brighter ones in binoculars. With 6-inch reflectors, quite a few amateurs have managed to find every object in the Messier catalogue.

M	NGC	R.A. h m (1950)	Dec. ° '	Const.	Size ' '	Mag.	Type
1	1952	05 31.5	+21 59	Tau	6 x 4	10	Pl
2	7089	21 30.9	−01 03	Aqr	12	7	Gb
3	5272	13 39.9	+28 38	CVn	19	6	Gb
4	6121	16 20.6	−26 24	Sco	23	6	Gb
5	5904	15 16.0	+02 16	Ser	20	6	Gb
6	6405	17 36.7	−32 11	Sco	26	6	Cl
7	6475	17 50.6	−34 48	Sco	50	5	Cl
8	6523	18 00.7	−24 23	Sgr	90 x 40		Di
9	6333	17 16.2	−18 28	Oph	6	7	Gb
10	6254	16 54.5	−04 02	Oph	12	7	Gb
11	6705	18 48.4	−06 20	Sct	12	6	Cl
12	6218	16 44.6	−01 52	Oph	12	7	Gb
13	6205	16 39.9	+36 33	Her	23	6	Gb
14	6402	17 35.0	−03 13	Oph	7	8	Gb
15	7078	21 27.6	+11 57	Peg	12	6	Gb
16	6611	18 16.0	−13 48	Ser	8	7	Cl
17	6618	18 17.9	−16 12	Sgr	46 x 37		Di
18	6613	18 17.0	−17 09	Sgr	7	7	Cl
19	6273	16 59.5	−26 11	Oph	5	7	Gb
20	6514	17 59.6	−23 02	Sgr	29 x 27		Di
21	6531	18 01.6	−22 30	Sgr	12	7	Cl
22	6656	18 33.3	−23 58	Sgr	17	6	Gb
23	6494	17 53.9	−19 01	Sgr	27	7	Cl
24	6603	18 15.5	−18 26	Sgr	4	6	Cl
25		18 28.8	−19 17	Sgr	35		Cl
26	6694	18 42.5	−09 27	Sct	9	8	Cl
27	6853	19 57.5	+22 35	Vul	8 x 4	8	Pl
28	6626	18 21.5	−24 54	Sgr	15	8	Gb
29	6913	20 22.1	+38 22	Cyg	7	7	Cl
30	7099	21 37.5	−23 25	Cap	9	8	Gb
31	224	00 40.0	+41 00	And	160 x 40	4	Sp
32	221	00 40.0	+40 36	And	3 x 2	9	El
33	598	01 31.1	+30 24	Tri	60 x 40	7	Sp
34	1039	02 38.8	+42 34	Per	30	6	Cl
35	2168	06 05.8	+24 21	Gem	29	6	Cl
36	1960	05 32.8	+34 06	Aur	16	6	Cl
37	2099	05 49.1	+32 32	Aur	24	6	Cl
38	1912	05 25.3	+35 48	Aur	18	7	Cl
39	7092	21 30.4	+48 13	Cyg	32	6	Cl
40*							
41	2287	06 44.9	−20 41	CMa	32	6	Cl
42	1976	05 32.9	−05 25	Ori	66 x 60		Di
43	1982	05 33.1	−05 18	Ori			Di
44	2632	08 37.2	+20 10	Cnc	90		Cl
45		03 44.5	+23 57	Tau	120		Cl
46	2437	07 39.6	−14 42	Pup	27	9	Cl
47*							
48*							
49	4472	12 27.3	+08 16	Vir	4 x 4	9	El
50	2323	07 00.6	−08 16	Mon	16	6	Cl
51	5194-5	13 27.8	+47 27	CVn	12 x 6	9	Sp
52	7654	23 22.0	+61 19	Cas	13	7	Cl
53	5024	13 10.5	+18 26	Com	14	8	Gb
54	6715	18 52.0	−30 32	Sgr	6	8	Gb
55	6809	19 36.9	−31 03	Sgr	15	5	Gb
56	6779	19 14.6	+30 05	Lyr	5	8	Gb
57	6720	18 51.8	+32 58	Lyr	1 x 1	9	Pl
58	4579	12 35.1	+12 05	Vir	4 x 3	10	Sp
59	4621	12 39.5	+11 55	Vir	3 x 2	11	El
60	4649	12 41.1	+11 49	Vir	4 x 3	10	El
61	4303	12 19.4	+04 45	Vir	6 x 6	10	Sp
62	6266	16 58.1	−30 03	Oph	6	7	Gb
63	5055	13 13.5	+42 17	CVn	8 x 3	10	Sp
64	4826	12 54.3	+21 57	Com	8 x 4	8	Sp
65	3623	11 16.3	+13 23	Leo	8 x 2	10	Sp
66	3627	11 17.6	+13 17	Leo	8 x 2	9	Sp
67	2682	08 48.5	+12 00	Cnc	18	7	Cl
68	4590	12 36.8	−26 29	Hya	9	8	Gb
69	6637	18 28.1	−32 23	Sgr	4	8	Gb
70	6681	18 40.0	−32 21	Sgr	4	9	Gb
71	6838	19 51.5	+18 39	Sge	6	9	Gb
72	6981	20 50.7	−12 44	Aqr	5	9	Gb
73	6994	20 56.2	−12 50	Aqr			
74	628	01 34.0	+15 32	Psc	8 x 8	11	Sp
75	6864	20 03.2	−22 04	Sgr	5	8	Gb
76	650-1	01 39.1	+51 19	Per	2 x 1	11	Pl
77	1068	02 40.1	−00 14	Cet	2 x 2	9	Sp
78	2068	05 44.2	+00 02	Ori	8 x 6		Di
79	1904	05 22.2	−24 34	Lep	8	8	Gb
80	6093	16 14.1	−22 52	Sco	5	7	Gb
81	3031	09 51.5	+69 18	UMa	16 x 10	8	Sp
82	3034	09 51.9	+69 56	UMa	7 x 2	9	Ir
83	5236	13 34.3	−29 37	Hya	10 x 8	9	Sp
84	4374	12 22.6	+13 10	Vir	3 x 3	10	El
85	4382	12 22.8	+18 28	Com	4 x 2	10	El
86	4406	12 23.7	+13 13	Vir	4 x 3	10	El
87	4486	12 28.3	+12 40	Vir	3 x 3	10	El
88	4501	12 29.5	+14 42	Com	6 x 3	10	Sp
89	4552	12 33.1	+12 50	Vir	2 x 2	11	El
90	4569	12 34.3	+13 26	Vir	6 x 3	11	Sp
91*							
92	6341	17 15.6	+43 12	Her	12	6	Gb
93	2447	07 42.5	−23 45	Pup	18	6	Cl
94	4736	12 48.6	+41 23	CVn	5 x 4	8	Sp
95	3351	10 41.3	+11 58	Leo	3 x 3	11	Sp
96	3368	10 44.2	+12 05	Leo	7 x 4	10	Sp
97	3587	11 11.9	+55 18	UMa	3 x 3	11	Pl
98	4192	12 11.3	+15 11	Com	8 x 2	11	Sp
99	4254	12 16.3	+14 42	Com	4 x 4	10	Sp
100	4321	12 20.4	+16 06	Com	5 x 5	10	Sp
101	5457	14 01.4	+54 35	UMa	22 x 22	8	Sp
102*							
103	581	01 29.9	+60 26	Cas	6	7	Cl
104	4594	12 37.3	−11 21	Vir	7 x 2	8	Sp
105	3379	10 45.2	+12 51	Leo	2 x 2	10	El
106	4258	12 16.5	+47 35	CVn	20 x 6	10	Sp
107	6171	16 29.7	−12 57	Oph	8	9	Gb
108	3556	11 08.7	+55 57	UMa	8 x 2	10	Sp
109	3992	11 55.0	+53 39	UMa	7	11	Sp


THE MESSIER OBJECTS
Hrs.
Degrees
COMA-VIRGO
MESSIER OBJECTS
PLANETARY NEBULAE
DIFFUSE NEBULAE
OPEN CLUSTERS
GLOBULAR CLUSTERS
GALAXIES

SKY NOTES



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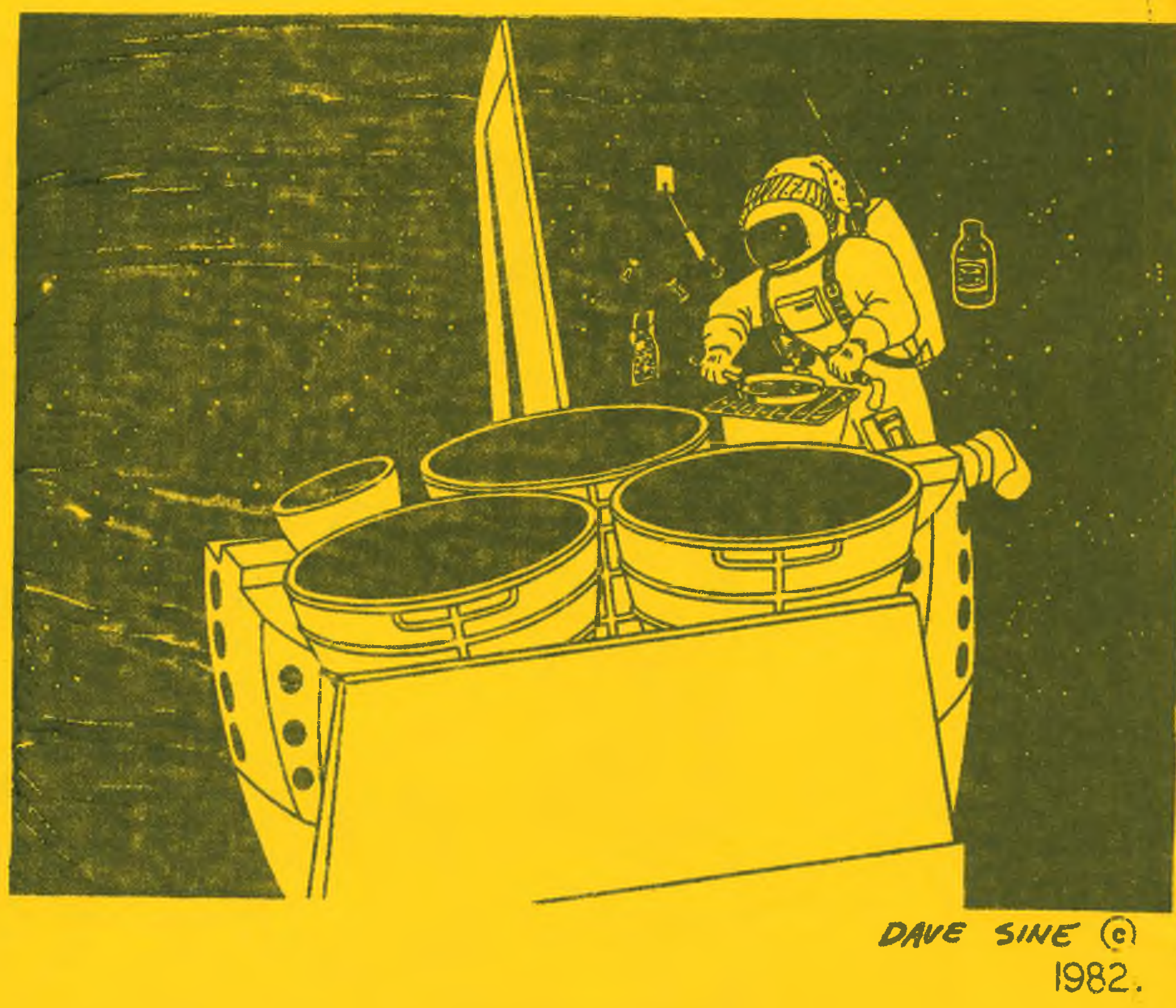
SKY NOTES



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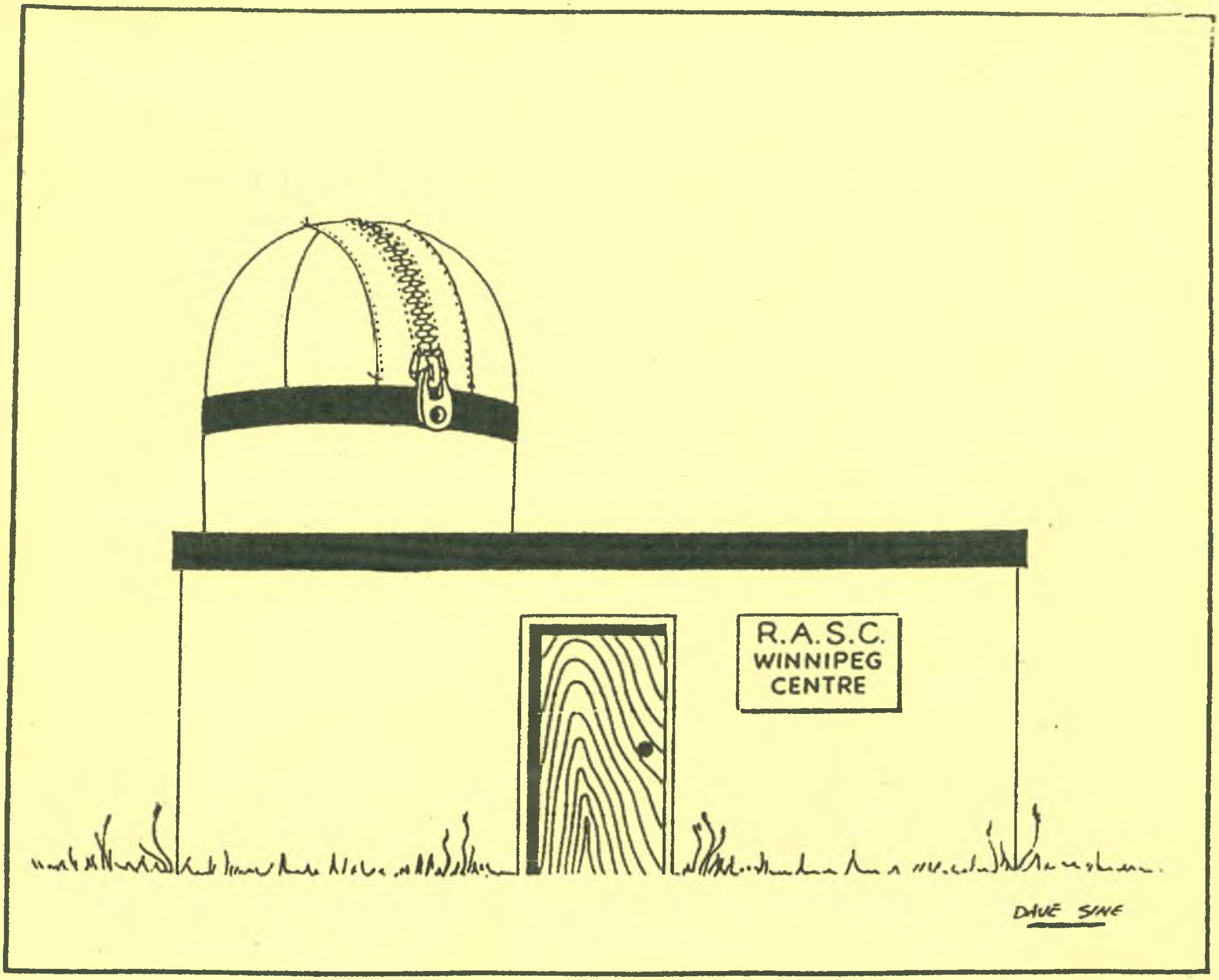

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