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by Robert Burnham

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A supplement to *Astronomy* magazine

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Naked-eye astronomy

DARYL POWELL

COVER PHOTO: LARRY LANDOLFI; MARS IMAGE: STScI

▲ **ALASKAN AURORA.** Years of high solar activity often produce displays of the aurora borealis, or northern lights. (24mm lens at f/2, Fuji 800 Superia film; taken March 19, 2001) MICHAEL J. O'LEARY

▼ **ICY BEAUTY.** The famed Pleiades cluster (M45) is a lovely sight in binoculars. (Astro-Physics 6-inch f/7 telescope, composite image on Kodak PPF ISO 400 film, 45-minute exposure) ALLEN HWANG

Every clear evening when the Sun sets, the sky darkens and the stars come out. As our local piece of planet Earth turns away from the Sun and daytime fades into night, we look out toward the universe.

The simplest way to discover the stars is to begin as the earliest observers began, using just your own two eyes. If this evening is clear, why not step outside and spot a few star patterns? The backyard offers convenience, while a local park or schoolyard may provide a view of the sky less cluttered by trees or buildings.

Ancient skywatchers had a big advantage over us. Their skies were dark. Today, countless lights from streets, parking lots, vehicles, and buildings brighten the skies over suburban locations. But even so, the brightest stars still shine through.

Getting oriented

Under the night sky, take a look around. Can you find the Big Dipper in the north? It may be high in the sky and upside down, or lower toward the horizon. It's a bit longer than your hand at arm's length with the fingers spread. The two outer stars in the "bowl" point toward Polaris, the North Star. Polaris is part of a constellation called Ursa Minor the Little Bear. The Dipper's stars likewise form part of Ursa Major the Great Bear.

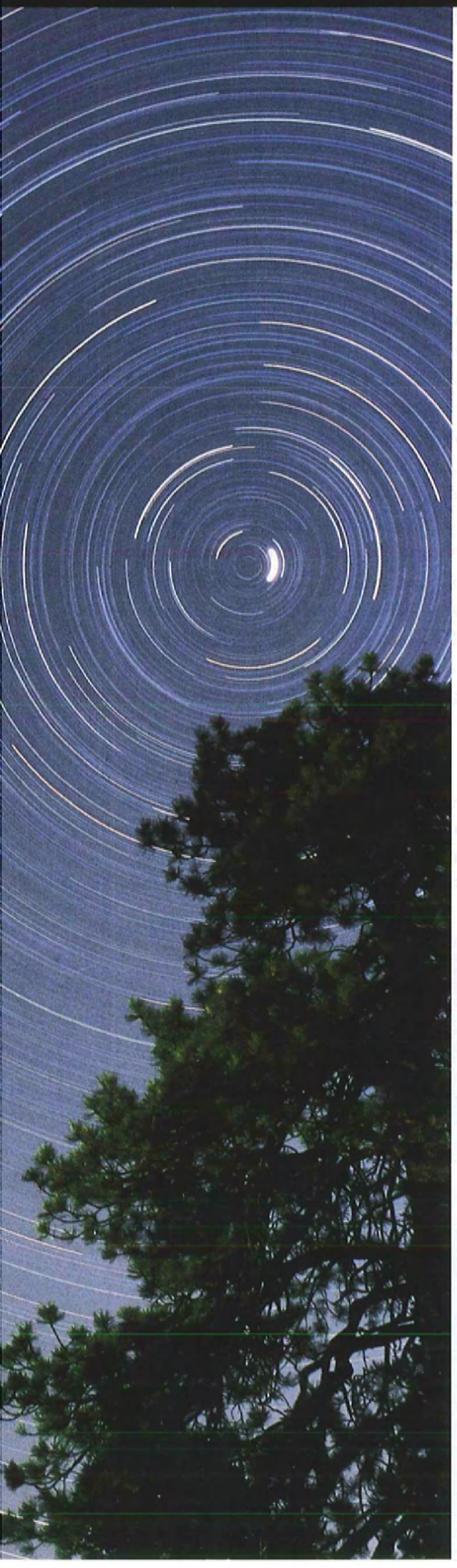
If you don't see any bears, don't worry. Constellations are invented patterns that began as pictures in the sky to help early people remember important myths and legends. Some constellations, such as spring's Leo the Lion, summer's Scorpius the Scorpion, and winter's Taurus the Bull, are prehistoric. They first appear in ancient Mesopotamian records at the dawn of history. Others were invented more recently to gather stars unclaimed by earlier constellations. Today, 88 constellations cover the sky with no overlaps or gaps between them.

To learn them properly, check out *Astronomy* magazine. Every month, it publishes beautiful, easy-to-use color sky maps showing the stars and planets visible to the eye. It also showcases all the month's sky events, so you'll miss nothing.

With Polaris identifying north, turn and look southward. If it's winter, you may see

▼ **MILKY WAY.** A wide-angle view takes in lots of sky and a meteor. Such views are easy to find away from city lights. (16mm lens at f/4, tripod-mounted, 10-minute exposure, Fuji NHG II 800 film) DOUG ZUBENEL

Naked-eye astronomy



the tall figure of Orion the Hunter, his feet scraping the bare trees and rooftops. In spring, the figure will be Leo, whose shape clearly resembles a crouching feline. On summer nights, the southern sky is dominated by Scorpius the Scorpion, and higher up, Cygnus the Swan. In autumn, the main figure overhead is the Great Square of Pegasus the Flying Horse. To learn constellations, use a sky map to locate the major figure for the appropriate season. Then, let that figure's stars guide you to fainter constellations.

Starlight, star bright

You'll notice immediately that stars differ in brightness. Astronomers rank stars on a magnitude scale that originated with ancient Greek skywatchers. They ranked the brightest stars as first magnitude and the dimmest as sixth magnitude. All others lay in between. Astronomers now use decimals to note small steps in brightness, and even employ negative magnitudes for bright objects. For example, Sirius in Canis Major the Great Dog shines at magnitude –1.4. The trick to keep in mind is that a larger magnitude number means a dimmer star.

Every star has a magnitude, but only a few hundred stars have names. Many star names come from their place in the constellation as described by the ancients. For example, Rigel, which marks Orion's left knee, means "left leg of the giant" in Arabic. (Why Arabic? Because antiquity's astronomy came to Europe in the Middle Ages through Arabic translations.)

Each hour, stars move westward about as far as your fist held at arm's length with the thumb extended. If you look north, figures like the Big Dipper or Cassiopeia the Queen creep around Polaris like the hands of a giant clock running backward. Besides this daily motion due to Earth's rotation, the constellations also slip westward as weeks pass.

LOOKING NORTH. Stars trail as Earth rotates. Polaris is the short, bright trail at top center. (24mm lens at f/2.8, tripod-mounted, Fuji Astia 100 film, 4-hour exposure) JOSHUA VAUGHN

TWILIGHT TRIO. A crescent Moon, Venus, and Mars (lower right) stand together in the evening sky on May 14, 2002. (Nikon Coolpix 995 digital camera) FRED ESPENAK

This seasonal movement reflects Earth's yearly travel in its orbit around the Sun.

No one notices the sky changing from one night to the next. Yet any given star rises about 4 minutes earlier each evening due to Earth's orbital motion. Four minutes difference per day means that after a month, stars rise 2 hours earlier and set 2 hours sooner. Thus, constellations slowly drift westward throughout the year.

Wandering stars

Planets don't reappear regularly each season the way stars do because planets constantly orbit the Sun, just as Earth does. Yet planets always are found somewhere along a band of constellations that straddles an imaginary line called the ecliptic — Earth's orbit projected onto the stars. Because all planets have orbital planes close to Earth's, their positions don't vary much from the ecliptic. That's why you see the ecliptic plotted on star maps.

Two planets, Mercury and Venus, orbit closer to the Sun than Earth. You will see them only before sunrise or after sunset. Mercury in particular is hard to spot, being often low in the twilight. (Binoculars help.) Venus, however, can blaze so brightly people frequently mistake it for a UFO.

COMET IKEYA-ZHANG. Bright comets are rare, but when they appear, a naked-eye view is often the most satisfying. (300mm lens at f/2.8, Fuji 800 film, 5-minute exposure taken April 14, 2002) ANTHONY GALVAN III

The outer planets (which lie farther from the Sun than Earth) move slowly among the stars, with changes becoming apparent only after a few weeks. Typically, they remain visible for months. Mars often appears bright and reddish-orange. Jupiter, colored white, usually shines even brighter. Saturn, dimmer than Jupiter, looks ivory-white. The outermost planets — Uranus, Neptune, and Pluto — glow weakly and belong in telescope territory.

Far outshining any planet is the Moon, its face darkly mottled with lava flows. The Moon circles Earth, keeping one side turned toward us. It first appears as a thin crescent in the evening sky. Night by night, the lit portion grows. The half-lit point is called First Quarter because the Moon has completed one-fourth of its monthly orbit. At Full Moon, it is completely lit and floods Earth with reflected sunlight. After Full Moon, the lit portion shrinks. When Last Quarter Moon arrives, we see it in daytime morning hours as well as at night. After passing Last Quarter, the Moon shrinks to a crescent visible shortly before sunrise. Then it reappears low in the west after sunset, and the cycle begins anew.

Be prepared

Star-watching is easy, but a few basic preparations make it a lot more comfortable. Depending on the season, you may want long underwear and a ski cap — or insect repellent. Buy or make a dim red-lensed astronomer's flashlight for reading charts. The red light keeps your eyes dark-adapted. Take a lawn chair and a thermos filled with hot cocoa or tea.

If you have binoculars, bring them along. But learning your way around the sky goes better if you start with no optical aid at all. Constellation patterns are easiest to find with the wide-field view your eyes alone can provide. Newcomers to astronomy often feel overwhelmed at the array of telescopes and accessories in magazine ads and reviews. How can you possibly choose among them? Where do you even start?

/// VIEWING AN ECLIPSE

A total solar eclipse is one of nature's most awe-inspiring events — and a spectacle no onlooker ever forgets. The Moon slowly turns broad daylight into night as it glides in front of the Sun, blotting it from view. At mid-eclipse, the Sun vanishes, but its outer atmosphere — the corona — surrounds the blackened Moon like an exotic flower.

Total solar eclipses occur because the Moon happens to be just big enough to cover the Sun as seen from Earth. During every New Moon, the Earth, Moon, and Sun line up approximately. But an eclipse results only when the alignment is exact, which happens just once or twice a year.

Because the path of totality created by the Moon's shadow is narrow and can fall anywhere on Earth, your chances are low for seeing a total eclipse in any given place. So it's no wonder that many eclipse-tour companies have sprung up, making it easy for a dedicated eclipse-chaser to make a thrilling "journey into darkness."

Lunar eclipses typically occur at Full Moon before or after a solar eclipse because that's when the Moon is most likely to pass through Earth's shadow. A lunar eclipse is easy to see, safe to look at, and lasts several hours. If skies are clear, anybody on Earth's night side can follow the eclipse's progress using their naked eyes, binoculars, or a telescope.

COPPER MOON. You can observe total eclipses of the Moon easily with just your eyes. (10-inch Meade LX-200 Schmidt-Cassegrain telescope at f/10, six-image mosaic taken with an SBIG ST-8 CCD camera) DARYL POWELL

As the Moon glides into total eclipse, it turns reddish-copper in color. This occurs because the shadow is faintly lit by sunlight filtered through Earth's atmosphere. It's the light of all the world's sunrises and sunsets falling on the Moon at once.

SUN FLOWER. During a total solar eclipse, the Sun's pearly corona frames the Moon like flower petals. Special image-processing has revealed details in the corona visible to the eye but difficult to capture on film. MARGE AND ROLAND CHRISTEN

Choosing a telescope

▶ **CHECK OUT A SCOPE.** A good way to look through different kinds of telescopes under real observing conditions is to visit a star party. Many of these get-togethers take place every year. FRANK ZULLO

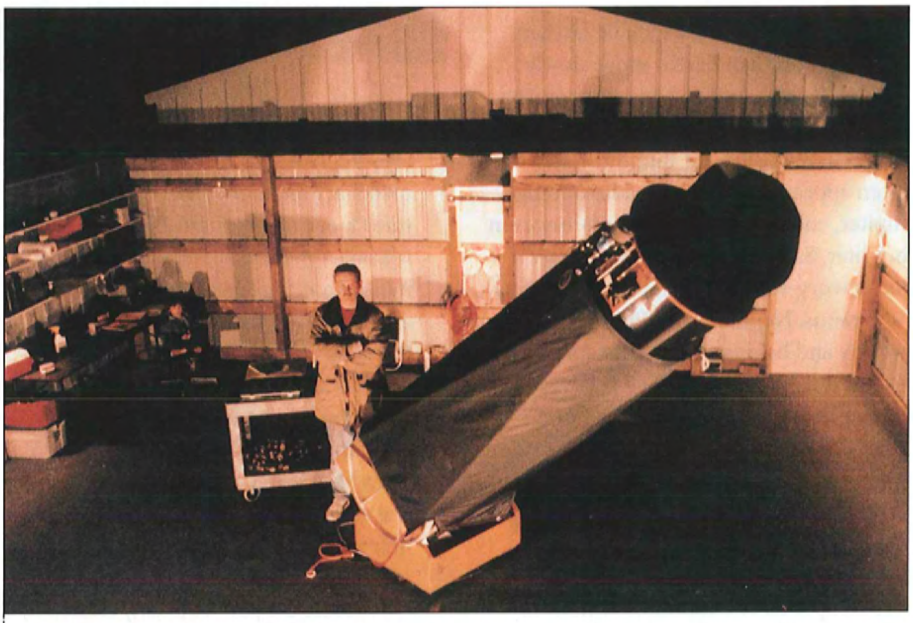
Relax. The telescope market has a lot of variety, but choosing a scope is simpler than it seems. The goal here is to help you sort through the different kinds. And because the market is changing all the time, keep an eye on the ads and equipment reviews in *Astronomy* to stay up-to-date.

It's all done with mirrors

A telescope's purpose is to gather and focus light. To do this, optics either reflect light or refract (bend) it. In a reflecting telescope, mirrors form the image.

In the common Newtonian design (invented by Sir Isaac), a curved mirror sits at the bottom of an open-ended tube. Light enters the tube and reflects from the mirror, converging to a focus. Before it reaches focus, a flat mirror directs the light through a hole in the tube's side into a focusing device. The focuser holds a high-quality magnifying glass called an eyepiece. By changing the eyepiece, you change the magnification of the telescope.

Reflectors, like all telescopes, are specified by aperture (the diameter of the main mirror) and focal ratio, abbreviated as f-ratio. The f-ratio is the focal length — the distance from the main mirror to the focus point — divided by the aperture. Thus a 6-inch reflector with a 48-inch focal length is an f/8 telescope. Focal ratios for reflectors run from about f/4 to f/10 or larger. Those with small f-ratios have wide fields of view and are good for sweeping through star fields at low power. Larger f-ratios are often chosen for planetary viewing, where a wide field of view matters less.



DREAM SETUP. Home observatories reflect an owner's style of skywatching. This one, with a big Dobsonian-mounted reflector, uses a roll-off roof for whole-sky access. DAVE KRIEGE

Reflectors are deservedly popular. They provide the most light-gathering ability for the price and are easy to use. Their optics require occasional tweaking to keep in alignment (called collimation), but this takes only a minute or two.

Reflectors range in size from about 4-inches aperture to behemoths with mirrors 3 feet across. Big ones reveal faint galaxies and nebulae that smaller scopes can't show. Small reflectors, however, make good first telescopes because you can handle and transport them easily. A telescope you can take on a car trip far from city lights will reveal unforgettable wonders.

But even at home, size and convenience matter. Use this rule of thumb: The best telescope to own is one you'll use often. If setup is time-consuming, or if the scope is difficult to transport, you'll use it less.

BIG DOB. Dobsonian-mounted reflectors have revolutionized astronomy by offering big apertures at low cost. MAGGIE McKEE

BIGGER DOB. Really big Dobs pull in lots of light. Fortunately for owners, they disassemble for transport. MARK DAHMKE

TRACK THE SKY. Equatorial mountings make viewing easier and are a must for astrophotography. MAGGIE McKEE

GO-TO POWER. Computer-controlled mounts make it easier for beginners to find objects — and they help even experienced observers spend less time searching and more time viewing. MAGGIE McKEE

QUALITY REFRACTOR. A well-made refractor on a sturdy alt-azimuth mounting has several strong points: It is highly portable, easy to use, and gives super views. *ASTRONOMY*: WILLIAM ZUBACK

Holding it steady

Optics are only half the telescope; the other half is the mounting. The least expensive mounting is the Dobsonian, named for John Dobson, who popularized it. (He devised it for public sky-viewing on the sidewalks of San Francisco.) It pivots from side to side and swings up and down — the hallmark of an altitude-azimuth, or alt-az, mounting. You keep sky objects in view by moving the telescope by hand. It's easier than it sounds; most people quickly get the hang of it.

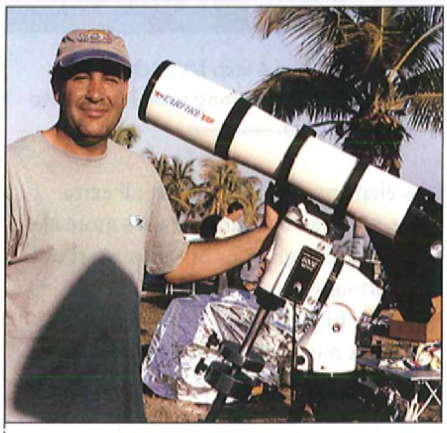
A sophisticated variation is the popular (and pricier) go-to mounting. This has motors to drive the telescope under computer control. Most also contain a list of sky objects stored in memory.

The last kind of mounting is the equatorial, which lets you follow the sky with a single motion, often using a small electric motor. Equatorial mountings are more complex than an alt-az and, accordingly, cost more. They also require careful setup. However, for sky photography, an equatorial mount is essential, and having one certainly makes visual observations easier.

Bending light

Refracting telescopes are what most people think of when you say "backyard telescope."

EQUATORIAL REFRACTOR. An equatorial mounting lets the telescope follow the stars with a single motion. MAGGIE McKEE



SOLID STABILITY. Top-quality refractors are highly capable instruments, so a solid mounting makes sense. MAGGIE McKEE

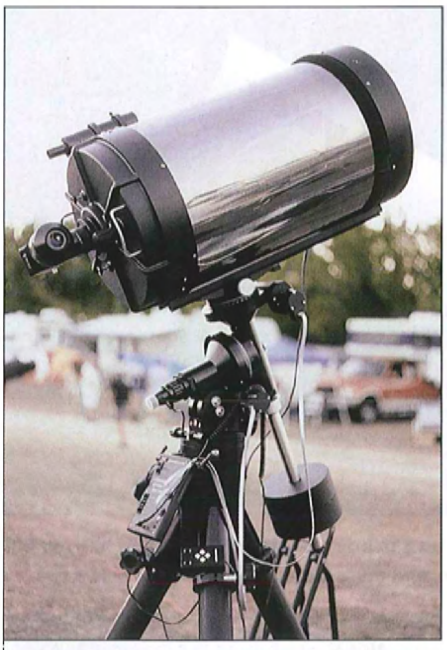
Light passes through a lens at the telescope's front and converges to a focus at the back. As with a reflector, you change eyepieces to change magnification. Focal ratios go as low as f/4, but most refractors use f/6 or longer. Refractors range in size from 2.4 inches (60 millimeters) upward.

Inexpensive refractors have earned a bad reputation over the years thanks to low-quality models sold in some discount stores and on TV shopping channels. Avoid these. (A tipoff is advertising that stresses magnification, such as "See 800x!!")

A well-made refractor is a delight to use. The closed tube makes for an essentially maintenance-free telescope that's ready to go at a moment's notice. Because of their small size, the 3- to 5-inch models with low f-ratios make good travel scopes.

Refractor optics come in two kinds, the achromat and the apochromat. Both seek to correct the spurious color that single lenses create when light passes through. (Briefly, an uncorrected lens acts like a weak prism and puts false-color halos around bright objects.) An achromatic lens couples two

Choosing a telescope



BIG EYE. This 14-inch f/11 Schmidt-Cassegrain folds a long focal length into a stubby tube. MAGGIE McKEE

PORTABILITY PLUS. Schmidt-Cassegrain telescopes (SCTs), like the 8-inch model pictured above, rank as popular items in the small-telescope market. Besides high-quality optics and good portability, most feature go-to mounts. KENNETH D. WHEAT

lens elements to cancel nearly all extra color, while an apochromat uses more elements, special glass, or both to cancel out all spurious color.

Is the high-price apochromat worth the extra money? For an experienced backyard astronomer or astrophotographer, yes. But for most ordinary visual uses, a good achromat works fine.

Refractors often are sold with equatorial mountings. Some models also offer quality alt-az mountings, and go-to versions are gaining in popularity. The mounting on an entry-level refractor often gives unsteady views. A sturdy mounting is well worth paying extra for. High-quality equatorial mountings can cost as much as the optics, especially with motor drives and controls. For astrophotography, however, an excellent equatorial mounting is essential.

Hybrid optics

A third kind of telescope uses a lens and mirrors — the catadioptric, or compound telescope. Two main designs dominate: the Schmidt-Cassegrain and Maksutov-Cassegrain. (Manufacturers also produce Schmidt- and Maksutov-Newtonian scopes.) Light enters the tube through a corrector lens, bounces off a main mirror, goes up to a secondary mirror attached to the corrector, and travels back down the tube to pass through a hole in the main mirror to the focuser and eyepiece.

This "straight-through" optical-path efficiently folds a long focal length into a short tube. Such a design makes even large models smaller than you'd guess by their f-ratios, which average f/10.

SCTs and Maks (as they are known) range from 2.8 inches (70mm) to 16 inches (406mm) in aperture. You'll find them easily portable in sizes under 8 inches, and they're highly versatile. While suitable for viewing any target, they excel when pointed at small objects (like planets) seen best at higher magnifications.

Most SCTs and Mak telescopes have alt-azimuth mountings (with or without a go-to drive). With the addition of an accessory called a wedge, you can change the mount to equatorial. The alt-azimuth arrangement works well for most observing, however.

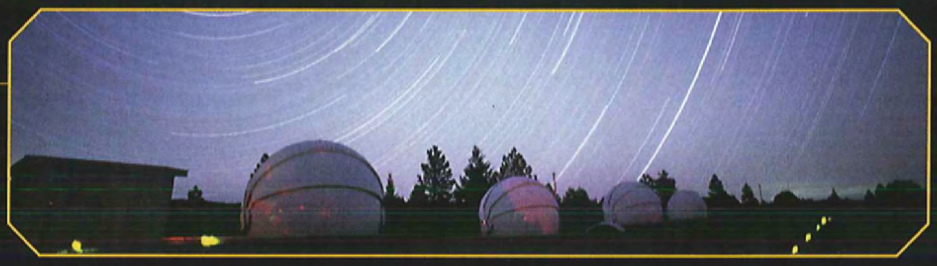
Making the choice

Research your telescope purchase thoroughly, and set a realistic budget. If it's under $300, wait to save more or perhaps purchase 7x50 or 10x50 binoculars. Resist those $99 refractors — their low quality will sour your whole astronomy experience.

One source for advice is a local astronomy club. A better idea is to visit one of the star parties held all over North America each year, mostly from spring through fall. (See Astronomy.com's listings.) At a star party, you can look through many different telescopes under a real sky.

Starting simple is a good idea. Fine starter scopes include a 6-inch Newtonian reflector, a 2.4- to 4-inch refractor, or a 3.5- to 5-inch catadioptric.

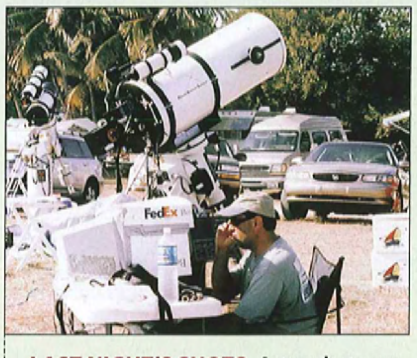
These instruments will introduce you to the many wonders of astronomy. Each of them can show you the Moon and planets,



▶ STARLIGHT HOTEL. A new trend in backyard skygazing is to visit resorts located in dark-sky country. You can bring your own telescope and equipment — or use a telescope that the resort provides. JOHN NEMY

GETTING IN DEEP. Really dedicated skywatchers have setups far beyond what most beginners imagine. In certain cases, that means building 20-inch Dobsonian-mounted binoculars. MARTY CURRAN/MAGGIE McKEE

I SEE YOU. Some amateur astronomers transport observatory-quality telescopes and charge-coupled device (CCD) cameras to dark locations hoping to capture elusive celestial prey unseen from cities. MARTY CURRAN/MAGGIE McKEE



LAST NIGHT'S SHOTS. Astrophotographers sometimes bring a computer and image-processing software with them to star parties. This lets them work on images and share their results with others. MARTY CURRAN/MAGGIE McKEE

plus enough star clusters, nebulae, and galaxies to fill a lifetime's exploring. Viewing the night sky with the unaided eye provides memorable sights, but you aren't much better off than our earliest skywatching ancestors. Telescopic astronomy began in 1609 when Galileo Galilei turned a small, crude telescope on the Moon, planets, and stars — and opened a doorway into the universe.

Exploring the lunar world

The first celestial object anyone with a telescope looks at is the Moon. Nothing else is as bright (except the Sun), reveals so many details, or is so easy to explore.

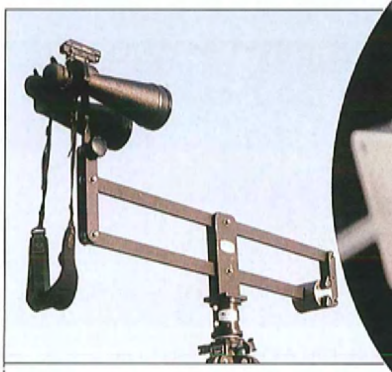
The best way to see lunar features is to observe the terrain lying close to the terminator — the line that divides the Moon's light and dark portions — where sunrise or sunset occurs. With no lunar atmosphere, grazing sunlight reveals the Moon's features with starkness and clarity.

The adventure begins with a slender Moon in the western sky after sunset. Aim your telescope, insert a low-power eyepiece — and sprawled before you lies a stunning wilderness of craters.

The same time on the following night, the Moon stands higher above the western horizon and its sunrise line falls farther from its edge. Features that were inky pools of darkness last night now show craterlets, landslides, and other geological details.

▼ FINE GLASS. High-quality eyepieces are key to getting the best views through a telescope. MAGGIE McKEE

LOOK HERE. A finder scope is an essential "extra" for any telescope — and installing a quality 8x50 model is a good upgrade. MAGGIE McKEE



HOLD STEADY. Astronomical binoculars can be heavy, and using them is easier with a parallelogram mounting. MAGGIE McKEE

Sky tour

► **SEEING DOUBLE.** Between Cassiopeia and the center of Perseus lies the Double Cluster (NGC 869 and NGC 884), a beautiful sight in binoculars. (Takahashi 9-inch, Kodak Gold 400 film, 45 minutes at f/3.9) PHILLIPPE DURVILLE

MOON SHOW. Jovian moon Io passes in front of Jupiter, casting its shadow on the giant planet's softly tinted cloud tops. (Astro-Physics 7-inch at f/9, Sony camcorder video frame) DAVID HANON

STAR CITY. Globular cluster M13 in Hercules contains hundreds of thousands of stars. (20-inch RC Optical Systems telescope, SBIG ST-10XME CCD camera, three-image composite) TOM BASH AND JOHN FOX/ADAM BLOCK/NOAO/AURA/NSF

BANG! Lunar crater Cassini measures 35 miles across and more than half a mile deep. LEO AERTS

So it goes, night by night, through the month. Features such as the Moon's "seas" — vast lava floods that fill shallow impact basins — appear with mountains rimming their margins. Some have shoreline craters, partly melted down and buried under old lava flows. Others show infinite variations in light and dark, especially as the phase approaches Full Moon.

Every lunar explorer discovers favorites — the crater Copernicus, the Alpine Valley, or the tangled terrain of the ancient southern highlands. You'll watch them change shape and form as sunlight plays across the landscape. Your telescope lets you become a lunar astronaut, walking in imagination across dusty plains and looking over yawning craters.

Beyond the Moon

All the planets are fair game for backyard telescopes — even distant Pluto. But the most popular are Jupiter, Saturn, and Mars because they show the most features.

Jupiter spins in less than 10 hours, so the vista changes all the time. What looks like a cloud-striped surface on Jupiter is the top of a deep hydrogen atmosphere churned by heat from below. Spots and markings appear, last for months or years, then merge and disappear. The Great Red Spot, twice the size of Earth, has lingered for more than 300 years. Jupiter-watchers monitor the planet for changes, and alert scientists when they occur.

Around Jupiter, a family of moons swirls like a miniature solar system. Galileo discovered the biggest four, which you can easily follow in any size telescope. (See the monthly illustration in *Astronomy*.)

Saturn is a smaller, lighter, cooler Jupiter, so its cloud bands are less pronounced — but the prominent ring system makes a world of difference. Saturn never fails to elicit a gasp when people see it for the first time. You'll want to look at its jewel-like beauty all night long.

The Red Planet

No one has yet stood on the sands of Mars, but you can peer into a backyard telescope and sometimes see hazy clouds over its large volcanoes. Occasionally, dust storms gather to veil parts of Mars — or all of it. Polar caps grow and shrink as seasons pass.

Mars is a challenging world to observe from Earth because of its small size and varying distance — it's close to Earth for only 2 months out of 26. Yet, in many ways, Mars is our most earthlike neighbor. This exerts an irresistible pull on every backyard telescope owner.

The Sun

Before leaving the solar system, take a look at its central star — the Sun. Solar viewing requires a special solar filter that fits over the front of the telescope — never use an eyepiece solar filter. A front-mounted solar filter lets you safely view features such as

SPIRAL GALAXY. NGC 7331 shows the classic form: spiral arms, dust clouds, and a disk with hot, blue stars. (14.5-inch Cassegrain, Kodak Royal Gold 200 film, composite image) TONY AND DAPHNE HALLAS

FADING STAR. The Dumbbell Nebula took shape when an aging star threw off shells of gas. (Meade LX-200 12-inch, Pictor 416XTE camera, color filter wheel, four-image composite) MIKE FULLER

sunspots, which are relatively cool and dark regions far bigger than Earth. They occur where the Sun's magnetic field becomes knotted and hinders the flow of internal heat. For reasons no one yet understands, sunspot numbers wax and wane over an 11-year cycle.

The starry sky

Scanning the sky — and particularly the Milky Way — with a telescope, you find stars in pairs and triplets. Some are chance groupings, but most are real multi-star systems, locked together by gravity. While they orbit at high speeds, their distances are so great that decades or centuries will pass before changes become apparent.

Stars also gather in clusters — tight, rich groups that stand out from the background. Open clusters contain a few dozen to a few thousand members. The Pleiades (M45) in Taurus is a beautiful open cluster, more populous and less scattered than its neighbor, the Hyades.

Stars also group together as globular clusters. If open clusters are like small towns, globulars are entire cities, containing tens of thousands to upward of a million stars each. When you look at a globular through a telescope, you see a bright core region sprinkled with stars that run outward until the blackness of space takes over. A globular cluster looks like a tiny pile of sugar dropped on black velvet.

The best place to look for open clusters is along the Milky Way, but globulars are usually found flanking it. The region of sky richest in globular clusters lies in Scorpius and Sagittarius, best seen in summer. But a superb globular, M13, lies in spring's Hercules, where it shines bright enough to see by eye from a dark observing site.

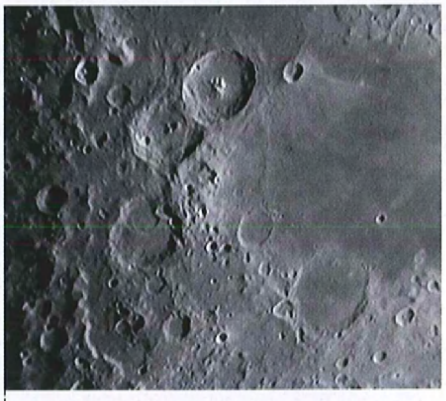
Star clusters are born from vast clouds of dust and gas — nature's star factories

NEIGHBOR GALAXY. You'll barely see the Andromeda Galaxy (M31) with your naked eyes from a dark site. (14.5-inch reflector, SBIG ST-10E CCD camera, four-part composite exposure) TONY AND DAPHNE HALLAS

Sky tour

► **FACE TO FACE.** Looking upon the face of M101, a spiral galaxy in Ursa Major the Great Bear, we see its bright starlike nucleus and its curling arms traced by red nebulae and hot, young, blue-white stars. JAMES FOSTER

RECYCLING PROGRAM. A supernova created the Crab Nebula, and its expanding debris will help make new stars. (Centurion 18.2-inch at f/2.8, SBIG ST-8E camera and color filter wheel) CLIFF WRIGHT



CRATERSCAPE. The shore of the Moon's Mare Nectaris shows craters and other features in all states of preservation. DANIEL ETHIER

— that occur throughout the Milky Way. Astronomers call such clouds nebulae, and they make favorite targets for telescope users. A nebula looks like a soft haze through the eyepiece. Irregular in shape, many nebulae contain an open star cluster, born from the nebula perhaps in the last few million years. A famous example is the Orion Nebula (M42).

Another kind of nebula is the planetary nebula, so-called because through small telescopes many resemble Neptune. A planetary nebula represents the end of a star's life. As middleweight stars age, they blow off symmetrical shells of gas around their hot cores. The Dumbbell Nebula (M27) in Vulpecula the Fox is a favorite planetary. Not all stars die quietly, however. The Crab Nebula (M1) in Taurus marks where a star exploded about 1,000 years ago. The remnant is expanding, shooting gaseous debris back into space, where much of it will wind up in a new generation of stars.

Realms of infinity

You can take your first step beyond the Milky Way just by using your naked eyes. A dark autumn night shows the Andromeda Galaxy (M31) as a pale smudge of light near the Great Square of Pegasus. M31 lies 2.5 million light-years away. A telescope shows off its bright nucleus and lets you trace its tightly wrapped spiral arms. And the Andromeda Galaxy is just the start; beyond lies a realm of galaxies you can spend the rest of your life discovering.

Backyard astronomers who prowl for galaxies are the deepest of the deep-sky explorers. As they peer into the telescope, they look back in time, deciphering light that took millions of years to arrive.

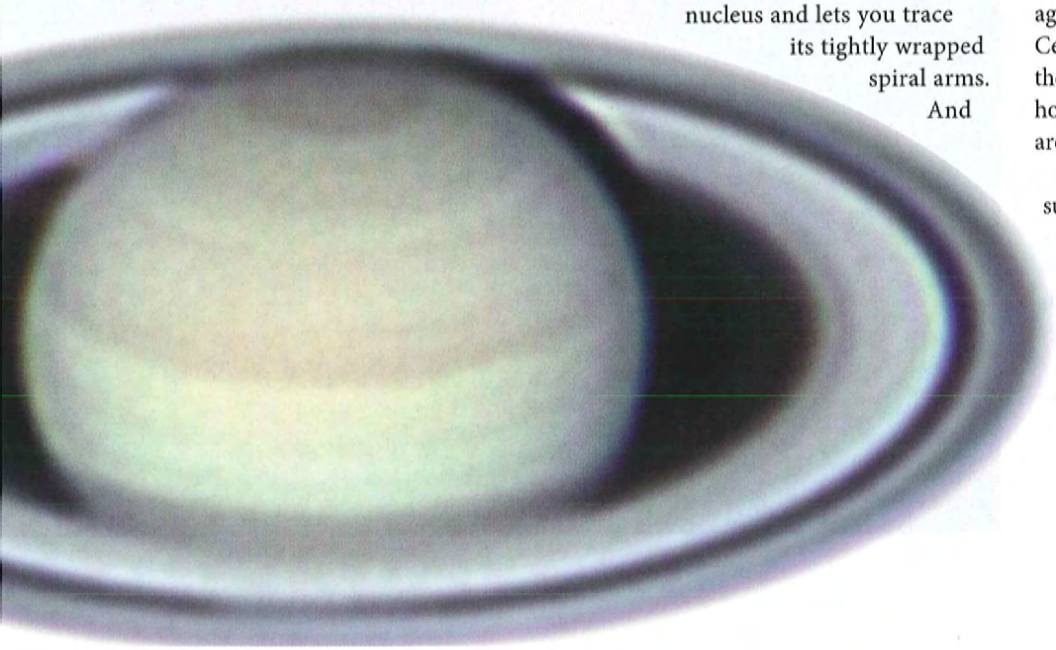
Quirks of geometry present some galaxies edge-on, like pencil beams of light. Some have ragged edges. Others, tipped face-on, tantalize us with spiral arms that hover on the edge of invisibility. A few galaxies show dark smudges like black eyes, where dust lies thick and the star-making factories are running day and night.

The Milky Way and Andromeda galaxies both belong to the Local Group, a cluster of some 40 galaxies. Nearby in Virgo lies a much larger galaxy cluster, one of many millions that shape the framework of the universe. Backyard astronomers can explore this realm in part — but even the pros haven't sounded its depths.

Of space and time

When we turn from the realm of the galaxies and look homeward, distances shrink, and the light our telescopes receive grows younger. Globular clusters appear as they were perhaps 20,000 to 50,000 years ago. And star clusters like the Pleiades shine as they were hundreds to thousands of years ago. Light from the nearest star — Alpha Centauri — takes 4.3 years to crawl from there to here. Pluto orbits some 5 light-hours away from the Sun, while Earth zips around just 8 light-minutes from the Sun.

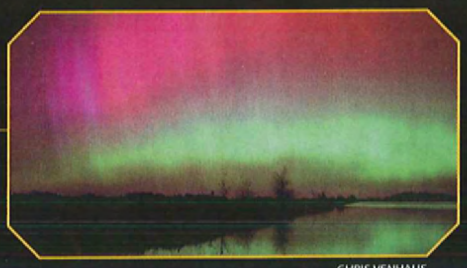
And what about moonlight? It's reflected sunlight that left the Moon's dusty surface just 1.3 seconds ago. When you look through a telescope, you get more than a spaceship of the imagination — you get a time machine, too.



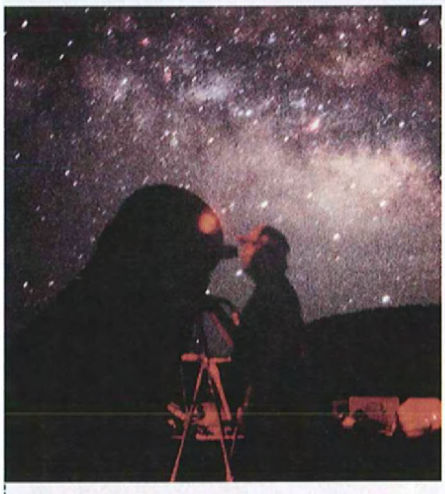
◄ **LORD OF THE RINGS.** Saturn's ring system is one of the most breathtaking sights backyard astronomy has to offer. (Astro-Physics 7-inch f/9, Sony camcorder video frame) DAVID HANON

STAR FACTORY. Below Orion's three-starred belt lies the Orion Nebula, a vast cloud of dust and gas where stars are being made. (Takahashi 6-inch at f/3.3, 40-minute exposure) JOHN CHUMACK

Shooting the sky



CHRIS VENHAUS



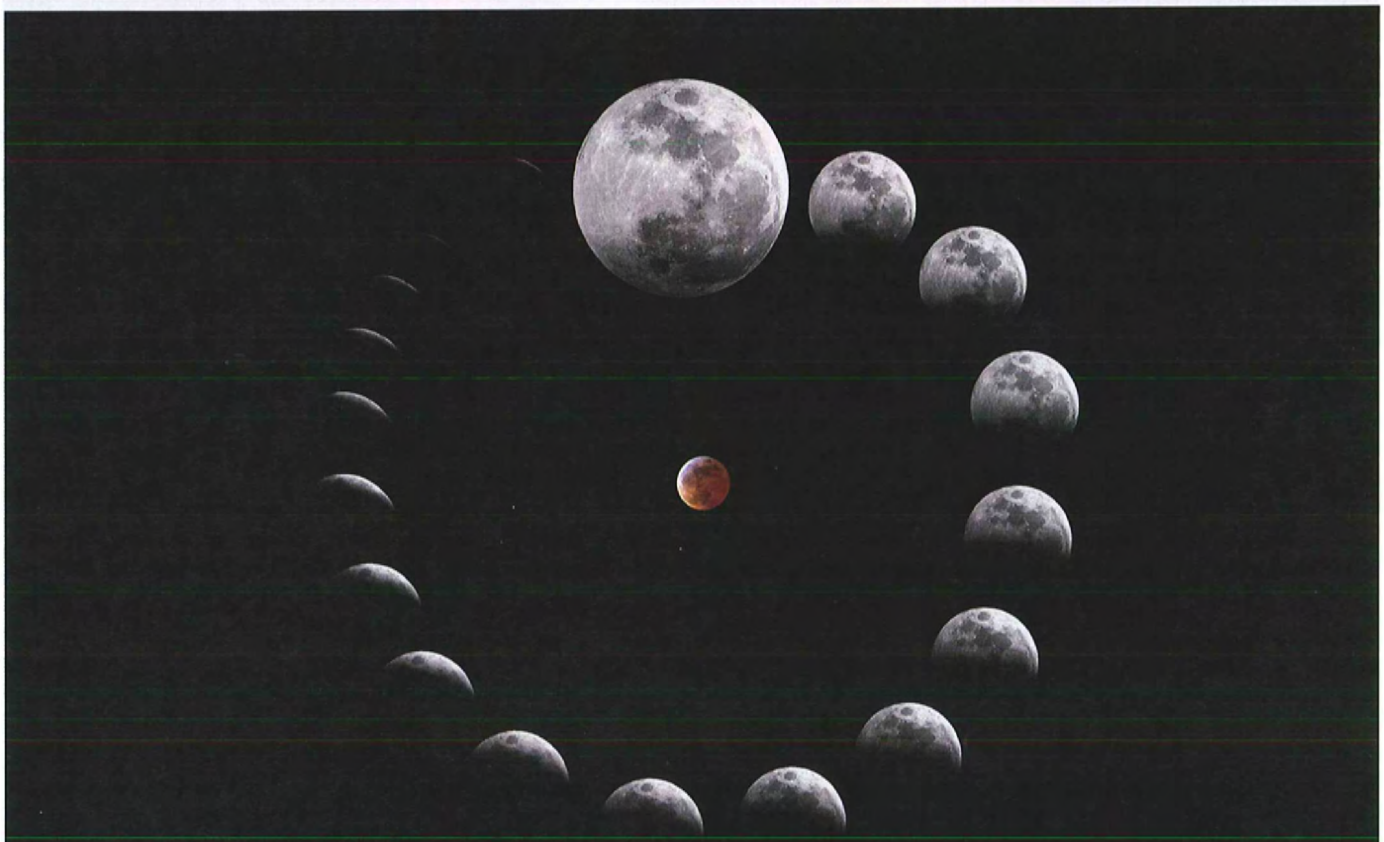
OUR GALAXY RISING. A big telescope looks toward the east as the Milky Way rises into view. TIM KIMBLER

With simple gear, you can produce great photographs, or, with a digital camera, electronic images. Mount a camera that can take time exposures on a tripod. Set the focus to infinity, and open the aperture fully. Try exposures of 30 seconds, 1 minute, 5 minutes, and so on. (Keep notes.) Dark skies are a huge plus, well worth a trip away from streetlights.

Another technique lets you piggyback your camera (with lens) to a telescope that has a motor-driven equatorial mount. Be sure to attach the camera securely. The mount tracks the stars during the exposure. The result is a wide field of view with pinpoint stars all across the image. Try using different lenses. Caution: The technique doesn't work with an alt-azimuth go-to drive because the star field will rotate around the center of the photo.

Skyshooting's major leaguers use the telescope as the camera lens. This is more challenging than it looks. You need top-notch equipment: a camera; a solid mount; accurate, automated tracking; and superb optics. You also need a T-ring and T-adapter, two inexpensive accessories that let you connect the camera to the focuser.

Shooting the sky is the ultimate goal for many just starting out in astronomy. It's only natural that, as you learn to identify more celestial objects, you'll want images of them. And the sooner you get started looking at the sky, the sooner you'll have amazing images to show your friends.



ECLIPSE SEQUENCE. March 3, 2007, brought the first total lunar eclipse in 2½ years. The photographer used a Meade ETX-90EC telescope for this sequence. MIGUEL CLARO

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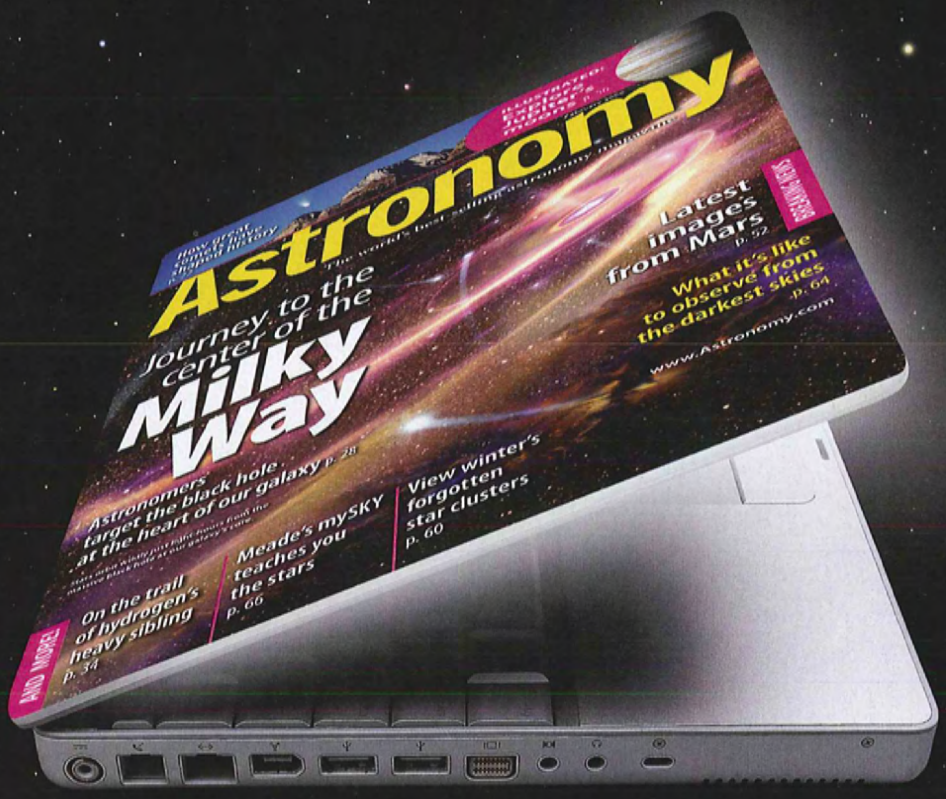

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