Some amateur astronomers consider binoculars an accessory, but many regard them as a necessity. I've written often that a beginning amateur should purchase binoculars first to view the sky. If your interest in astronomy continues, then upgrade to a telescope. Most of the advanced observers I know own several binoculars.

In some ways, binoculars may be a better choice than a telescope, especially for those starting out in astronomy. Binoculars have a wide field of view and provide right-side-up images, making objects easy to find. They require no effort or expertise to set up - just sling them around your neck, step outside, and you're ready to go. That portability also makes binoculars ideal for those clear nights in the middle of the week when you don't have the time or inclination to set up a telescope. And, for most people, observing with two eyes open rather than one seems more natural and comfortable.

Also, binoculars are easier on your wallet. Unless you're considering imagestabilized models, binoculars offer a more affordable way to tour the sky than a telescope. If you're a parent hoping to foster a child's interest in the universe, binoculars are a good first step. Even if the appeal of stargazing eventually wanes, binoculars can be used for more down-to-earth pursuits.

In common usage, you may hear someone refer to binoculars as a "pair of binoculars." This isn't accurate. The unit is simply binoculars. Technically speaking, I suppose you could refer to them as a pair of monoculars, but you'll never actually hear that.

## The numbers

Every binocular has a two-number designation, such as $7 \times 50$. The first number (in this case, 7) is the magnification (power). The second number (50) is the


Binoculars use prisms to bend incoming light several times before it reaches your eyes. Manufacturers have to position all optical components correctly so that no light is lost. Holley y. Bakich
diameter in millimeters of each of the objective lenses.

This example, 7 x 50 , is the binocular I recommend as a first unit for observing. A magnification of 7 is in the "medium" range, just high enough to bring out some detail in large astronomical objects.

Using too high a magnification will over-magnify involuntary motions of your hands. That motion causes celestial objects to move around in the field of view. A high magnification also limits the field of view, making objects more difficult to find for beginners.

Most advanced amateur astronomers can hold binoculars up to 16 x for short intervals. Also, binoculars with higher power (like a telescope with a shorter focal length eyepiece) will reveal fainter stars by increasing the contrast between the star images and the sky background. Here's a tip: When holding high-power binoculars, position your hands toward the front of the binoculars, and the view will be steadier.

In our example, 50 millimeters is the aperture (size) of each of the front lenses. The larger this number, the more light


Actual fields of view through binoculars vary. High-power binoculars generally have smaller
fields of view. Photo: Milt Gosney ; illustration: Astronomy: Roen Kelly
the binoculars collect, and that makes the target brighter. Binoculars with front lenses measuring 50 mm collect more than twice as much light as those measuring 35 mm across. Astronomically speaking, this is a gain of nearly 0.8 of a magnitude in light-grasp. But larger front lenses make binoculars bigger, heavier, and more expensive.

## Optics

The components inside binoculars that bend the light (several times) so the image appears right-side up are the prisms. Binocular prisms come in two basic designs: roof and Porro (capitalized because they're named for 19th-century Italian inventor Ignazio Porro). Roof prisms are lighter and smaller, but I don't recommend them for astronomy.

Porro prisms are better for astronomy and are made of either BaK-4 or BK-7 glass. BaK-4 prisms (barium crown glass) are the highest quality available. BK-7 prisms (borosilicate glass) are also good quality, but image sharpness falls off slightly at the edge of the field of view compared to the view through prisms made of BaK-4.

Most high-quality binoculars are multicoated on all optical surfaces. You'll most often see this referred to as "fully multicoated." In the 1950s, manufacturers developed coatings that reduced light loss and internal reflections.

## Mechanical considerations

Center-focus binoculars move both optical tubes simultaneously. Other models
let you focus each tube independently. All else being equal, choose binoculars with individual focus.

Center-focus units add some mechanical complication. And even center-focus binoculars allow you to adjust one tube separately because most people's eyes do not come to the same focus.

Individual-focus binoculars tend to be more rugged and weatherproof. In either case, once you focus your binoculars on a night sky object, the focus will be good for all other objects because all appear infinitely distant.

## Exit pupil

One of the most important terms when dealing with binoculars is "exit pupil." This is the diameter of the shaft of light coming from each side of the binoculars to your eyes. If you hold the binoculars at arms' length and point the front lenses at a bright surface, light, or the sky, you'll see two small disks of light exiting at the eyepieces. These disks are the exit pupils.

The diameter of the exit pupil equals the aperture divided by the magnification. So for our 7x50 binoculars, the exit pupil diameter would be 50 divided by 7 , or roughly 7 mm . For astronomy, you want to maximize this number because the pupils in our eyes dilate in darkness. The wider the shaft of light, the brighter the image will be because light is hitting more of your eye's retina.

This loose rule, however, is only true up to a point. If a binoculars' exit pupil is
too large to fit into your eye, you will lose some of the instrument's incoming light.

You can measure your pupil size with a gauge available from some telescope suppliers. You also may be able to get one from a pharmaceutical company or from your eye doctor.

## Eye relief

Eye relief is a function of the eyepiece. It's the manufacturer's recommended distance (for best performance) your eye's pupil should be from the eyepiece's exit lens. Eye relief generally decreases as magnification increases. Eye relief less than 10 mm requires you to position your eye quite close to the eyepiece.

For beginners, longer eye relief allows the head more freedom of movement. Also, those who choose to wear eyeglasses need longer eye relief.

## A buyer's guide

How should you choose your first binoculars? Through the years, I've advised many amateur astronomers to conduct a short test before their purchase.

First, pick up the binoculars and shake them gently. Then twist them gently. Then move the focusing mechanisms several times. Move the barrels together, then apart. What you're assessing is quality of workmanship. If you hear loose parts or if there's any play when you twist or move the binoculars, don't buy them. Another thing to consider at this point is the weight of the binoculars. If you're


If you point your binoculars at a light source, the circles formed by the eyepieces are the exit pupils. For most observers, binoculars with exit pupils measuring 7 mm are just right. Michael E . Bakich
going to be holding them, try to imagine what they will feel like at the end of a long observing session.

Look into the front of the binoculars and check for dirt or other contaminants. Ignore a small amount of dust on the outside of the lenses. The inside of the binoculars, however, should be immaculate.

Hold the binoculars in front of you with the eyepieces toward you. Point them at a bright area. You'll see the exit pupils - disks of light formed by the eyepieces. They should be round. If they're not round, the optical alignment of the binoculars is bad and the prisms are not imaging all the light.

Of course, you must look through the binoculars. Try to do this outdoors and at night. Nothing will reveal flaws in the design of binoculars better than star images. If it's impossible to test the unit at night, or even outdoors, look through a door or window at distant objects. How well do the binoculars focus? Are objects clear? If there's any sign of a double image, the two barrels are not aligned. Put them down, and walk away.

If you're wearing glasses - and if you plan to observe with them on - can you get your eyes close enough to the binoculars to see the entire field of view? Move the binoculars visually across a straight line like a phone wire or the horizon, if possible. Does the line look distorted? A tiny amount of distortion near the edges of the field of view is not a big problem.

Repeat the tests with several different binoculars. Once you become more familiar with how binoculars compare, you will be well on your way to purchasing an excellent unit.

One factor you may hear about is "field curvature." This optical flaw is present in all binoculars to some extent. Field curvature results from the lens forming a sharp image on a curved surface. When the eyepieces are set to meet the part of the image that is in focus, say, the center, you must change the focus to make the edges of the image sharp.

The quality of the binoculars is directly proportional to the extent that the unit minimizes this problem. An

A parallelogram binocular mount allows people of all heights to view the same object in the sky - just move the swinging arm up or horizontally. A movable use binoculars of different weights. Holley y. Bakich

excellent instrument shows field curvature only at the edge of the field. When the entire field of the binoculars is in focus, manufacturers call it a flat field. If you use binoculars that have a flat field, you won't soon forget it. Such units are expensive, however, because binoculars that are flat across most of the field require top-notch optics.

## Image-stabilized binoculars

To enjoy both a wide field of view - the kind binoculars provide - and moderately high magnification in hand-held binoculars is to have the best of both worlds. Manufacturers achieved this by creating image-stabilized (IS) binoculars.

IS binoculars use different methods to stabilize the image. Some have batteries that power a gyroscopic mechanism. Others use a non-powered design that
relies on a gimbaled prism. In all designs, you push a button to engage the stabilization. The results are dramatic. For example, I can now hold binoculars steady enough to obtain good, long looks at Jupiter's moons.

## Giant binoculars

Giant binoculars have front lens apertures greater than or equal to about 4 inches ( 102 mm ). Classifying giant binoculars by size is a bit of a gray area, however. Some manufacturers label the largest binoculars they sell "giant," which may be true for them. When most amateur astronomers imagine giant binoculars, however, they think of a pair of short focal length 4 -inch refractors connected together - or something even larger.

As with smaller models, magnification varies. Some giant binoculars allow you
at any camera store. If you must wipe the lenses, use only lens paper and change it frequently, rather than using the same piece to wipe back and forth.

The body of your binoculars also will get dirty. When it does, simply wipe it with a damp cloth.

## Binocular mounts

For the steadiest images possible, nothing beats mounting your binoculars to a tripod or custom binocular mount. Smaller, well-mounted binoculars with less magnification will, after a few minutes of continuous use, beat hand-held binoculars of larger aperture and magnification.

The simplest binocular mount is a metal "L" bracket. Attach it to the mounting hole on the binoculars' center post. The other end of the L attaches to a camera tripod. This setup is adequate if the objects you're observing aren't too high in the sky. For objects near the zenith (the overhead point), tripod-mounted binoculars are uncomfortable - and in some cases impossible - to use.

Another option is to purchase or build a binocular mount. Most amateur astronomers purchase commercially made mounts. Such units employ a design based on a movable parallelogram. This arrangement keeps the binoculars pointed at an object over a wide range of motion, allowing people of varying height to use them.

When selecting a binocular mount, choose one that is sturdier than you require. Then you can upgrade your binoculars to a larger (heavier) model in the future.

A binocular mount is rugged if, a few seconds after you've found an object, the image settles down and shows no vibration (unless a strong wind is blowing). If the image is not stable, your mount may be at fault.

The fault also could lie with the second piece of equipment you'll need: the
tripod to which the mount attaches. Most camera tripods are inadequate for this purpose. They simply are not robust enough to handle the weight of the binoculars plus the weight of the mount. Balance also could be a problem. If you have a tripod, by all means try it. You'll know immediately if it's up to the task.

A tripod can fail in more ways than by being flimsy. Maybe your sturdy tripod, even at full extension, is not high enough to allow you to stand under your binoculars and view objects near the zenith.

## To the sky

Now that you have the background about the numbers, features, and functions of binoculars, it's time to head outside. And who could be a better guide than Astronomy's own Phil Harrington? His column, "Phil Harrington's Binocular Universe," is a popular feature in each month's issue.

We've selected some of the material from his columns for the following year-through-binoculars roundup. All you'll need is this guide, binoculars, and a clear sky. Although a dark sky beats one that's light-polluted, you'll see much of what Phil describes even from urban settings.
decrease the magnification. No giant binoculars can be hand-held. They are simply too heavy. If a case didn't come with your giant binoculars, buy one. Don't try to save money at this point because you'll regret the decision later.

## Maintenance

Caring for your binoculars is easy. Most units come with lens caps, eyepiece caps, and a case. Use them. They will help protect your binoculars from dust and moisture. Don't leave your binoculars exposed to direct sunlight, even if they're in their case. Most binoculars (and their cases) are black or dark-colored and will absorb a lot of heat. Heat will cause the carefully placed elements of binoculars to expand (and later contract) - not a good scenario.

Cleaning is sensitive only when it involves the lenses. If your lenses become dusty, blow them off with compressed air or brush them with an approved optics brush. You'll find both of these products


The Astronomical League recognizes several binocular observing clubs. The league awards this certificate if you have observed 50 or more deep-sky objects out of the 109 on Charles Messier's list. Michael E. Bakich
scattered in small clumps and patterns. While most of the stars appear white or blue-white, a few show slight tinges of yellow or orange. Search for the orange star Sigma ( $\sigma$ ) Persei, one of three suns forming a small triangle south of Mirfak. Also, look for two whitish double stars to Mirfak's north.

Together, the stars gathered into this football-shaped area form the Alpha Persei Association. A stellar association contains mostly hot blue-white and white stars, like many of the sky's open star clusters. Typically, however, the stars in an association gather more loosely than those in open clusters.

The Alpha Persei group congregate around Mirfak. In the case of this group, some 50 stars are bound by their mutual - but weak - gravitational field.

In Perseus, you'll find two wonderful open star clusters that appear as two overlapping circles on the star chart to the upper right. Their labels, NGC 869 and NGC 884, correspond to their entry numbers in the New General Catalogue. You might also know them by their combined nickname, the Double Cluster.

Even from suburban skies, your unaided eyes can spot the Double Cluster as a small, faint smudge of light between Perseus and Cassiopeia. Find them through your binoculars by extending a line from Gamma ( $\gamma$ ) Cassiopeiae, the center star of the W, through Delta ( $\delta$ ) Cas and continuing east.

If you maintain a straight course, you'll see both clusters as two tiny knots of stars. The one closer to Cassiopeia, NGC 869, appears more densely packed. Most of the stars look either white or blue-white, but you might notice a few yellow and orange stars as well. To make subtle star colors stand out more vividly, defocus your binoculars slightly.

Finally, let's take aim at open cluster M34. You'll find it about halfway between the stars Almach (Gamma Andromedae) and Algol (Beta [ $\beta$ ] Persei). A great target for binoculars, M34 covers an area as large as the Full Moon. Look for the brightest of its roughly 100 stars within the glow of fainter, unresolved suns.


When you point your binoculars toward the constellation Perseus, you won't miss the Double Cluster (NGC 869 and NGC 884). Don't stop there, however. Check out open cluster M34. Astronomy: Richard Talcott and Roen Kelly

FEBRUARY
The Hunter becomes the hunted
Often, a student will come up to me before the semester's first astronomy class and ask, "So, what's this class all about?" My answer? "Orion!"

I usually get a perplexed look back, but the fact is that I can condense much of the semester into that single constellation. Orion is a "mine of wonders; this great constellation embraces almost every variety of interesting phenomena that the heavens contain," according to Garrett P. Serviss (1851-1929) in his 1888 book Astronomy with an Opera Glass.

If you want to see star birth in action, look toward the middle star of Orion's "sword." That "star" is not a single sun, but rather a glowing cloud known as the Orion Nebula (M42), one of the sky's busiest delivery rooms.

M42 is just the tip of a nebulous "iceberg" that engulfs nearly the entire constellation. As this giant cloud sprawls from northwest to southeast, it has deposited pockets of newly formed star clusters in its wake. To the north, the cloud has parted to reveal several easy-to-find open star clusters.


Orion is one of the sky's brightest and most recognized constellations. It contains numerous binocular targets like the Orion Nebula (M42) and three large Collinder clusters: numbers 65, 69, and 70. Astronomy: Richard Talcott and Roen Kelly

All three of Orion's brilliant "belt" stars, along with another hundred or so fainter suns, belong to the open star cluster known as Collinder 70. Swedish astronomer Per Collinder (1890-1974) first identified this object as a cluster in his 1931 catalog.

Many of the 471 open clusters that Collinder included are too large and sparse to appreciate through most telescopes, but they're perfect for binoculars.

Most of Collinder 70's stars shine brighter than 9th magnitude, within range of 50 mm binoculars from suburban skies. Overall, Orion's three belt stars mark the width of Collinder 70. A distinctive S-shaped chain of 11 faint stars snakes from Mintaka, the belt's western star, to Alnilam at its center.

Follow the trail of star formation north to Orion's triangular head. The triangle's top star (Lambda [ $\lambda$ ] Orionis) and several dozen fainter suns within about $1^{\circ}$ all belong to another open cluster, Collinder 69. Most binoculars reveal between 15 and 20 stars ranging in brightness from 5th to 9th magnitude.

A third Collinder cluster, Collinder 65, spills into adjacent Taurus. By adding a few non-cluster stars to the east and north, I imagine this cluster as a spear that Orion is about to heave at the Bull. Orion's "spear" measures about $8^{\circ}$ tip to tip, which makes it perfect for 7 x binoculars.

## MARCH

## Visit the Charioteer

Head outside some March evening, and look overhead. If you live in mid-northern latitudes, you'll find a lone beacon cresting near the zenith - the point in the sky straight overhead - as the sky darkens. Capella lies in Auriga the Charioteer.

Tracing back to ancient Rome, the name Capella translates to "mother goat," a reference to the position it holds in the Charioteer's picture. Near Capella lie three stars that represent the goat's kids - three 3rd-magnitude stars in the shape of an isosceles triangle. They glisten beautifully through binoculars. Two shine pure white, while the third, Zeta ( $\zeta$ ) Aurigae, appears orange.

Hop a little more than a binocular field south of, or below, the triangle to see a neat little pattern of five faint stars. Four form a parallelogram, while the fifth lies just below. This isn't a star cluster, but an asterism - one of those fun shapes you bump into every now and again.

Given March's windy days, the pattern reminds me of a kite with a tail whipping about. With your unaided eyes from a dark site, you might see the kite's oblong glow west of the constellation's center.

Look north of the box kite for a dim glow among the stars. That's M38, one of Auriga's three Messier open clusters. Don't be surprised if you can't see M38 at first. This cluster can be tough to pick out from among the surrounding stars.


The Salt-and-Pepper Cluster (M37) in Auriga is one of the sky's brightest open clusters. Through binoculars, you'll see a misty patch composed of several hundred stars. Neil Fleming


When you finish watching Capella (Alpha [ $\alpha$ ] Aurigae) sparkle through your binoculars, aim them at open clusters M36, the Salt-and-Pepper Cluster (M37), and M38. Astronomy: Richard Talcott and Roen Kelly

While looking for M38, you might notice M36, a second fuzzy glow snuggled between two faint field stars about half a binocular field to the east. M36 is a smaller and more condensed open cluster than M38, so you should be able to spot it more easily.

If you have good eyes and 70 mm or larger binoculars, you might see a few faint stars peering back at you. Telescopes reveal the cluster's brightest stars forming a crooked Y pattern.

The brightest Messier open cluster in Auriga, the Salt-and-Pepper Cluster (M37), rests about a binocular field east of M36. Because its brightest stars shine at only 9th magnitude, M37 appears as a faint, misty patch through binoculars.

## APRIL

## Two crabby clusters

If I asked you to name your favorite springtime constellation, odds are you wouldn't mention Cancer the Crab. After all, Cancer isn't much to look at, and just finding it is difficult enough - its brightest stars shine at 4th magnitude. That makes this one tough crab to catch.

Look midway between the bright stars Castor and Pollux (Alpha $[\alpha]$ and Beta $[\beta]$ Geminorum) in Gemini and Regulus (Alpha Leonis) in Leo. There, you'll find Cancer's four-star shelled body.

Look inside the Crab's body with your binoculars, and you'll notice it frames a swarm of faint stars - the Beehive Cluster (M44). One of history's first published observers, the Greek philosopher Aratus discovered this cluster in 260 в.с.

When I look at the Beehive through my $10 \times 50$ binoculars, I see the shape of a right triangle. Of the 36 cluster stars I can count, most shine between magnitudes 7 and 9. Many form interesting pairs or patterns with their neighbors.

For instance - maybe because April signals the start of baseball season - I see M44's five brightest stars grouped as a home plate just south of the cluster's center. A closer look at the star marking the plate's pointy tip reveals it as a triangle of stars. Multiple-star fans know this group as Burnham 584. Before you try to spot the three stars, brace your binoculars. A second conspicuous pairing of stars also stands out just north of the cluster's center.

To find Cancer's second cluster, trace its southeastern leg away from the Crab's trapezoidal body to the 4th-magnitude star Acubens (Alpha Cancri). Center your view on Acubens, then shift your attention to the binocular field's western half. You should spot the dim glow of M67. You might even pick out a few faint stars shining within M67's haze.


Two open clusters in Cancer beckon your binoculars. The brighter one is the Beehive Cluster (M44). It's an easy naked-eye object from a dark site. M67, on the other hand, will test your eyes if you view it through small binoculars. Astronomy: Roen Kelly


Sharp-eyed observers with high-quality binoculars will have no trouble spotting Bode's Galaxy (M81) and the Cigar Galaxy (M82) in the same field of view from a dark site. Adam Block/NoAo/AURA/NsF

## MAY

## The Big Dipper

Remember the cry of excitement when you recognized the Big Dipper for the first time? Let's first examine each of the four stars that make up the bowl: Dubhe (Alpha [ $\alpha$ ] Ursae Majoris), Merak (Beta [ $\beta$ ] UMa), Phecda (Gamma [ $\gamma]$ ), and Megrez (Delta [ $\delta$ ]). All shine nearly white, except for Dubhe at the bowl's northwest corner, which radiates an orangish glow.

Using your imagination, draw a line from Phecda, at the bowl's southeastern corner, to Dubhe. Extend that line an equal distance to the northwest until you come to a small right triangle of stars. The star marking the right angle itself is 24 Ursae Majoris, while most star charts don't name the other stars.

If you look carefully, you just might spot a faint blur to the triangle's southeast. That's no star, but rather Bode's Galaxy (M81). Admittedly, finding M81 can prove daunting at first. Through $7 \times 35$ binoculars, the galaxy's oval shape appears small and dim. Larger binoculars increase the contrast between the galaxy's bright center and the dimmer surrounding halo, although binoculars won't resolve the spiral arms.

Look just north of M81, and try to make out a dimmer splinter of grayish light. If you do, you've found the Cigar

Galaxy (M82). Even 7x35 binoculars reveal this galaxy's famous shape, provided your sky is dark. Unlike M81, however, which shows a brighter core, M82 appears uniformly dim from end to end.

M81 and M82 form a striking galaxy pair. Other galaxies belong to the M81 Group, but we can see only one - NGC 2403 - through binoculars. It lies a good distance away, across the border within the faint constellation Camelopardalis.

Hunting down NGC 2403 can be tough, but here's how I do it. Start at M81, and move about 1 binocular field southwest to a slender triangle formed by 5th-magnitude stars Rho ( $\rho$ ), Sigma ${ }^{1}\left(\sigma^{1}\right)$, and Sigma ${ }^{2}\left(\sigma^{2}\right)$ Ursae Majoris. This distinctive triangle points toward the westnorthwest, right at a lone magnitude 5 star about a field of view away. From there, jog another binocular field southwest to a larger right triangle of three 6th-magnitude stars. Our target lies halfway between the triangle's right angle and its southern corner.

Next, look at the bend of the Big Dipper's handle. There, you'll find the star Alcor (80 Ursae Majoris). With Mizar (Zeta [弓] UMa), it makes a fun naked-eye test and an easy target for even the smallest binoculars. Mizar shines at 2nd magnitude, while Alcor glows at 4th.

From Mizar, aim toward Alkaid (Eta [ $\eta$ ] Ursae Majoris), the star at the end of the Dipper's handle. Look half a binocular field to Alkaid's west-southwest for a


Ursa Major the Great Bear ranks as the thirdlargest constellation. A good test for your sky, your binoculars, and your eyes is to try to spot two deep-sky objects: Bode's Galaxy (M81) and the Cigar Galaxy (M82).


Search the eastern part of Ursa Major for spiral galaxy M101. If your binoculars reveal it, you'll have no problem finding the Whirlpool Galaxy (M51) in nearby Canes Venatici. Astronomy: Roen Kelly

4th-magnitude star, and then move an equal distance farther south to a pentagon of dimmer suns. If you look carefully just inside the pentagon's eastern corner, you might spot a dim glow. That's the beautiful Whirlpool Galaxy (M51).

Through 70 mm and larger binoculars, you might notice M51 appears lopsided. You aren't looking at just one galaxy, but two. Charles Messier missed M51's companion, so you won't find it in his catalog. We know it today as NGC 5195. NGC 5195 glows at about 10th magnitude.

## JUNE

## Star clusters close-up

Let's kick off June with a visit to the bright star Arcturus (Alpha [ $\alpha$ ] Boötis). We can use Arcturus to find other objects of interest in the area.


Boötes contains Arcturus (Alpha [ $\alpha$ ] Boötis), the sky's fourth-brightest star. Look northwest of it for globular cluster M3, then west again for the Coma Berenices star cluster (Mel 111). Astronomy: Richard Taloott and Roen Kelly

For instance, if you move away from Arcturus toward the west (down and to the right in the evening sky in the Northern Hemisphere) about 4 binocular fields, you come to a dense group of stars. You might even see it as a hazy glow with your eyes alone. That's the Coma Berenices star cluster - also known as Melotte (Mel) 111 - one of my favorite binocular star clusters. This collection of about eighty 5th- to 10th-magnitude stars is perfect for 7 x to 10 x binoculars because it spans $5^{\circ}-10$ Full Moon-widths.

The cluster is not especially large. Instead, it looks big because it lies nearby. Today, we know the Coma star cluster is about 250 light-years away, making it the open cluster third-closest to us.

The brightest stars in the Coma star cluster resemble the lower-case Greek letter Lambda ( $\lambda$ ); or, if you're viewing from south of the equator, Gamma $(\gamma)$. Most shine white, while some show hints of yellow or orange. For instance, the star at the top of the Lambda, 15 Comae, is another type K star, like Arcturus.

Look for 17 Comae, a prominent double star just east of the cluster's center. Even opera glasses show 17 Comae's 5thmagnitude primary and its magnitude 7 companion easily.

Now, look for the star Cor Caroli (Alpha $[\alpha]$ Canum Venaticorum), the lone star visible to the naked eye just under (south of) the end of the Dipper's handle. Aim your binoculars halfway
between Arcturus and Cor Caroli, and then look for a right triangle of three dim stars that points toward the southeast.

Spot it? If so, look at the star marking the right angle. If you look carefully, you'll notice it's not a perfect point of light. Instead, it looks like a tiny, fuzzy "star blob." You're actually seeing a distant group of more than 100,000 stars a globular cluster called M3. To me, it looks like a distant ball of celestial cotton.

## JULY

## A tail's tale

The constellation Scorpius is a rare breed. Why? Because Scorpius actually looks like what it's supposed to represent.

The bright orange star Antares (Alpha $[\alpha]$ Scorpii) marks the Scorpion's heart. Immersed in the glow of the Milky Way, Antares makes a jumping-off point to search for many hidden treasures. Let's begin with globular cluster M4. It's just a half degree to the west of Antares. Look for a dim, round glow that appears fuzzy.

At 7,200 light-years away, M4 is relatively close to Earth for a globular cluster. This makes it appear bigger than most and easy to identify through $6 x$ binoculars. But because M4 has loose structure, its lack of a condensed center can confound observers in light polluted areas.

Scorpius houses a second Messier globular cluster that proves challenging
through binoculars: M80. This cluster rests halfway between Antares and Graffias (Beta $[\beta]$ Scorpii). Although its starlike core is typical, M80 is tiny compared to M4, so identifying it from surrounding stars can be difficult.

Now, place Antares at the western edge of the field and look on the opposite side for a close-set pair of 5th-magnitude stars lying across the invisible border in Ophiuchus. The globular cluster M19 lies just a degree to their south. Looking a little larger and slightly brighter than M80, M19 should reveal itself as a fuzzy "star" through 7x binoculars.

While viewing M19 through 10x50 binoculars, Jim Elliott of Lee County, North Carolina, observed an unusual arc of three optical double stars curving around M19 to the northeast. I call this assembly of stars (which includes 24, 26, and 36 Ophiuchi and SAO 184892, 185020, and 185033) the Dish o' Doubles because they remind me of a satellite dish, with M19 at the focus.

Next, look for the fainter globular cluster M62 about half a field to the south. M62 appears featureless through 8x42 binoculars; however, my $15 \times 70$ binoculars reveal a brighter, stellar core.

Next, proceed southward along the Scorpion's crooked body to the tip of its stinger, marked by the stars Shaula (Lambda [ $\lambda]$ Sco) and Lesath (Upsilon [ $v$ ] Sco). If you place the pair on the bottom edge of your binoculars' field, to the north and northeast you should see two distinct clumps of stars (above and to the left): M6 and M7, respectively.

The brightest stars in M6 form a rectangle, although more inventive eyes can imagine a butterfly's outline among the stars. Look for two wings outstretched from the insect's body. The butterfly appears to be headed southeast.

M7 is larger and brighter than M6. Even through the smallest binoculars, M7 will burst into a striking assortment of stars covering an area larger than the Full Moon. Several of its roughly 80 stars show subtle hues of yellow and blue, with the brightest a yellow beacon lying close to the group's center.

## AUGUST

## I'm a little teapot ...

In August, a celestial teapot gets all steamed up and pours out into the heav-


Search near Scorpius' stinger for open clusters M6 and M7. Then point your binoculars toward brilliant Antares (Alpha $[\alpha]$ Scorpii), and find globular clusters M4 and M80. Astronomy: Richard Talcott and Roen Kelly


Ptolemy's Cluster (M7) is an easy binocular target. To find it, just look to the left of Scorpius the Scorpion's stinger. Adam Block/NoAo/AURA/NsF
ens. Of course, I am referring to the constellation Sagittarius. Ancient eyes strained to see a centaur aiming a bow and arrow at the star Antares, the Scorpion's heart. Today's stargazers find a teapot among the pattern's eight brightest stars.

Let's begin with the finest bright nebula in the summer sky: the Lagoon Nebula (M8). The Lagoon lies about a binocular field west of Kaus Borealis (Lambda $[\lambda]$ Sagittarii), at the tip of the teapot's top. Locate the star in your binoculars, and then look toward the western edge of the field. You should spot several stars enmeshed in a glowing cloud. Many of those stars belong to the open cluster NGC 6530, which is forming within the Lagoon.

Careful examination should show that the Lagoon isn't uniform, but instead looks lopsided. The western side glows brighter and appears more bulbous than the eastern half. A lane - or "lagoon" of obscuring dust divides the nebula.

Now, without moving your binoculars, look less than half a field north of the Lagoon to find a small diamond-shaped pattern of stars. The southernmost star in the diamond actually is surrounded by a second, much smaller, patch of nebulosity known as the Trifid Nebula (M20).

Sagittarius offers five globular clusters to observe through binoculars. Through telescopes, these clusters look like mounds of sugar poured onto a velvety black background.

The sweetest globular of the bunch is M22. Look toward Kaus Borealis at the top of the teapot's lid, and then scan just to the east. M22 is the blurry, round disk next to an isosceles triangle of faint stars.

Now, pan just to the northwest of Kaus Borealis for a second, much


Sagittarius the Archer resembles a stellar teapot. It lies in the rich star fields of the Milky Way, so you'll find lots of binocular treats here. You can spot no less than five globular clusters in this area. Astronomy: Richard Talcott and Roen Kelly
tougher, globe of stars. Through binoculars, M28 looks like a small smudge between Kaus Borealis and a dim field star. It's much harder to find than M22, but take your time and M28 eventually will surrender to your hunt.

Our final three globulars lie along the bottom of the teapot, but be forewarned, they are daunting tests through binoculars. Use a pair of fainter stars east of the star Kaus Australis (Epsilon [ $\varepsilon]$ Sagittarii) as a guide. M69 lies just to their north, while M70 is to their east. M69 and M70 each shine at only 8th magnitude, so wait for a clear, haze-free sky before trying your luck. Under better than average conditions, I can see each as a faint, slightly fuzzy "star" through my 10x50s.

The third globular in this area, M54, is easiest to find by starting at Ascella (Zeta [弓] Sagittarii), the teapot's lower-left star. M54 lies directly to its west, just south of a triangle of dim stars. Like its two compatriots, M54 will impress you as a tiny, blurry point of light highlighted by a slightly brighter center.

## SEPTEMBER

## Strum the Harp

The brilliant stellar sapphire Vega (Alpha [ $\alpha$ ] Lyrae) sparkles high in the west this month. Famous as the fifth-brightest star in the night sky, Vegas dazzling glow punches through even severe light pollution. You simply can't miss it!

Lyra, Vega's constellation, symbolizes the harp owned by the mythological musician Orpheus. Vega marks part of
the harp's handle, while a parallelogram of four fainter stars frame its body.

Sheliak (Beta [ $\beta$ ] Lyrae), at the parallelogram's southwestern corner, is actually an eclipsing binary that is perfect for binocular study. In just under 13 days, an unseen companion star causes Sheliak to brighten from magnitude 3.3 to 4.3 . Compare Sheliak's brightness to that of nearby stars that do not vary.

The most photographed planetary nebula of all, the Ring Nebula (M57), lies along the southern edge of the parallelogram. To spot it, look midway between Sheliak and Sulaphat (Gamma [ $\gamma]$ Lyrae) for three faint stars that create a tiny right triangle. The "star" at the right angle is actually the Ring. Although it takes at least 50 x to make out its smoke-ring shape, I've seen M57 as a faint starlike point through 7x35 binoculars.

Now, scan southeast of Sulaphat toward the star Albireo (Beta Cygni), and pause about halfway in between. There, you'll find a conspicuous asterism shaped like the number 7. If you look just to the 7's southeast, you should spot a smudge that doesn't quite look like a star. That's globular cluster M56.

Even the smallest pocket binoculars, however, will reveal Delta ( $\delta$ ) Lyrae, at the Harp's northeastern corner, as two close-set stars. In fact, some sharp-eyed stargazers don't need any optical aid at all to see them. The pair's brighter star, magnitude 4.3 Delta $^{2}$, looks orangish, while magnitude 5.6 Delta ${ }^{1}$ is bluish-white. The two Delta stars belong to a scattered open cluster nicknamed the Delta Lyrae Cluster and cataloged as Stephenson 1.

Fifteen stars belong to Stephenson 1, with most too faint for binoculars. Although both Deltas belong to this cluster, studies suggest that Delta ${ }^{1}$ lies about 1,200 light-years away, while Delta ${ }^{2}$ rests about 200 light-years closer to us - a classic example of an optical binary star.

The next stop on our tour is Epsilon ( $\varepsilon$ ) Lyrae, just to Vega's northeast. Through binoculars, Epsilon easily resolves into two points of light. The northernmost of the pair is labeled Epsilon ${ }^{1}$, while the other is Epsilon ${ }^{2}$.

Many observers also know this system as the Double Double because Epsilon ${ }^{1}$ and Epsilon ${ }^{2}$ are each close-set pairs of stars. Unfortunately, it takes at least 80x to see all four stars, so you won't spot the pairs through binoculars.

Under dark skies, scan southeastward a binocular field diameter to the 3rdmagnitude star Delta Aquilae, and then an equal distance farther southeastward to 3rd-magnitude Lambda ( $\lambda$ ) Aquilae. Lambda and two fainter adjacent stars form an arc that hooks counterclockwise, directly toward the Scutum Star Cloud.

Scutum the Shield is a faint constellation that's difficult to pick out. But through binoculars, the Scutum Star Cloud stands out as one of the Milky Way's richest regions.

As you look around, notice several pockets where the star density increases. The Wild Duck Cluster (M11) stands out as a dazzling sight. You can find it as a bright smudge of starlight just to the west of the Eagle's tail-feather stars.

Because most of M11's stars are too faint to see through binoculars, they blend into a small round mist of starlight,


Not everything in the sky appears bright. Scan the Milky Way in Aquila the Eagle for two dark nebulae that form the letter E - Barnard 142 and Barnard 143. Michael Stecker


High in the Northern Hemisphere's summer sky, you'll see the small constellation Lyra the Harp. Trying to spot the famous planetary nebula the Ring Nebula (M57) through binoculars is a real challenge. Astronomy: Richard Talcott and Roen Kelly
except for a lone 8th-magnitude sun that shines above the fray.

A second smudge of condensed starlight lies about half a binocular field southwest of M11. Look for it southwest of a slender right triangle of stars formed by Alpha, Delta, and Epsilon Scuti.


The Wild Duck Cluster (M11) lies just off the tail stars of Aquila the Eagle in the small, faint constellation Scutum the Shield. M11 stands out well even in a rich Milky Way star field. Michael Stecker

M26 includes about 30 stars. None shines brighter than 10th magnitude so the cluster is not bright enough for you to see through most binoculars. Instead, M26's light produces a hazy glow covering about a quarter of a degree, or about half of the Moon's diameter in our sky.


With binoculars, scan the Milky Way southwest of Aquila the Eagle. Here, the Scutum Star Cloud provides two treats: the Wild Duck Cluster (M11) and another open cluster, M26. Astronomy: Richard Talcott and Roen Kelly

## OCTOBER

## The Swan delights

Although you'd never know from looking at it casually, Deneb (Alpha [ $\alpha$ ] Cygni), marking the tail feathers of Cygnus the Swan, is one of the most luminous stars in the entire sky. Even though it appears fainter than Vega and Altair, Deneb actually emits much more energy than either.

Cygnus marks one of my favorite binocular playgrounds. Even from my moderately light-polluted suburban backyard, I can sit back, peer through my 10x50 binoculars, and trace the gentle glow of the Milky Way from Deneb southward to the star Albireo (Beta [ $\beta$ ] Cygni), which marks the bird's beak.

Small telescopes reveal Albireo as a showpiece double star with a magnitude 3 golden primary star accompanied by a 5th-magnitude sapphire-blue companion. Their colors don't show up as well, but you'll spot both stars through steadily held 10x50 binoculars.

If double stars interest you, then stop by Omicron (o) Cygni, one of the finest doubles through binoculars. Look for it $5^{\circ}$ - or about two-thirds of a binocular field - northwest of Deneb. This system is another colorful pair: a 4th-magnitude orange star accompanies a magnitude 5 bluish sun. Their colors stand out even in their rich neighborhood.

Up for a couple of challenges? Good. Let's begin with the open star cluster M39, found along the lane of the Milky Way about $9^{\circ}$ - or approximately 1.5 binocular fields - northeast of Deneb.


The North America Nebula (NGC 7000) resides in Cygnus the Swan. Find it southeast of the bright star Deneb, just west of Xi ( $\xi$ ) Cygni. The easiest sections to see are the eastern seaboard and the Gulf of Mexico. Augie Orlandi

To find M39, scan from Deneb to a small arrowhead of stars just to the northeast. Follow the arrowhead's aim to a string of six faint stars that continues to the east-northeast. M39 lies to the east of the sixth (easternmost) star in that line. Through most binoculars, M39 will look like a tiny triangular grouping of about two dozen faint points. Whenever I am fortunate enough to view from a dark location, M39 appears suspended in front of a blanket of faint stardust.

Let's finish with the North America Nebula (NGC 7000). Although spotting this celestial continent is tough, it's easier to see through binoculars than through the narrow fields of most telescopes. Take aim at Deneb, and then look about $3^{\circ}$ (half a binocular field) to its east.

No luck? Here's a hint. Look for the "East Coast," from the Carolinas to Florida, and the Gulf of Mexico. These are the nebula's easiest parts to see, thanks to the darkness of the "Atlantic Ocean" formed by a separate dark nebula silhouetted in the foreground. The "West Coast" is more difficult to distinguish.

## NOVEMBER

## In the Queen's court

After the Big Dipper and Orion, the most recognizable star pattern visible from the


The North America Nebula (NGC 7000) in Cygnus can be tough to spot through binoculars. Observe under a dark sky, scan east of Deneb (Alpha [ $\alpha$ ] Cygni), and be patient. Astronomy: Richard Talcott and Roen Kelly

Northern Hemisphere may be the W of Cassiopeia, the mythical Queen of Ethiopia. During November, Cassiopeia rides high above Polaris and looks resplendent in the Milky Way's gentle glow.

One of my favorite open clusters in Cassiopeia is M52. To find it, draw a line from Schedar (Alpha $[\alpha]$ Cassiopeiae) to Caph (Beta [ $\beta$ ] Cas), the westernmost stars in the W , and continue it an equal distance to the northwest. There, you should spot a slender, four-star diamond pattern. M52 lies to the diamond's south.

Although about 200 stars call M52 home, few are bright enough to crack the binocular barrier; the rest blend into a little cloud of misty starlight.

Once you've enjoyed M52, return to the star Caph in the Cassiopeia W. Can you spot three pairs of stars just to its south-southwest? Although none of them is a true binary system, each pair forms the corner of a slim triangular asterism that reminds me of a skinny hang glider. The brightest star in the asterism, Rho ( $\rho$ ) Cassiopeiae, is one of the two at the glider's nose, while 5th-magnitude Sigma $(\sigma)$ Cas - the brighter of the two stars is at the end of the southern wing.

You might even spot a faint stain on the leading edge of the glider's southern wing. That's NGC 7789, a distant open cluster. Don't expect to see a lot of stars through binoculars. Instead, NGC 7789
looks like a faint round glow with one or two elusive points shining through.

One of Cassiopeia's fine sights lies near the star Zeta ( $\zeta$ ) Cas. Through binoculars, 4th-magnitude Zeta's distinct aquamarine hue contrasts nicely against Schedar's orangish tint.

Zeta lies at the end of a semicircular asterism of seven fainter stars. Together, they resemble a backward 3 or a miniature Corona Borealis. Because older depictions of the constellation show Zeta representing the Queen's head, "Cassiopeia's crown" seems an appropriate name for this little asterism.


Cassiopeia the Queen boasts many open clusters you'll enjoy observing through binoculars. Be sure to target open clusters M52 and the Owl Cluster (NGC 457). Astronomy: Richard Talcott and Roen Kelly


Open cluster M52 in Cassiopeia looks great on its own, but be sure to scan the surrounding area for other nice star patterns. Anthony Ayiomamitis

Let's go deeper into the constellation by following the zigzag path along the Cassiopeia five-star W to Ruchbah (Delta [ $\delta$ ] Cas), at its lower-left corner. Aim half a binocular field to the southwest of Ruchbah toward 5th-magnitude Phi ( $\phi$ ) Cas. You'll see a second fainter star just to Phi's southwest as well as a tiny smear of dim starlight to the north. Together, they form the Owl Cluster (NGC 457). The two brightest stars mark the owl's eyes, while the fainter suns outline its body and outstretched wings.

Next, let's stop by open cluster M103, located on the other side of Ruchbah. My $10 \times 50$ s show this group as a small triangular patch of starlight nestled in a pretty Milky Way field. I can make out four or five separate stars here. The rest of its 170 members pool their faint light to create what looks like a tiny arrowhead. Others think M103 resembles a hand-held fan.

## DECEMBER

## Visit the Andromeda Galaxy and the Pleiades

Welcome to the end of the year and a great binocular target: the Andromeda Galaxy (M31). To find M31, first locate the star Alpheratz (Alpha [ $\alpha$ ] Andromedae). From Alpheratz, slide about one binocular field northeast, to the faint star Delta ( $\delta$ ) And, then another field farther northeast to Mirach (Beta [ $\beta$ ] And). Take a sharp right turn northwestward, first stopping at $\mathrm{Mu}(\mu)$ Andromedae and then onward to $\mathrm{Nu}(v)$ Andromedae.

Finally, look just northwest of Nu for a dim, elongated blur. It may not look like
much at first, but you've found the Andromeda Galaxy, the combined light of several hundred billion suns.

Binoculars show it as a broad oval smudge of grayish light highlighted by a prominent core. From a dark rural location, you can see the full span of the extensive spiral-arm disk. M31 reaches out as far as $5^{\circ}$ - that's as wide as 10 Full Moons stacked side by side!

You can spot M31's two largest satellite galaxies through binoculars, although each will push your limits. The smaller and brighter of the pair, M32, is a starlike patch due south of M31's core. The second companion, NGC 205, is larger, fainter, and more difficult to observe. Look for it to the north of M31's core, about twice as far as M32.

Next, we come to my favorite binocular open star cluster: the Pleiades (M45). Is there any object more beautiful than the sapphire-blue stars of the Seven Sisters glistening through binoculars?

The Pleiades holds many double and multiple stars. For instance, Atlas and Pleione form a wide pair in binoculars, while Asterope is a pair of easily observed 6th-magnitude stars.


The Pleiades (M45) is one of the sky's finest binocular targets. You'll spot several dozen stars here and, if your sky is dark, perhaps even the Merope Nebula (NGC 1435). chris schur

On a clear evening, you may see a hint of faint interstellar dust surrounding some of the brighter stars. The brightest portion of the Pleiades nebulosity, NGC 1435, encircles Merope and extends south. Many stargazers are fooled into thinking they've seen the nebulosity when they notice a bright glow around each of the brightest Pleiades.

What they are really seeing is starlight scattering inside their binoculars. To make sure you're glimpsing the real thing, check the nearby Hyades open star cluster. If you also see nebulosity there, where there is none, then your binoculars are fogged or need cleaning.


Many observers list the Andromeda Galaxy (M31) as their favorite deep-sky object. It ranks as the brightest galaxy north of the celestial equator. You can see it - and two of its fainter companion galaxies M32 and NGC 205 - through binoculars from a dark site. Astronomy: Richard Talcott and Roen Kelly

