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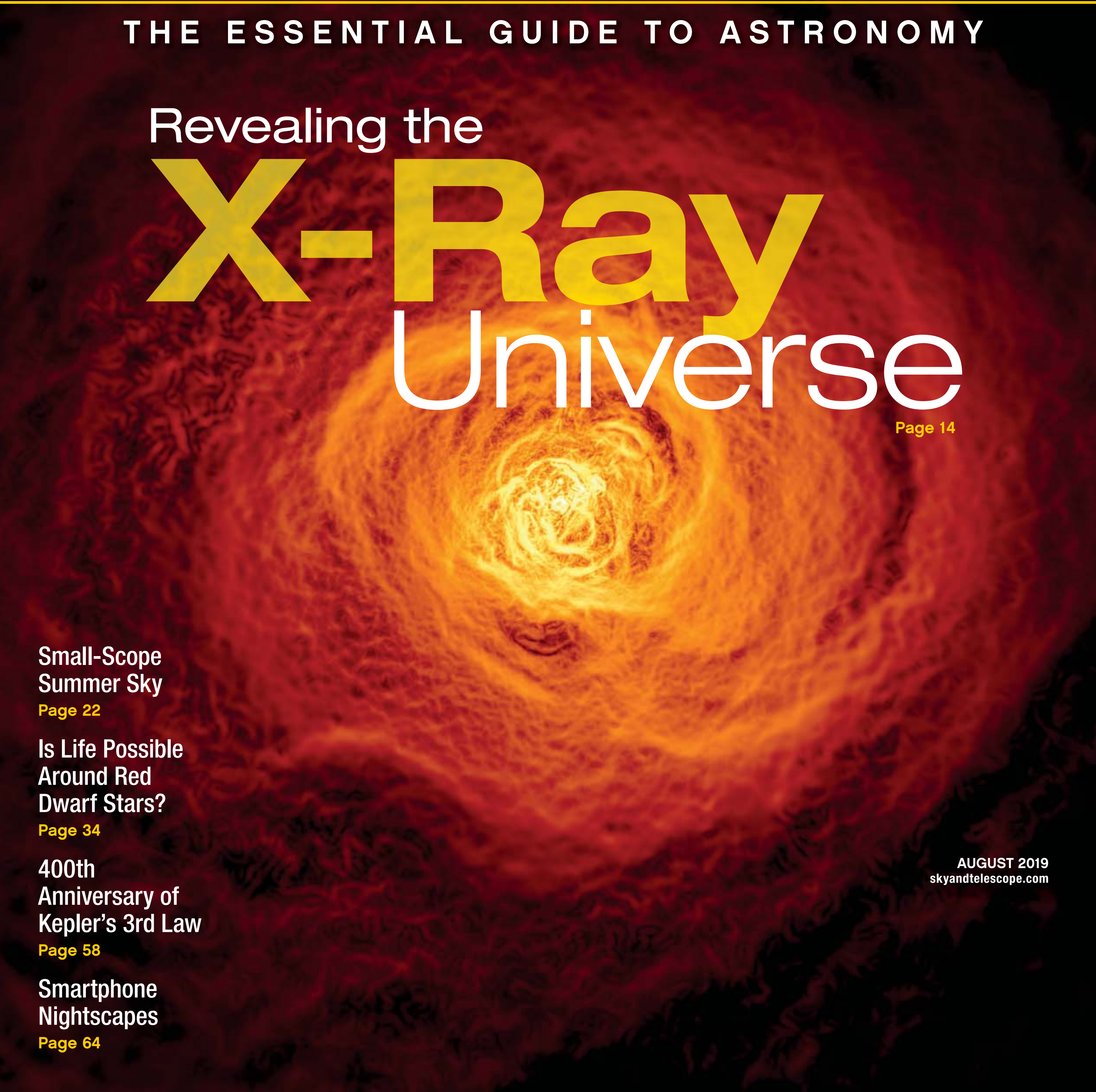
THE ESSENTIAL GUIDE TO ASTRONOMY



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During his investigations of the structure of the atom in the early 20th century, the brilliant physicist and Nobel Prize winner Ernest Rutherford worked in a ramshackle lab with a limited budget. Although competing against far better-funded researchers, Rutherford remained undeterred and resourceful, and inspired his colleagues with a simple declaration: "We haven't got the money, so we'll have to think."

A practical man, Rutherford embraced the constraints of his situation and turned them to his advantage. In amateur astronomy, deep-sky visual observers with small telescopes face their own constraints, especially light-gathering capability. When you have a big 18-inch Newtonian, for example, the universe is yours. You can choose from thousands of objects which to observe, hundreds of which will appear big, bright, and spectacular. When you plan an observing session, you can have your pick from an embarrassment of celestial riches. In a smaller telescope, all these sights will look dimmer and most will appear less impressive — if they're visible at all. Dedicated deep-sky observers with small telescopes might echo Rutherford's challenge and say, "We haven't got the aperture, so we'll have to think."

Aside from being lightweight and easy to handle, a small telescope has one big advantage over a larger instrument: It has a much wider field of view. For example, a small telescope, say a refractor or Newtonian reflector with a focal ratio of f/6 or f/7 and a focal length of 480 mm to 700 mm, along with a 1.25-inch 24-mm eyepiece with an apparent field of view of 68°, provides a generously wide true field of 2.3° to 3.4°. Move up to a 35-mm eyepiece of the same design with a 2-inch barrel and you get a true field of view of 3.4° to 5°. With this sort of field, dark skies, and with a little planning, it's just a matter of finding beautiful deep-sky objects — and especially groupings of objects — that not only look magnificent in such a small scope, but actually look better than in a larger instrument. There are many such groupings to find in the night sky, enough to keep you engaged for a long time, especially in the relatively rich skies of northern summer.

Small-Scope Summer

Embrace the constraints of a small instrument for deep-sky observing this season.

BRIAN VENTRUDO

Clusters and Supergiants in Scorpius

Turn a small scope towards the widest part of the summer Milky Way in Sagittarius and Scorpius, for example, and it's hard not to see something good.

Start with the region around the red supergiant star **Alpha (α) Scorpii** (Antares) at the heart of the constellation Scorpius. Center your field of view between Antares and the star Sigma (σ) Scorpii and you'll see within a 2° field the colorful supergiant as well as two globular clusters, all set against a rich tapestry of stars along the Milky Way. The brighter cluster, 6th-magnitude **Messier 4**, is a little more than 1° west of Antares. At a distance of 7,200 light-years, this relatively loose cluster, noted for its central bar that runs north-south, is one of the nearest such objects to Earth. Look about ½° northwest of Antares to glimpse the 10th-magnitude globular cluster **NGC 6144**, a somewhat challenging object to see because of the glare of Antares and its distance of around 30,000 light-years. To the north, in the same field, the stars eerily drop off to near darkness as a result of an inky foreground dark nebulosity. You can't take all this in at a glance with a big reflector.

If you can manage a 4° field of view, you can capture the splendid, widely spaced triple star **Rho (ρ) Ophiuchi**, north of the dark nebula Barnard 44, in the same field as Antares and M4. In dark sky, the reflection nebula **IC 4604** appears as a ghostly wisp surrounding Rho. About 2° west-northwest of Rho lies the globular cluster **M80**.

Move eastward and southward in Scorpius and you arrive at the dazzling open clusters **M6** and **M7**. These objects are a little too far apart to fit in a single field of view in most small telescopes, but each is large enough to frame nicely in a 2° field that's bejeweled with stars. M6, the Butterfly Cluster, is the smaller of the two clusters. The larger and more impressive M7, sometimes called Ptolemy's Cluster, is nearly 1½° across. Observe each of these galactic clusters with an 80-mm extra-low dispersion (ED) refractor on a night when the sky over the southern horizon is particularly clear, and you'll recall why you became a stargazer in the first place.

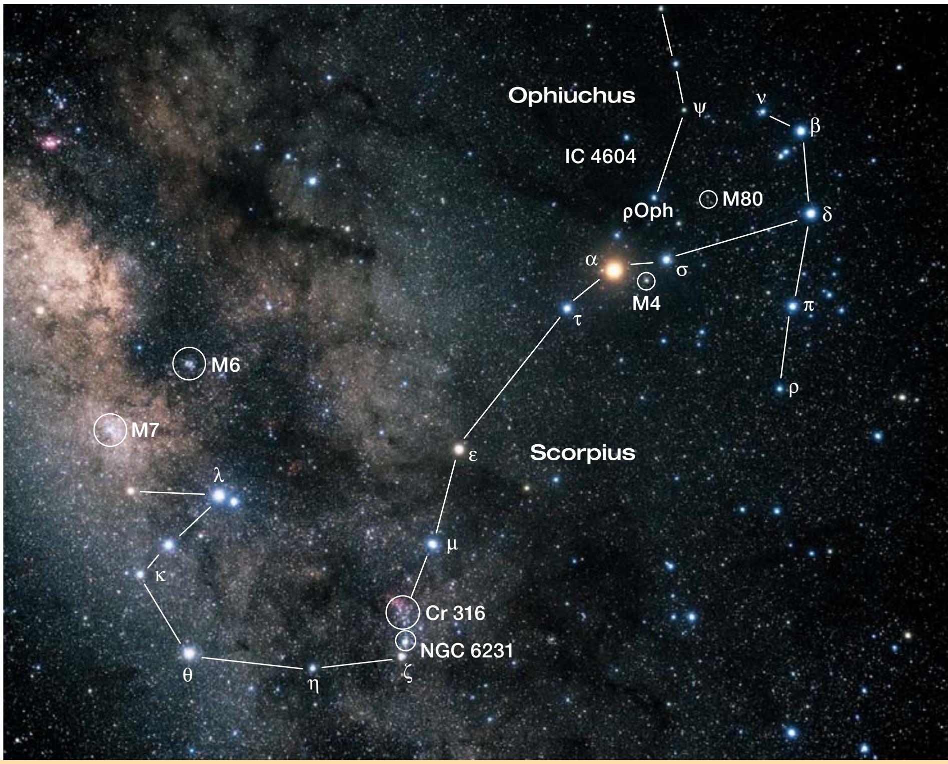
Farther south in Scorpius lies another lovely grouping of faint stars that appears to emanate northward from the star **Zeta (ζ) Scorpii**. The striking gauzy appearance of this nearly 2°-long assembly to the unaided eye has led many stargazers to call it the **False Comet**. Were it not so far south, it would surely have made Messier's list; it's hard to find a more comet-like apparition in the entire sky.

Turn a small telescope toward the False Comet and the region explodes into a profusion of relatively young, blue-white supergiant stars. At the southern end, Zeta Sco is a wide optical double, easy to split in binoculars. The fainter of the two components, 5th-magnitude Zeta^1 Sco, is one of the intrinsically brightest stars in the galaxy with a luminosity of nearly one million Suns. Just north of Zeta^1 lies **NGC 6231**, a tiny open cluster that makes up the head of the False Comet. Sometimes called the Northern Jewel Box, NGC 6231 lies at a distance of about 5,200 light-years and is packed with big, blue supergiant stars. If NGC 6231 lay at the same distance as the Pleiades from Earth, it would appear roughly the same size as that cluster, but its stars would be some 50 times brighter, with some as bright as Sirius!

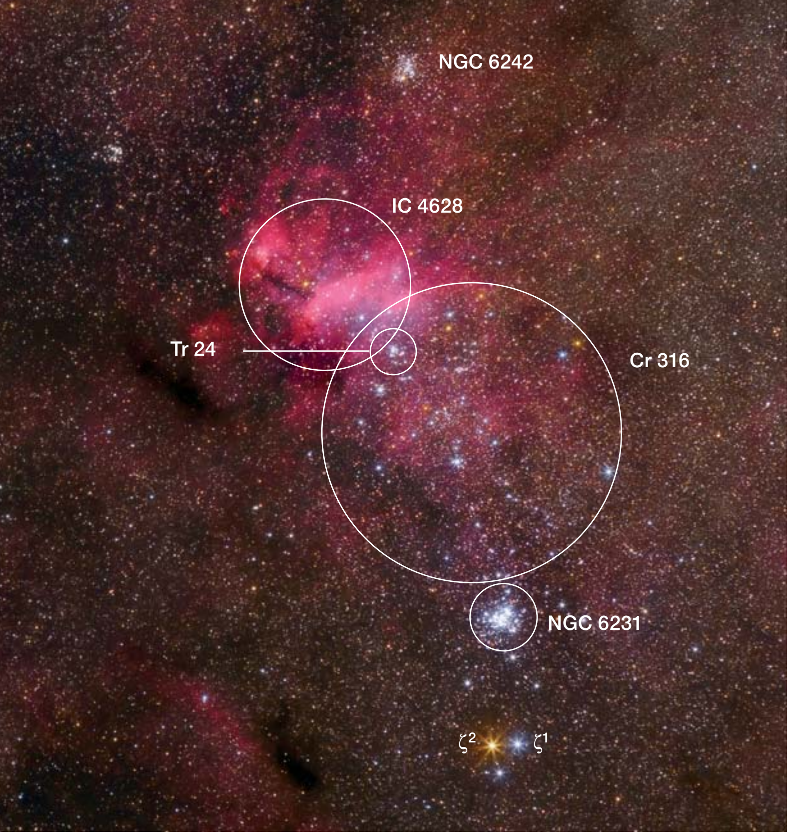
Move north-northeast of NGC 6231 and in the same 2° field of view you see the looser open clusters **Trumpler 24** and **Collinder 316**, which make up the "tail" of the False Comet. Together, these objects form one of the finest fields in the sky, but one that's difficult to see from the middle latitudes of the Northern Hemisphere because of its declination of about –42°.

Turn a small telescope toward the False Comet and the region explodes into a profusion of relatively young, blue-white supergiant stars.

▼ A RICH FIELD The region of Scorpius is rich with deep-sky sights. That it crawls so close to the southern horizon for observers at mid-northern latitudes can be frustrating. Any clear summer night is a good night to observe, but still, transparent skies will offer the best looks. Try to time your session for when the target stands at its highest.

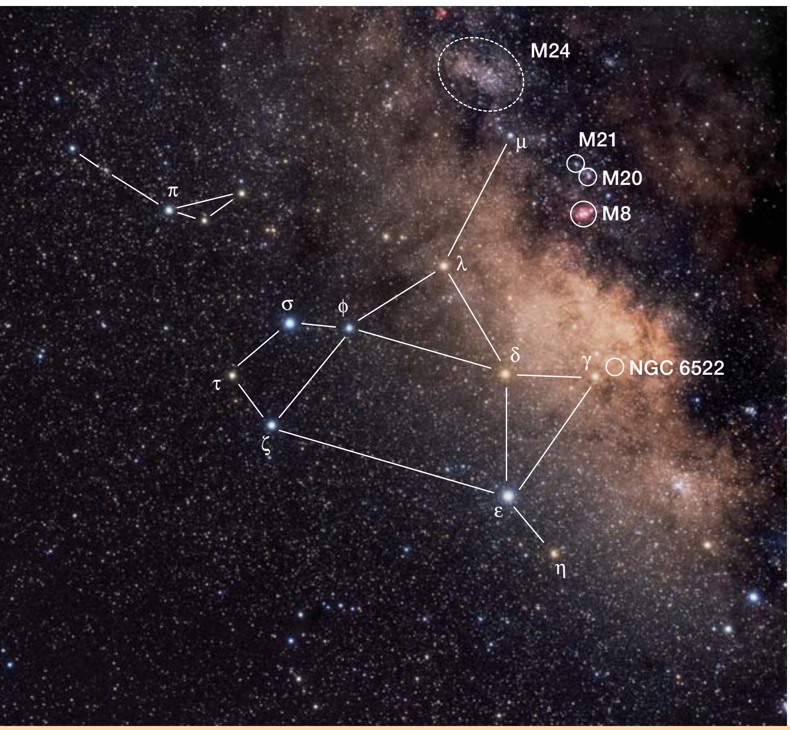


AKIRA FUJII



▲ **FALSE COMET** The curl of the Scorpion's tail cradles a stunning collection of deep-sky objects. NGC 6231, Trumpler 24, Collinder 316, and IC 4628 combine to mimic the appearance of a comet passing through the southern sky.

▼ **LOOK INSIDE** The spout of the Teapot asterism of Sagittarius points to a portal to the universe — or at least, a portal to our galaxy. Baade's Window, a piece of sky unobscured by dust or gas, allows astronomers to look some 25,000 light-years back toward the galactic center. The opening surrounds the globular cluster NGC 6522, which glimmers next to Gamma Scorpii.



Surfing the Star Fields of Sagittarius

While Scorpius is a delight, Sagittarius is even better. Look about ½° northwest of Gamma (γ) Sagittarii, the star that marks the tip of the spout of the Teapot asterism of Sagittarius. Center your gaze on the faint smudge of the 10th-magnitude globular cluster NGC 6522. Within a region about 1½° across that surrounds the cluster, you can look through **Baade's Window**, a break in the dark, sooty clouds of the Milky Way that offers a clear view for some 25,000 light-years just south of the galactic center. These are some of the most distant stars you can see in our galaxy. While this area is arguably more appealing in a larger instrument, seeing a slice of the central core of the Milky Way with a 3- or 4-inch instrument makes for an inspiring stop on this tour.

Now move 6.5° north of Gamma to center your field on **M8** and **M20**, two naked-eye emission nebulae better known as the Lagoon Nebula and the Trifid Nebula, respectively. Here, within a single 3° field of view, are assembled a half dozen lovely deep-sky sights. The most obvious is the Lagoon Nebula. Within the brighter and larger western half of its luminous cloud shines the 6th-magnitude star 9 Sgr. Across the gulf created by the dark nebulae Barnard 88 and Barnard 296 lies the fainter half of the Lagoon, which partly shrouds the newly minted star cluster NGC 6530, the hot, young stars of which set the nebula aglow.

The Trifid Nebula lies just 1.5° north of the Lagoon complex. It's smaller and less distinct than the Lagoon but spectacular nonetheless. The Trifid gets its name from the dark cloud Barnard 85, which appears to split the nebula into three sections (*S&T:* June 2016, p. 57). This trifurcation is visible in small scopes, although it takes a little effort and patience to see. A nebula filter, one with a relatively broad bandwidth around the O III and H-beta bands, can improve the contrast of the emission nebulosity without dimming the stars too much. The Lagoon Nebula is about 4,100 light-years away, but the Trifid may be almost twice as far, with current estimates reaching as high as 9,000 light-years. Both lie in a rich star-forming region of the Milky Way.

Without repositioning your field of view, look northeast of the Trifid to find the relatively loose open star cluster **M21**. This cluster is often passed over in favor of M8 and M20, but it's a fine object in a glittering field. Look also for the group of 6th- and 7th-magnitude stars connecting M20 with M21. This asterism is sometimes called Webb's Cross after Reverend T. W. Webb, the 19th-century amateur astronomer who first noted it. The cross has its base in the Trifid Nebula and its head in M21. The somewhat crooked arms stick out in a southeast-northwest direction.

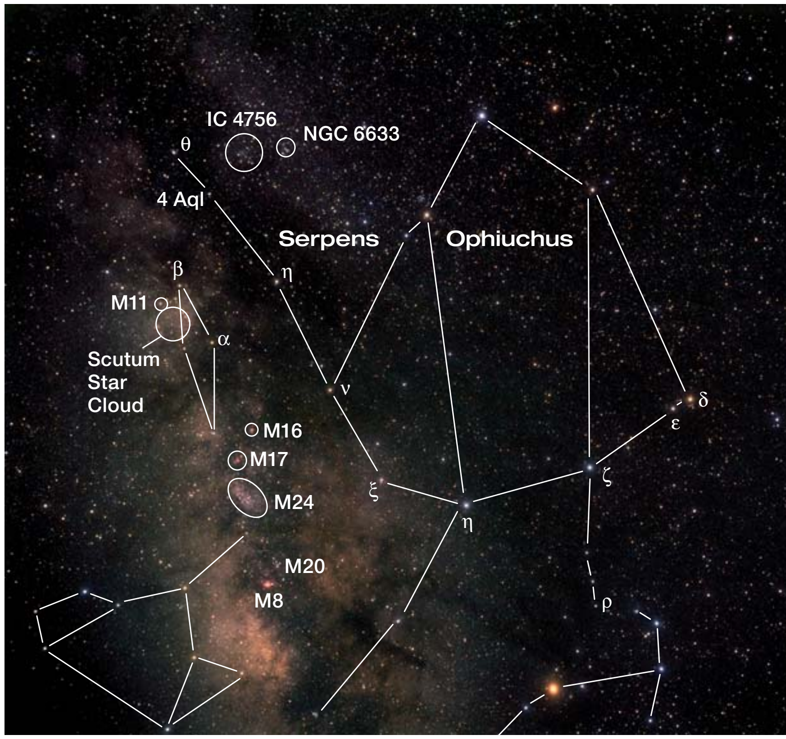
While it's not a star cluster, nebula, or galaxy, **M24**, the Small Sagittarius Star Cloud, must surely rank high on any list of the best sights for a small telescope. M24 appears as a bright patch of Milky Way about 2° north of Mu (μ) Sagittarii at the top of the Teapot, and it spans an oval region

FALSE COMET: LORAND FENYES / STOCKTREK IMAGES / GETTY IMAGES; SAGITTARIUS: AKIRA FUJII roughly 1° × 2° in size, ideal for any small telescope and a low-power, wide-field eyepiece.

Like Baade's Window, the shimmering M24 complex appears as a result of a gap in the dark galactic dust clouds, affording us a clear view more than 9,000 light-years into the Sagittarius Arm of the Milky Way. If there were no dust or cold gas, the entire Milky Way from Cygnus to Scutum and into Sagittarius (and beyond into Centaurus and Crux in the Southern Hemisphere) would appear as bright and luminescent as M24, more than bright enough to cast shadows on a dark night. The individual stars in M24 range from magnitude 6 down to invisible in a small telescope. The cloud takes on a three-dimensional quality in a good scope and steady seeing, and some observers see the aggregate color as blue or even green. If you have a very dark sky, look for the small oval dark nebulae Barnard 92 and Barnard 93 on the north edge of the cloud. You could spend an entire night examining M24, and it would not be a wasted night.

The Northern Summer Milky Way

Moving northward from M24, pause to take in **M17** (the Swan Nebula) and **M16** (the Eagle Nebula). The pair is separated by about 2.3° of sky, so you need a good 3° field of view to frame them well. Initially, they may not seem as impressive as the Lagoon and Trifid, but patient observers with pristine sky are rewarded with a glimpse of the shape and structure of these distant star factories.



▲ **MOVING NORTH** Follow the spangled course of the Milky Way from the Teapot in Sagittarius through Scutum to the tail of Serpens Cauda. Gently nudge your field of view northwest of Theta Serpentis to find the broad open cluster IC 4756.

AKIRA FUJII

Observations and Discoveries with Small Scopes

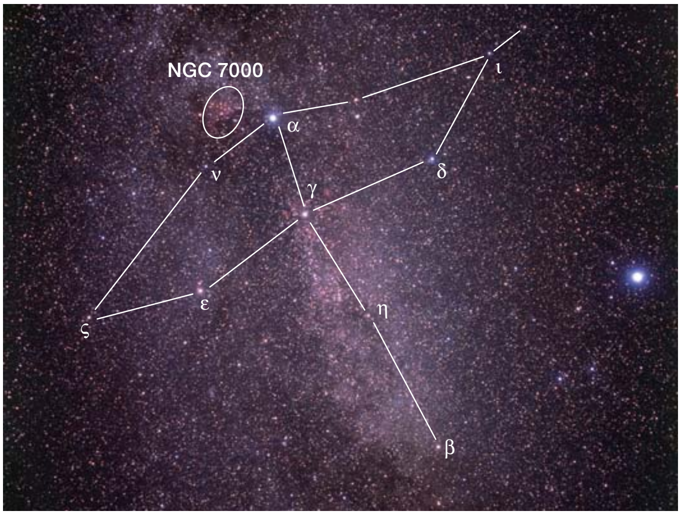
Until the late 18th century, most astronomical discoveries were made with small telescopes, usually long-focal-length refractors with apertures of less than three or four inches. The biggest moons of Jupiter were discovered by Galileo and Simon Marius in 1610 with 1-inch refractors. Christiaan Huygens discovered the rings of Saturn and the planet's largest moon, Titan, with a 63-mm refractor, which he often stopped down to 35 mm. William Herschel discovered the planet Uranus with a 6-inch reflector, but he might as well have used a smaller telescope because Uranus is relatively bright.

And, of course, there were the comet hunters and pioneering deep-sky observers. Charles Messier and Pierre Méchain discovered 21 comets between them, along with dozens of objects that now comprise the famous Messier List. They used 4-inch (or smaller) refractors. Even after Herschel made an exhaustive catalog of the deep sky, subsequent observers continued to discover a few deep-sky stragglers. The 6th-magnitude reflection nebula NGC 1333 in Perseus, for example, was overlooked by Herschel, but discovered in 1855 by the German astronomer Eduard Schönfeld with a 3-inch refractor.

In the 20th century, the pace of discovery with small telescopes slowed but didn't stop. Patrick Moore's first research paper, about craterlets on the Moon observed with a 3-inch refractor, was published when he was still a teenager.

Many comet hunters through the 20th century favored small, wide-field telescopes. Famed comet hunter Minoru Honda honed his craft with a 3-inch refractor he built from a discarded lens. His first observations were made from a battlefield near Singapore during World War II while his fellow soldiers slept. His work inspired a generation of Japanese comet hunters armed with small instruments. A little luck aided some discoveries: In 1983, George Alcock discovered Comet IRAS–Araki–Alcock (C/1983 H1) with a pair of 15×80 binoculars while kneeling on the floor of his home and looking through a double-paned window.

Serious observation and discoveries with small scopes continue to the present day. In 2004, amateur astronomer Jay McNeil discovered a variable nebula with a 3-inch refractor and CCD. The nebula waxes and wanes due to outbursts from an active protostar. In 2016, Giuseppe Donatiello discovered a dwarf spheroidal galaxy some 10 million light-years away with a 5-inch refractor and CCD. Amateur Donald Bruns used a 4-inch refractor to detect the deflection of starlight predicted by Einstein's general theory of relativity, improving on the 1919 measurement by Sir Arthur Eddington (*S&T:* Aug. 2018, p. 22).



◀ **CONTINENTAL CLOUD** The emission nebula NGC 7000, familiarly called the North America Nebula, is about 120 arcminutes across. This makes it too big to fit into the field of view of all but the widest of wide-view telescopes, but it's a great binocular object.

Continue north-northeast to find yet another gap in the dark interstellar soot. Look for the tight knot of the open cluster M11, the Wild Duck Cluster, about 2° from Beta (β) Scuti. This attractive cluster marks the northern edge of the **Scutum Star Cloud**, a dazzling, hammer-shaped agglomeration of stars that appears as an offshoot of the immense dark nebulosity of the Great Rift that bisects the Milky Way. Visible to the naked eye, the cloud is about 1.5° across and is surrounded by large and small patches of dark nebulae.

About 5° north of the celestial equator and 4½° degrees northwest of Theta (θ) Serpentis, look for **IC 4756**, one half

LIGHTED LACE The Veil Nebula is usually considered a target for large telescopes. While it's true that it takes aperture and magnification to reveal the nebula's structure, a small scope equipped with a nebula filter can capture the brighter parts of the cloudy complex.

CYGNUS: AKIRA FUJII; VEIL NEBULA: NASA / ESA / HUBBLE HERITAGE (STSCI / AURA) / DSS2 / J. HESTER (ASU) / DAVIDE DE MARTIN (ESA) of a pair of splendid open clusters. Its partner in light, **NGC 6633**, shines about 3° beyond it. To frame both clusters in the same field requires at least a 4° field of view, but if you can manage it, you'll be rewarded with an impressive sight in a busy but beautiful part of the sky. IC 4756 is by far the larger of the two clusters, spanning at least 1° in an already rich field. This may explain why many early deep-sky cartographers with narrow-field instruments passed it by. Messier missed it, and even the venerable *Norton's Star Atlas* didn't include this sprawling cluster.

Just 3° northwest of IC 4756, NGC 6633 is tighter and easier to distinguish from the background field. It's arguably more beautiful as well, with a thick bar that runs northeast to southwest. Both NGC 6633 and IC 4756 are at least 600 million years old, old enough to have evolved a few colorful stars. NGC 6633 lies about 1,000 light-years away. IC 4756 is more distant at 1,300 light-years, which means their difference in size is real.

▲ **A MISNOMER** Although this wispy section of the Veil Nebula is named after Edward Charles Pickering, director of the Harvard College Observatory from 1877 to 1919, it was actually discovered photographically in 1904 by Harvard computer Williamina Fleming.

As was the case with Sagittarius, when you aim a wide-field scope toward the constellation Cygnus, it's hard not to see something pleasing to the eye, especially in the **Cygnus Star Cloud** between **Beta Cygni** (Albireo) and Gamma Cygni (Sadr). Albireo itself, a colorful and easily split double, is set against a glittering background of stars. Just east of Alpha Cygni (Deneb), at the tail of the celestial swan, lies **NGC 7000**, the North America Nebula, which is just a little too wide to frame in all but the widest-field telescopes.

And then there's the **Veil Nebula**, as intricate and sublime a sight to be found anywhere in the northern sky. A sprawling remnant of a star that detonated as a supernova some 8,000 years ago, the Veil is a rewarding target with any good telescope, large or small. The entire complex, known as the Cygnus Loop, consists of three main sections. The eastern Veil is a long braided arc composed of two bright segments, **NGC 6992** and **NGC 6995**. **NGC 6960**, which comprises the western Veil (sometimes called the Witch's Broom), is more linear and clearly bisected by the 4th-magnitude foreground star 52 Cygni. Eastern and western elements fit in a 4° field and are visible in a small telescope in pristine, dark sky. A nebula filter with a generous passband helps. Between these two extremities, at the north end of the Loop, lies **Pickering's Triangle**, a much more challenging sight. A small scope reveals little of the famous braided texture in each segment of the Veil Nebula; that's a job for a larger instrument. But only a small, wide-field scope can give you an expansive view of the entire complex.

There are plenty more deep-sky arrangements and groupings for a small telescope in the summer months, and dozens more on the autumn and winter side of the sky and in the Southern Hemisphere. And while this tour may not cure you of aperture fever, it might help you embrace the constraints of small optics and think more expansively about what to look for in the deep sky. Hopefully I've given you some ideas and inspiration to seek out celestial sights and vistas that are not only passably observable in a small telescope, but are actually more beautiful and accessible than in a larger instrument. It's a big universe, and even with a little telescope, there's a lot to see.

■ **BRIAN VENTRUDO** is a writer, scientist, and longtime amateur astronomer. Although he never turns down a look through a big Dobsonian, he usually observes with smaller telescopes from the relatively dry and clear skies of Calgary, Canada. Brian writes about astronomy and stargazing at his website **CosmicPursuits.com**.

Wide-field Observing Tips

To get the best possible view with a small scope, you need to maximize the amount of light coming through the eyepiece while minimizing light from other sources. Avoid light pollution and follow these suggestions.

1. Make sure your optics are clean, especially your eyepieces. Remove the oil and dust and other deposits, especially on the eye lens and filters. A little dust on your objective lens won't hurt, however.
2. Ensure your observing eye is completely dark-adapted and make sure it stays that way during your observing session.
3. Use averted vision to expose the most sensitive part of your retina.
4. If you use a filter, make sure it has a relatively broad bandwidth (20–30 nm) around the H-beta and O III lines around 500 nm.
5. Wait until objects are near the meridian, their highest point in the sky, so their faint light passes through less of Earth's atmosphere. It also helps to observe on nights of low humidity and high atmospheric clarity to minimize the scatter caused by dust and water vapor in the atmosphere.