NOVEMBER/DECEMBER 2022

SkyNews

WHERE EARTH MEETS SKY

Stars of fall
Tour the autumn skies with your binoculars

Heavens revealed
Celestron opens skies with new telescope

Whither the Wonder of Jena?
World's first Zeiss planetarium: 100 years later

JAMES WEBB SPACE TELESCOPE

GATEWAY TO THE UNIVERSE

ASTRONOMY'S FAVORITE TRACKING MOUNT — BACK IN STOCK

SKY-WATCHER'S STAR ADVENTURER 2i PRO PACK IS BACK JUST IN TIME FOR THE HOLIDAYS...AND ECLIPSES

After the last two and a half years of pandemic and the related supply chain delays, we could all use some good news. And we have some! Sky-Watcher's immensely popular Star Adventurer 2i multi-function tracking mount is back in stock, and not a moment too soon.

With the holidays fast approaching, now is the perfect time to get your hands on this versatile little mount. Whether you're interested in visual observing, long exposure astrophotography, or creating stirring time-lapse videos of the night sky, the Star Adventurer 2i is a superb addition to your small optics setup. The longer winter nights will reward you.

Also looming large on the calendar are the solar eclipses criss-crossing over the U.S. in 2023 (annular) and 2024 (total). With its dedicated solar tracking mode, the Star Adventurer 2i is the ideal solar eclipse travelling companion to join your journey to totality. It's the perfect platform to capture one of the best shows in the solar system. The next total solar eclipse in the U.S. won't be for another two decades!

Star Adventurer 2i Pro Packs include the tracking mount, Dec bracket, latitude (EQ) base, and counterweight kit.

Contact your preferred, authorized Sky-Watcher dealer or visit www.skywatcherusa.com for more details.

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SkyNews

NOVEMBER / DECEMBER 2022
VOLUME 28, ISSUE 4

Gateway to the Universe

Learn how the James Webb Space Telescope is cutting through visible light with a Canadian edge. By **Vincent McDermott**.

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DEPARTMENTS

FEATURES

ON THE COVER: The James Webb Space Telescope's image "Cosmic Cliffs" highlights NGC 3324, the star-forming region about 16 light-years across in the Carina Nebula. The picture, which was one of the first released using data captured by the telescope, shows a portion of the nebula that stretches over 7.3 arcminutes in our sky. (NASA, ESA, CSA, and STScI)

By Allendria Brunjes

A meteor flashes through the heart of Cygnus (the Swan) at the zenith and flares green beside Fawaris (Delta Cygni), in the bird's left wing. Taken at the Saskatchewan Summer Star Party at Cypress Hills Interprovincial Park on August 26, 2022. (Stephen Bedingfield)

Back to basics

WHAT A GORGEOUS, star-studded year this has been.

As 2022 began, my wee little 80mm refractor telescope gave new astronomers the chance to see things they'd never seen before — the Orion Nebula from a deck in Mattawa, Ontario; Saturn and Jupiter from parking lots in Toronto; and the Moon on numerous occasions from backyards and farms in between. These were all objects I'd observed on my own while working on the The Royal Astronomical Society of Canada's Explore the Universe program, and I was happy to help others find them, too.

This summer, for the first time, I located and observed the Andromeda Galaxy with my naked eye and through my binoculars, while perched on a pink granite rock on the edge of Georgian Bay near Killarney, Ontario. This galaxy is one of the first objects I ever saw through a telescope. Many years ago while taking RASC's New Observers to Visual Astronomy (NOVA) course, I caught a glimpse of our galactic neighbour after a York University student slewed one of the institution's massive telescopes to it.

This year, I carried my copies of *SkyNews* along with me wherever I went. I followed Alan Dyer's summer binocular tour (in the July/August 2022 magazine) while on an epic canoe trip in Temagami, Ontario. I also did a good chunk of his autumn binocular tour — on Page 32 — while editing this issue. The targets were still rather low in the sky, but I was delighted by the Perseus Association and dismayed by the trees blocking Kemble's Cascade (a target that Chris Vaughan also mentions in our July/August 2022 issue).

Speaking of Chris Vaughan — this summer, he and I met in person for the second time. He set up a Celestron StarSense Explorer 10-inch Dobsonian, which he reviews on Page 18, and gave me a quick tour of the easy-to-use scope in front of the David Dunlap Observatory in Richmond Hill, Ontario.

The James Webb Space Telescope, featured in an article starting on Page 40, made many of us starry-eyed about what the future of space science holds. Returning to parties and social gatherings this summer, whenever people I met found out where I worked, they lit up describing their first glimpses of Webb's first deep field, the Carina Nebula and Stephan's Quintet.

Now, as we sit on the precipice of the Artemis missions, Randy Attwood looks back on Page 12, at the Apollo program and the 50th anniversary of its last mission launch.

With all this in mind, as we close the year, I reflect on all that RASC makes available to people interested in astronomy and how that knowledge can reverberate outward from each of us. It really is astounding, and it's wonderful to see such interest in the Universe that hosts our little planet. ✶

SkyNews

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ADVERTISER DIRECTORY

AFTER TWO YEARS AS A SUBSCRIBER of *SkyNews* magazine, it's time to write a few words to the editors.

First of all, thank you for the nice and useful magazine. I learned a lot of my knowledge in astronomy from *SkyNews* (since I'm not using the web much).

The first time I read about astrophotography in *SkyNews*, I thought that I would probably never even try it. But last night I tried.

Since I'm in the Laurentians these days, far from the city, I checked a light-pollution map for a darker area, and I found one within a 20-minute drive. I went with my 12-year-old daughter and took along my Canon G 7X camera, tripod and binoculars.

It was impressive to see the Milky Way for real. We were able to see it clearly for the first time.

I took some gorgeous pictures — as a beginner — and attached a few of them.

Also, I was able to find the Kemble's Cascade, which I learned about in the latest *SkyNews*, in the article by Chris Vaughan ("Canada in the stars," July/August 2022).

So thank you to all the editors.

Leo Weiss
Montréal, Québec

AFTER READING CHRIS VAUGHAN'S ARTICLE "Canada in the stars" in the July/August *SkyNews*, I was inspired and decided to capture the Tulip Nebula. I wrote an article on my blog where I mentioned both Chris and *SkyNews*.

The scope was an Explore Scientific ED80CF APO refractor, on a Celestron AVX mount. The imaging camera was a ZWO ASI533MC PRO (cooled at -10 C), with Optolong L-eXtreme filters.

Total integration time was just one hour (20 × 180 seconds, plus dark, flat and bias).

Claudio Oriani
RASC Toronto Centre

Read Claudio Oriani's full post about this image.

Chris Vaughan is a public outreach and education specialist at AstroGeo and an operator of the David Dunlap Observatory telescope.

Brian Ventrudo is a writer and amateur astronomer. He writes about astronomy and stargazing in his blog CosmicPursuits.com from his home in Calgary, Alberta.

Alan Dyer enjoys stargazing and testing telescope gear from his rural home in southern Alberta. If you are looking to contact him, visit AmazingSky.com.

Vincent McDermott is an award-winning journalist covering the oil industry, the environment, Indigenous issues and politics in Fort McMurray.

David A. Rodger was the first director of Vancouver's H.R. MacMillan Planetarium, and served in that capacity from 1967 to 1980. He is a life member of RASC.

Randy Attwood is an amateur astronomer and space exploration historian. He is the former executive director of The Royal Astronomical Society of Canada.

THE TWO MOST RECENT ISSUES of *SkyNews* are terrific! I really liked the astronaut interviews with Joshua Kutryk (May/June 2022) and Bob Thirsk (July/August 2022), and I hope these interviews might become an ongoing regular feature.

In particular, I was glad to see Joshua Kutryk talk about the role of Canadian satellites in tackling climate change. In addition to RADARSAT and the planned WildFireSat mission, my employer GHGSat has an operational constellation of six microsatellites that are monitoring greenhouse gas emissions around the world. GHGSat's three newest satellites, Luca, Penny and Diako, were launched in May (all of our satellites are named for the children of employees), and we plan to have ten satellites in space by the end of next year.

Eric Choi
Toronto, Ontario

SEPTEMBER/OCTOBER WAS CHOCK FULL of great stuff! The cover just grabs the reader, and the articles keep our interest all the way through. I have a couple of more specific comments.

The QR codes (for example, on Pages 6, 7 and 9) are a fabulous feature for print readers like me. I don't have the patience to type in the long URLs, but with a click of my phone or iPad, I can follow up on more detailed info. Please use lots!

The Nerd Anomaly cartoon on Page 5 hits the spot with respect to the Event Horizon Telescope images. I asked myself, "Why do they look so blurry?" None of the articles I've read so far about these amazing images explain the blurriness. Is this what the black holes actually "look" like? Another possibility: the angular size of the black hole event horizon is incredibly tiny, so instead, maybe the blurriness is an artifact of the imaging, the same way a small telescope looking at Jupiter can't show the detail of Hubble or Galileo images. Can you find someone to ask? By the way, thanks for devoting a whole page (44) to the awesome image itself.

Michael Attas
Pinawa, Manitoba

We asked Nathan Hellner-Mestelman, the comic artist, for his view on the question. Here's his response:

The Sagittarius A* and M87 black hole images were both taken by the Event Horizon Telescope, which consists of many telescopes around the world. There's a rule that the wider your telescope aperture is, the higher the resolution you can get. That's why things look clearer with a 10-inch telescope than a two-inch one. The EHT sort of "hacked" the system, and created an aperture the size of our whole planet by putting telescopes around the world and using them all as if they were one giant telescope. Despite all that, the resolution was only enough to resolve the black holes as fuzzy circles. Still, it's impressive; the angular size (apparent size in the sky) of Sagittarius A* was only a dozen micro-arcseconds, which is equivalent to observing an orange on the surface of the Moon. I haven't managed to convince the EHT team to observe that yet.

I ENJOYED READING CHARLES O'DALE'S "Lasting Impacts" article in the July/August issue.

Concerning the Charlevoix crater, he notes that half of the crater is missing and describes this as a "mystery still unsolved." In fact, the missing half has been pushed under the Appalachian tectonic plate. There is a major fault, called the Logan fault, which runs along the St. Lawrence River, from Sept-Îles to Montréal. West of the fault, you are on the Canadian Shield. East of the fault, you are into the Appalachian province, as geologists call it.

There is a very interesting information centre in La Malbaie called L'Observatoire de la géosphere de Charlevoix, with a scaled version of the crater. This centre also has a good selection of meteorites on display, including shatter cones from the Charlevoix crater. It is open during summer months and staffed by science students from the nearby CÉGEP.

A small note: driving time from Québec City is an hour, not four as mentioned. Finally, in the photograph, I can see where I live and where my observatory is located. I believe that the Charlevoix crater is the only crater on Earth where people actually reside.

Hugues Lacombe
Baie-Saint-Paul, Québec

CHARLES, I HAD TO WRITE TO CONGRATULATE you on the article you wrote for the summer issue of *SkyNews* ("Lasting impacts," July/August 2022). It is chock full of info and fine pictures and shows what passion you have for the subject of terrestrial impact craters. Sorting by boat/non-boat is a great way to categorize the ones you highlighted. My only "criticism" (not really) is that you didn't include the crater closest to where I live: West Hawk Lake. Of course, you couldn't include them all!

Michael Attas
Pinawa, Manitoba

More beginner photos, please

I HAVE BEEN A *SKYNEWS* READER FOR MANY YEARS and have always enjoyed the magazine. One thing I think you could do better is to have a section for beginners' astrophotos. I don't mean the Photos of the Week, as most beginners just don't have the skills yet to compete, but I am sure they would be proud to share their first attempts. I must admit, I am a visual astronomer and have been since I built my own telescope when I was 13. To me, there is nothing like the experience of having those photons from millions of light-years away hit your retina from the eyepiece. But there are times when I would like a souvenir of my experience. So, I started some basic astrophotography. I think my basic tips below may help others.

1. Start with the equipment you have. If it's just a cellphone on a rock, or a DSLR on a stand-alone tripod, you can get great photos.

2. You can take great photos with a telescope on a mount and a DSLR. You don't need a fancy equatorial mount. Yes, you will be limited in exposure time to about 30 seconds before you get star trails, but the photo I have attached is an example of what can be done. I used a Celestron NexStar Evolution 9.25-inch telescope on an altitude-azimuth mount, with a Celestron ×0.63 reducer and a Canon T7i. No guiding — just 150 30-second exposures at 3200 ISO, 20 darks and 100 bias. All I did was some basic post-processing in Affinity Photo. These types of photos are what you need to publish to inspire others to take up the hobby. The equipment used by many of the Photos of the Week are way beyond the budgets of most beginners.

3. Don't jump into the purchase of dedicated astronomy cameras. Cameras like those from ZWO or QHY are good, but have very small sensors and will cause a lot of frustration in trying to find your target.

astronomy.tools' Field of View Calculator

4. Check what your target will look like through your equipment before you image it. You can use a site like astronomy.tools' Field of View Calculator to determine what your picture will look like based on your equipment. Why waste hours of exposure time if your target doesn't fit into your field of view?

5. If you can afford it, try a tool like ASIAIR. I had been very frustrated with just using a DSLR, swapping the eyepiece in and out with the camera trying to find my target and get it in focus, and then trying to get all of the various software packages on a laptop to work together to take the photos. With the ASIAIR app, I was creating stacked images within an hour of getting the device set up. It even uses plate solving — a method of determining where the telescope is pointing based on a star field catalogue — to ensure that your target is in the centre of the field of view.

6. Don't be intimidated by post-processing. There are a number of videos for beginners that will give you just the basics to get the colours out of your target and darken the background. For me, life is too short to spend hours and hours getting every last pixel correct.

Here is my first attempt at photographing Messier 51. I hope this article helps some beginners, and I hope to see more beginner tips, techniques and photos in future issues. ✶

__Mike Warkentin__ has been a RASC member and SkyNews subscriber for more than a decade. Holding a degree in physics and astronomy from the University of Toronto, he spent many undergraduate nights working at the David Dunlap Observatory. He recently retired after 40 years in the computer industry, and he is now chair of the Dark Sky Committee for the Bruce Peninsula Biosphere Association and runs the Bayside Astronomy program on the northern Bruce Peninsula.

Dalhousie University students extend their studies to space

IN ONE SMALL STEP FOR NOVA SCOTIAN SCIENCE, students at Dalhousie University are launching the first Atlantic Canadian-built satellite into space.

The tiny nanosatellite, called LORIS (Low Orbit Reconnaissance and Imagery Satellite), was slated to fly into orbit sometime between August and October as part of a suite of Canadian Space Agency satellite missions for students called the Canadian CubeSat Project.

It was Dalhousie's first-ever effort among a field crowded by more experienced universities, but it comes at a crucial moment for the province: Maritime Launch Services is readying a spaceport to bring missions from Nova Scotia to space. So it's very possible that the students working at Dalhousie today will form the first generation of Nova Scotian space industry professionals working in-province to serve the fast-growing space market.

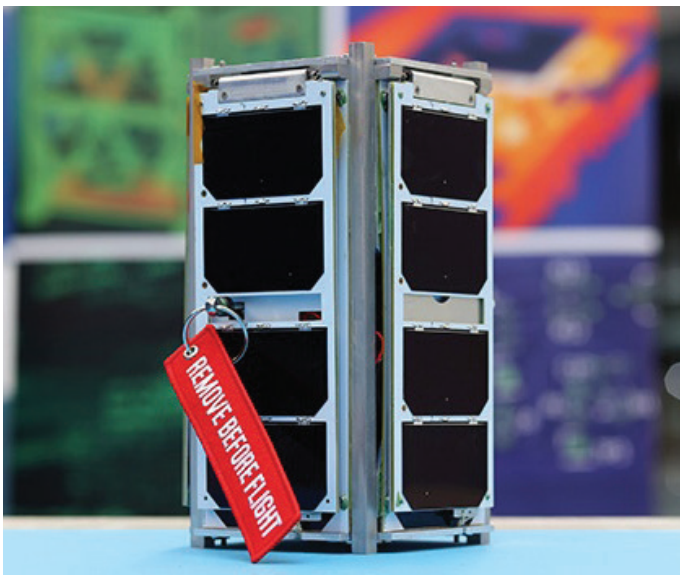
Even the mission screams Nova Scotia — its goal is to look at the province's peninsula and surrounding waters to get a high-definition view of the shorelines and ocean life.

"One of the most important aspects of this has been the years of work for all the students who have been involved in the project," said Arad Gharagozli, founder of Dalhousie's Space Systems Lab and lead of the LORIS project. Around 250 students were involved with LORIS over several years, meaning the little satellite had a big impact that will continue to ripple through space projects for decades.

"[There were] all of the amazing, invaluable lessons that everyone learned from Day 1 — planning, to project management, to mission concept reviews, all the way to doing critical design reviews," Gharagozli added. "They also did background research about all the space engineering and science that goes into putting a spacecraft in orbit and operating it."

Most were engineering students, but a handful came from other disciplines, showing how space is a cross-discipline field. They also worked with new engineering instruments designed by Galaxia Mission Systems, a space technology company that Gharagozli created in 2020 based on his own Dalhousie research.

Like many space projects, this satellite effort was not without obstacles. Completion was at first targeted for 2020, but the pandemic obstructed those efforts by a year and a half. Ongoing supply chain problems, chip shortages and other issues resulted in the CSA authorizing its participants in the challenge to postpone until things got a bit better.



TOP: Arad Gharagozli, founder of Dalhousie's Space Systems Lab, shown left with members of the LORIS satellite team in Montréal. (Dalhousie University); **BOTTOM:** Dalhousie University's LORIS spacecraft is slated to head into space. (Nick Pearce/Dalhousie University)

Now that the immediate problem has eased, the satellite is in final "integration" testing at CSA headquarters near Montréal to make sure it is readied for the Nanoracks launcher system that will send it from the International Space Station. To get to the orbiting complex, LORIS will ride atop a SpaceX Falcon 9 rocket later in the fall.

Gharagozli said more projects will be in the works at Dalhousie and that he hopes a future one will focus on astronomy research, as there weren't the resources to take on that space field with this launch. The university even has cameras ready; now they're looking for another ride and an opportunity to work with companies that want to test products in space, he said.

— Elizabeth Howell

Increasing spacefaring opportunities for Black and Indigenous students

A Halifax student satellite program gearing up its next season is well on its way with a $435,000 three-year federal grant over the next three years, and it's now looking for Indigenous and Black researchers to participate.

The Atlantic Academy of Space (ATLAS) is run out of Dalhousie University through three organizations: SuperNOVA, which runs camps focused on science, technology, engineering and math (STEM); Dalhousie Space Systems Lab, which does CubeSats and other space engineering; and Galaxia Mission Systems, which focuses on space and Earth observations.

The program already has two summer cohorts under its belt — in 2021 and 2022 — with students entering Grades 10, 11 or 12 with "an enthusiasm for coding, mechanics, personal tinkering projects or a variety of related passions," according to Dalhousie materials.

For its next iteration, ATLAS aims to recruit at least 50 per cent of its participants from Black and Indigenous populations.

"Participation in the ATLAS program builds skills to support future professional and academic careers, such as technological fluency, project design and execution, and problem-solving," representatives wrote in a recent tweet.

ATLAS is just one of the initiatives that SuperNOVA is conducting to address STEM skills among students from underrepresented communities. For example, a more environmentally focused initiative recently took place in collaboration with Acadia First Nation and Ulnooweg Education Centre. The program, which ran in August, brought 20 high schoolers into a land-based education program that included discussions of fish life cycles and participation in a sweat lodge, all to discuss Indigenous knowledge and culture in alignment with STEM.

— Elizabeth Howell

On March 17, Don Hladiuk captured this image of the historic rollout of NASA's Space Launch System (SLS) rocket. Before this, the last time a human-rated NASA Moon rocket rolled out of the Vehicle Assembly Building (VAB) was August 1972, for the Apollo 17 mission.

Launch complications

A series of pre-launch failures kept Artemis 1 earthbound on August 29 and September 3. Those scheduled launch dates were cancelled due to system issues, including a communications delay, fuel leaks and a crack in the insulating foam. The uncrewed Moon-orbiting mission is the first to use NASA's Space Launch System (SLS) rocket and the complete Orion spacecraft. At the time of publication, a new launch window had been set for September 27 between 11:37 a.m. and 12:47 p.m EDT.

— Allendria Brunjes

During NASA's Artemis I mission, two identical "phantom" torsos named Helga and Zohar will be equipped with radiation detectors while flying aboard Orion to measure the effects of radiation in space. (StemRad)

Before humans go mannequins

Artemis 1 will be aiming to send three mannequins around the Moon in a test to see how well a new spacecraft and a new rocket can adapt to the rigors of deep space. The "Moonikins" — Helga, Zohar and Campos — are simulated humans from NASA and the German space agency (DLR), outfitted with sensors to assess radiation, acceleration and other threats the human body will face close to the Moon. A Canadian is slated to be aboard the rocket for Artemis 2, so the Artemis 1 mannequins will be key in helping that Canadian ride out to the Moon as safely as possible.

— Elizabeth Howell

APOLLO 17: THE END OF THE BEGINNING

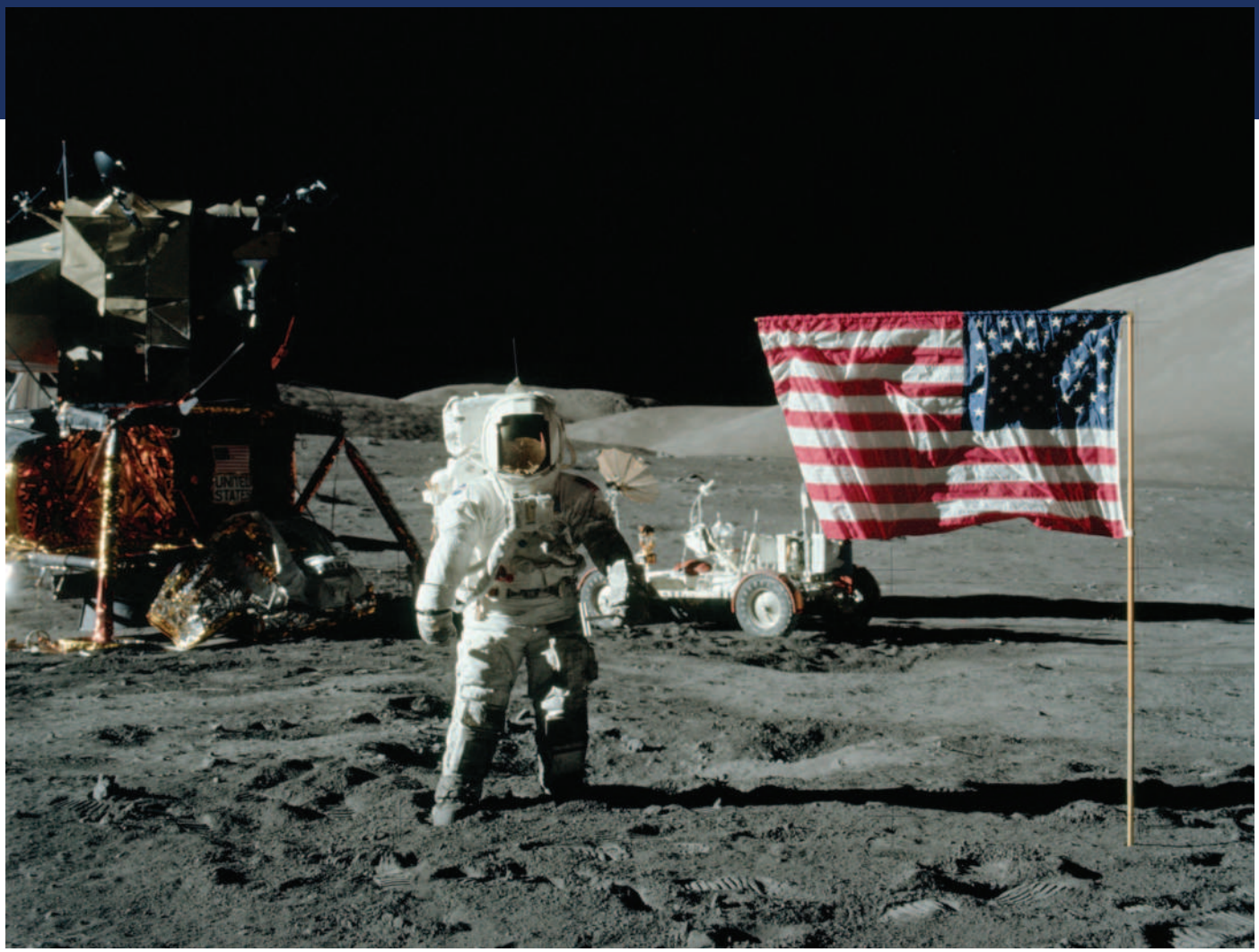
This December marks 50 years since the final mission in NASA's first human spaceflight program

By Randy Attwood

BY THE SUMMER OF 1972, the end of the Apollo program was in clear view. As the last Saturn V rocket destined to take astronauts to the lunar surface was rolled to its launch pad, journalists looked back at the accomplishments of the Apollo program and looked forward to new programs.

Meanwhile, the American public was losing interest in the Moon landings. The U.S. Congress had cut NASA's budget in 1970, resulting in cancellation of the Apollo 18 and 19 Moon-landing missions. Then-president Richard Nixon was tired of the Apollo program. He was up for re-election in 1972 and feared the loss of an Apollo crew would hurt his chances. He seriously considered cancelling Apollo 16 and 17 and using the money to fund the Vietnam War. Even NASA managers were looking at the cash that a cancelled Moon-landing mission could provide for post-Apollo programming, such as Skylab and the space shuttle. In the end, the last two missions, Apollo 16 and 17, went ahead.

The Apollo 17 crew consisted of Gene Cernan (commander), Ron Evans (command module pilot) and Jack Schmitt (lunar module pilot). Cernan and Schmitt would spend three days on the Moon, with Evans remaining in the command service module in orbit about the Moon. Schmitt was the first geologist to land on the Moon. Although the previous Apollo crews had been given extensive



LEFT: This was the Saturn V's first night launch, required to arrive at the Taurus-Littrow valley landing site at the desired time. (NASA/KSC); **TOP:** Schmitt is standing to the left of the American flag, with the lunar rover and the MESA — modularized equipment stowage assembly — in the background. (NASA)

geology training, having Schmitt on a flight was a priority for the science community.

The Apollo 17 crew took off at 12:33 a.m. on December 7, 1972. This was the Saturn V's first night launch, required to arrive at the Taurus-Littrow valley landing site at the desired time. The site interested scientists who expected to find not only samples of old lunar highlands material but young volcanic material, as well.

After a successful lunar landing, the crew completed three moonwalks . Cernan and Schmitt spent just over 22 hours working on the lunar surface. They drove a total of 35.9 kilometres in the lunar rover and collected 741 individual rock and soil samples — even drilling three metres below the surface — for a total of 111 kilograms of material. At one point during a moonwalk, the crew discovered bright orange volcanic soil next to a large crater. A remote-controlled television on the lunar rover provided the clearest television views ever of astronauts on the lunar surface.

To commemorate the final Moon landing of the Apollo program, NASA and the U.S. Department of State invited youth from all the countries in the United Nations to take part in the NASA International Youth Science Tour. They would follow the mission together and watch the launch of Apollo 17 in Florida as space ambassadors.

You can relive Apollo 17 live. Torontonian Ben Feist has developed a website with all the sights and sounds of the mission.

Canada held an essay contest to choose their delegate. The essay was on the importance of space exploration to humanity. Then-teenager Jaymie Matthews (now an astronomer at the University of British Columbia) won the contest. After watching the launch, the young people followed the moonwalks from mission control in Houston. At the end of the last moonwalk, Cernan displayed a melon-sized rock to the TV camera. When brought back to Earth, this rock was cut into pieces and distributed to the space ambassadors. Matthews presented his piece to then-governor general Roland Michener. →

"It's almost as if JFK reached out into the 21st century where we are today, grabbed hold of a decade of time, slipped it neatly into the '60s and '70s, called it Apollo."

—Apollo 17 Commander Gene Cernan

TOP: Jack Schmitt (left), Ron Evans (right), and Gene Cernan (seated) pose for a crew portrait in September 1972. The Apollo 17 Saturn V is on Pad 39 A in the background. (NASA); **BOTTOM:** This picture shows Cernan passing between Schmitt and the lunar module during the initial test drive. (Jack Schmitt/NASA)

The Apollo crew successfully completed their mission on December 19, 1972, splashing down in the Pacific Ocean and bringing the Apollo program to a conclusion.

It began when then-president John F. Kennedy challenged NASA to land an American on the Moon by the end of the 1960s. Eight years later, the Apollo 11 crew took humanity's first steps on the Moon, and within three-and-a-half years, 12 men walked on the lunar surface.

NASA was not only working to achieve the goal made by an assassinated president, but it was also racing to beat the Soviet Union to the Moon, and they were given all the money and resources they needed.

Even so, there was an employee toll. George Skurla, the Grumman team manager in Florida who prepared each lunar module for flight, told me in an interview in 1997 that many people are unaware of the "human carnage of Apollo." People working on the various spacecraft chose to work double shifts (but were only paid for one shift), just to ensure that "an astronaut would not be stuck on the Moon because a part I was responsible for failed." Skurla said the pressure on these people was so great that there were cases of alcoholism, many broken marriages and even some suicides.

In spite of this, there was tremendous pride in their accomplishment. The Grumman employees placed a banner on the last lunar module they built that read, "It may be our last, but it is our best." And this was true; Apollo 17 flew with the fewest problems of all the Moon-landing flights.

The media, which had enjoyed high ratings covering the earlier flights, cut back live mission coverage. For Apollo 17, the live moonwalk coverage was replaced with a 30-minute highlights program shown at 11:30 p.m.

Apollo 17 was the culmination of an amazing program of exploration. What was accomplished with 1950s and 1960s technology is still mind boggling. ✶

Gift Guide

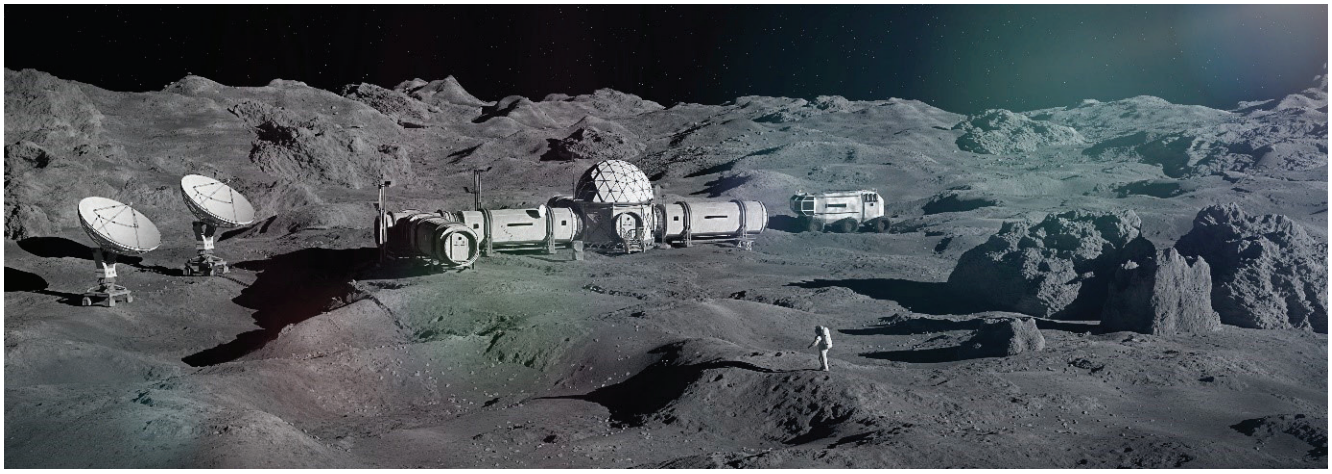
Suggested by the *SkyNews* team, here's a range of celestial gifts for the space aficionado in your life

AS SOLAR ACTIVITY picks up over the next few years, the Lunt 40mm Hydrogen-alpha solar telescope will help you see all the action in the Sun's seething ruby-red chromosphere. With a tunable Hα solar filter and diagonal, this compact f/10 refractor reveals active prominences, filaments, fibrils, flares and many other constantly changing solar phenomena. The scope includes a helical focuser and mounting rail that fit on many standard astronomy mounts. Just add your own nighttime eyepieces or get a set of dedicated Lunt solar eyepieces. A perfect little instrument to help you get a close-up view of our home star. — *Brian Ventrudo*

NEAR THE TOP OF MY ASTRO-WISH LIST this year is the new iOptron SkyHunter Portable EQ/AZ mount. It can handle up to five kilograms (11 pounds) and will track the sky at four rates: sidereal, half-sidereal, lunar and solar, all in either equatorial or altitude-azimuth mode. I can polar align it and let it track the sky, or use its built-in wifi adapter for full GoTo control via iOptron's Mobile iOptron Commander app for Android or iOS. It also has a USB port for ASCOM or INDI control and encoders on both axes. And at 1.3 kilograms (2.9 pounds; including the internal rechargeable battery), it's small enough to fit into my stocking! — *Chris Vaughan*

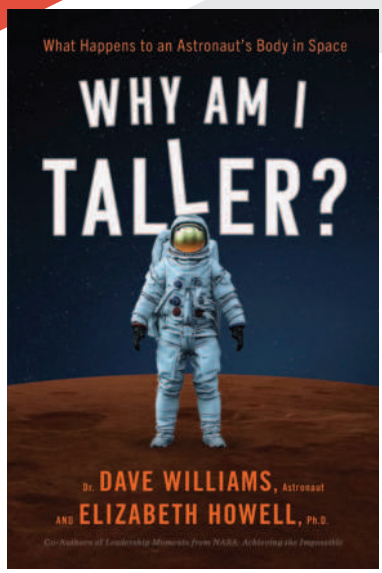
AT THE TOP OF MY WISH LIST is one of the new generation of harmonic drive mounts that was introduced by several companies in 2022: the ZWO AM5 Harmonic Drive Mount. They are remarkably light and compact for the payload they can carry, even more so because they don't require counterweights. The ZWO AM5, for example, weighs just 5.5 kilograms (12 pounds) but is rated as capable of handling more than twice that, which would include most of the refractors I use for imaging. The AM5 is attractive for its integration into ZWO's "ecosystem" of imaging products. And it looks good in ZWO's trademark red. — *Alan Dyer*

WITH CANADA SET TO WITNESS two solar eclipses over the next two years, I'd love to add a telescope solar filter to my arsenal. I think my wee little 80mm scope could nicely take a Baader ASTF80 AstroSolar Telescope Filter 80mm, which costs about $70. The Kendrick Baader (80mm-95mm) Solar Filter 6002-SF would do the trick, too, costing just over $100. It's a simple tool that is rather affordable by astronomy-gear standards, and it will protect my eyes and telescope for decades to come. — *Allendria Brunjes*



An artist's impression of a future lunar settlement. (Canadian Space Agency)

MY WISH IS FOR LUNAR GATEWAY PROGRESS. I'll admit it — I had my doubts when I learned about the space station. Former president George Bush Sr. told NASA to develop a space station as well as crewed lunar and Mars missions. His successor, Bill Clinton, focused on the International Space Station. George Bush Jr. wanted Americans on the Moon in 2020. Barack Obama wanted to skip the Moon and have a Mars mission by the 2030s. Naturally, I was skeptical about Donald Trump's enthusiasm for Artemis and the Lunar Gateway. But private and international partnerships — including one with the Canadian Space Agency — keep the dream alive. And if I can't have that, I want a Sony A7IV mirrorless camera. — *Vincent McDermott*



WHY AM I TALLER?: WHAT HAPPENS TO AN ASTRONAUT'S BODY IN SPACE
By Dr. Dave Williams and Elizabeth Howell

Release date: November 1, 2022

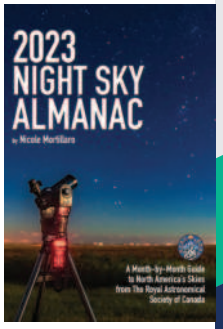
If you've seen astronauts returning to Earth, you'll have noticed that they have difficulty standing up, because their muscles and bones have weakened. They also have problems with their vision, their sense of smell and the bottoms of their feet. This pop-science book examines what happens in space that causes the human body to react and change. What do studies on Earth tell us about planetary exploration, and what do studies in space tell us about life on Earth? These questions will be important to the future of space exploration and to related studies of seniors and people with reduced mobility on our home planet.

Author Dave Williams has flown to space twice, logged more than 17 hours of spacewalks and trained with Chris Hadfield. He is also a medical doctor who once ran one of Canada's busiest emergency rooms. Elizabeth Howell is a *SkyNews* contributor, a staff writer at Space.com and one of the few Canadian journalists to report regularly on space exploration.

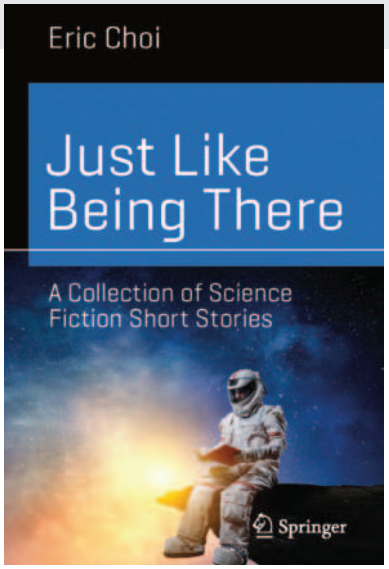
2023 NIGHT SKY ALMANAC: A MONTH-BY-MONTH GUIDE TO NORTH AMERICA'S SKIES FROM THE ROYAL ASTRONOMICAL SOCIETY OF CANADA
By Nicole Mortillaro

Release date: August 2022

The *2023 Night Sky Almanac* is the ideal resource for both novice and experienced sky watchers in the United States and Canada, with all of the advice, information and data that enthusiasts need to understand and enjoy the wonders of the night sky. This in-depth guide first introduces readers to the objects in the sky — from stars to comets to globular clusters — and then takes them through the cosmic events to look out for each month in 2023, with sky maps, Moon phase charts and information about the planets.



SkyNews contributor Nicole Mortillaro is an avid amateur astronomer, author, editor, S\senior science reporter for CBC News and the editor-in-chief of the *Journal of The Royal Astronomical Society of Canada*. She is the author of *Saturn*, and lives in Toronto, Canada.



JUST LIKE BEING THERE: A COLLECTION OF SCIENCE FICTION SHORT STORIES
By Eric Choi

Release date: June 2022

Just Like Being There is the first collection of short stories by award-winning Canadian writer, editor and aerospace engineer Eric Choi. Most of the stories in the collection are space- or astronomy-themed, including the Aurora Award-winning "Crimson Sky" about a rescue mission on Mars; the title story "Just Like Being There", which explores the pros and cons of human versus robotic space exploration; and the new novelette "A Sky and a Heaven" about the Space Shuttle Columbia accident. Each story is followed by an afterword that explains the underlying engineering or science. ✶

Scanning the skies with your phone and a Dobsonian

***SkyNews* writer Chris Vaughan reviews the newest addition to Celestron's arsenal: the StarSense Explorer 10-inch Dobsonian telescope**

Chris Vaughan prepares Celestron's StarSense Explorer 10-inch Dobsonian telescope in front of the David Dunlap Observatory in Richmond Hill, Ontario. (Allendria Brunjes)

When the Celestron StarSense Explorer line of telescopes was released in 2020, they solved some major challenges for beginner stargazers: how to identify those bright objects in the sky and how to find and view fainter objects, especially under light-polluted conditions. Celestron's solution was to combine the power of a mobile smartphone astronomy app with several affordable — and portable — tripod-mounted telescopes.

With the technology now well proven, Celestron has added 8-inch and 10-inch aperture Dobsonian reflector telescopes to the line, allowing users of any experience level to see more than ever before. I was lucky enough to borrow and field test the 10-inch model this past summer.

By adding the fast and simple StarSense Explorer technology to large-aperture Dobsonian reflectors, Celestron has literally opened the heavens to everyone. Whether you observe from pristine rural skies or urban driveways, these new telescopes will please brand new stargazers learning the sky, school astronomy clubs and even seasoned pros. You won't want the night to end!

How StarSense Explorer works

The StarSense Explorer system uses a specially designed bracket to firmly

attach your smartphone to the telescope tube. A mirror within the bracket directs an image of the sky that the telescope is pointed at into your camera's phone. Your phone provides everything you need to locate objects in the sky: your current location via GPS, the date and time, deep-sky catalogues of celestial objects (courtesy of the StarSense Explorer app), a compass and gyroscope to track telescope motions and the processing power to figure it all out in real time. You don't even need an internet connection. Since you are pushing the telescope around by hand — a "push-to" system — the telescope doesn't need expensive motors or encoders, keeping the price affordable.

By taking pictures of the sky, the StarSense Explorer app uses a technique called plate solving to rapidly identify the stars in the current view, and then uses your phone's sensors to tell you where to move the telescope to put a selected object in the eyepiece, using fresh images to refine the pointing accuracy. Better yet, as targets drift due to Earth's rotation, the app shows you which way to nudge the telescope to bring them back into view.

Once the telescope is aligned to the sky and a target is selected, arrows and a red bull's-eye are overlaid upon a detailed sky map. You simply push the telescope in the direction of the arrows. As you get closer, the sky around the target will zoom in to improve your accuracy and the indicator will change to a yellow reticule. When that changes to green, you are there. If you give the app a moment, it will perform another plate solve and display an updated reticule to get you even closer. Your quarry will now be close to the centre of your eyepiece's field of view. It's like magic!

The app

The StarSense Explorer app was developed in collaboration with Simulation Curriculum, the creators of SkySafari and Starry Night. Users of that app will feel right at home, but even complete novices will have no problem mastering the system. Even kids! The current list of phones that the StarSense system works with is available at starsenseexplorer.simcur.com.

A card included in the box provides instructions for downloading the app on your phone from Google Play or the Apple App Store, and an activation code. That code will allow you to activate the app five times, which is helpful if you switch phone operating systems in the future or want to allow another family member or a friend to try out your system. Celestron also provides a free download of Starry Night Basic Edition software for your computer.

The first time you use the app, it will prompt you to enter the code and an email address and to select the model of StarSense Explorer telescope you are using. You can switch to another telescope model at any time.

When you launch the app, the home screen displays the current sky for your phone's location. Finger swipes allow you to pan around and zoom in and out. The best objects to view are highlighted with labelled blue circles. Tapping any object, highlighted or not, will place a Celestron orange reticule around it and a button with its name at the bottom of the screen. Tap that to summon a page with a written description with images. An Observing Tips tab outlines what to expect to see, when it will look its best, which filters will help and more. A tab labelled Data provides the information that advanced beginners appreciate — apparent magnitude, upcoming events, size, rise, transit and set times, and much more. Tapping the Center icon at lower left will return you to the sky view.

Screenshots from Celestron's StarSense Explorer app. (Chris Vaughan/Celestron)

The app doesn't allow you to move off of the current time, but it does employ a transparent horizon panorama so that you can see objects that will rise soon. Although you can't select objects that are below the horizon, you can still zoom in on them. I used that to preview the arrangement of Jupiter's moons.

Four icons appear at the bottom of the home page. The leftmost "hamburger" symbol opens a settings menu, where you can switch the display to Night Vision mode (with reddened screen), change the telescope model, swipe through a series of Quick Start Tutorial pages, and choose another observing site by manually entering the coordinates, by selecting from a list of towns, or by dropping a pin on a map.

A star icon summons the Tonight page, which lists suggested targets, split into Tonight's Best Objects (the bright planets, Messier objects and stars) and Tonight's Challenge Objects (fainter planets, Messier objects and double stars). Tapping any entry will open its Object Info page. From there you can tap the centring icon to show it in the sky and then direct the telescope to it.

A search icon occupies the lower right corner of the display. On the Search screen, you can type in all or part of a name or designation, or peruse items listed in ten categories, such as planets, constellations, Messier objects and best double stars. Most lists are sorted in the order of their numerical designation, Messier 1, NGC 1 and so on. The stars are sorted by magnitude, and the double stars by their constellation and designation. In the app's latest version,

1.1.7.1, a category named More Deep Sky Objects has been added, offering additional targets visiblewith larger-aperture telescopes.

One of the great benefits of an app-based system like StarSense Explorer is the automatic updating of the celestial objects catalogues. While I was field testing the system, comet C/2017 K2 (PanSTARRS) was observable, and StarSense led me right to it.

All of the app features I've described are available even without mounting your phone to the telescope. Once you do so, the fun really starts. The StarSense icon, second from the right on the home screen, will pulse to prompt you to begin aligning the phone and telescope to the sky. When pressed, it will ask whether the system is still aligned or whether alignment is needed. If you select Needs Alignment, the app will explain the process of mounting your phone and centring its camera over the mirror, step by step, using short videos to show the procedure. If you plan to always use the same phone, some of those steps can be done in daytime. Take that opportunity to calibrate the provided StarPointer red-dot finderscope, too.

The phone bracket uses adjustment knobs and gears to line up your phone's camera, and the spring-loaded clamp will accommodate a variety of phones, even those in protective cases. Once your phone's camera is lined up with the telescope, the app will prompt you to point the telescope toward a clear patch of sky, so that it can capture a star field and perform an initial plate solve. When it reports a successful fix, you are aligned and ready to select a target.

The telescope

The telescope I field tested was Celestron's 10-inch (254mm) Dobsonian reflector. The primary mirror's fast focal ratio of f/4.7 means the telescope's steel tube is only 1.118 metres (44 inches) in length. That large aperture and low focal ratio provide a bright and generous field of view. The primary and secondary mirrors use Celestron's XLT silicon dioxide and tantalum pentoxide protective overcoatings. The built-in 2-inch single-speed Crayford focuser included a 2-inch extension tube and a 1.25-inch adapter. A sturdy knob mounted near the focuser and a large handle at the optical tube assembly's centre of gravity aided in moving the telescope while in use and when lifting it in and out of the base.

Pros

Locates targets easily and rapidly under a dark, open sky

StarSense app does not require an internet connection and updates its catalogues automatically

Convenient handles for moving the optical tube assembly and base

A good complement of accessories (assembly tools, collimation cap, StarPointer red-dot finder, eyepiece tray)

Cons

The app can drain your phone

Plate solving will be challenged by tall trees or buildings

Mirror cover needs a tether

Balancing in the 10-inch model

The phone bracket's mirror is tilted slightly to allow for viewing objects that are low in the sky. Plastic baffles shield the mirror from stray light, and a cover protects it when not in use.

In addition to the StarPointer red-dot finderscope (battery included) and a collimation cap, the telescope comes with a 1.25-inch barrel 25mm Plössl eyepiece that yields a one-degree field of view at 48×. Any eyepieces you already own should work nicely in the telescope. I enjoyed views through a Baader-Hyperion 8-24mm zoom eyepiece and Televue Nagler eyepieces between 40mm and 7mm focal lengths.

The base, made of lacquered particle board, is more than sturdy enough to handle the telescope's weight. It features a large azimuth bearing, an 8-inch-diameter altitude bearing, a metal eyepiece tray that holds three 1.25-inch eyepieces and one 2-inch eyepiece, and a lifting handle. Large knobs guide the OTS into place and one of them serves to tighten the altitude bearing. The base took about an hour to assemble, but Celestron provides detailed illustrated instructions and all the required tools.

Field testing the StarSense Explorer

My first attempt to use the telescope was in my light-polluted driveway in the suburbs of Toronto, and only a week before the June solstice. The limited patch of open sky available between some tall trees and my house significantly lengthened the time it took for the app to successfully align. Eventually, I switched to using the telescope without StarSense, employing the red-dot finder to see some nice views of Messier 13 and Messier 3 — the benefits of a large aperture.

Reviewer Chris Vaughan shows a new astronomer how the StarSense Explorer system works. Vaughan says he finds the system fast and simple to use. (Allendria Brunjes)

Noticing some distortion in the stars during my initial views, I checked the collimation indoors the next day. The provided collimation cap revealed some slight misalignment, which I confirmed with my laser collimator. Using instructions on Celestron's Newtonian collimation webpage, I used the convenient, tool-free knobs at the base of the primary mirror to easily align the optical path.

For my next foray, I took the system to Glen Major Forest, a popular observing site located 40 minutes northeast of Toronto. Even though the site is still affected by the light dome of Toronto, the Milky Way is visible from there after astronomical twilight. The StarSense Explorer system really impressed me in the wide-open sky. Even before the sky was completely dark, it aligned the telescope within minutes and was taking only a few moments to guide me to each new target. I recruited several RASC Toronto Centre members and their guests to try out the system. Even with no prior experience using a telescope, the non-astronomers were finding and viewing summer favourites in no time.

Making the most of StarSense Explorer

With any new technology there are always a few kinks to iron out. Here are the issues I noted and some suggested solutions.

The optical tube of the 10-inch Dobsonian was very bottom heavy. I had to tighten the altitude knobs to prevent the telescope from tilting. Celestron should easily be able to tweak the balance in future editions. For now, you could try strapping a light ankle weight under the front end of the tube or use heavier eyepieces. The primary mirror's low focal ratio produced a nice, wide field of view without making the optical tube excessively long. That made the eyepiece height convenient for viewing any part of the sky, but it also introduced some coma, an aberration where the stars in the outer edges of the field of view were distorted. Objects in the centre of the field of view were coma-free, however. Purchasing a coma corrector and using well-corrected eyepieces should alleviate the issue.

The StarSense bracket's mirror is exposed to the sky above you, allowing dew or frost to accumulate on it. Moreover, it is front-silvered, at risk for scratches if you wipe it dry. (Don't be tempted to use household mirror-cleaning solutions on the mirror!) The supplied cover can be placed over it between plate solves, but I suggest tying a string the cover, to prevent it from falling into the grass in the dark.

Because the camera bracket sits atop the optical tube assembly, the mount for the red-dot finder is on the far side of the telescope from the focuser, making it very awkward to look through from the eyepiece side of the telescope. Thankfully, you won't need it while using the StarSense Explorer system.

The app's colour-coded bull's-eye was very effective for zeroing in on targets, but those colours all become red when the app is in night-vision mode. A workaround would be to leave night vision off and turn your phone's display to minimum brightness. Since the StarSense Explorer app stands ready to find your next target, or to get it back in the eyepiece if someone bumps the telescope, it can drain your phone's battery during a long observing session. I suggest starting the night with a fully charged phone, or running a power cord to your phone from a portable battery.

I've wanted to try the StarSense Explorer system for a while, and it exceeded my expectations for speed and ease. I was sorry to see the big telescope go before I'd had a chance to view the gas giant planets and spend some time on the Moon. Nothing beats a large aperture Dobsonian-mounted reflector for visually observing deep-sky objects. The Celestron StarSense system is so good and so fast, you'll be having too much fun to go to bed! ✶

By Chris Vaughan

Year-end treats both near and far

The end of the year brings a selection of spectacular close clusters and remote galaxies that you may have previously overlooked

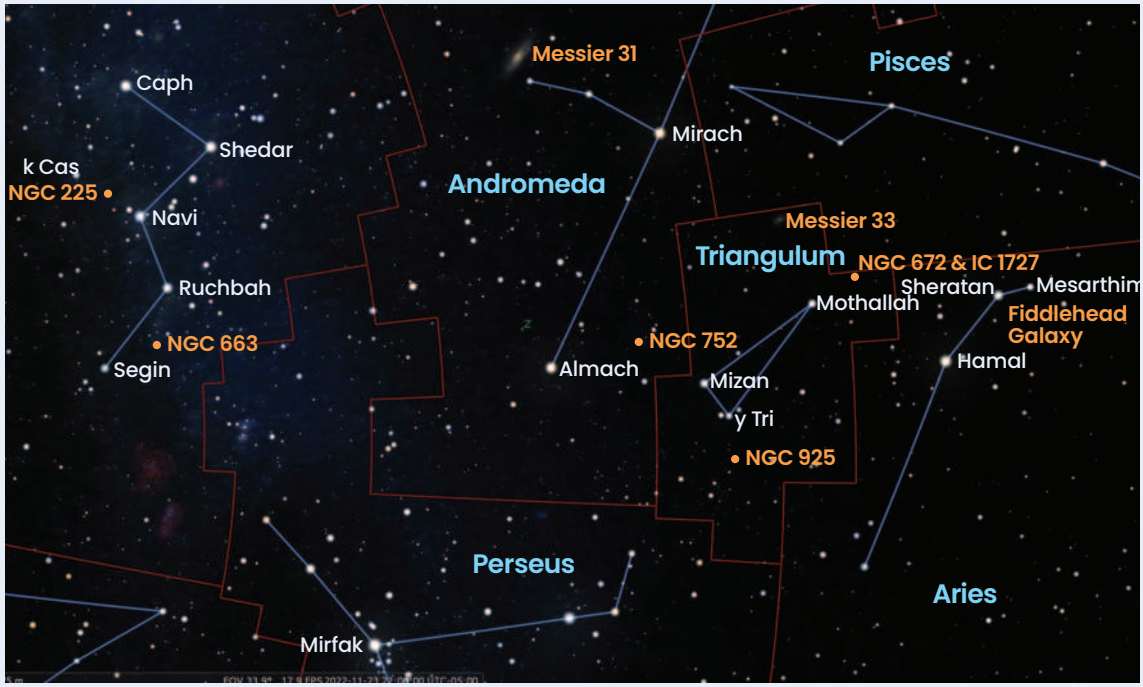
WHILE SPRINGTIME IS DISTANT GALAXY SEASON and summer skies host deep-sky objects mostly located within and around our Milky Way galaxy, November and December nights offer Canadian observers a mix of both. When the fainter outer rim of our galaxy climbs overhead toward year-end, it brings a rich harvest of open clusters, including Messiers 52, 103 and 34. But the sky around Cassiopeia is also populated with plenty of pretty clusters many people haven't seen.

Meanwhile, we can peer through that sparser winter Milky Way and see galaxies located just south of the galactic plane, including the famous, but relatively nearby, Andromeda and Triangulum galaxies (Messiers 31 and 33, respectively) and a number of lesser-known, farther-away spirals.

Here are some terrific Milky Way clusters that are visible through binoculars or a small telescope, and some distant galaxies that will work with a range of telescope sizes.

With the Sun setting early in November and December, I have selected objects that are nearly overhead in mid-evening, when they'll look their best. If you find viewing targets near the zenith a challenge, tackle them right after dusk when they are still climbing the eastern sky, or wait until midnight, when they will be descending in the west. In 2022, the evenings of November 15 to 26 and December 15 to 25 will be dark and moonless, offering ideal conditions for the galaxies. The moonlight-tolerant open clusters can be viewed on any evening, except perhaps the nights around November 7-8 and December 7-8, when a full Moon will be shining nearby.

Below, I've provided each object's common name and/or the NGC/IC catalogue number as well as the RASC Finest NGC number (FNxxx) for any visual observer who is working toward that observing certificate. (The entire Finest NGC list begins on Page 318 of the 2022 *Observer's Handbook* or Page 316 of the 2023 version.) Two of these objects are on the Caldwell List, which I described in the January/February 2022 issue of *SkyNews*.



Tip: 90× is a good starting magnification for most of these objects — that would be the view with a 10mm Plossl eyepiece in either a 6-inch f/7.8 reflector or an 80mm f/11 refractor. Experiment with much less magnification for the open clusters and more for the galaxies.

Sky chart facing east on November 23 at 10 p.m., with a 34-degree field of view. (Chris Vaughan/ Stellarium)

The open cluster NGC 225 harbours a treat for imagers, the reflection nebula vdB 4 (Hunter Wilson/Wikimedia Commons)

Beauties in our own backyard

NGC 752 is a very large, magnitude 5.7 open star cluster in Andromeda. It's detectable with unaided eyes, but it will look its best with binoculars or through any size of telescope using low magnification. This under-appreciated beauty is number 53 on **David Levy's list of Deep-Sky Gems** (beginning on Page 324 of the 2022 *Observer's Handbook*, and Page 322 of the 2023 version) and Sir Patrick Moore's Caldwell 28. The cluster is located 4.5 degrees south of the bright double star Almach (Gamma1 and Gamma2 And), a thumb's width to the west of the mid-point on a line connecting Almach to Mizan (Beta Tri). NGC 752's large, 1.25-degree diameter is due to its mere 1,470 light-years distance and to its extreme age, which has given its stars time to disperse and to evolve into golden F-, G- and K-class members. There's even a blue straggler toward the southwestern edge.

Most of the stars are magnitudes 9 and 10, loosely distributed and arranged in curving lines or pairs, with no concentrated centre. In the eyepiece, you should see about a dozen brighter members and 50 or so smaller stars. A bright golden star named HD 11885 dominates a small triangle pointing inward from the southern sector of the cluster, but it's a foreground star only 880 light-years away.

The prominent magnitude 5.7 stars 56 Andromedae and HD 11727 shine together half a degree to the south-southwest of the cluster. For a challenge, try splitting Struve 179 located 34 arcminutes to their west. Owners of large aperture telescopes viewing under dark skies can also try to observe many small galaxies gathered some 1.8 degrees southwest of the cluster — or jump 8.5 degrees in the same direction to visit the big, bright Triangulum Galaxy.

NGC 225 was first recorded by Caroline Herschel in 1783. Another object for binoculars, it is a magnitude 7.0 open cluster located about 2,200 light-years from the Sun, in Cassiopeia. Since Cassiopeia circles the celestial pole, the easiest way to locate the cluster is to centre your optics a thumb's width "above" Gamma Cas, the star that marks the central peak of Cassiopeia's "W" and is informally known as Navi. You could also split the difference between Navi and the magnitude 4 star Kappa Cas, which sparkles 3.5 degrees northwest of Navi.

The 20-odd magnitude 9 and 10, B-class stars that form this cluster are loosely spread across 13 arcminutes of sky. They appear to be grouped into a curved line of whitish B-stars on the east and a triangular patch, populated with some yellowish G-class stars to the west. Some observers have imaged them forming a mini-Cassiopeia or a sailboat. The cluster's interior is lacking in fainter stars, perhaps due to dark dust. Under very dark skies, watch for a starless patch stretching south from the cluster, and for the soft glow and dark lanes of the reflection nebula vdB 4 surrounding the star V594 (or HIP 3401) just north of the triangular patch. Reduce the magnification and see if you can trace out a 44-arcminute-wide Valentine's heart shape formed by two ovals of stars looping 30 arcminutes to the north and the northwest, starting from the brightest portion of NGC 225.

NGC 663 in Cassiopeia. The open cluster covers about half a Moon's width in the sky. (Ron Brecher)

NGC 663 is another fine open star cluster in Cassiopeia. Brighter, larger and closer than nearby Messier 103, it was selected by Moore and Alan Dyer to be Caldwell 10 and FN009, respectively. NGC 663 is located just outside of the shallower half of Cassiopeia's "W," one degree southeast of the midpoint between the bright stars Ruchbah (Delta Cas) and Segin (Epsilon Cas). Cassiopeia rotates through the night — so remember to search on the Perseus-Andromeda side of that line.

The cluster is approximately 7,000 light-years away. It's possible to glimpse it with unaided eyes and easily through binoculars and any size of telescope. It is dominated by two dozen bright, white B-class stars interspersed with many fainter members that appear with increased aperture. A central, dark dust lane bisects the cluster, producing a deep "V" lined with bright stars in its centre. Look for a well-split pair of bright magnitude 9 stars at each tip of the "V," and then zoom in to see that the eastern star in each pair is a close double. Slew around the cluster to see more starless patches and streams of stars extending southeast and southwest.

Bright clusters tend to collect nicknames. Stellarium refers to this one as the "Lawnmower" or "Letter S," while Stephen O'Meara saw a "Horseshoe." To me, two magnitude 8 red supergiant stars beyond the cluster's southern edge look like eyes above a crooked open mouth, reminding me of the Sesame Street Yip Yip Martians!

Galaxies far, far away

At magnitude 10.1, **NGC 925** is the second-brightest deep-sky object in Triangulum, after its famous eponymous galaxy. This barred spiral galaxy is much smaller than M33, but its 55-degree inclination has boosted the surface brightness of its central portions, making it visible through 80-100mm aperture telescopes despite its 30 million light-years distance. To find NGC 925, locate the three stars of Triangulum, and then take the span from Mizan (Beta Tri) to magnitude 4.0 Gamma Tri and hop that same distance east from Gamma (i.e., roughly downward on autumn evenings). Alternatively, aim your finder at the centre of the triangle formed by Gamma and the magnitude 5.5 stars 11 Tri and 15 Tri.

Don't over-magnify this galaxy. With a small telescope, you'll mainly notice its bar-like core spanning 2 × 0.5 arcminutes and aligned west-northwest. Several foreground stars, including a magnitude 11 star positioned 3.3 arcminutes directly south of the core, plus magnitude 13 pairs positioned just north of centre and off to its west, might trick you into thinking the galaxy is larger and brighter. Telescopes in the 6-inch to 8-inch aperture range will start to reveal the galaxy's oval halo, which is dominated by two loosely wound arms. Knots of star-forming regions within them will make the galaxy appear to stretch unevenly east-west over at least 2 × 5 arcminutes. A larger telescope and averted vision will resolve some structure, grow the halo and show that the galaxy is a squashed S-shape with indistinct edges.

NGC 672 and **IC 1727** are a pair of interacting barred spirals in Triangulum, located close to the line connecting the bright

NGC 925, imaged from the Burke-Gaffney Observatory at St. Mary's University in Halifax, Nova Scotia. The image is a 300-second luminance shot, north-up. (Chris Vaughan)

star Hamal (Alpha Ari) to Mirach (Beta And), and only 2.4 degrees from the magnitude 3.4 star Mothallah (Alpha Tri). The duo are cosy enough to share the eyepiece of your telescope. Their tableau reminded me of the Whale and Hockey Stick galaxies in Canes Venatici, or the much larger and brighter pair of Messiers 81 and 82 in Ursa Major. Shining at magnitude 10.9 and 11.6, respectively, NGC 672 and IC 1727 are the third- and fifth-brightest galaxies in Triangulum. NGC 672's inclination only 20 degrees from edge-on has boosted its surface brightness enough to make it observable through telescopes of 80mm and up. IC 1727 is not as bright, despite being edge-on to our line of sight. Both galaxies are located about 23 million light-years away.

With smaller telescopes, NGC 672's core will pop as a 1.5 × 0.5 bright lozenge aligned nearly east-west. Averted vision and more aperture will surround that with a diffuse oval halo spanning as much as 4 × 1.5 arcminutes. Like NGC 925, two spiral arms festooned with brighter clumps form a compressed, backward S-shape with indistinct edges. IC 1727 sits between NGC 672 and a magnitude 10.6 star shining 11.5 arcminutes to its south-southwest. IC 1727's core looks like a 1 arcminute-long, lumpy slash oriented at right angles from its partner (i.e., SE-NW). A large aperture telescope will reveal that the core is surrounded by a very faint and irregular halo measuring 1.3 × 3.5 arcminutes across and somewhat brighter on the northwestern side. The galaxy's irregular form is likely due to tidal interactions with NGC 672. Imagers should look for the tiny edge-on slash of the deep background galaxy PGC 1803573 in the same frame.

The magnitude 10.3 **Fiddlehead Galaxy** in Aries deserves far more attention from stargazers. Formally known as **NGC 772**, this unbarred spiral, located 112 million light-years away, is brighter than some Messier galaxies twice as large as our Milky Way, and features a prominent arm that arcs to the west — making its unusual form worthy of being number 78 in Halton Arp's *Atlas of Peculiar Galaxies*. Dyer deservedly made it FN014.

NGC 772 is easily located by noting the 1.5-degree span from the bright star Sheratan (Beta Ari) to the terrific double star Mesarthim (Gamma 1,2 Ari), and then hopping east (i.e., left on autumn evenings) by the same distance.

The galaxy is inclined by 30 degrees from edge-on. Its bright, compact core will be visible with smaller telescopes as a hazy star, but a 6-inch to 8-inch aperture telescope will reveal the smooth oval of its innermost set of arms, which are aligned northwest-southeast and span 1 × 1.5 arcminutes. Use averted vision and a larger telescope to see the fainter outer arms covering 4.75 × 3.8 arcminutes. The large single arm that forms the fiddlehead shape will be visible as an arc of uneven brightness curving much of the way around the core and then across the halo toward the northwest. Gravitational interactions with the bright, little elliptical galaxy **NGC 770** located just 3.5 arcminutes to the south-southwest of NGC 772 appears to have created the arm and triggered bright clumps of star-forming regions within it. ✶

The Fiddlehead galaxy and the small elliptical NGC NGC 700 in a 300-second luminance image from the Burke-Gaffney Observatory. (Chris Vaughan)

Canada's night sky for November/December

Compiled by James Edgar • Cartography by Glenn LeDrew

CELESTIAL CALENDAR

* *Impressive or relatively rare astronomical event*

NOVEMBER 1 ◐
Moon at first quarter

NOVEMBER 1
Saturn 4° north of Moon

NOVEMBER 2
*Double shadow transit on Jupiter

NOVEMBER 4
*Jupiter 2° north of Moon

NOVEMBER 5
South Taurid meteors peak at 2 p.m. EDT

NOVEMBER 6
Daylight Saving Time ends

NOVEMBER 8 ○
Full Moon at 6:02 a.m. EST

NOVEMBER 8
*Total lunar eclipse, seen from all of North America (See Page 29)

NOVEMBER 8 ○
*Uranus 0.8° south of full Moon; occultation in northwest Canada (See Page 29)

NOVEMBER 9
*Uranus at opposition (See Page 29)

NOVEMBER 11
Mars 2° south of Moon

NOVEMBER 12
North Taurid meteors peak at 1 p.m. EST

NOVEMBER 14
Moon at apogee (404,921 km)

NOV. 16 ◑
Moon at last quarter

NOVEMBER 17
Leonid meteors peak at 7 p.m. EST

NOVEMBER 237 ●
New Moon, 5:57 p.m. EST

NOVEMBER 25
Moon at perigee (362,826 km)

NOVEMBER 28
Saturn 4° north of Moon

NOVEMBER 30 ◐
Moon at first quarter

NOVEMBER 30
*Juno 1.2° south of Moon, occultation over most of North America

NOVEMBER 30
*Mars at closest approach to Earth

DECEMBER 1
Jupiter 3° north of Moon

DECEMBER 5
*Uranus 2° to 4° from Moon

DECEMBER 7 ○
Full Moon at 11:08 p.m. EST

DECEMBER 7
*Mars 0.5° south of full Moon, occultation in most of North America (See Page 31)

DECEMBER 8
*Mars at opposition (See Page 30)

DECEMBER 11
*Pollux 1.8° north of Moon

DECEMBER 11
Moon at apogee (405,888 km)

DEC. 14
*Geminid meteors peak at 8 a.m. EST

DECEMBER 16
Moon at last quarter

DECEMBER 21
*Mercuryat greatest elongation east (20°)

DECEMBER 21
*Winter solstice

DECEMBER 22
Ursid meteors peak at 5:00 p.m. EST

DECEMBER 23
New Moon, 5:16 a.m. EST

DECEMBER 24
Moon at perigee (358,270 km); large tides

DECEMBER 24
*Mercury 4° north of Moon, Venus nearby

DECEMBER 26
Saturn 4° north of thin crescent Moon

DECEMBER 28
Neptune 3° north of Moon

DECEMBER 29
*Mercury 1.4° north of Venus (See Page 31)

DECEMBER 30 ◐
Moon at first quarter

PLANETS AT A GLANCE

	DATE	MAGNITUDE	DIAMETER (")	CONSTELLATION	VISIBILITY
Mercury	Nov. 1 Dec. 1	— 0.6	— 5.0	Virgo Ophiuchus	— Dusk
Venus	Nov. 1 Dec. 1	— −3.9	— 9.9	Libra Ophiuchus	— Dusk
Mars	Nov. 1 Dec. 1	−1.3 −1.8	15.0 17.0	Taurus Taurus	Evening Evening
Jupiter	Nov. 1 Dec. 1	−2.8 −2.6	47.1 43.0	Pisces Pisces	Evening Evening
Saturn	Nov. 1 Dec. 1	0.8 0.7	17.0 16.0	Capricornus Capricornus	Evening Evening
Uranus	Nov. 1 Dec. 1	5.6 5.6	3.8 3.8	Aries Aries	Evening Evening
Neptune	Nov. 1 Dec. 1	7.8 7.9	2.3 2.3	Aquarius Aquarius	Evening Evening

Our chart shows the major stars, planets and constellations visible from Canada and the northern United States within one hour of these times:

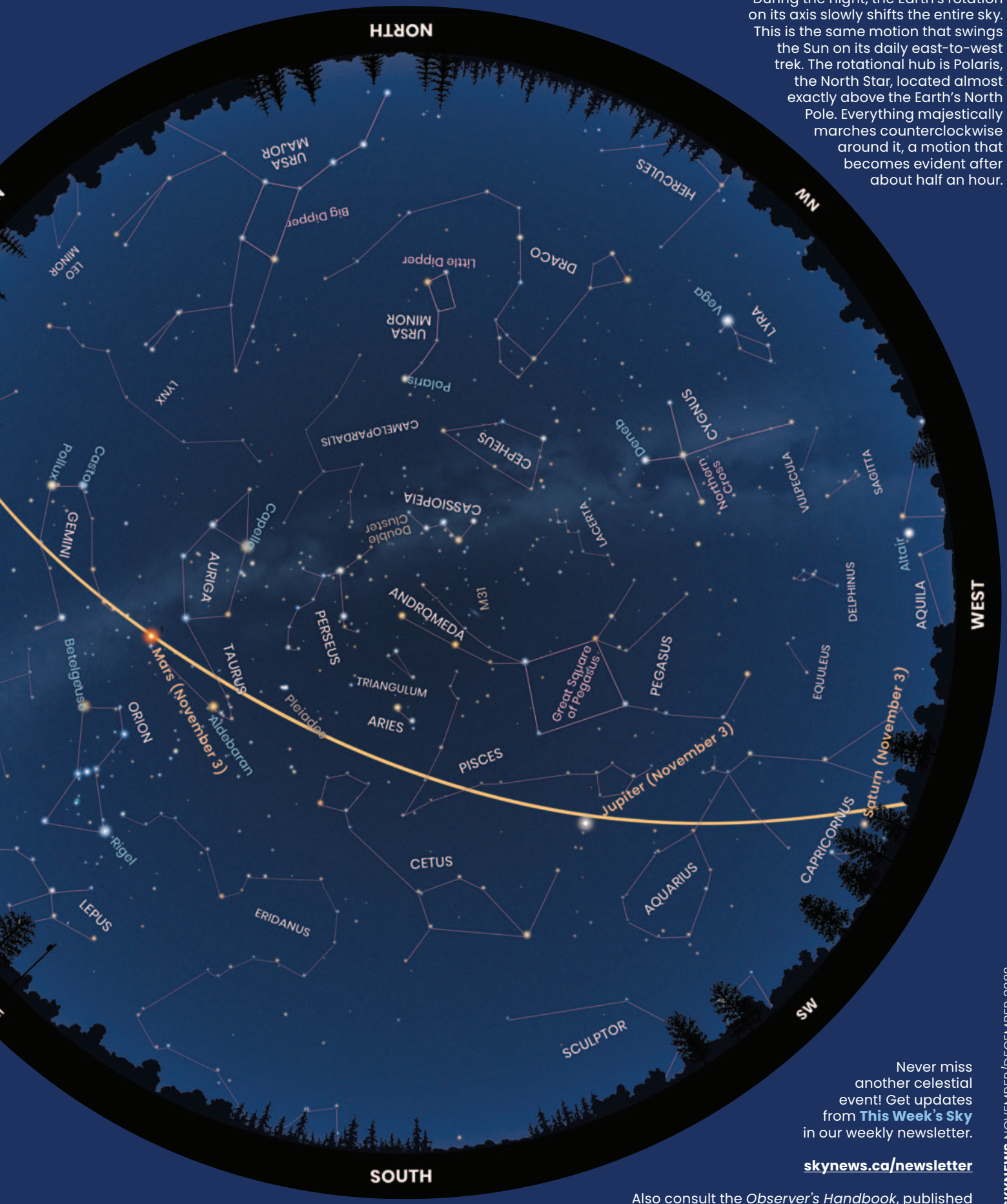
Early November:	11:30 p.m.
Late November:	11:00 p.m.
Early December:	10:00 p.m.
Late December:	9:00 p.m.

USING THE STAR CHART:

The edge of the chart represents the horizon; the overhead point is at centre. The faintest stars depicted shine at magnitude 5.0 — a little brighter than what you can see under ideal conditions. On a moonless night in the country, you will see more stars than are shown here; deep in the city, you will see fewer. (The planets, when visible, are plotted for the dates as marked.)

The star groups linked by lines are the constellations approved by the International Astronomical Union as a way of mapping the night sky.

The chart is most effective when you use about one-quarter of it at a time, which roughly equals a comfortable field of view in a given direction. Outdoors, match the horizon compass direction on the chart with the actual direction you are facing. Don't be confused by the east and west points on the chart lying opposite their location on a map of Earth. When the chart is held up to match the sky, with the direction you are facing at the bottom, the chart directions match the compass points. For best results when reading the chart outdoors, use a small flashlight heavily dimmed with red plastic or layers of brown paper. Unfiltered lights greatly reduce your night-vision sensitivity.



ROTATING NIGHT SKY: During the night, the Earth's rotation on its axis slowly shifts the entire sky. This is the same motion that swings the Sun on its daily east-to-west trek. The rotational hub is Polaris, the North Star, located almost exactly above the Earth's North Pole. Everything majestically marches counterclockwise around it, a motion that becomes evident after about half an hour.

Never miss another celestial event! Get updates from **This Week's Sky** in our weekly newsletter.

skynews.ca/newsletter

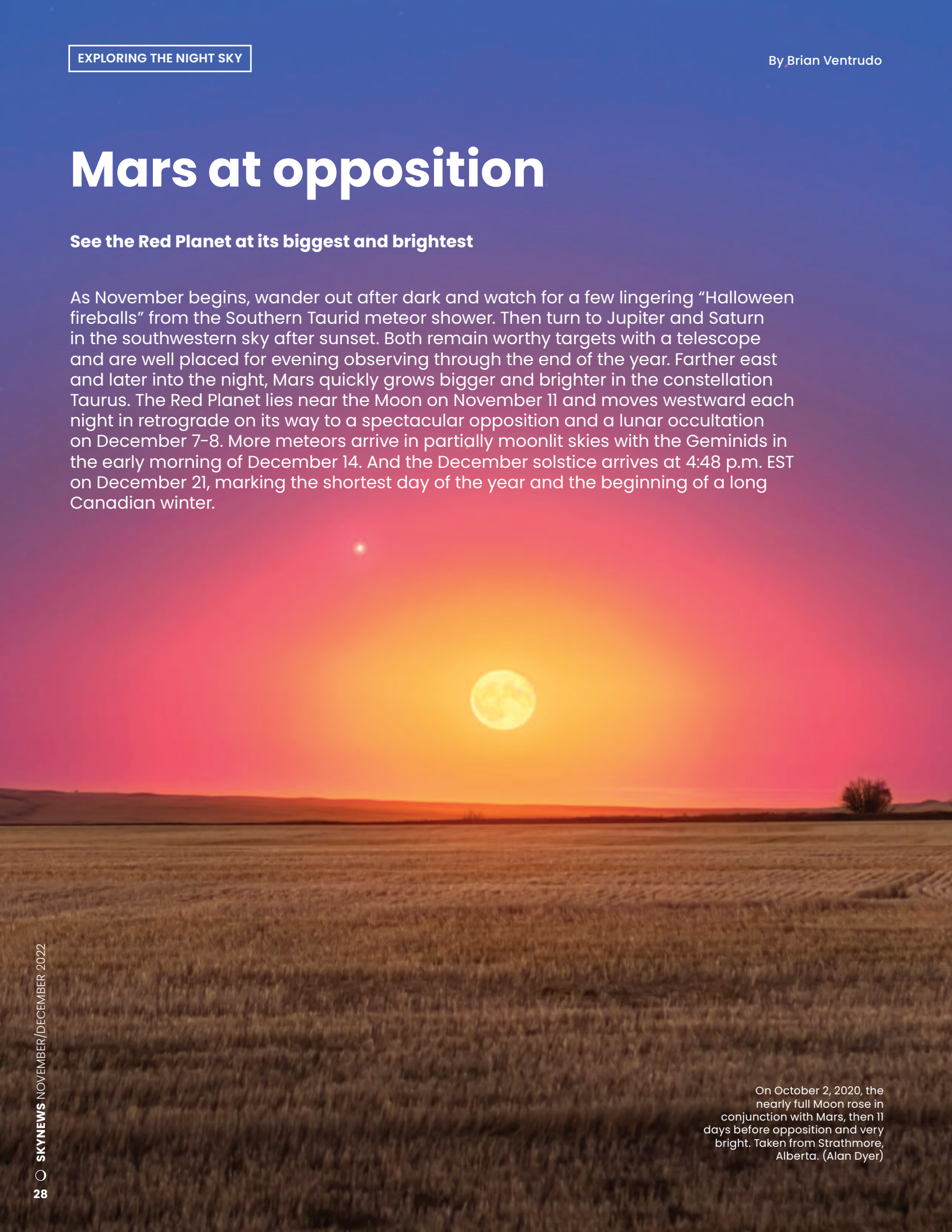
Also consult the *Observer's Handbook*, published by The Royal Astronomical Society of Canada, available at **rasc.ca** or by calling 1-888-924-7272.

By Brian Ventrudo

Mars at opposition

See the Red Planet at its biggest and brightest

As November begins, wander out after dark and watch for a few lingering "Halloween fireballs" from the Southern Taurid meteor shower. Then turn to Jupiter and Saturn in the southwestern sky after sunset. Both remain worthy targets with a telescope and are well placed for evening observing through the end of the year. Farther east and later into the night, Mars quickly grows bigger and brighter in the constellation Taurus. The Red Planet lies near the Moon on November 11 and moves westward each night in retrograde on its way to a spectacular opposition and a lunar occultation on December 7-8. More meteors arrive in partially moonlit skies with the Geminids in the early morning of December 14. And the December solstice arrives at 4:48 p.m. EST on December 21, marking the shortest day of the year and the beginning of a long Canadian winter.

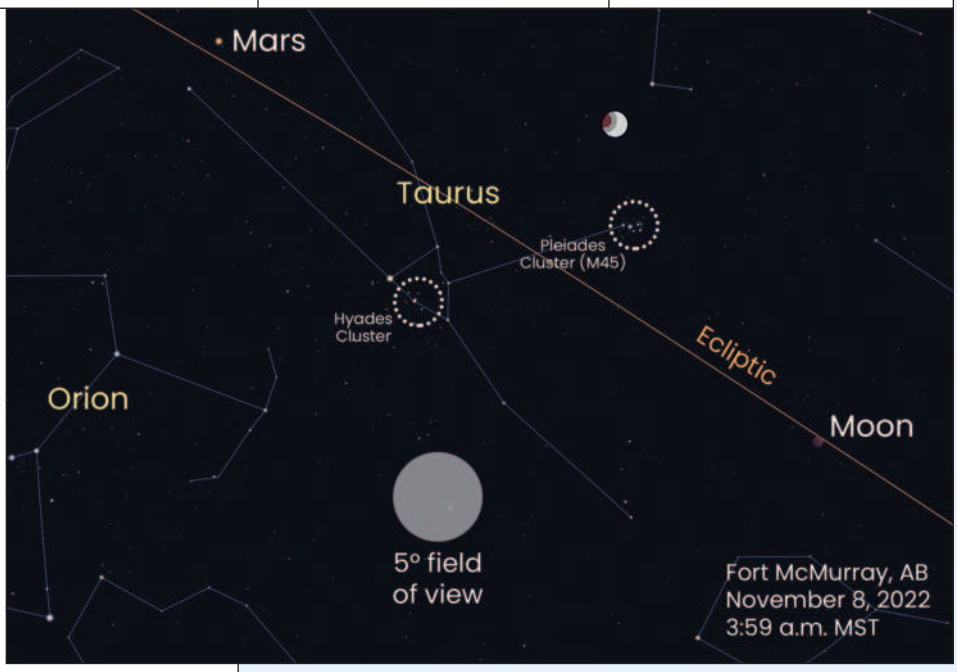


On October 2, 2020, the nearly full Moon rose in conjunction with Mars, then 11 days before opposition and very bright. Taken from Strathmore, Alberta. (Alan Dyer)

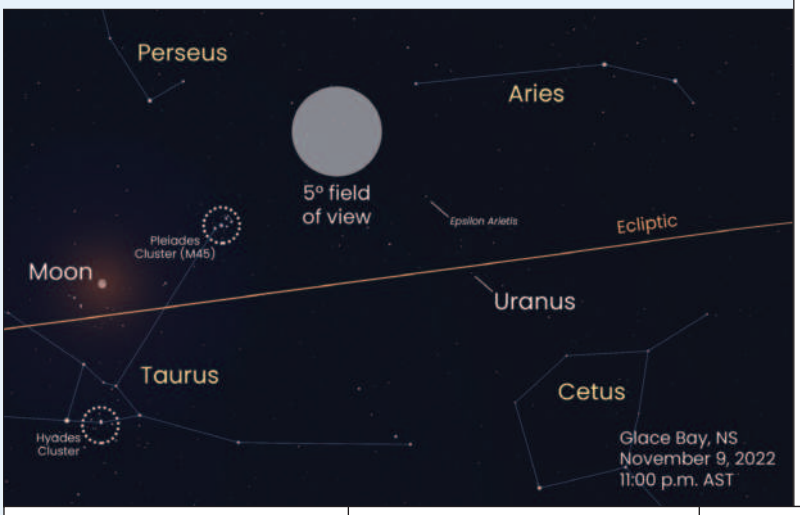
DATE:	TYPE:	TIME:	VIEW:
November 8, 2022	Total lunar eclipse	Early morning	Naked eye, binoculars

A full Beaver Moon eclipse

The second total lunar eclipse of the year arrives with the November full Beaver Moon. The eclipse occurs while the Moon appears a little smaller than average, as it lies near apogee. Look for it in Aries about 16 degrees west of the Pleiades. The eclipse happens from 1:02 a.m. MST to 6:56 a.m. MST on November 8, with totality running 86 minutes from 3:16 a.m. MST to 4:42 a.m. MST. Peak eclipse arrives at 3:59 a.m. MST. Observers east of Saskatchewan see the eclipse still in progress at moonset, but virtually all of southern Canada enjoys totality. During this eclipse, the Moon lies at the northern edge of the umbra, the darkest part of the Earth's shadow, so it appears slightly brighter at its northern limb and darker toward its southern limb.



In sub-zero temperatures from the east end of St. John's, Newfoundland and Labrador, Jim Stacey caught the total lunar eclipse of May 15–16, 2022, at one-minute intervals from its cloudy beginnings to mostly clear skies back to cloud. Stacey said this image was his favourite that he captured: the last frame prior to totality, with the last hint of sunlight disappearing from the limb and the stars emerging from the depths of space, the occluded Moon glowing crimson from sunlight refracted through the Earth's atmosphere.



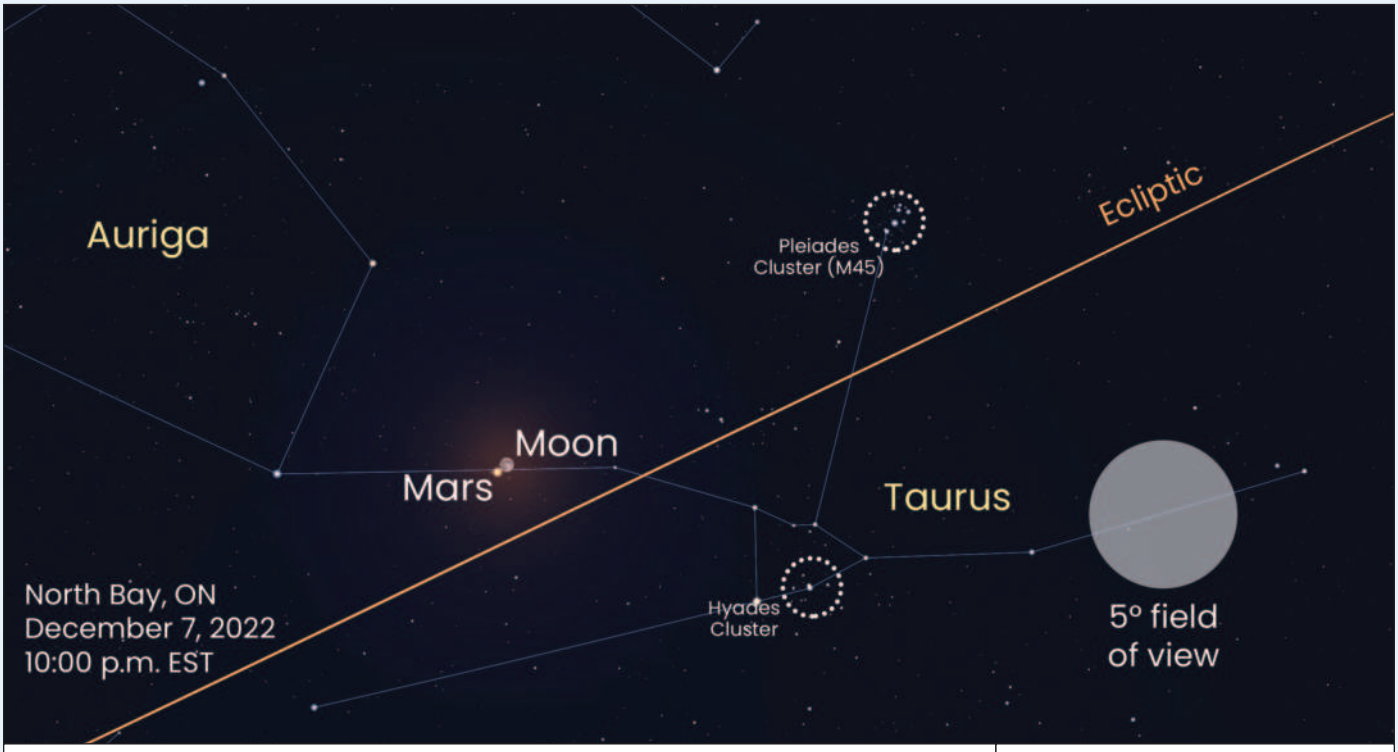
Uranus at opposition

Uranus reaches opposition as it rises in the east while the Sun sets in the west. The planet shines just at the edge of naked-eye visibility at magnitude 5.7 with a disk that spans about 3.7 arcseconds. Look for it about five degrees south of the magnitude 5 star Epsilon Arietis. Uranus remains visible through the rest of the year in this part of the sky. If you want a challenge, try to see the planet without optics in a dark sky when the Moon is out of the way. An even bigger challenge for telescopic observers is spotting one (or all) of the planet's five brightest moons, all of which lie close to its disk and are somewhat overwhelmed by its glare. →

DATE:	TYPE:	TIME:	VIEW:
Uranus at opposition	November 9, 2022	All night	Binoculars, telescope

A stretch of northwestern Canada will be able to see the Moon occult Uranus during the early morning hours of November 8, 2022.

Charts by Allendria Brunjes (Stellarium)



A spectacular Martian opposition

Mars makes its closest approach to Earth on November 30 at a distance of 81.4 million kilometres and reaches opposition on the night of December 7-8. It's the first Martian opposition since October 2020. At magnitude -1.9 tonight, Mars lies tangled among the horns of Taurus northeast of the Hyades star cluster. You can't miss it.

While Mars isn't as large as the past few oppositions, the planet lies near the northern extreme of the ecliptic and is perfectly placed for Canadian observers. The disk spans 17 arcseconds, big enough to reveal detail with a telescope if the air is steady. To observe Mars through a telescope, start at low magnification and work your way up to as much as atmospheric conditions allow. Try an orange (Wratten #21) filter to improve contrast between darker features and the rusty desert regions. The planet begins to slowly shrink and dim over the coming weeks.

DATE:
December 7-8

TYPE:
Planetary opposition

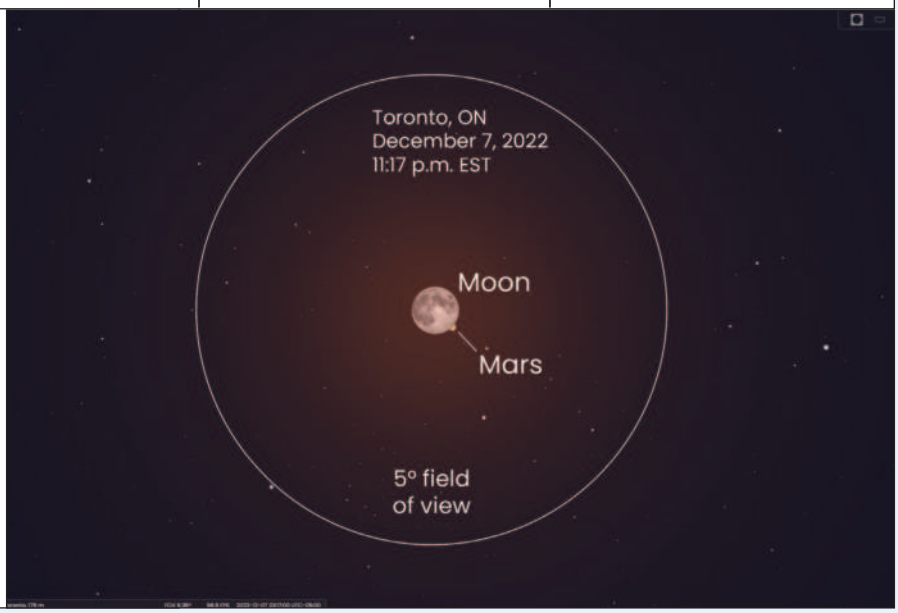
TIME:
All night

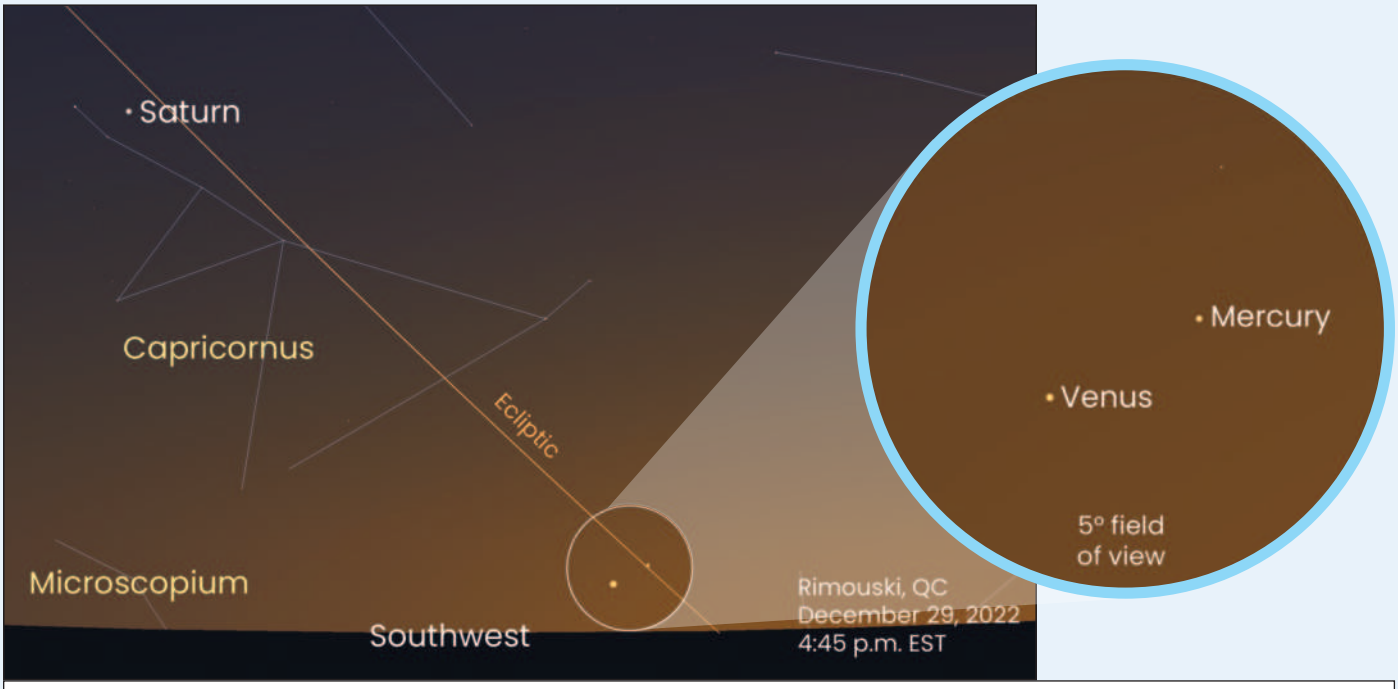
VIEW:
Naked eye, binoculars, telescope

DATE:	TYPE:	TIME:	VIEW:
December 7-8	Lunar occultation	Late evening	Naked eye, binoculars, telescope

Full Moon occults Mars

As Mars reaches opposition tonight, it's also occulted by the full Moon, a remarkable event visible across the entire country. The precise time of the occultation depends on location, but in Toronto it begins at 10:29 p.m. EST and ends as the planet re-emerges at 11:18 p.m. EST. In Vancouver, Mars passes behind the Moon at 7:55 p.m. PST. and reappears at 8:52 p.m. PST. You can see the event without optics, but a pair of binoculars or small telescope will give you a better view.



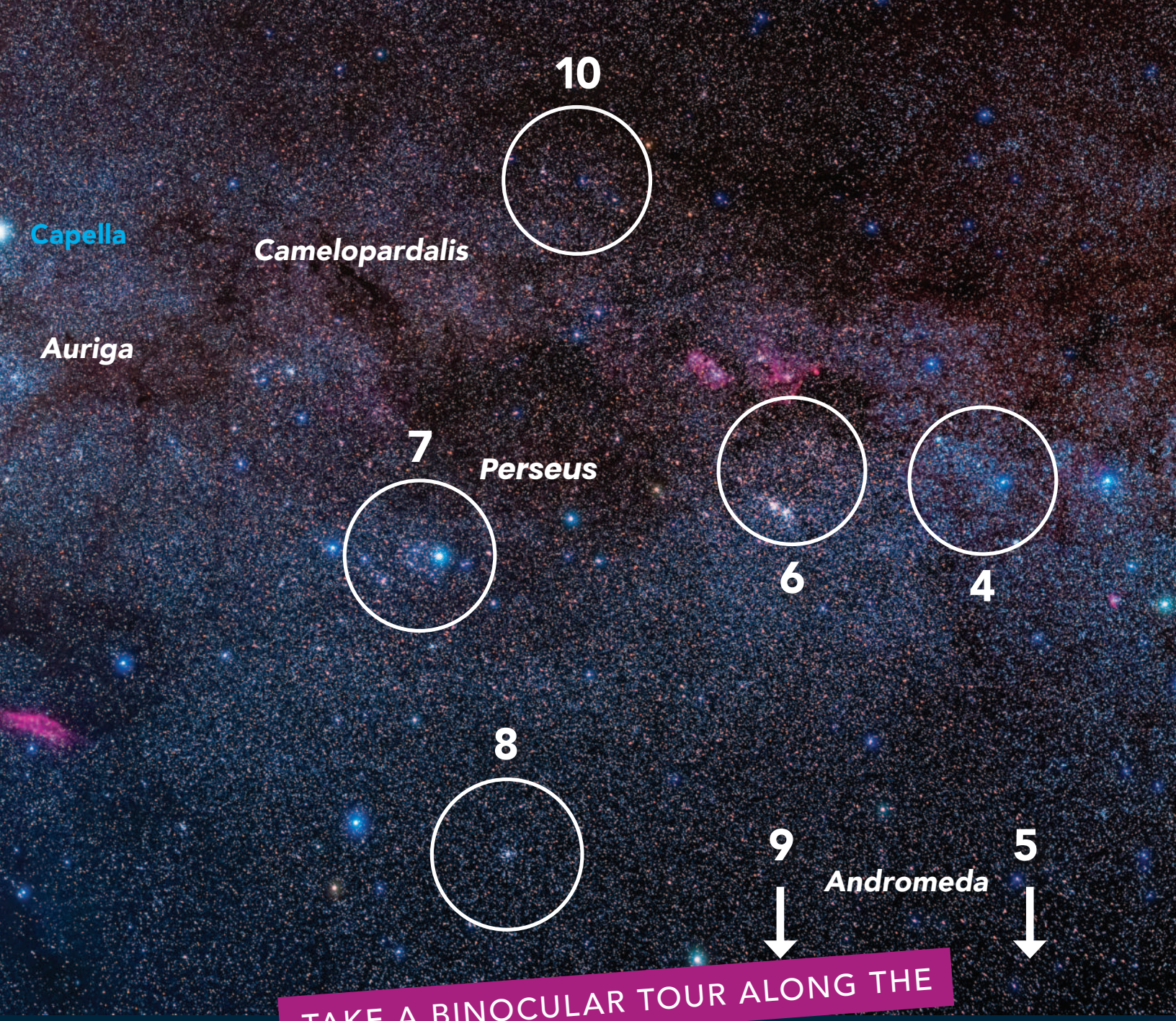


Mercury and Venus make close approach

Grab a warm coat and a pair of binoculars and wander outside just after sunset to see Venus and Mercury just 1.4 degrees apart low over the southwestern horizon. Venus, just below Mercury, outshines the smaller planet by four full magnitudes. The evening twilight and low elevation of the pair make this observation a little tricky. Well to the upper left of Mercury and Venus lie Saturn, a waxing crescent Moon and Jupiter. If it's not too cold, linger under the emerging stars with your binoculars and take in Cassiopeia and Perseus overhead and Auriga and Taurus farther east. It's been a good year for stargazing, and many spectacular celestial events lie ahead in 2023. ✶

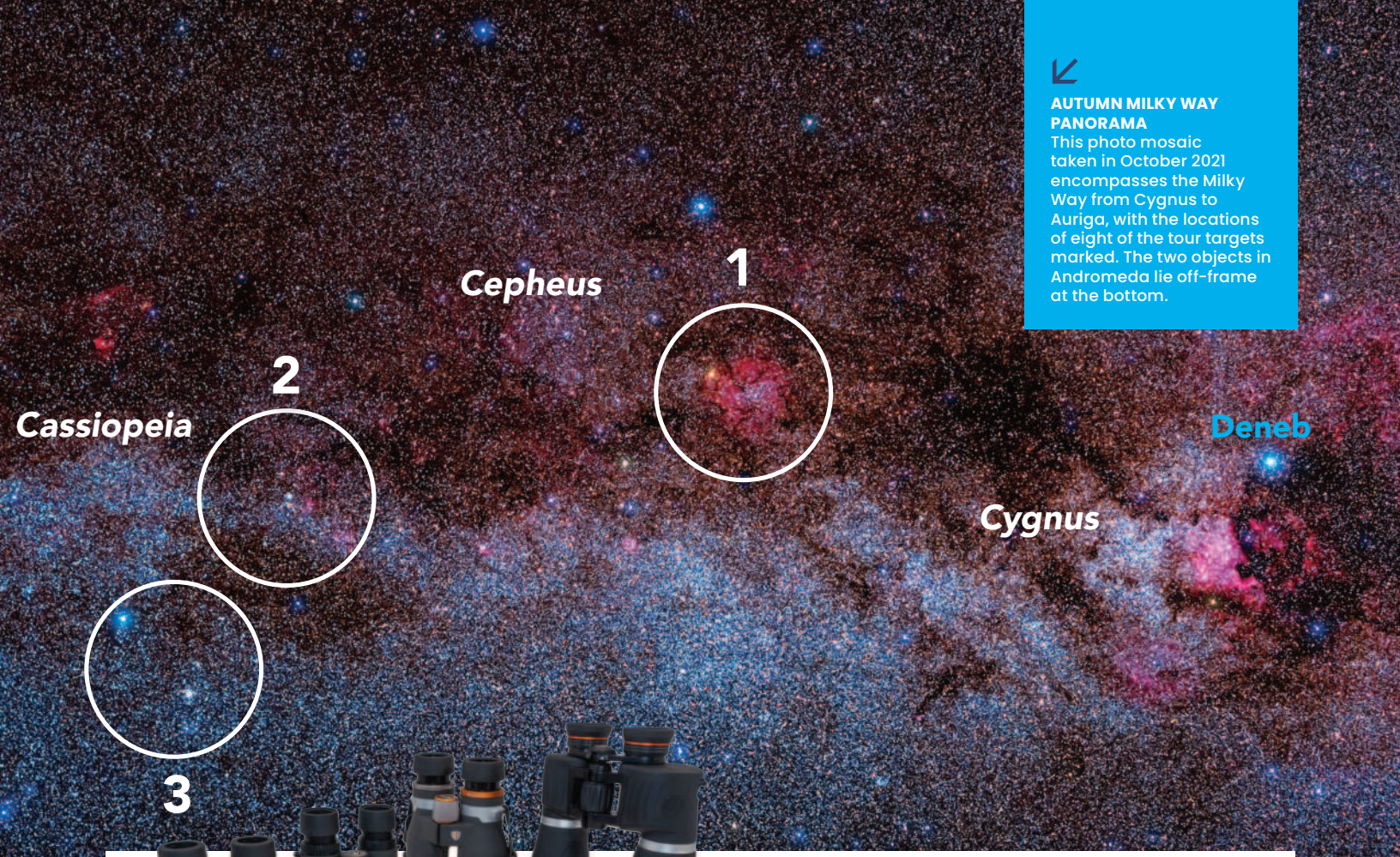
DATE:	TYPE:	TIME:	VIEW:
December 28-29	Conjunction	After sunset	Binoculars, telescope

Charts by Allendria Brunjes (Stellarium)



TAKE A BINOCULAR TOUR ALONG THE

Autumn Milky Way



AUTUMN MILKY WAY PANORAMA
This photo mosaic taken in October 2021 encompasses the Milky Way from Cygnus to Auriga, with the locations of eight of the tour targets marked. The two objects in Andromeda lie off-frame at the bottom.

BINOCULAR QUARTET: The author used these binoculars to compile notes for the tour, from left to right: a Nikon PROSTAFF P7 10 × 42, a Vortex Diamondback 10 × 50, a Maven B4 10 × 56 and a Celestron SkyMaster Pro 15 × 70.

Here is Alan Dyer's pick of TOP 10 TARGETS along — and around — the autumn Milky Way.

By Alan Dyer

I FIND FEW NIGHTS UNDER THE STARS MORE PLEASURABLE than those spent simply lying back and scanning along the Milky Way with binoculars. The observing is uncomplicated but the views, especially from a dark site, can be spectacular.

In autumn, the Milky Way arcs overhead, with our planet turned so we gaze toward the outer Perseus Arm of our galaxy. It is a region populated by some of the best clusters of stars in the sky. Venture off the Milky Way and we can travel beyond our galaxy to visit another galaxy entirely.

As a sequel to my summer binocular tour in the July/August 2022 issue, I've prepared a ramble through the autumn sky, picking my ten favourite targets suitable for binoculars. I've selected a variety of object types, from red stars to unique asterisms.

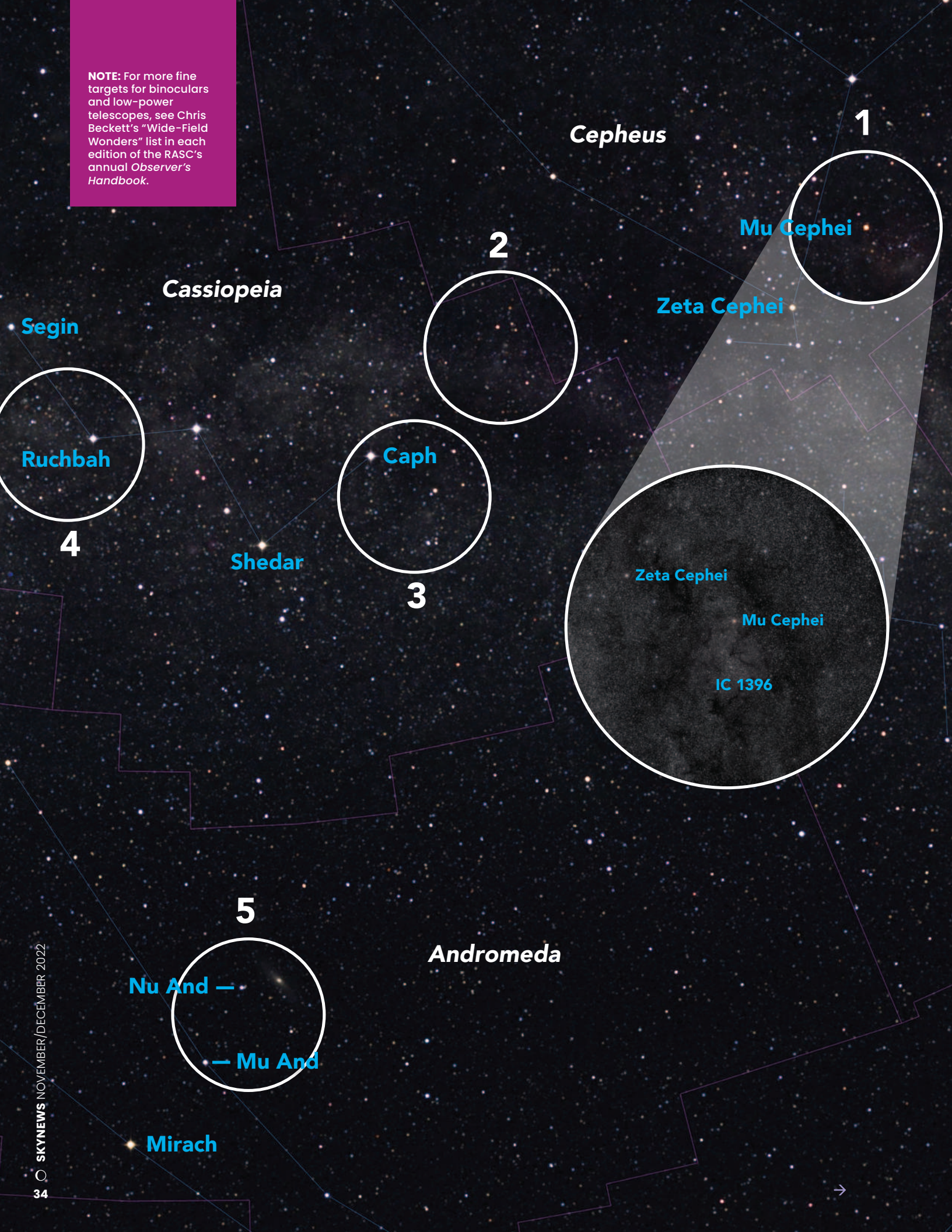
However, unlike my summer tour, this one doesn't stop at any nebulae, the amorphous gas clouds where stars are born and die. While the autumn Milky Way is rich in reddish nebulae (as the photo above records), all are either too small or too faint to be ready targets for modest binoculars. No worries. There's lots to see!

As with my summer tour, the close-up images I've included of our destination objects are processed to simulate their visual appearance through binoculars, with typical 6.5-degree fields of view.

All the objects can be seen with 42mm-aperture binoculars (I observed them all with a new favourite model, a Nikon PROSTAFF P7 10 × 42, on some fine nights in July earlier this year). All targets will appear slightly brighter with 50mm or 56mm binoculars. In 15 × 70mm or larger binoculars, the views will be brighter still, with the higher power better for resolving star clusters, though with a narrower 3- to 4-degree field of view.

However, the best views come not with bigger gear but better skies. Get to a dark site around the new Moon, and enjoy the simple pleasure of binocular gazing under the Milky Way. →

NOTE: For more fine targets for binoculars and low-power telescopes, see Chris Beckett's "Wide-Field Wonders" list in each edition of the RASC's annual *Observer's Handbook*.



PART 1: Cepheus, Cassiopeia and Andromeda

I've split the tour into two halves, with the first picking up where my summer tour left off, starting in southern Cepheus just north of the summer constellation of Cygnus. We then enter autumn "cluster country" in Cassiopeia.

1. Mu Cephei in Cepheus

We start with a star. Herschel's Garnet Star is a red supergiant named for 18th-century astronomer William Herschel. With the 6.2-inch reflector he used to discover Uranus, Sir William logged his eponymous star, also known as Mu Cephei, on September 27, 1782, describing it as "a very fine deep garnet." Through binoculars I see it as orange. Look for a spray of faint stars to the south. That's the big, sparse star cluster IC 1396, a label also attached to the large nebulosity south of Mu that is too faint for binoculars.

2. Messier 52 in Cassiopeia

We come to our first Messier object, from 18th-century observer Charles Messier's catalogue. Messier 52 is an open star cluster. Find it by drawing a line between Schedar and Caph, the fourth and fifth stars in the "W" of Cassiopeia, and extending it just over a binocular field up. Look for a small, brighter knot within the Milky Way and flanked by dark lanes above and below it. M52 won't resolve with 10× binoculars; seeing it as a stellar cluster demands 15× or more.

3. NGC 7789 in Cassiopeia

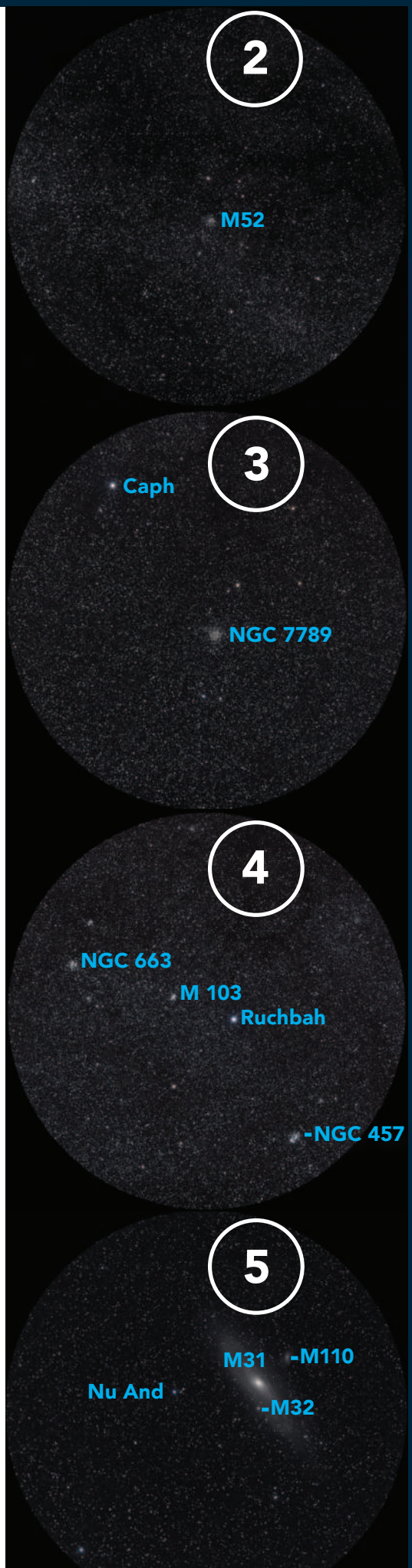
This star cluster from the later New General Catalogue is easier to see than some of the Messiers. NGC 7789 is called Caroline's Rose, after William Herschel's sister Caroline who discovered it in 1783. Hop from Schedar to Caph again, but now take a right-angle turn southwest at Caph. Within a binocular field, look for a uniform, hazy patch that appears very comet-like. How Messier missed this "false comet," exactly what he was cataloguing, is a mystery, as it is obvious in a dark sky.

4. Cass cluster trio — NGC 457, NGC 663 and Messier 103

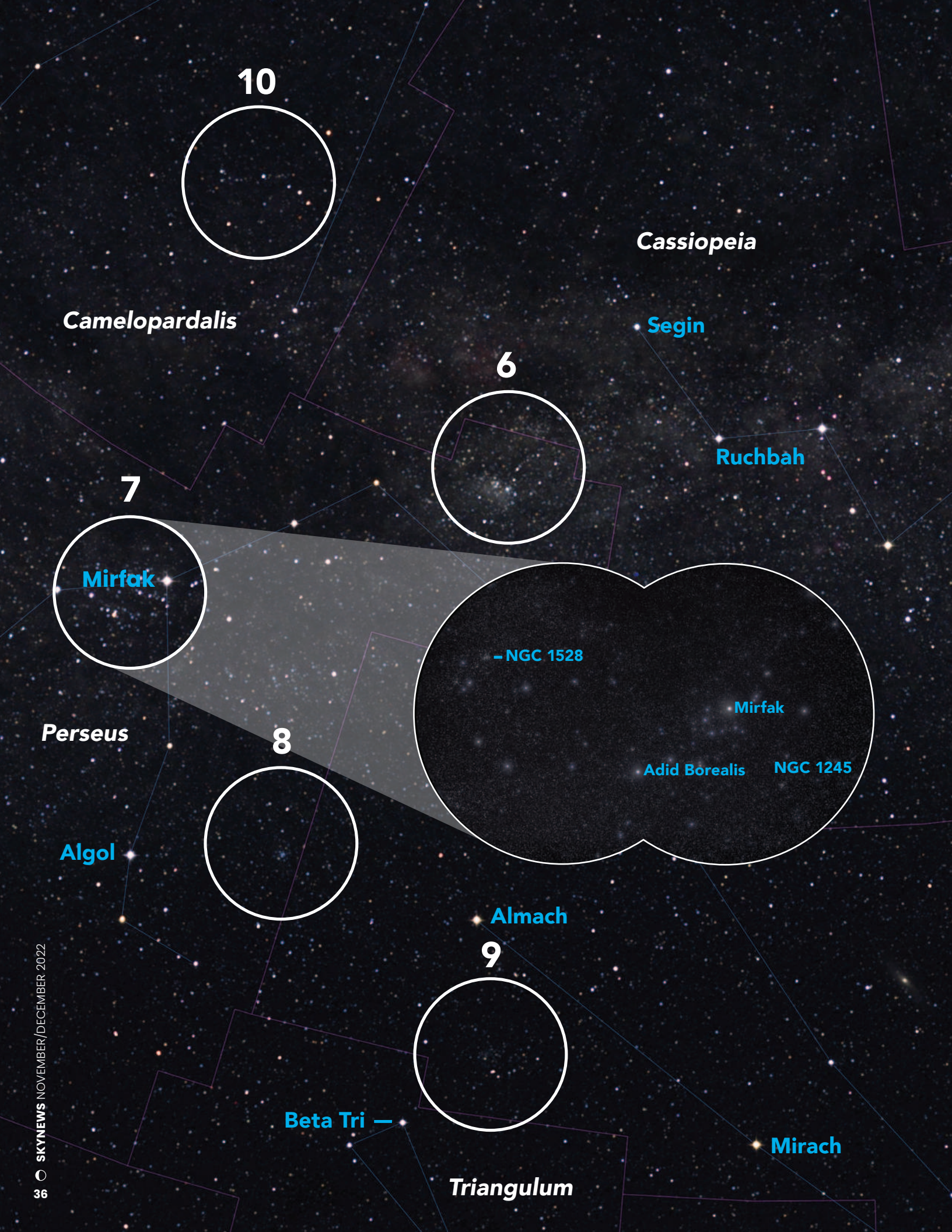
Here we are treated to three star clusters at once. Look halfway between and just below a line joining Segin and Ruchbah, the first and second stars in Cassiopeia's "W," for another rich non-Messier cluster, NGC 663. My 10 × 42s resolved it. Now pan south to Ruchbah to find NGC 457, a.k.a. the E.T. Cluster, just above the star Phi Cassiopeiae and its close companion. They form the stellar eyes of E.T., the Extraterrestrial, with his tiny body outlined in the cluster's stars. Between NGC 663 and Ruchbah lies Messier 103, appearing as just a line of three or four stars.

5. A side trip to Andromeda — Messier 31

The only target on our tour not in our Milky Way is Messier 31, another galaxy in its own right. Find Mirach in the middle of Andromeda and pan up past Mu and Nu Andromedae to locate M31's elliptical glow. In a dark sky, it will span half the field of 10× binoculars and almost all the field of 15× glasses. The challenge is seeing its companion galaxies. M110 above M31 isn't too hard, but M32 is tougher as it appears as a tiny, soft star embedded in M31's lower edge. In this group of galaxies, you are seeing light that is 2.5 million years old. →



Background star chart courtesy StarryNight/Simulation Curriculum
Eyepiece simulations by Alan Dyer


10
Cassiopeia
Camelopardalis
Segin
6
Ruchbah
7
Mirfak
NGC 1528
Mirfak
Perseus
8
Adid Borealis
NGC 1245
Algol
Almach
9
Beta Tri
Mirach
Triangulum

PART 2: Andromeda, Perseus and Camelopardalis

In the second half, we first resume our trek along the Milky Way, then venture below the misty band to visit two star clusters ideal for binoculars. We end with a wander well above the Milky Way into the empty quarter of Camelopardalis.

6. A triple cluster in Perseus — NGC 869 and 884 plus Stock 2

The famous Double Cluster in Perseus (a.k.a. NGC 869 and 884) is one of the sky's showpiece objects, through binoculars or any telescope. But binoculars turn it into a "Triple Cluster," as just above it lies the large and loose cluster Stock 2, nicknamed the Muscleman Cluster. I see him as a rectangle of stars with an arm coming off one side. Between him and the Double Cluster, look for a striking arc of stars joining the clusters. This is one of the finest star cluster fields for binoculars.

7. The Perseus Association

We can say the same for this rich field. Catalogued as the star cluster Melotte 20, this wide group is also classed as an "association," a loose collection of hot, blue-white stars of spectral type O and B. The bluish stars of the Perseus OB3 Association snake across a binocular field south of Mirfak, a yellow giant star. The image shows the width of two binocular fields, and the location of two more NGC clusters you might glimpse.

8. Messier 34 in Perseus

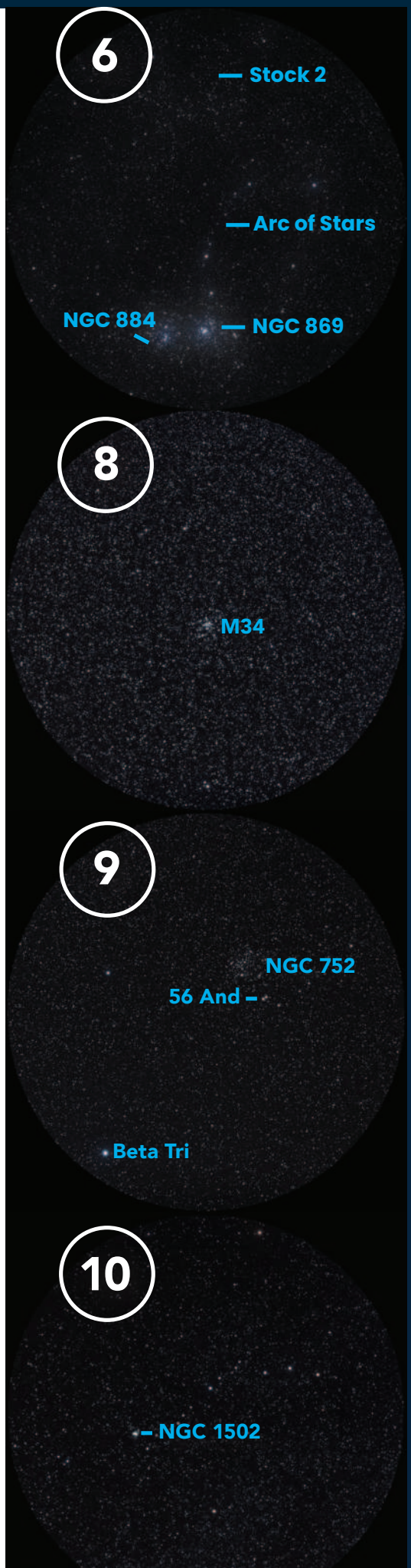
Find Algol, the variable Demon Star, south of Mirfak, then scan a binocular field to the west. Here at last is a Messier cluster that is obvious. M34 is bright and stands out well from the sparser background off the Milky Way. I find it appears somewhat box-shaped and nicely resolved with 10 × 42 binoculars. While Messier catalogued it, M34 was logged as far back as 1654, during the early years of telescope use more than a century before Messier's time.

9. NGC 752 in Andromeda

Venture farther to the southwest from M34, and within a binocular field below Almach in Andromeda (or above Beta Trianguli), you'll come across NGC 752. It requires a dark sky for it to stand out, but this big, loose cluster is best seen through any set of binoculars. Look for a uniform mass of faint stars with an equally matched "headlight" double star, 56 Andromedae, on its southwest side. NGC 752 looks as good with 15 × 70 or larger binoculars as many smaller clusters do through telescopes.

10. A chain of stars — Kemble's Cascade

All astronomers who met him admired the observing acumen of Father Lucian Kemble, a Franciscan friar based in Alberta and Saskatchewan. He came across this unique field with his 7 × 35 binoculars and included it in a 1980 observing report to Walter Scott Houston, a columnist for *Sky & Telescope*. Houston dubbed it Kemble's Cascade, as it looks like a fall of stars tumbling down to the tiny star cluster NGC 1502. Find the Cascade in the faint constellation of Camelopardalis, the Giraffe, by aiming at the vertex of a broad triangle with Mirfak and Segin at the other two corners. It is well worth the hunt. ✶

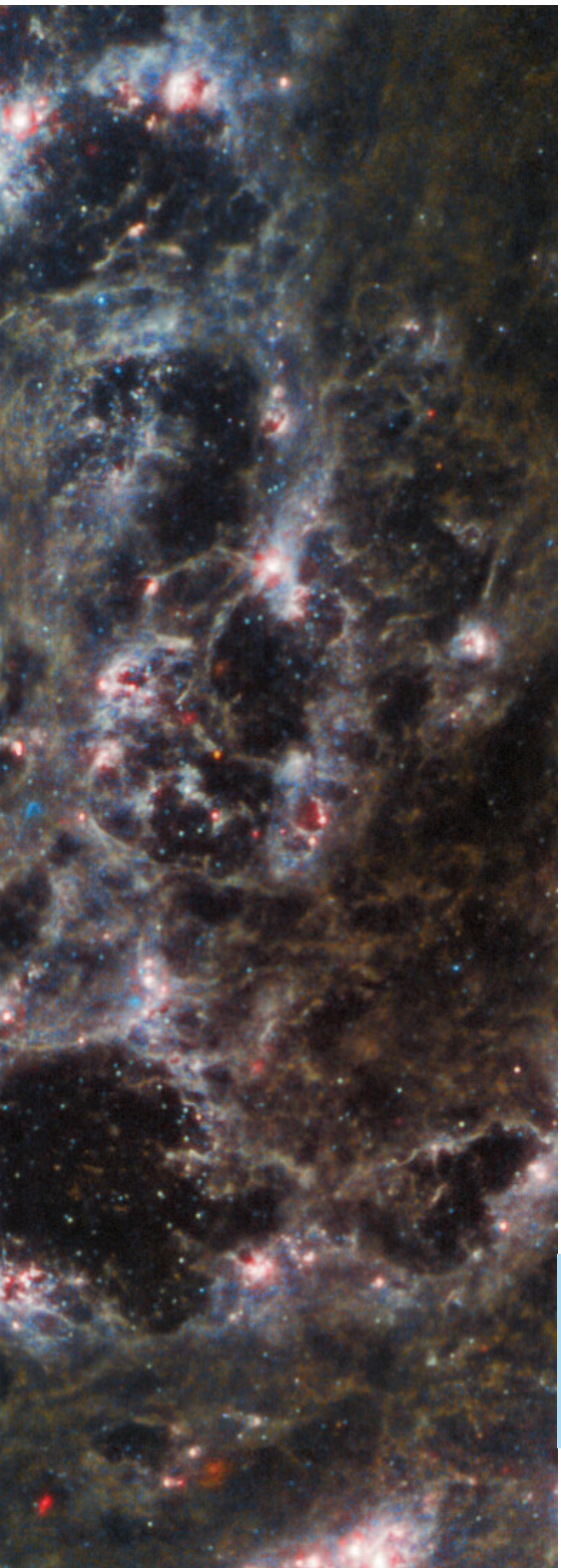


Background star chart courtesy StarryNight/Simulation Curriculum
Eyepiece simulations by Alan Dyer

GATEWAY TO THE UNIVERSE

How the James Webb Space Telescope is cutting through visible light with a Canadian edge

By Vincent McDermott



The James Webb Space Telescope has unfolded its gold-plated beryllium mirrors, unfurled its tennis court-sized heat shield, switched on its instruments and started uncovering the wonders of the Universe. At about 100 times more powerful than the Hubble Space Telescope, Webb is the most sophisticated and expensive telescope — US $10 billion, if you're wondering — ever built.

The first few discoveries will keep scientists busy for years, and more data keeps pouring in. On September 1, a team from the University of Exeter used Webb to photograph the gas giant HIP 65426 b which lies 385 light-years from Earth. Scientists have also found evidence of carbon dioxide and water in the atmospheres of exoplanets and collected data on some of the oldest stars and galaxies in the known Universe, formed just after its birth.

As the power of the James Webb Space Telescope comes into focus, institutions in Canada are playing a role. Researchers are leading or co-leading 26 projects that will use Webb's instruments. Two of those instruments were built in Canada, guaranteeing time with the far-reaching space telescope.

"We're going to be finding a lot of unusual things. I think astronomy, the nature of the study of the — Universe — is going to look quite different in a couple of years once we've completed some major observations with James Webb," said Chris Willott, an astronomer with National Research Council Canada's Herzberg Astronomy and Astrophysics Research Centre.

Canada's involvement

Canada officially joined the James Webb Space Telescope program in 2007, when the federal government announced a $39-million contract to develop the telescope's fine guidance sensor, which keeps the telescope locked on its target. A press release from the Canadian Space Agency at the time compared the precision needed for the task to focusing on a dime from 1,000 kilometres away.

Development of a second device, called the tunable filter imager camera, was cancelled in 2011 to focus on another Canadian-made device, the Near Infrared Imager and Slitless Spectrograph (NIRISS). This device will help astronomers study the atmospheres of exoplanets and observe distant galaxies.

"The data from NIRISS is going to leave a very great legacy for Canadian astronomy," said Olivia Lim, a PhD student at the Université de Montréal.

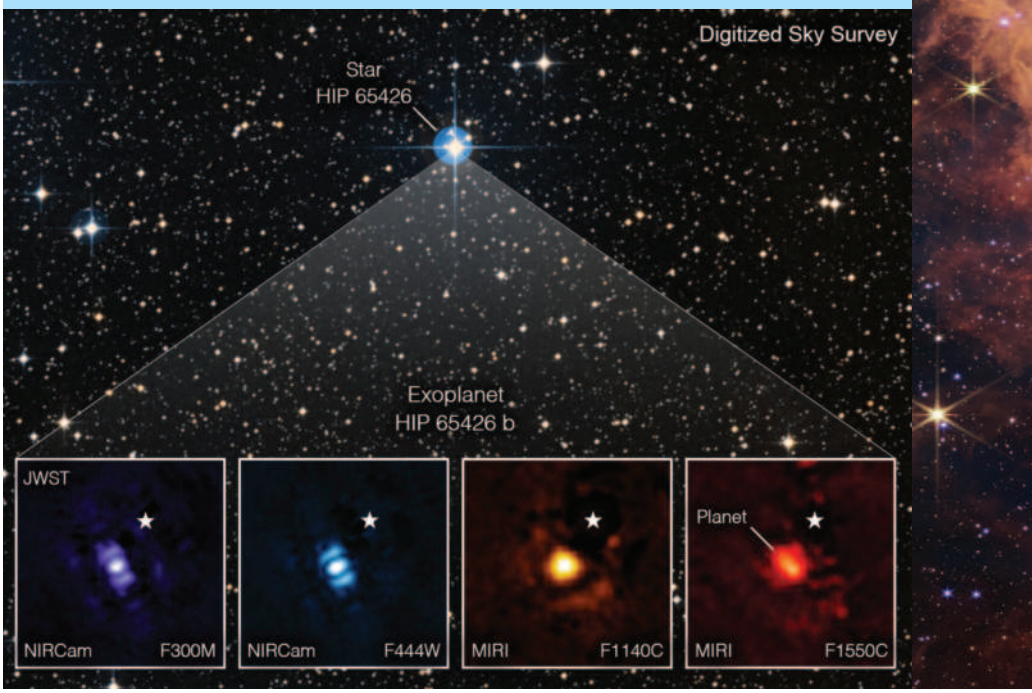
Canada's contributions to Webb have now totalled $134.3 million. The country's initial contribution marked the first of many exciting moments for Canadian astronomers who felt Canada had been left out of developing Hubble.

Dividing time

CSA's involvement also means

← This image of Messier 74 — the Phantom Galaxy — uses data collected with Webb's Mid-InfraRed Instrument (MIRI) along with ultraviolet and visible light data from the Hubble Space Telescope to reveal particularly bright areas of star formation known as Hydrogen II regions, along with observations from ground-based radio telescopes such as the Atacama Large Millimeter/submillimeter Array. (ESA/Webb, NASA & CSA, J. Lee and the PHANGS-JWST Team; J. Schmidt)

↓ **BELOW:** The James Webb Space Telescope has imaged its first exoplanet, the gas giant HIP 65426 b. The planet is about six to eight times the mass of Jupiter, and young as planets go — about 15 to 20 million years old, compared to our 4.5-billion-year-old Earth. This image highlights Webb's science in progress, which has not yet been through the peer-review process. (NASA/ESA/CSA, A Carter (UCSC), the ERS 1386 team, and A. Pagan (STScI))



Canadian astronomers are guaranteed five per cent of Webb's time. Webb's first few years of operation include 450 hours for the Canadian Webb science team, with 403 hours split between two Canadian-led programs.

One of those programs is the NIRISS Exploration of the Atmospheric diversity of Transiting exoplanets (NEAT), a Université de Montréal program studying the atmospheres of exoplanets.

Willott is leading the second program, the Canadian NIRISS Unbiased Cluster Survey (CANUCS). This program studies some of the earliest known galaxies, which formed during the first few hundred million years after the Big Bang.

The remaining 47 hours will be shared by seven smaller Canadian programs studying rogue planets, brown dwarfs and exoplanets. Another five per cent of observing time is reserved for Canadian astronomers selected through a competitive process.

Willott said this is a healthy amount of time for a country when one considers the size of Canada's scientific community.

"It's not just a hammer. It's a brand new hammer, and it's a new kind of nail, and we're now trying to figure out how to use it," said Wesley Fraser, an astronomer at Dominion Astrophysical Observatory in Saanich, British Columbia. "Just about every optical and near-infrared astronomer in Canada is thinking similar things."

Project details

Fraser and a team of astronomers will use Webb's Near Infrared Camera — NIRCam — to search for objects that are less than 10 kilometres wide in the Kuiper Belt, a ring of icy objects left-over from the formation of the Solar System and found beyond Neptune's orbit. Webb is being used alongside the Hubble Space Telescope so researchers can compare their findings with visual data of what they are studying.

Fraser hopes the project will help researchers understand the surfaces of Kuiper Belt objects and the early stages of how planets are formed. He hopes his next project with Webb will be studying the surface of Arrokoth, a Kuiper Belt object visited briefly by the New Horizons probe in 2019.

"That would be absolutely wild. It's kind of giving me chills just thinking about getting it," he said.

Willott said only Webb will be able to collect the information he needs for CANUCS. This includes much more accurate distance measurements and information about the physical state of the gases in galaxies.

"We're looking to not just find galaxies in the early Universe, but we're dissecting them and examining their structure to understand how they're formed," Willott said. "We're going to be able to compare them with a lot of simulations to gain a much deeper understanding of galaxies."

Webb is also an opportunity for a younger generation of astronomers to rewrite and update science textbooks.

Lim was not yet born when a 1996 report from a committee tasked with replacing Hubble proposed Webb. She was an undergraduate student in 2016 when Belgian astronomers excitedly announced there were seven planets orbiting the red dwarf TRAPPIST-1, located roughly 40 light-years away. Ranging from roughly the size of Mars to slightly larger than Earth, three of the planets are in the habitable zone.

Now, nearly 26 years after the initial seeds of Webb were planted, Lim is planning to learn about the atmospheres of TRAPPIST-1's worlds. She will use Webb to observe how the star's light is filtered through a planet's atmosphere. How certain wavelengths of light are absorbed by different molecules will tell her the composition of a planet's atmosphere. This includes elements and compounds that could hint at different forms of life, such as carbon dioxide, methane or water vapour.

← The image "Cosmic Cliffs" highlights NGC 3324, the star-forming region in the Carina Nebula. The picture captures a portion of the nebula about 16 light-years across, which stretches over 7.3 arcminutes in our sky. (NASA, ESA, CSA)

Only Webb could have been used to carry out this research thanks to the size of its mirror, its ability to see the Universe in infrared and its position in orbit around the Sun 1.5 million kilometres away from Earth.

"Exoplanets are a fairly new topic of study. The first exoplanet was discovered in 1995. But there's lots of room for innovation in the field," Lim said.

The future

The general public has been just as excited about Webb as astronomers, which Nathalie Ouellette, the CSA's outreach scientist for Webb, said is important for this new age of astronomy.

Ouellette, who is also the coordinator of the Institute for Research on Exoplanets (iREx) at the Université de Montréal, describes astronomy as "a gateway science." She noted that despite the importance of the work, not everyone is going to be enamoured with engineering, microscopes or mixing chemicals.

"One way to get especially children and the general public interested in science is talking about astronomy," she said.

Learning about the Universe can introduce people to basic scientific principles: evidence, theories, analysis, debate and methods of thinking that are critical, creative and curious. A tool like the most powerful space-based observatory ever built has lots of potential to encourage people to be curious and skeptical.

"Most people know the importance of having a society that is very scientifically literate, that is conscious of all of the great advancements that science and technology can do, and that it must be wielded carefully," Ouellette said.

"I think astronomers are very privileged that almost everyone already automatically loves our science. We have a great responsibility as astronomers to try to get people more interested in science generally."

Canada's participation also gives the country an advantage for the day when Webb is replaced, noted Robert Smith, a space historian at the University of Alberta who has been watching Webb's development.

The next telescopes are in their planning stages and have yet to be approved by any space agency, but, much of their mission will be built upon Webb's discoveries. Webb's success — and price tag — will also make governments examine their own priorities for supporting future scientific research.

Willott said a question that scientists will be asked soon is what will Webb do next? Canada has a diverse field of projects that includes everything between our own Solar System and the far, distant edges of the Universe. The answer to that question will depend on what we find in the first few years.

"James Webb is here, and it's going to be here for a long time. There are so many things that are going to happen," said Fraser. ✶

Whither the Wonder of Jena?

As we roll up to the 100th anniversary of the installation of the world's first Zeiss planetarium, we look at the dawn of the device

By David A. Rodger

ONE AUGUST DAY IN 1923, engineers, technicians and company guests assembled under a temporary dome on a roof of the Carl Zeiss Optical Works in Jena, Germany. They came to witness the culmination of over 10 years of research and development at Zeiss. And it was time to share the results with the world.

As the lights dimmed, a strange-looking machine in the centre of the domed room came to life. Across the dome's inner surface, tiny pinpricks of light began to appear. And there, above and around those present, was the brilliant starry sky as they might see it in the nearby Harz Mountains.

The demonstration continued. The projected sky began to turn westward in a speeded-up simulation of its nightly motion. And then came the Zeiss team's supreme achievement.

Their machine proceeded to show, in stunning reality, the motions and positions of the five naked-eye planets (Mercury, Venus, Mars, Jupiter and Saturn), as well as the movements of the Sun and Moon — all as viewed from Earth. The planets appeared as stars, moving along or near the ecliptic in compressed time, passing one another

LEFT: Edmonton's retired Zeiss projector with the original and long-retired Spitz projector at its "feet." (Telus World of Science Edmonton)
TOP: First show for school children at the Jena Planetarium with the Zeizz Model II projector in 1926. (Zeiss Planetariums)

and going through the retrograde loops that had so puzzled observers centuries before. And the Moon was seen going through its phases as it moved across the sky.

Zeiss called the device a "projection planetarium," alluding to its mechanical and optical properties. This was fitting, for it was the machine's complex system of gears and optics that produced the motions and positions of the stars, planets, Sun and Moon. As word of its marvels spread, it was nicknamed "the Wonder of Jena."

Around the world

It was the renowned Deutsches Museum in Munich, Germany, that had prompted Zeiss to develop the projection planetarium. So it was appropriate that, when the demonstrations in Jena were completed, the machine was reinstalled in Munich. Except during the Second World War, when it was hidden away for its protection, the projector was in operation until 1960, when the latest model Zeiss projector replaced it. Dubbed the Model 4, it — and its predecessors, Models 2 and 3 — had the familiar "dumbbell" configuration.

To the functions of the original, Models 2, 3 and 4 added the ability to display the sky from any latitude on Earth, as well as precession of the equinoxes. Thus, it could show the nighttime sky over Chile or Iceland, or anywhere else, while the instrument's precession axis could be set so the sky now revolved around a celestial pole near, for example, Thuban in Draco (3,500 BCE) or Vega in Lyra (14,000 CE), rather than Polaris.

During the 1930s, Zeiss projectors were installed in American cities such as Chicago, Philadelphia, Los Angeles, New York and Pittsburgh. At the same time, the meaning of the word "planetarium" was expanded to denote a building with a Zeiss projector.

Canada's zeal for Zeiss

Canada's first Zeiss projector was unveiled in Montréal in 1966. After Montréal, Zeiss projectors were installed in Calgary in 1967, then Winnipeg, Toronto and Vancouver in 1968.

TOP RIGHT: Crowds await shows at the first projection planetarium on the roof of the Zeiss factory in Jena in 1924. (Zeiss Planetariums) **BOTTOM RIGHT:** The first Zeiss Planetarium at the German Museum in Munich in 1925, with the Model I. (Zeiss Planetariums)

The idea of a planetarium "show" was seldom considered in the early days. Indeed, audiences usually saw a live lecture or demonstration that showed the projector's capabilities. Many planetariums, in fact, were quasi-academic institutions headed by research astronomers.

Over the years, skilled technicians have created optical systems to supplement what the Zeiss machine does. Want to show the sky from Italy, where Galileo lived and observed? Then, at the base of the dome, surrounding the audience, show a photographic or painted panorama of that city using slide projectors working in tandem. How about a comet tracking across the nighttime sky? Or an orbiting spacecraft? Or a Moon landing? Any of these can be shown by using slide and movie projectors hidden from the audience's view. Add music, sound effects and professional, scripted narration, and the result is a polished multimedia show.

Like movie theatres and concert halls, planetariums face competition from IMAX/OMNIMAX theatres as well as, to some extent, television, smartphones and personal computers. Though many planetarium projectors are still operating, others have been phased out. That's what happened in Edmonton, Alberta.

"We used a Zeiss Cosmorama GP-85 projector from 1984, when the Telus World of Science Edmonton opened, until 2008," said Frank Florian, the facility's senior manager, planetarium and space sciences. "Then we retired the Zeiss projector, and installed a digital projection system from Sky-Skan Inc., a U.S. company. The old optical-mechanical Zeiss did a nice representation of the night sky, but the new Sky-Skan system can do that and much more. For instance, we can sail above Earth and look down on it, we fly around the Solar System and then explore the Milky Way galaxy and beyond."

The future of planetariums

Should planetariums just focus on the starry sky and other aspects of celestial-sphere astronomy, and not worry about the multimedia competition? Is there an audience for traditional planetarium lectures and demonstrations? Perhaps for school and college classes, but for the general public, there may not be a large enough audience to cover costs. It doesn't help that today's bright city lights are making beautiful starry nights a rare occurrence, decreasing public interest and awareness in visual astronomy.

One suggestion is to return to live staging, but in "nightclub style." Done well, a live planetarium presentation with an entertaining, well-informed presenter can be a unique and memorable experience. With digital video technologies now available from Zeiss and other firms — Zeiss also offers digital projection systems — the presenter could cue the latest reports coming in from space and animated features on fascinating astronomical topics. The fact is, people are very interested in things like black holes, exoplanets, space exploration and the latest discoveries about the Universe and our own galaxy.

It has been nearly a century since Zeiss introduced the Wonder of Jena. Since then, planetariums have evolved from one-projector, lecture-style demonstrations to multimedia productions, then back to one all-sky digital video projector.

Whither the Wonder of Jena? It's still with us, continually evolving. ✶

David A. Rodger, an amateur astronomer since 1956, was the founding director of the H.R. MacMillan Planetarium in Vancouver, where he worked 1967-1980.

Early adopters in Alberta

Canada's first public planetarium was the Queen Elizabeth Planetarium in Edmonton, opened in 1960 under the direction of Ian C. McLennan, a local amateur astronomer and photographer. Its small star projector was purchased from U.S.-based Spitz Inc., since available funds could not cover the cost of a Zeiss projector.

Despite the theatre's size (eight metres in diameter, compared with 20 metres in most Zeiss planetarium theatres) and bench seating for around 80, the Edmonton facility was soon recognized as a world-class innovator in planetarium production techniques and educational programs.

In 1984, it was replaced by the Edmonton Space Sciences Centre, now the Telus World of Science Edmonton. It housed a Zeiss projector when it opened. Meanwhile the Queen Elizabeth Planetarium, mothballed for many years, has recently been restored, reopened and given heritage status.

As for Ian C. McLennan, he has been recognized as one of the world's foremost consultants on planetariums, science and interpretive centres and show production.

For further reading, look for *Planetarium: Window to the Universe* by Charles F. Hagar, *Captured Stars* by Heinz Letsch or *Geared to the Stars: The Evolution of Planetariums, Orreries and Astronomical Clocks* by Henry C. King.

Dear *SkyNews* readers

From the desk of Charles Ennis, president of The Royal Astronomical Society of Canada

The James Webb Space Telescope (JWST) will give scientists a new view of the sky, and we've already had some glimpses of what it will be able to achieve. But only a select few of those who'd like to use the world's largest telescopes — there are only 46 large telescopes down here on Earth and two large space telescopes up there in orbit — actually get time on them.

That's where amateur astronomers come in. Space telescopes like Kepler and TESS get the raw data, but then someone has to get the light curve to confirm the discovery of an exoplanet, and amateur astronomers have big enough telescopes to do that. Organizations like the American Association of Variable Star Observers use amateur astronomers to check out variable stars for scientists. Many amateur astronomers hunt for supernovae and comets.

You don't even need a telescope to help scientists. The Astrophysical Research Consortium directing the Sloan Digital Sky Survey in 2000 rapidly discovered that they had so much data that if their team spent the rest of their natural lives processing it, they'd never finish. The solution they came up with was inviting the public to assist. They created the Galaxy Zoo website, with simple instructions on how to classify galaxies, and in months cleared the entire list. Galaxy Zoo has now gone through several editions and expanded into 3D and radio versions.

Word of Galaxy Zoo's success quickly caused it to be expanded into an even bigger website: Zooniverse, which includes 107 different scientific projects. Rainy day? I just sign on to Galaxy Zoo and join more than 87,000 volunteers classifying galaxies. You can help map the surface of Mars, the Moon and the Rosetta Comet; go cloudspotting on Mars; identify meteors in radio data and help look for supernova remnants. You can help search for exoplanets, hunt down gravitational waves, help the SuperWASP black hole and variable star hunters, search for superactive asteroids, classify the light curves of variable stars, classify stellar explosions, spot discs around stars, study aurorae, locate supermassive black holes and search for brown dwarfs and additional planets in our Solar System.

Amateur astronomers play a vital role in scientific research. It seems likely that some projects using James Webb telescope data will show up on Zooniverse in the coming years, so amateur astronomers like us may get time on JWST after all.

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RASC GA 2022 astrophotography contest winners
1. Moon & celestial bodies, Kimberly Sibbald, Super Flower Full Moon **2.** Drawings & sketches, Eric Klaszus, Mosaic sketch of Comet Leonard and M3 **3.** Deep sky, Andrew Lesser, Rosette **4.** Widefield & landscape, Kimberly Sibbald, Milky Way over Canyonlands **5.** Light pollution, Adrian Bradley, Down by the Lake

RASC General Assembly 2022 — a success!

The Royal Astronomical Society of Canada's 2022 General Assembly drew the highest number of attendees in recent years.

A total of 364 people registered for the four-day event, which took place online June 24-27.

Samantha Jewett, RASC's outreach co-ordinator and General Assembly project manager, said she thought the event went great.

"It was so cool to hear the different citizen science projects and presentations from members, as well as what different committees have been doing over the past year," she said. "We had some amazing keynote speakers. And everyone truly had a chance to connect with each other through our virtual observing and our GatherTown social place."

RASC will be publishing the presentations on YouTube from keynote speakers who have given permission to have their content placed there. Visit youtube.com/RASCanada for the full public playlist.

If you registered for the 2022 General Assembly, visit the rascga2022.ca/attendee-hub and enter the password you received when registering for the full list of videos.

Astronomical inspiration through Creation Station

In 2021, The Royal Astronomical Society of Canada's Education and Public Outreach (EPO) Committee introduced "Creation Station," a website for astronomers aged 5-12 to share their space-inspired creations. From short stories to drawings, we discovered a lot of talented young astronomers. Some of these inspired submissions were shared at our General Assembly and each participant received a personalized certificate.

In 2022, submissions were invited from youth ages 5-17 and included an option for multimedia content. This year's entries included a multimedia painting of fantastical planets, a comic strip illustrating how much we treasure looking out at dark skies and a song recording of the moon "like a big pizza pie. Visit rasc.ca/creationstation for more details on creations.

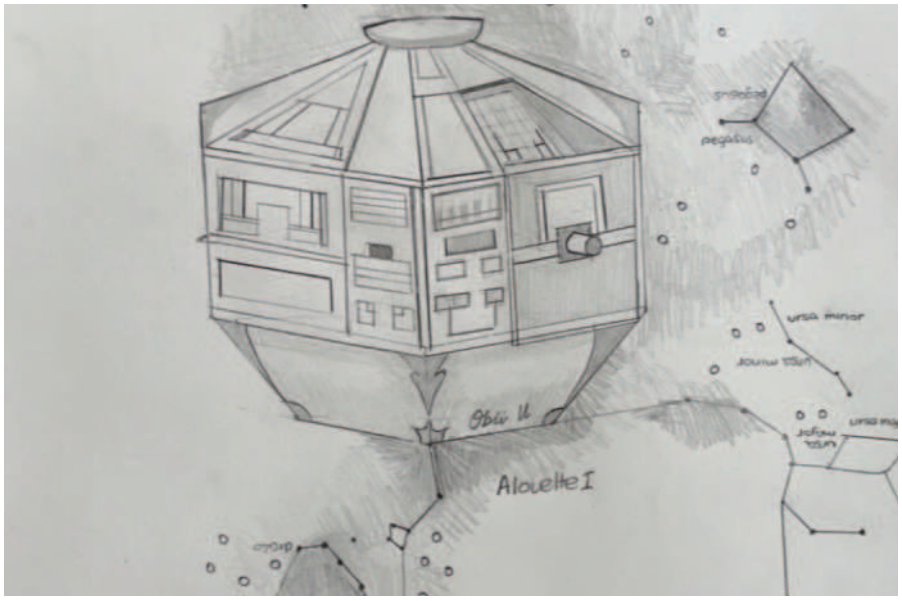
If you know a young person who's fascinated with space, consider giving the gift of a membership to the RASC. Many people who have gone on to careers in astronomy and space science got their start in clubs like the RASC. With organized observing, interesting publications and regular meetings, there's lots to do and see.

Visit www.rasc.ca/new-members or secure.rasc.ca/membership/account/register for details.

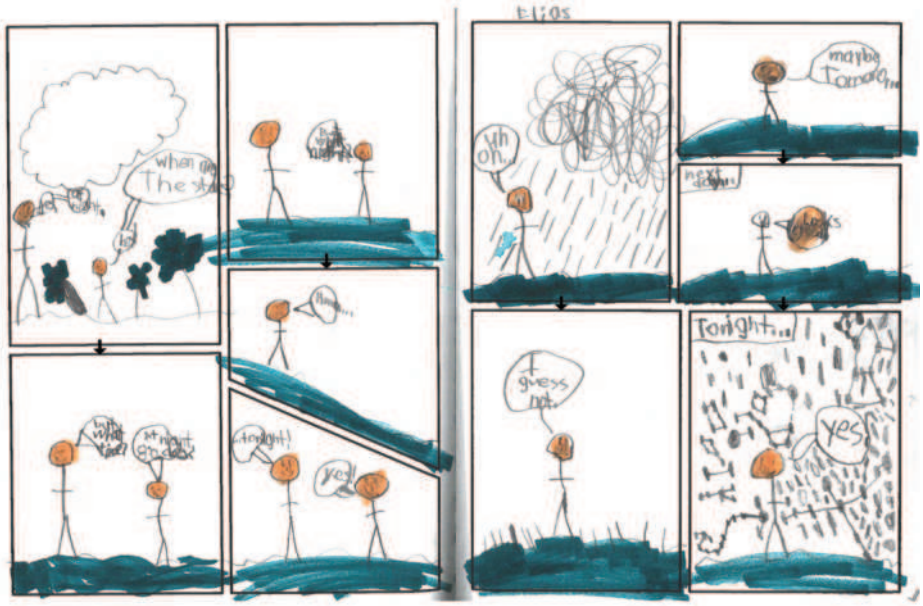
Stay tuned for more from Creation Station in spring 2023! ✶

TOP: "Out in space: Puffy paint of space." *— Aadam, 5 years old, Cambridge, Ontario*

LEFT: "This drawing is of a frog jumping on the planets of our Solar System. It combines my two favourite things: frogs and space!" *— Grace, 10 years old, Toronto, Ontario*



" This is a drawing I made of the Alouette 1, a famous Canadian satellite."
— Obii, 16 years old, Saskatoon, Saskatchewan



"Yes, stars! A comic about waiting for a clear night to see the stars."
— Elias, 8 years old, Whitehorse, Yukon

Photo by Paul Owen

A swirl of stars

Estimated to be about 170,000 light-years across and to contain at least one trillion stars, the Pinwheel Galaxy graces the sky in the constellation Ursa Major. Also known as Messier 101, the face-on spiral galaxy is located about 25 million light-years away from Earth. Clusters of hot, blue, newborn stars can be seen in the arms of the galaxy.

Astrophotographer Paul Owen said he captured the image on August 15, 2022, from Hampton, New Brunswick.

"The transparency conditions were fair with my Bortle 4 sky," he said. "The position of this target was very favourable."

He used a Sky-Watcher Equinox 120mm (reduced to f/6.5) and ZWO ASI2600mm mono camera with a ZWO electronic filter wheel carrying 36mm Optolong RGB filters. The mount was a Sky-Watcher EQ6 PRO.

To capture the image, Owen collected 24 180-second exposures in red, green and blue, and 15 300-second Hydrogen-alpha exposures. ✳

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