Explore the Universe Observing Program

Welcome to the *Explore the Universe* observing program, designed to provide any observer with a well-rounded introduction to the night sky visible from the Northern Hemisphere. Following EtU is an excellent way to gain knowledge and experience in amateur astronomy. You will find that a planned observing session based on EtU results in a more satisfying and interesting experience. You will learn and improve your observing skills, an excellent preparation for more challenging observing programs such as the *Messier Catalogue* and *The Finest NGC Objects*. Those who complete the observing program and have their observations validated will earn a certificate and pin (**RASC membership not required**).

The program covers the full range of astronomical objects. Here is a summary:

Observing Objective	Requirement	Available
Constellations and Bright Stars	12	24
The Moon	16	32
Solar System	5	10
Deep-Sky Objects	12	24
Double Stars	10	20
Total	**55**	**110**

In each category, a range of objects is provided so that you can begin the program at any time of the year. **In order to earn your certificate you need to observe a minimum of 55 of the 110 objects available**. Here is a summary of some of the terms used in this program:

Instrument (V/B/T)	**V** – Visual (unaided eye) **B** – Binocular **T** – Telescope
Season	The season when the object can be best seen in the evening sky. Objects may also be observed in other seasons.
Description	A brief description of the object, its common name, and other details.
Con.	The constellation in which an object can be found. See www.iau.org/public/themes/constellations/
Mag.	Magnitude—an object's brightness, with smaller numbers indicating the brighter objects.
Seen? ✓	Mark each item with a check mark when you have observed it.
Log Page	Cross-reference to the logbook page where you have recorded your observations.

Binoculars are an ideal first observing instrument and this program has been designed so that it can be completed using binoculars alone. By mounting your binoculars on a tripod, you will find that you can see more detail and observe more comfortably. For more information see the *Explore the Universe Guide, 2nd Ed.* (RASC, 2017, p. 13) or the RASC *Observer's Handbook* (RASC, 2017, p. 60).

The Bayer Star Catalogue

First published in 1603, the Bayer Catalogue is based solely on bright visual stars that can be seen with the unaided eye in each constellation. Using the Greek alphabet, starting with Alpha, stars are labelled according to how bright they are (with some exceptions). Thus the brightest star in Ursa Minor is called "Alpha Ursae Minoris" and written α UMi. Here is a list of all the 24 Greek letters used in astronomy:

α - Alpha	β - Beta	γ - Gamma	δ - Delta	ε - Epsilon	ζ - Zeta	η - Eta	θ - Theta
ι - Iota	κ - Kappa	λ - Lambda	μ - Mu	ν - Nu	ξ - Xi	ο - Omicron	π - Pi
ρ - Rho	σ - Sigma	τ - Tau	υ - Upsilon	φ - Phi	χ - Chi	ψ - Psi	ω - Omega

The Flamsteed Star Catalogue

Another major catalogue is the Flamsteed Catalogue compiled in 1725. This catalogue lists stars visible to the unaided eye by constellation in order of increasing Right Ascension (west to east), labelled in Arabic numerals—the higher the number, the further east in a constellation is a given star. Typically, in star atlases and star charts, if a star also has a Bayer designation, that takes precedence; otherwise the Flamsteed number is used.

Reference Sources

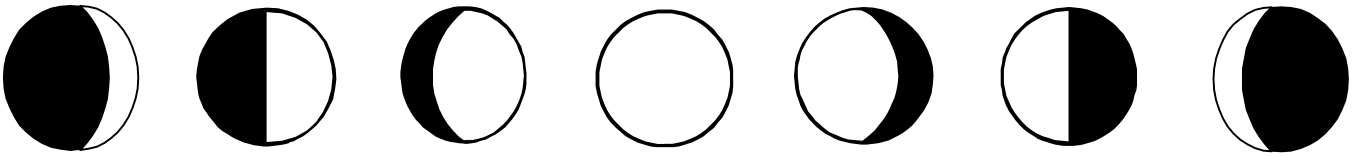
The *Explore the Universe* observing program can be used in conjunction with the *Explore the Universe Guide, 2nd Ed.* (RASC, 2017). This RASC publication provides a simple introduction to the observation of astronomical phenomena and appropriate observing techniques. Terence Dickinson's *NightWatch (4th Edition)* is also highly recommended. In addition to guide books, you will need a basic **star atlas** or **software** to help you find several objects in this program. The *Explore the Universe Guide, 2nd Ed.* and *NightWatch* are available at the RASC shop at www.rasc.ca

Constellations and Bright Stars (12 of 24)

Season	Constellation	Abbr.	Observing Notes	Bright Star(s)	Mag.	Bayer	Flamsteed	Seen? ✓	Log Page
Spr	**Ursa Major** The Great Bear	UMa	Contains "The Big Dipper," with pointer stars leading to *Polaris* and *Arcturus*.	*Dubhe*	1.81	Alpha (α)	50 UMa	☐	
				Merak	2.34	Beta (β)	48 UMa	☐	
Spr	**Leo** The Lion	Leo	Large constellation that actually looks like its name. Note the "Sickle" asterism.	*Regulus*	1.36	Alpha (α)	32 Leo	☐	
				Denebola	2.14	Beta (β)	94 Leo	☐	
Spr	**Virgo** The Maiden	Vir	Home to the Virgo Cluster of galaxies, many visible in small telescopes.	*Spica*	0.98	Alpha (α)	67 Vir	☐	
Spr	**Libra** The Scales	Lib	In ancient times, the two brightest stars were the two claws of Scorpius.	*Zubenelgenubi*	2.75	Alpha (α)	9 Lib	☐	
				Zubenelschamali	2.61	Beta (β)	27 Lib	☐	
Spr	**Bootes** The Herdsman	Boo	Arc from Big Dipper's handle to *Arcturus*, the 3rd brightest star in the night sky.	*Arcturus*	–0.05	Alpha (α)	16 Boo	☐	
Spr	**Ursa Minor** The Lesser Bear	UMi	Contains *Polaris*, the Pole Star, and "The Little Dipper".	*Polaris*	1.97	Alpha (α)	1 UMi	☐	
				Kochab	2.07	Beta (β)	7 UMi	☐	
Sum	**Scorpius** The Scorpion	Sco	Runs roughly north to south with bright red *Antares* ("Rival of Mars") at its heart.	*Antares*	1.06	Alpha (α)	21 Sco	☐	
Sum	**Hercules** Son of Zeus	Her	*Rasalgethi* is south of the distinctive "Keystone" asterism. Look for M13.	*Rasalgethi*	2.78	Alpha (α)	64 Her	☐	
Sum	**Sagittarius** The Archer	Sgr	Look for "The Teapot". Rich Milky Way region with many clusters and nebulae.	*Nunki*	2.05	Sigma (σ)	34 Sgr	☐	
Sum	**Lyra** The Lyre or Harp	Lyr	Beautiful star fields in binoculars. *Vega* is the 5th brightest star in the night sky.	*Vega*	0.03	Alpha (α)	3 Lyr	☐	
Sum	**Aquila** The Eagle	Aql	Look for a diamond-shaped pattern. *Altair* is the 12th brightest star in the night sky.	*Altair*	0.76	Alpha (α)	53 Aql	☐	
Sum	**Capricornus** The Sea Goat	Cap	A wide, V-shaped star field, *Algedi* is a wide visual double star.	*Algedi*	3.60	Alpha (α)	6 Cap	☐	
				Dabih	3.05	Beta (β)	9 Cap	☐	
Sum	**Cygnus** The Swan	Cyg	Rich in Milky Way stars. Look for the "Northern Cross" asterism.	*Deneb*	1.25	Alpha (α)	50 Cyg	☐	
				Albireo	3.36	Beta (β)	6 Cyg	☐	
Aut	**Pegasus** The Winged Horse	Peg	Look for the "Great Square of Pegasus" with *Markab* opposite *Alpheratz*.	*Markab*	2.49	Alpha (α)	54 Peg	☐	
Aut	**Andromeda** Cassiopeia's daughter	And	Look for two lines of stars extending from *Alpheratz*. Home to galaxy M31.	*Alpheratz*	2.07	Alpha α	21 And	☐	
Aut	**Cassiopeia** Queen of Ethiopia	Cas	Cassiopeia contains a distinctive "W" or "M" shape in the northern Milky Way.	*Schedar*	2.24	Alpha (α)	18 Cas	☐	
Aut	**Aries** The Ram	Ari	Look for a hockey stick between Pegasus and Taurus.	*Hamal*	2.01	Alpha (α)	13 Ari	☐	
				Sheratan	2.64	Beta (β)	6 Ari	☐	
Aut	**Perseus** Andromeda's rescuer	Per	The rich star field near *Mirfak* is best in binoculars. Look for variable star *Algol.*	*Mirfak*	1.79	Alpha (α)	33 Per	☐	
				Algol	2.1v	Beta (β)	26 Per	☐	
Win	**Taurus** The Bull	Tau	The wide, open cluster "The Hyades" forms the head of Taurus the Bull.	*Aldebaran*	0.87	Alpha (α)	87 Tau	☐	
Win	**Auriga** The Charioteer	Aur	Look for a pentagon shape. *Capella* is the 6th brightest star in the night sky.	*Capella*	0.08	Alpha (α)	13 Aur	☐	
Win	**Orion** The Hunter	Ori	Prominent constellation with a rich star field around the 3 belt stars.	*Betelgeuse*	0.45	Alpha (α)	58 Ori	☐	
				Rigel	0.18	Beta (β)	19 Ori	☐	
Win	**Canis Major** The Big Dog	CMa	Located southeast of Orion. *Sirius* is the brightest star in the night sky.	*Sirius*	–1.44	Alpha (α)	9 CMa	☐	
Win	**Canis Minor** The Little Dog	CMi	A small constellation. *Procyon* is the 8th brightest star in the night sky.	*Procyon*	0.41	Alpha (α)	10 CMi	☐	
				Gomeisa	2.89	Beta (β)	3 CMi	☐	
Win	**Gemini** The Twins	Gem	*Castor* and *Pollux* are the names of the twins. Beta is the brightest of the pair.	*Castor*	1.58	Alpha (α)	66 Gem	☐	
				Pollux	1.16	Beta (β)	78 Gem	☐	

Observing the Moon (16 of 32)

As the closest major celestial object to Earth, the Moon reveals more detail to observers than any other object, so much so that a large number of lunar features can be clearly identified in binoculars. To observe the Moon successfully requires a good Moon map, an understanding of lunar phases, and sturdy tripod-mounted or image-stabilized binoculars. *Explore the Universe Guide, 2nd Edition* contains a Moon map for the specific features listed below. East and west on the Moon follow the convention for planets, that is, opposite from the sky directions east and west, while north and south remain the same. That is, the Moon's terminator, dividing night from day on the Moon, continually moves from east to west on the lunar surface. Binoculars with 10x magnification will work best although observers can easily complete this section with 7x magnification.



Day 3 Day 7 Day 11 Day 15 Day 18 Day 22 Day 26

Lunar Phases (4 of 8 observations are required)

The RASC *Observer's Calendar* and RASC *Observer's Handbook* provide day-to-day images of the phases of the Moon and exact times of First Quarter, Full Moon, Last Quarter, and New Moon.

Approx. Day	Phase	V/B/T	Observing Notes	Seen? ✓	Log Page
3	**Waxing Crescent**	V	Visible within 3 hours of sunset.	☐	
7	**First Quarter**	V	Within 18 hours before or after exact time of phase.	☐	
11	**Waxing Gibbous**	V	Visible 3–4 days after First Quarter.	☐	
15	**Full Moon**	V	Within 18 hours before or after exact time of phase.	☐	
18	**Waning Gibbous**	V	Visible 3–4 days after Full Moon.	☐	
22	**Last Quarter**	V	Within 18 hours before or after exact time of phase.	☐	
26	**Waning Crescent**	V	Visible within 3 hours of sunrise.	☐	
Any	**(Orbital Motion)**	V	Over 1–2 days, track the Moon's orbital motion against background stars	☐	

Lunar Basins / Maria (6 of 12 observations are required)

The dark lava plains known as lunar basins or *maria* are the most easily visible feature on the Moon. The following *maria* are listed from east to west in the order that they appear during the lunar cycle, as the sunrise terminator crosses the Moon's disk. All the *maria* can be seen at Full Moon. Note the relative sizes ranging from 55,000 km² to over 2 million km².

Best Phase	Feature	V/B/T	Size 1000 km²	Lat	Long	Observing Notes	Seen? ✓	Log Page
Day 3	**Mare Crisium**	B	180	17º N	59ºE	**Sea of Crises** 570 km across, size of Great Britain. Large impact basin.	☐	
Day 3	**Mare Fecunditatis**	B	330	4º S	50ºE	**Sea of Fertility** 850 km across.	☐	
Day 7	**Mare Nectaris**	B	100	15º S	35ºE	**Sea of Nectar** 340 km across.	☐	
Day 7	**Mare Tranquillitatis**	B	420	8º N	32ºE	**Sea of Tranquillity** 880 km across, size of Black Sea. *Apollo 11* landing site.	☐	
Day 7	**Mare Serenitatis**	B	370	28º N	22ºE	**Sea of Serenity** 870 km across. Lake of Dreams & Lake of Death on border.	☐	
Day 7	**Mare Vaporum**	B	60	13º N	3ºE	**Sea of Vapours** 230 km across. Circular basin located southeast of the Apennine Mountains.	☐	
Day 11	**Mare Frigoris**	B	440	58º N	45ºW–45ºE	**Sea of Cold** 1450 km long, variable width. Northernmost basin, near Plato.	☐	
Day 11	**Mare Imbrium**	B	830	14º–51º N	40ºW–6ºE	**Sea of Rains** 1250 km across. Large impact basin.	☐	

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Best Phase	Feature	V/B/T	Size 1000 km²	Lat	Long	Observing Notes	Seen? ✓	Log Page
Day 11	**Mare Nubium**	B	250	20° S	15° W	**Sea of Clouds** 720 km across	☐	
Day 11	**Sinus Iridum**	B	55	45° N	32° W	**Bay of Rainbows** 260 km across, flooded partial crater extending into Mare Imbrium.	☐	
Day 11	**Mare Humorum**	B	110	24° S	39° W	**Sea of Moisture** 380 km across, nicely paired with Mare Nubium	☐	
Day 15	**Oceanus Procellarum**	B	2100	42° N–14° S	68° W–27° W	**Ocean of Storms** 2600 km across. Largest continuous feature covers the northwestern part of the Moon.	☐	

Impact Craters (6 of 12 observations are required)

For many years, the craters on the Moon were thought to be volcanic in nature. We now know that most of them are a result of major impacts by asteroids and comets. This has contributed greatly to our understanding of the formation and evolution of the Solar System.

"Best Phase" is approximately the age of the Moon (in days after New) when the objects will be near the lunar day/night terminator and therefore easiest to see with detail, as the low angle of the sunlight casts long shadows of the rough lunar features. There is a complementary phase during the waning period when the same object will also be on the terminator but lit at lunar sunset instead of at lunar sunrise; however these phases will need to be observed after midnight or just before dawn.

Best Phase	Object	V/B/T	Diameter km	Lat	Long	Observing Notes	Seen? ✓	Log Page
Day 3–4	**Petavius**	B/T	177	25° S	60° E	Prominent crater with central peak. One of the Gang of Four (with non-EtU craters Langrenus, Vendelinus, and Furnerius).	☐	
Day 3–4	**Cleomedes**	B/T	126	28° N	56° E	Located near Mare Crisium. Easily found in binoculars.	☐	
Day 4–5	**Posidonius**	B/T	95	32° N	30° E	Located on the shore of Mare Serenitatis. Crater walls 2300 m high.	☐	
Day 5–6	**Theophilus**	B/T	100	11° S	26° E	Prominent crater with 1400 m central peak. Cyrillus and Catharina nearby.	☐	
Day 5–6	**Aristoteles**	B/T	87	50° N	17° E	In Mare Frigoris. Deep terraced walls. Look for Eudoxus nearby on the shore of the mare.	☐	
Day 8–9	**Ptolemaeus**	B/T	153	9° S	2° W	Prominent walled plain. Alphonsus and Arzachel to the south.	☐	
Day 8–9	**Plato**	B/T	101	52° N	9° W	Outstanding crater that is easy to spot due to its dark floor.	☐	
Day 8–9	**Tycho**	B/T	85	43° S	11° W	Famous crater featuring spectacular rays that are best observed at or near full Moon.	☐	
Day 9–10	**Clavius**	B/T	225	58° S	14° W	Very large crater encompassing several smaller craters.	☐	
Day 8–9	**Copernicus**	B/T	93	10° N	20° W	Spectacular crater with 3760 m deep terraced walls; also features prominent rays at or near full Moon.	☐	
Day 11–12	**Gassendi**	B/T	110	18° S	40° W	Prominent crater on the northern shore of Mare Humorum.	☐	
Day 13–14	**Grimaldi**	B/T	222	5° S	67° W	Very large dark-floored crater located near the western limb of the Moon.	☐	

The Solar System (5 of 10)

The Solar System contains the Sun, planets, dwarf and minor planets, comets, and other wonders. Consult the RASC *Observer's Handbook* or planetarium software for details on current positions and visibility.

Object	V/B/T	Observing Notes	Seen? ✓	Log Page
Mercury	V/B/T	Mercury is the closest planet to the Sun. Unlike other planets, Mercury is visible only for a few weeks at a time; so check an annual guide such as the *Observer's Handbook* for the best times to spot this fast-moving, elusive object.	☐	
Venus	V/B/T	The brightest planet. Telescope users can see Venus go through phases similar to those of the Moon.	☐	
Mars	V/B/T	Known as the "Red Planet," it is best observed at opposition about every 26 months although it can be seen often at other points of its orbit.	☐	
Jupiter	V/B/T	The largest planet in the Solar System with four bright moons nearby that can be seen in binoculars. Each moon can be identified by name using the *Observer's Handbook* but this is not mandatory.	☐	
Saturn	V/B/T	Any astronomical telescope will show Saturn's rings. Saturn has one bright moon named Titan and several fainter ones visible in telescopes.	☐	
Uranus	B/T	This planet can be seen clearly in binoculars, particularly when they are mounted on a tripod. A detailed finder chart is published annually in the *Observer's Handbook*. Telescopes will reveal the small round disk of this far away world.	☐	
Neptune	B/T	Neptune is similar to Uranus, but even further away and fainter. It also can be seen in binoculars using the same method as for Uranus. Seeing the disk of Neptune is more difficult but well within the reach of good amateur telescopes.	☐	
Orbital Motion	V/B	Plot the orbital motion of a planet: This can be done easily by drawing the star field around a planet on two or more separate nights and recording the movement of the planet against the background stars, which do not move. Orbital motion can be plotted visually, through binoculars or telescopes, with the outer planets being the easiest to plot.	☐	
Artificial Satellites & Meteors	V	Observe at least 3 Earth-orbiting artificial satellites (including spacecraft and the *International Space Station*) and 3 meteors (either sporadics or from a meteor shower).	☐	
Sunspots	filtered T	WARNING! USE PROPERLY FILTERED TELESCOPES OR BINOCULARS. A high-quality full-aperture solar filter is required. This observation may best be done through the telescope of an experienced solar observer who has one set up for public viewing or club events.	☐	

(See next page for *optional* Solar System observations)

The Solar System—optional observations

Object	V/B/T	Observing Notes	Seen? ✓	Log Page
Eclipses	V/B	Eclipses occur when one Solar System object passes in front of and hides another Solar System object. A **solar eclipse** occurs when, on passing between the Sun and the Earth, the Moon is closely enough aligned to hide at least part of the Sun, as viewed from the Earth. A **lunar eclipse** occurs when, on passing between the Sun and the Moon, the Earth is closely enough aligned for its shadow to fall upon at least some of the Moon. For both solar and lunar eclipses, use the predictions listed in the RASC *Observer's Handbook* to plan your observations.	☐	
Conjunctions	V/B	When two or more celestial objects appear close together in the sky, it is called a conjunction. These are regular occurrences that are listed in the *Observer's Handbook*, and in popular astronomy magazines.	☐	
Meteor Showers	V	**Sporadic meteors** can be seen on most dark, clear nights. **Meteor showers** are regular events occurring at different times throughout the year with high rates of meteors appearing to come from a specific zone or **radiant** in the sky. Look for a dark moonless night and be prepared to stay up late, as the best observing is usually after midnight.	☐	
Aurorae	V	Aurorae borealis (Northern Lights) are caused by streams of solar particles striking the upper atmosphere and causing it to glow. Best in dark skies.	☐	
Comets	V/B/T	Small bodies left over from the birth of the Solar System, comets are usually quite faint and require a medium- to large-sized telescope to observe. Occasionally, a comet will appear that is bright enough to be seen through binoculars or even visually.	☐	
Zodiacal Light	V	For mid-northern observers, the best time to view this pyramid of light is after dusk in the western sky **during February and March** and in the pre-dawn eastern sky **during September and October**. A dark sky is essential.	☐	
Dwarf or Minor Planets	B/T	Dwarf planet Ceres and several minor planets are bright enough to be seen in binoculars and small telescopes. You can locate these objects by using a finder chart in the RASC *Observer's Handbook* or desktop planetarium software.	☐	

Deep-Sky Objects (12 of 24)

"Deep-Sky Objects" is the catch-all description applied to some of astronomy's most interesting sights including:

Open Clusters – Loose agglomerations of stars, recently emerged from the giant molecular clouds that gave them birth.
Globular Clusters – Ancient spherical clusters of stars, often containing hundreds of thousands of stars.
Emission/Reflection Nebulae – Glowing clouds of interstellar gas or dust, often marking the birth or death of stars.
Planetary Nebulae / Supernova Remnants – Glowing clouds of gas and dust marking the death of stars.
Galaxies – Huge "island universes," like the Milky Way, containing hundreds of billions of stars but so distant that they are merely hazy patches of light.

All of the deep-sky objects on this list can be observed with binoculars and many can be detected visually. Larger telescopes will reveal more detail. "Season" indicates best viewing during the evening hours, but many objects can also be found before and after the suggested time. Note on size: 1º = 60´ (arcminutes).

Season	Con.	Object	Mag.	RA	Dec	Observing Notes	Seen? ✓	Log Page
Spr	Cnc	**M44** The Beehive	3.1	08:40.1	+19º 59´	**Open cluster**, 95´. With a magnitude of 3.1, this cluster is bright enough to be quite easily seen with the unaided eye from a dark sky. To locate it, try scanning along an imaginary line from *Regulus* in Leo to *Pollux* in Gemini.	☐	
Spr	Com	**Coma Cluster** Melotte 111	1.8	12:25.0	+26º 00´	**Open cluster**, 275´. This large group of stars lies between Leo and Boötes. It is made up of several chains of mag. 5–6 stars that are said to be the amber tresses of Queen Berenice´s hair offered to the god Aphrodite for the safe return of her beloved king from battle.	☐	
Spr	Ser	**M5** NGC 5904	5.7	15:18.6	+02º 05´	**Globular cluster**, 17´. As big and bright as the more famous M13. It is located about 2½ binocular fields north of Beta Librae, the northernmost bright star in Libra.	☐	
Sum	Her	**M13** Hercules Cluster	5.7	16:41.7	+36º 28´	**Globular cluster**, 17´. This well-known globular cluster contains hundreds of thousands of stars. Look for a "fuzzy star" south of Eta, the northwest Keystone star in Hercules. Note the mag. 7 stars on either side.	☐	
Sum	Sco	**M4** NGC 6121	5.8	16:23.6	–26º 32´	**Globular cluster**, 26´. Located 1º west of *Antares* in Scorpius, this cluster is easily found under a dark sky. However, because most of its individual stars are quite dim, it can prove difficult from light-polluted skies.	☐	
Sum	Ser	**M16** Eagle Nebula	6.0	18:18.6	–13º 58´	**Emission nebula & open cluster**, 35´ x 28´. Located 4º north of M24 (see below), this nebulous open cluster contains between 20 and 30 stars of magnitude 8–10.	☐	
Sum	Sgr	**M8** Lagoon Nebula	3.0	18:03.8	–24º 23´	**Emission nebula**, 45´ x 30´. This huge cloud of gas is bisected at one end by a dark lane. To find this deep-sky object, first locate the spout of the Sagittarius "Teapot" and simply scan your binoculars upward 6º, about one binocular field.	☐	
Sum	Sgr	**M17** Swan Nebula	6.0	18:20.8	–16º 11´	**Emission nebula**, 20´ x 15´. Also known as the Omega Nebula. It is located about halfway between M24 & M16. Look for open cluster M18 to the south.	☐	
Sum	Sgr	**M22** NGC 6656	5.1	18:36.4	–23º 54´	**Globular cluster**, 24´. This cluster is almost a magnitude brighter than the well-known M13. Look for a nebulous disk 2º northeast from the top of the Teapot lid.	☐	
Sum	Sgr	**M23** NGC 6494	5.5	17:56.8	–19º 01´	**Open cluster**, 27´. Nearly 5º west of M24 (see below), this rich open cluster contains over 120 faint stars. Under dark skies, you may be able to resolve some of them with a pair of 10 x 50 binoculars.	☐	
Sum	Sgr	**M24** Sagittarius Star Cloud	4.6	18:16.5	–18º 50´	**Star cloud**, 95 ´x 35´. The Sagittarius Star Cloud lies a little over 7º north of the Teapot lid. On some charts it is mislabelled as the small open cluster NGC 6603. It's actually the large cloud surrounding NGC 6603.	☐	
Sum	Sgr	**M25** IC 4725	4.6	18:31.6	–19º 15´	**Open cluster**, 32´. Scan your binoculars about 3º east of M24, and you'll be rewarded with a view of this attractive little cluster containing several bright stars.	☐	

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Season	Con.	Object	Mag.	RA	Dec	Observing Notes	Seen? ✓	Log Page
Sum	Sct	**M11** Wild Duck Cluster	5.8	18:51.1	–06º 16´	**Open cluster**, 13´. Nearly 4º west of Lambda Aquilae, lying in the Scutum Star Cloud, one of the densest parts of the summer Milky Way:.	☐	
Sum	Vul	**Collinder 399** The Coathanger	3.6	19:25.4	+20º 11	**Open Cluster**, 60´. Also known as Brocchi's Cluster. This unmistakable collection of 10 stars lies a little over 7º south of Beta Cygni, the head of the Swan.	☐	
Aut	And	**M31** Andromeda Galaxy	3.4	00:42.7	+41º 16´	Nearest major **galaxy**, 185´ x 75´. The visibility of any galaxy depends on the background sky darkness. Follow the outline of Andromeda to the second pair of stars and scan the area just to the north for an elongated fuzzy patch of light.	☐	
Aut	Per	**Melotte 20** Alpha Persei Group	1.2	03:22.0	+49º 00´	**Open cluster**, 185´. This wide, beautiful group of stars is centred on Alpha Persei (*Mirfak*) and fills a 5º binocular field of view.	☐	
Aut	Per	**Double Cluster** NGC 869/884	5.3	02:19.0	+57º 09´	Two **open clusters**, each 30´. If you scan the Milky Way between Cassiopeia and Perseus under a dark sky, these two beauties will be hard to miss. Even without binoculars, you'll probably see a misty patch that betrays the presence of one of the northern sky´s grandest sights.	☐	
Win	Tau	**M45** Pleiades	1.2	03:47.0	+24º 07´	Visual **open cluster**, 110´. Known since ancient times, this spectacular cluster is best viewed through binoculars or a wide-field telescope.	☐	
Win	Tau	**Hyades** Melotte 25	0.5	04:27.0	+16º 00´	**Open cluster**, 330´. This group of stars forms the V-shaped head of Taurus, the Bull. Although it is easily visible with the unaided eye, take a closer look with binoculars and you´ll see the beautiful and colourful double stars Theta and Delta.	☐	
Win	Cam	**Kemble's Cascade**	4.0	03:57.0	+63º 00´	**Star chain**, 180´. From Alpha Persei, scan two binocular fields towards Polaris and you will see a long chain of stars resembling a waterfall. The asterism is named after the late Fr. Lucian Kemble, of the RASC Regina Centre. Look for the small open cluster NGC1502 at the end of the string.	☐	
Win	Aur	**M37** NGC 2099	5.6	05:52.4	+32º 33´	**Open cluster**, 20´. If you follow an imaginary line north along the feet of Gemini for a couple of binocular fields, you should see this cluster. Although you won´t be able to resolve many of this cluster´s faint stars with binoculars, if you look closely, you should notice how much more concentrated it becomes toward the centre. Look for M36 & M38 nearby.	☐	
Win	Ori	**M42** Orion Nebula	4.6	05:35.4	–05º 27´	**Emission nebula**, 65´ x 60´. The Great Nebula in Orion, the brightest nebula visible in the northern hemisphere. Appears as a bright green cloud surrounding Theta 1 and Theta 2 Orionis, the middle stars in Orion's sword. Once you find M42, look north for NGC 1981, an attractive little group of 7 stars shaped like an aardvark.	☐	
Win	Gem	**M35** NGC 2168	5.1	06:08.9	+24º 20´	**Open cluster**, 28´. This cluster lies at the feet of Gemini, appearing best under dark skies, but it can be seen fairly well with 10 x 50 binoculars from a suburban location.	☐	
Win	Pup	**M47** NGC 2422	4.4	07:36.6	–14º 30´	**Open cluster**, 29´. Starting from *Sirius*, look about two binocular fields eastward for a little splash of stars. In dark skies, you may also see the faint wisp of M46 (NGC 2437) in the same field.	☐	

Mag.: Magnitudes of deep-sky objects appear fainter than stars because they are diffuse, i.e. spread out over a small patch of sky.
Size: Measured in arcminutes (1 degree = 60 arcminutes, that is, 1º = 60´).
Right Ascension (RA) — the equivalent of longitude on Earth. Along the celestial equator, 1 hour of RA = 15º, increasing west to east.
Declination (Dec) — the equivalent of latitude on Earth, measured in degrees and seconds north and south (+/–) of the celestial equator.

Double & Multiple Stars (10 of 20)

Double stars appear to the unaided eye as a single star, but when viewed through binoculars or a telescope they can be split into two components. **Optical doubles** are a chance alignment in space whereby the stars appear adjacent to one another when viewed from Earth. **Physical doubles** are near one another (as part of an open cluster), while **binary stars** are known to orbit around a common centre of mass. For some binary stars, one can detect this orbital motion over a period of a few years, otherwise one notes common proper motion of the pair.

Double stars offer interesting colour contrasts, magnitude differences, and separations, and many can be viewed easily from locations with moderate to heavy light pollution. To complete this section, it is suggested that you work with binoculars mounted on a tripod. To find the stars listed, you will need a good star atlas where you can plot their location using the co-ordinates listed for each one. A good way to confirm that you are observing the double star you are looking for is to check the magnitude, separation, and position angle.

Separation (Sep.) is measured in arcseconds. The larger the separation, the more easily you can see the split between the stars. The **Position Angle** is the apparent direction from the brighter star to the dimmer star, measured in degrees counterclockwise from celestial north. The lines of Right Ascension (**RA**) on a star chart always point north. Be sure to carefully orient the map when comparing position angles with the binocular or telescope view. Note: some telescopes have mirror-reversed views, in which case Position Angle is measured clockwise.

Sea-son	Con.	Object	Mag.	Sep.	Position Angle	RA	Dec	Observing Notes	Seen? ✓	Log Page
Spr	Leo	**Zeta & 35**	3.4 & 5.9	330″	340º	10:16.7	+23º 25′	Secondary is 35 Leonis. Optical double. *Adhafera*	☐	
Spr	Com	**17**	5.2 & 6.6	146″	251º	12:28.9	+25º 55′	In Coma Star Cluster south of Gamma; visual binary.	☐	
Spr	Com	**32 & 33**	6.5 & 7.0	196″	51º	12:52.2	+17º 04′	South of Coma Star Cluster, west of Alpha Comae Berenices.	☐	
Spr	CVn	**15 & 17**	6.0 & 6.3	278″	277º	13:09.6	+38º 32′	Nice even-magnitude pair located east of Alpha Canum Venaticorum.	☐	
Spr	UMa	**Zeta & 80**	2.4 & 4.0	708″	70º	13:23.9	+54º 56′	*Mizar* and *Alcor,* in the handle of the Big Dipper. *Mizar* is itself a telescopic binary.	☐	
Spr	Lib	**Alpha^2 & Alpha^1**	2.7 & 5.2	231″	315º	14:50.9	–16º 02′	*Zubenelgenubi*, between Spica and Antares. Visual binary. Look for colour.	☐	
Spr	Boo	**Mu^1 & Mu^2**	4.3 & 7.0	107″	171º	15:24.5	+37º 23′	Located east of Beta and Delta Bootis, a nice contrast of magnitudes. *Alkalurops*	☐	
Spr	CrB	**Nu^1 & Nu^2**	5.4 & 5.6	361″	165º	16:22.4	+33º 48′	Look between the half circle of CrB and the Keystone of Hercules.	☐	
Spr	Dra	**17 & 16**	5.4 & 5.5	90″	194º	16:36.2	+52º 55′	Find the 4-star "Head of the Dragon" pattern, then use Gamma and Beta as pointers.	☐	
Spr	Dra	**Nu^1 & Nu^2**	4.9 & 4.9	63″	312º	17:32.2	+55º 11′	Located in the 4-star "Head of the Dragon" pattern An outstanding even- magnitude double!	☐	
Sum	Lyr	**Epsilon^1 & Epsilon^2**	5.0 & 5.3	210″	174º	18:44.3	+39º 40′	Wide easy binocular pair. Telescope users can try splitting each star again to see the Double Double.	☐	
Sum	Lyr	**Zeta^1 & Zeta^2**	4.3 & 5.6	44″	150º	18:44.8	+37º 36′	Zeta, Epsilon, and Vega form a wide triangle. **Use tripod-mounted binoculars or a telescope.**	☐	
Sum	Lyr	**Delta^1 & Delta^2**	4.5 & 5.6	630″	295º	18:53.7	+36º 58′	Very wide, binocular optical double with colour. From Vega, go to Zeta, then on to Delta.	☐	
Sum	Cap	**Alpha^1 & Alpha^2**	3.7 & 4.3	378″	292º	20:18.1	–12º 33′	Wide binocular double in nice star field. *Algedi*	☐	
Sum	Cap	**Beta^1 & Beta^2**	3.2 & 6.1	207″	267º	20:21.0	–14º 47′	Look for Beta just south of Alpha. Nice magnitude contrast. *Dabih*	☐	
Sum	Cyg	**Omicron^1 (Triple!)**	3.8, 7.7, & 4.8	107″ & 338″	173º & 292º	20:13.6	+46º 44′	Beautiful triple star for binoculars. Look for colour. 3rd component is 30 Cyg.	☐	

Sea-son	Con.	Object	Mag.	Sep.	Position Angle	RA	Dec	Observing Notes	Seen? ✓	Log Page
Sum	Cyg	**Beta (Albireo)**	3.4 & 4.7	33″	54°	19:30.7	+27° 58′	*Albireo* is one of the most beautiful coloured double stars in the sky. **Use tripod-mounted binoculars or a telescope.**	☐	
Aut	Cyg	**16**	6.0 & 6.2	39″	133°	19:41.8	+50° 32′	Impressive pair located in the area of Iota Cyg (mag. 3.8) and just next to Theta Cyg (mag. 4.5). **Use tripod-mounted binoculars or a telescope.**	☐	
Win	Tau	**Theta[1] & Theta[2]**	3.4 & 3.9	337″	348°	04:28.7	+15° 52′	Located in the beautiful Hyades star cluster between Alpha and Gamma.	☐	
Win	Cep	**Delta**	3.5–4.4 & 7.5	41″	191°	22:29.2	+58° 25′	This famous Cepheid variable is also a very pretty double star. **Use tripod- mounted binoculars or a telescope.**	☐	

Variable Stars—optional observations

A variable star is a star whose brightness changes, over time scales of a few days to several hundred days, either periodically or irregularly. These stars are among the most interesting and beautiful stars in the night sky, and it is well worth the effort to find them. There are several categories of variable stars, but there are two main classes: (1) **intrinsic variables**, in which the variation is due to physical or chemical changes within a single star; and (2) **extrinsic variables**, in which the variation is due to the interaction of a star with one or more other bodies, either stars or planets.

Observing variable stars is **not** a requirement to earn the *Explore the Universe* certificate, but we offer two typical and well-known—but quite different—examples below to whet your appetite, if you would like a bit of a challenge:

(1) **Mira** (Omicron Ceti) is an **intrinsic** variable star, a **Long Period Variable** in the **Pulsating Variable** category, whose brightness varies more than eight magnitudes over 11 months, alternately being visible and invisible to the unaided eye.

(2) **Algol** (Beta Persei) is an **extrinsic** variable star in the **Eclipsing Binary** category, whose brightness varies by more than one magnitude in less than 3 days, owing to a dim secondary star periodically passing in front of the bright primary star as they orbit one another. The times of minimum brightness of *Algol* are published in "The Sky Month By Month" section of the *Observer's Handbook*.

Observing a variable star requires multiple sessions involving regular estimation of its magnitude, by comparing the brightness of the star to that of nearby stars of known magnitude. Record the date and time of each magnitude estimate and the comparison stars used. Short-period variable stars such as *Algol* should be observed more often, hourly or even more frequently, as the brightness changes quickly. Long Period Variables such as *Mira* can be observed weekly, as it takes months to complete a cycle.

Two Typical Variable Stars: Mira and Algol

Con.	Star	Variable Type	Magnitude Range	Period (days)	RA	Dec	Notes
Cet	Omicron Ceti *Mira*	Long Period Variable	2.0–10.1	332	02:19.3	–02° 59′	Mira has the brightest maxima of all LPVs and is the prototype of its class.
Per	Beta Persei *Algol*	Eclipsing Binary	2.1–3.4	2.86	03:08.2	+40° 57′	Use Epsilon Per (Mag. 2.9), Delta Per (Mag.3.1), Kappa Per (Mag.3.8), and Gamma And (Mag.2.2) for comparison.

Observing variable stars is one of the ways that backyard astronomers can contribute helpful information to professional astronomers. Because of the great number of observations required for variable stars, large observatories cannot provide enough observing time for experts to monitor them all. More information about the various categories of variable stars can be found in the RASC *Observer's Handbook* and other observing guides. A highly recommended source of information is the **American Association of Variable Star Observers (AAVSO) at** www.aavso.org, who publish variable-star charts with the magnitudes of comparison stars indicated.

