

September's Total Lunar Eclipse



Alan
MacRobert

The whole western world can see the eclipse of September 27–28.

The current “tetrad” of four total eclipses of the Moon a half-year apart will end with a bang on Sunday evening, September 27th, for the Americas. Unlike last April’s eclipse, which may not even have been precisely total (see the July issue, page 12), this one will carry the Moon through the umbra of Earth’s shadow for a nice long hour and 12 minutes. Europe and Africa will see the eclipse happen on the local morning of the 28th.

Observers in eastern North America can watch every stage of the eclipse from beginning to end (weather permitting!), during convenient hours of late twilight or darkness with the Moon generally high in the sky.

Viewers in much of the American West will find the first partial stage of the eclipse already in progress when the Moon rises (due east) around the time of sunset.

But even on the West Coast, the Moon will lift above the eastern horizon before totality begins. The map on the facing page, and the diagram and timetable on page 28, tell what to expect at your location and when.

This eclipse is unusual in one particular way. It’s the *biggest* eclipsed Moon you’ll ever see! The year’s closest lunar perigee occurs just 59 minutes before mid-eclipse. The Moon (in Pisces) will appear 13% larger in diameter than it did when eclipsed last April 4th.

The events that happen to a shadowed Moon are more complex and interesting than many people realize. This eclipse, with its wide visibility, convenient evening schedule, and record size, is going to get a lot of publicity. So keep the following description handy for when family and friends ask you for the lowdown.



LASER MOONSHOT During the total lunar eclipse of April 15, 2014, laser rangefinders at New Mexico’s Apache Point Observatory shot powerful pulses at the Apollo 15 landing site through a 2.5-meter (100-inch) telescope. The Apollo astronauts left small corner reflectors on the Moon’s surface. Astronomers can time a reflected photon’s round trip well enough now to track the Moon’s position and orbital motion to millimeter accuracy. In this way they can watch vast amounts of subtle physics at work, including the most precise tests of general relativity that are currently possible. Sunlight interferes with the measurements when the Moon is full, but not when the full Moon is eclipsed.

DAN LONG / APACHE POINT OBSERVATORY

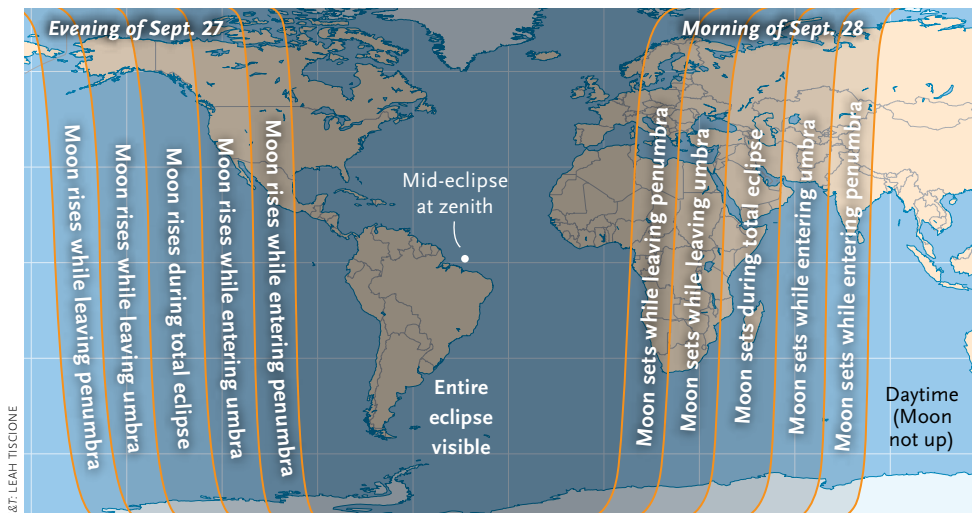


Stages of the Eclipse

A total lunar eclipse has five stages, with different things to watch for at each.

The first *penumbral* stage begins when the Moon's leading edge enters the pale outer fringe of Earth's

shadow: the penumbra. But the shading is so weak that you won't see anything of the penumbra until the Moon is about halfway across it. During this eclipse, watch for a slight darkening to become apparent on the Moon's celestial northeast side: its left side as seen from North



TWO ECLIPSES AGO Above:

Before dawn on October 8, 2014, Jeff McGrath shot the cirrus-hazed Moon through a 160-mm f/8 refractor at Stansbury Park Observatory Complex in Utah.

WIDE VIEW THIS TIME Left:

For your location, check whether the Moon will rise (or set) during some stage of the eclipse. An eclipsed Moon is always full, so the Sun sets (or rises) at almost the same time on the opposite horizon. This means that a lunar-eclipse moonrise or moonset always happens in a very bright sky!



CRATER TIMING GUIDE Craters and spots that stand out well during a lunar eclipse are identified here. Approximate times when the umbra's edge will cross them are listed at right.

end approaches, only a final bright sliver remains outside the umbra. By this time the rest should already be showing a dim, foreboding reddish glow.

The third stage is *total eclipse*, beginning when the last rim of the Moon slips into the umbra. But the Moon won't black out: it's sure to glow some shade of intense orange or red. This red light is sunlight that has skimmed and bent through Earth's atmosphere, all around the edge of our globe, on its way to the Moon. In other words, it's light from all the sunrises and sunsets that ring our world at any given moment. An astronaut standing on the Moon would see the dark Earth thinly rimmed with brilliant orange from the Sun hidden behind it — brilliant enough to illuminate the lunar landscape around him an eerie red.

This umbral light can change a lot from one eclipse to the next. Two main factors affect its brightness and color. The first is simply how deeply the Moon goes into the umbra while passing through; the center of the umbra is much darker than its edges. At mid-eclipse this time, the Moon's south-southeastern edge will be only a quarter of a lunar diameter inside the umbra, so expect that side to be distinctly brighter than the rest.

The other factor is the state of Earth's atmosphere along the sunrise-sunset line. If the air is very clear, the eclipse is bright. But if a major volcanic eruption has recently polluted the stratosphere with thin global haze, a lunar eclipse will be dark red, ashen gray, or occasionally almost black.

In addition, *blue* light is refracted through Earth's clear, ozone-tinted upper atmosphere above the thicker layers that produce the red sunrise-sunset colors. This

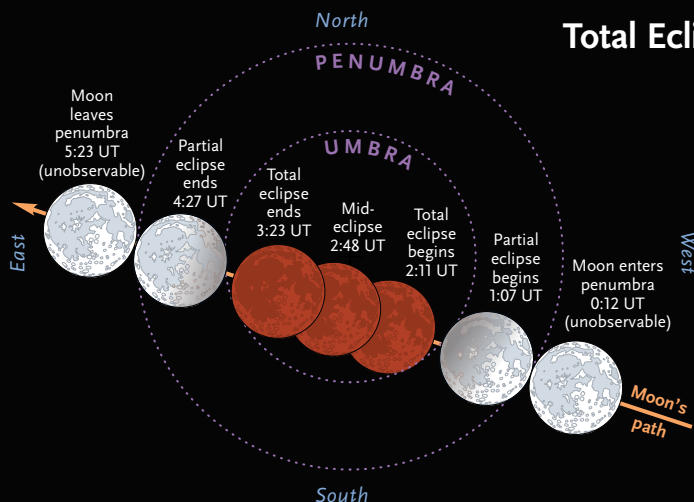
America, its upper left side as seen from Europe.

The penumbra is the region where an astronaut standing on the Moon would see Earth covering only part of the Sun's face. The penumbral shading becomes stronger as the Moon moves deeper in.

The second stage is *partial eclipse*. This begins much more dramatically when the Moon's leading edge enters the umbra: Earth's inner shadow where the Sun is completely hidden. With a telescope, you can watch the edge of the umbra slowly engulfing one lunar feature after another (see the Crater Timings box on the facing page), as the entire sky begins to grow darker.

The partial phase will last just over an hour. As its

Total Eclipse of the Moon, Night of September 27–28, 2015



Eclipse event	EDT	CDT	MDT	PDT
Penumbra first visible?	8:40 p.m.	7:40 p.m.	—	—
Partial eclipse begins	9:07 p.m.	8:07 p.m.	7:07 p.m.	—
Total eclipse begins	10:11 p.m.	9:11 p.m.	8:11 p.m.	7:11 p.m.
Mid-eclipse	10:48 p.m.	9:48 p.m.	8:48 p.m.	7:48 p.m.
Total eclipse ends	11:23 p.m.	10:23 p.m.	9:23 p.m.	8:23 p.m.
Partial eclipse ends	12:27 a.m.	11:27 p.m.	10:27 p.m.	9:27 p.m.
Penumbra last visible?	12:55 a.m.	11:55 p.m.	10:55 p.m.	9:55 p.m.

ozone-blue light colors the Moon a bit near the umbra's edge. The result can be a subtle mix of changing blue, gray, purple, and even green.

Time-lapse videos may show large “flying shadows” in the umbra, caused by changing cloud-shadowing effects around the sunrise-sunset line as Earth turns and the Moon moves.

And then, as the Moon continues eastward along its orbit, events replay in reverse order. The Moon's edge re-emerges into sunlight, ending totality and beginning stage four: a partial eclipse again.

When all of the Moon escapes the umbra, only the last, penumbral shading is left for stage five. By about 30 or 40 minutes later, nothing unusual remains.

We'll have more than two years' wait until the next total eclipse of the Moon, on January 31, 2018. And that will be visible only from the Eastern Hemisphere and the western side of North America.

The previous tetrad of lunar eclipses happened in 2003–04. The next begins on April 25, 2032.

Uranus Again

During the eclipse of October 8, 2014, eleven days short of a year before this one, the Moon was only about 1° from 6th-magnitude Uranus. This time Uranus is about 15° to the Moon's east. But take a look during a quiet few minutes if the Moon is high in a dark sky at your location while the eclipse is still total. Use the finder charts on page 49. Uranus is 15 times larger than the Moon but, on this night, it's 8,000 times farther away. It will be magnitude 5.7. In the darkness of the total lunar eclipse, can you glimpse Uranus naked-eye? ♦

Although S&T senior editor Alan MacRobert sees Earth totally eclipsing the Sun every clear evening from his house, he really wants to see it happening from Mare Crisium.

Crater Timing Predictions

ENTRANCES

Feature	UT
Grimaldi	1:11
Aristarchus	1:15
Billy	1:18
Kepler	1:18
Pytheas	1:25
Copernicus	1:26
Timocharis	1:28
Plato	1:30
Campanus	1:31
Aristoteles	1:38
Eudoxus	1:39
Manilius	1:39
Menelaus	1:42
Tycho	1:43
Dionysius	1:45
Plinius	1:46
Censorinus	1:53
Proclus	1:55
Taruntius	1:57
Goclenius	2:00
Langrenus	2:05

EXITS

Feature	UT
Grimaldi	3:31
Billy	3:33
Campanus	3:37
Tycho	3:38
Kepler	3:43
Aristarchus	3:45
Copernicus	3:51
Pytheas	3:53
Timocharis	3:58
Plato	4:04
Manilius	4:05
Dionysius	4:06
Menelaus	4:08
Censorinus	4:11
Plinius	4:11
Eudoxus	4:11
Aristoteles	4:12
Goclenius	4:12
Langrenus	4:16
Taruntius	4:18
Proclus	4:20

Crater Timings Sought!

The size of Earth's umbra varies slightly from one eclipse to the next for reasons that are still unknown. For 170 years, careful observers have timed when the edge of the umbra crosses lunar markings during eclipses. In the June issue (page 28) Roger Sinnott told of the massive analysis that he and his colleagues did of the 26,658 timings that are on record since 1842. And he called for readers to make timings during this upcoming eclipse, especially

because it offers a very similar repeat of the much-timed eclipse of September 27, 1996.

All you will need is a small telescope (use fairly high power), a timepiece that reads to the second, and a notepad and pencil.

Check in advance that your watch or device is accurately set to the second (for instance, at time.gov/widget). The idea is to time when the umbra's edge — defined as *where the shadow*

changes brightness most abruptly — crosses a feature's center. Record the time to at least the nearest 5 seconds.

The photo at the top of the facing page labels some standard timing targets. The table above gives many rough predictions, so you don't get caught flat-footed. It's fine to skip some.

Please report your timings to Roger Sinnott at rsinnott@post.harvard.edu. We'll publish results in a future issue. You can become a part of lunar history.

Telescopic Moon Map

The Moon shows fantastic detail in even the smallest telescope. And light pollution doesn't affect it a bit. In city or country, the Moon will be an intimate part of your astronomy life. Use this map — with the help of the previous four-page article — to explore our closest neighbor world.

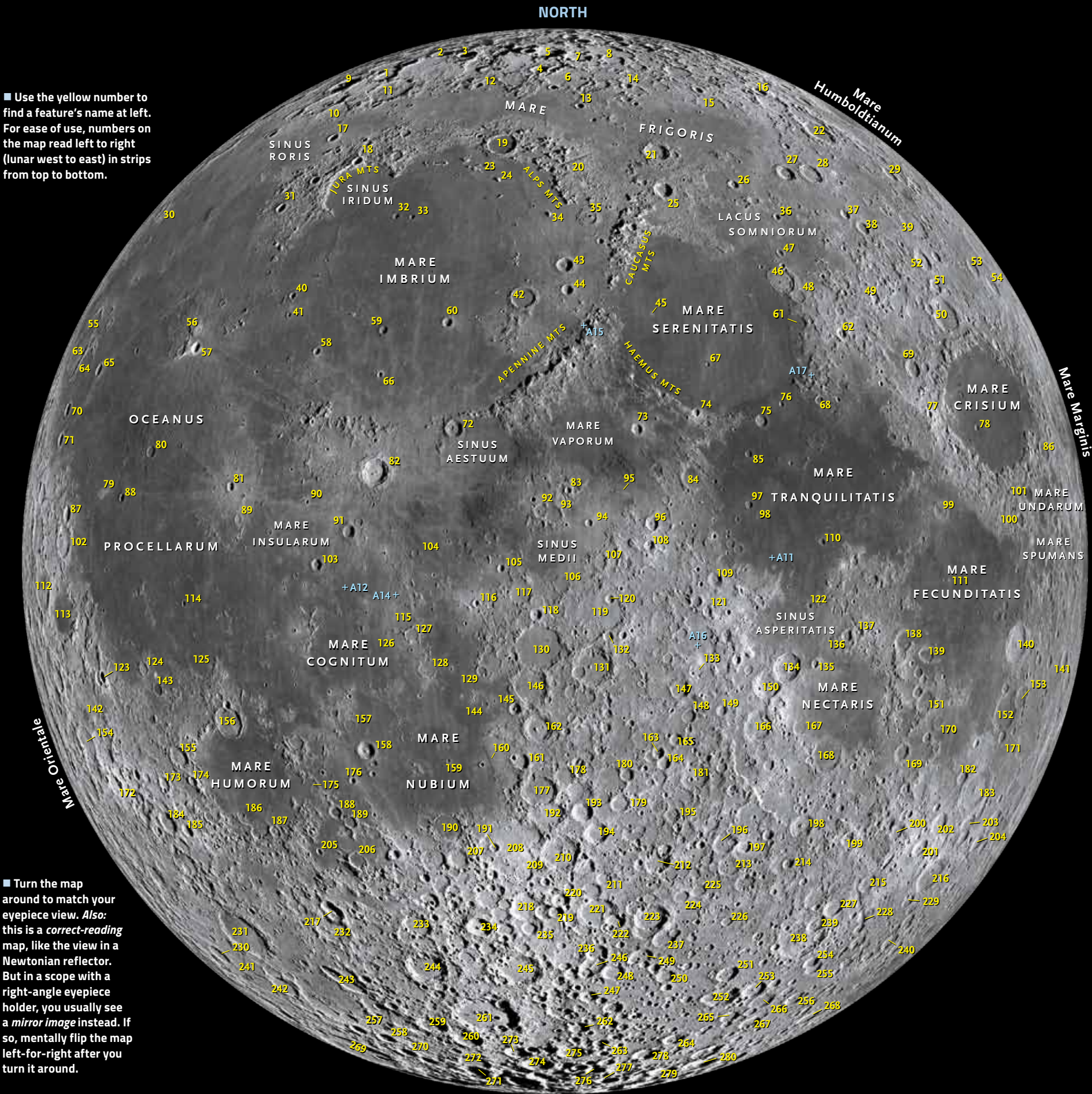
Lunar Features

Crater Names				
1 Anaximander	58 Euler	116 Lalande	174 Liebig	232 Mee
2 Anaximenes	59 Lambert	117 Flammarion	175 Hippalus	233 Wilhelm
3 Philolaus	60 Timocharis	118 Herschel	176 König	234 Tycho
4 Epigenes	61 Le Monnier	119 Hipparchus	177 Purbach	235 Saussure
5 Goldschmidt	62 Römer	120 Horrocks	178 La Caille	236 Licetus
6 W. Bond	63 Struve	121 Taylor	179 Apianus	237 Barocius
7 Barrow	64 Eddington	122 Torricelli	180 Playfair	238 Janssen
8 Meton	65 Seleucus	123 Sirsalis	181 Sacrobosco	239 Fabricius
9 Pythagoras	66 Pytheas	124 Hansteen	182 Wrottesley	240 Vega
10 South	67 Bessel	125 Letronne	183 Petavius	241 Wargentin
11 J. Herschel	68 Vitruvius	126 Bonpland	184 Vieta	242 Phocylides
12 Fontenelle	69 Macrobius	127 Parry	185 Fourier	243 Schiller
13 Archytas	70 Krafft	128 Guericke	186 Doppelmayr	244 Longomontanus
14 C. Mayer	71 Cardanus	129 Davy	187 Vitello	245 Maginus
15 Gärtner	72 Eratosthenes	130 Ptolemaeus	188 Campanus	246 Heraclitus
16 Strabo	73 Manilius	131 Albategnius	189 Mercator	247 Lilius
17 Harpalus	74 Menelaus	132 Halley	190 Pitatus	248 Cuvier
18 Bianchini	75 Plinius	133 Descartes	191 Hell	249 Clairaut
19 Plato	76 Dawes	134 Theophilus	192 Regiomontanus	250 Baco
20 Alpine Valley	77 Proclus	135 Mädler	193 Werner	251 Pitiscus
21 Aristoteles	78 Picraft	136 Isidorus	194 Aliacensis	252 Hommel
22 Endymion	79 Reiner Gamma	137 Capella	195 Pontanus	253 Vlacq
23 Teneriffe Mountains	80 Marius	138 Gutenberg	196 Zagut	254 Steinheil
24 Mt. Pico	81 Kepler	139 Goclenius	197 Lindenau	255 Watt
25 Eudoxus	82 Copernicus	140 Langrenus	198 Piccolomini	256 Biela
26 Bürg	83 Ukert	141 La Pérouse	199 Neander	257 Zucchi
27 Hercules	84 Julius Caesar	142 Crüger	200 Reichenbach	258 Bettinus
28 Atlas	85 Ross	143 Billy	201 Stevinus	259 Scheiner
29 Mercurius	86 Condorcet	144 Lassell	202 Snellius	260 Blancanus
30 von Braun	87 Cavalerius	145 Alpetragius	203 Hase	261 Clavius
31 Mairan	88 Reiner	146 Alphonsus	204 Adams	262 Zach
32 Helicon	89 Encke	147 Abulfeda	205 Ramsden	263 Pentland
33 Le Verrier	90 Hortensius	148 Almanon	206 Capuanus	264 Mutus
34 Mt. Piton	91 Reinhold	149 Tacitus	207 Gauricus	265 Nearch
35 Cassini	92 Pallas	150 Cyrillus	208 Deslandres	266 Rosenberger
36 Grove	93 Murchison	151 Colombo	209 Lexell	267 Hagecius
37 Cepheus	94 Triesnecker	152 Vendelinus	210 Walter	268 Pontécoulant
38 Franklin	95 Rima Hyginus	153 Lamé	211 Kaiser	269 Baillly
39 Messala	96 Agrippa	154 Darwin	212 Gemma Frisius	270 Kircher
40 Delisle	97 Arago	155 Mersenius	213 Rabbi Levi	271 Casatus
41 Diophantus	98 Lamont	156 Gassendi	214 Stiborius	272 Klaproth
42 Archimedes	99 Taruntius	157 Lubiniezky	215 Rheita	273 Gruemberger
43 Aristillus	100 Apollonius	158 Bullialdus	216 Furnerius	274 Moretus
44 Autolycus	101 Firmicus	159 Nicolle	217 Hainzel	275 Curtius
45 Linné	102 Hevelius	160 Straight Wall	218 Orontius	276 Simpelius
46 Posidonius	103 Lansberg	161 Thebit	219 Nasireddin	277 Schomberger
47 Daniell	104 Gambart	162 Arzachel	220 Miller	278 Manzinus
48 Chacornac	105 Mösting	163 Abenezra	221 Stöfler	279 Boguslawsky
49 Taurus Mountains	106 Réaumur	164 Azophi	222 Faraday	280 Boussingault
50 Cleomedes	107 Rhaeticus	165 Geber	223 Maurolycus	
51 Burckhardt	108 Godin	166 Catharina	224 Buch	
52 Geminus	109 Delambre	167 Beaumont	225 Büsching	
53 Berosus	110 Maskelyne	168 Fracastorius	226 Nicolai	
54 Hahn	111 Messier	169 Santbech	227 Metius	
55 Russell	112 Hahn	170 Cook	228 Young	
56 Schröter's Valley	113 Grimaldi	171 Holden	229 Fraunhofer	
57 Aristarchus	114 Flamsteed	172 Byrgius	230 Inghirami	
	115 Fra Mauro	173 Cavendish	231 Schickard	

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A11	Apollo 11
A12	Apollo 12
A14	Apollo 14
A15	Apollo 15
A16	Apollo 16
A17	Apollo 17

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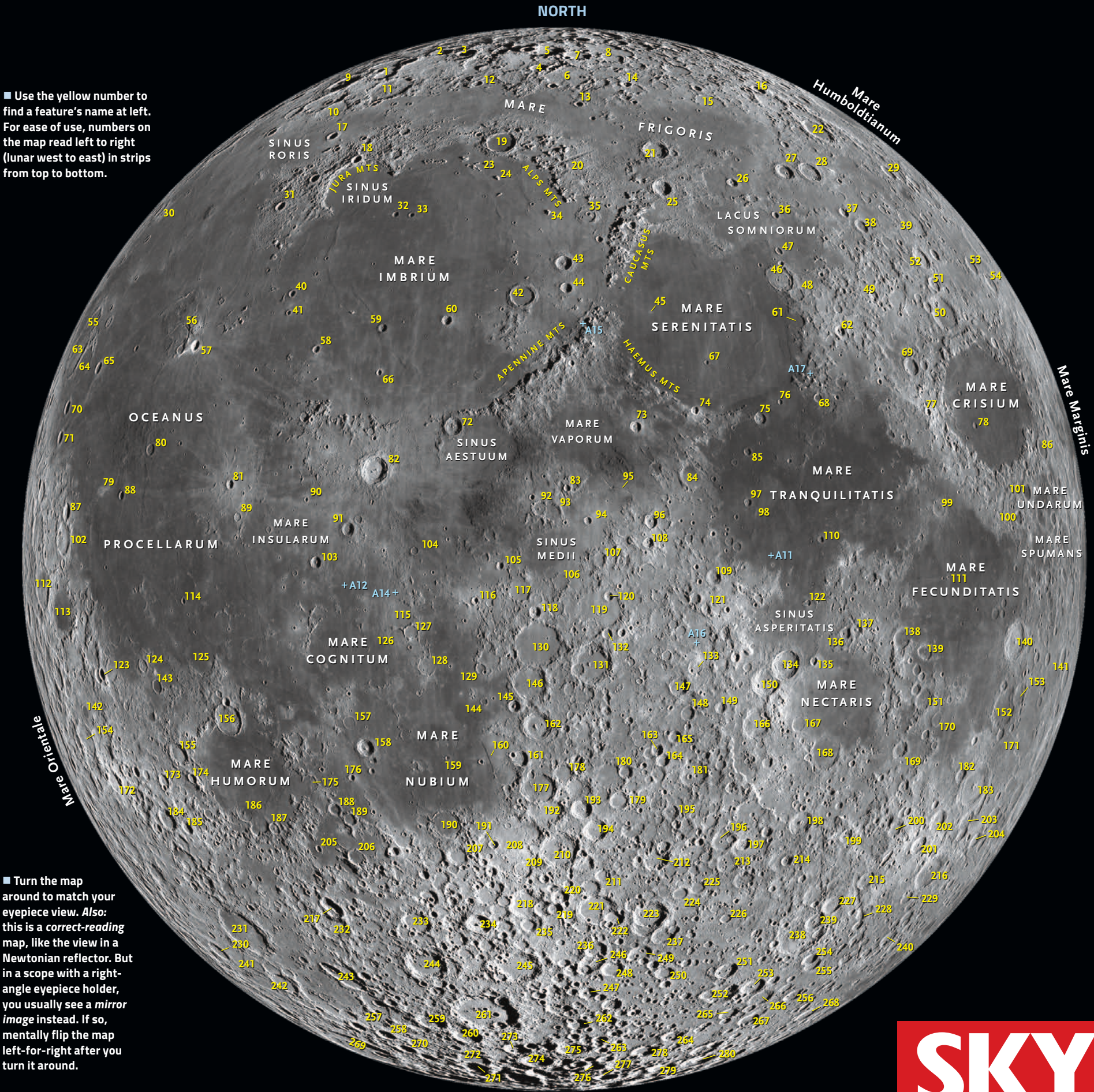
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