Western Sydney Amateur Astronomy Group

Introduction

Of all the things to do in astronomy, none is more important than public education and inspiration. Nor as satisfying. We promise you, the more you give, the more you will receive. What follows is a guide only, and with any luck, will need constant revision. No one source has a monopoly on knowledge. In fact, at the moment, *you* might be the leading authority on a given subject! If, for instance, you've just read a new edition on current thinking in planet formation, you're *it*. Share it. Perhaps, suggest additions to this resource.

We all have different interests; one person could show galaxies all night, another might know asteroids that can be seen to move as a family takes turns around the eyepiece, and another, show a nova explosion. *Viva la difference!* In fact, this is why this general information is useful. Finally, it can be cool to say 'I don't know', and *very* cool to say 'nobody knows'. What gives more sense of wonder - that 'Saturn's rings were formed by a moon that never came together' or that, even today, *No-one Knows*?

Constellations

There are 88 constellations, the boundaries having been standardised by the International Astronomical Union in 1930. Argo Navis is the only one of the 48 constellations listed by Ptolemy in the second century that is not in use today. It has since been split into the constellations Carina, Puppis and Vela. The stick figures used for constellations are not standardised and are asterisms of brighter stars. **Asterisms** are patterns formed by stars that are mostly not related physically, the stars often being at very different distances from the Earth.

On a public or visitor observing night, don't forget to point out the major constellations (e.g. Orion, Leo or Scorpius) and the brighter stars within them. It is surprising how many people don't even know where the Southern Cross and its Pointers are. Because of the rotation of the Earth, the constellations appear to move from east to west or, facing south, in a clockwise direction around the South Celestial Pole.

Under a dark sky, there are many naked eye objects and objects suitable for binoculars within the constellations e.g. SMC, LMC, Orion Nebula, Carina Nebula, Wishing Well Cluster (NGC 3532), omega Centauri, 47 Tuc or the nebulous weave of the Milky Way itself.

Stars

We can call today the Age of Stars; there was a time in the universe when there were none, and there will be again in the future. The **Sun** and planets are believed to have formed about 4.6 billion years ago. The Sun is a spectral type G2 star. Like all **main sequence stars**, it generates most of its energy by fusing core hydrogen into helium. The burning core is able to hold itself up against the force of gravity. When core hydrogen is consumed, the core will contract, releasing gravitational energy, and actually heat up. At the now higher temperature, helium fusion begins and carbon and oxygen are produced. The Sun's outer layers will expand and cool, and a **red giant** is born.

Sun-like stars (around 0.5-10 solar masses) may eventually become **planetary nebulae** after the giant stage, with the exposed stellar core now a fiercely hot **white dwarf star** energizing the ejected envelope, making some of the most beautiful objects in the universe. A white dwarf is about the size of the Earth but with a density of one tonne per cubic centimetre. A larger star (>10 solar masses) will form a **red supergiant**, probably explode as a **supernova** after an iron core collapse and form either a **neutron star** or **black hole** depending on mass. A neutron star has a radius of about 12km with a predicted density of around 500 million tonnes per cubic centimetre!

Taking the best possible naked eye limiting magnitude as 6.0 (it is less than 5.0 here in suburbia), there are about 5,000 naked eye stars, of which roughly 2,500 might be seen at any particular location.

The four brightest stars are **Sirius, Canopus, Rigil Kent (alpha Centauri)** and **Arcturus**. The alpha Centauri star system contains the closest stars to the Earth visible with the naked eye. Sirius is the fifth closest star system (it has a white dwarf companion) to the Earth. Arcturus is the closest giant star to the Earth.

The supergiant star **Deneb** in the constellation of Cygnus is the most distant first magnitude star. Due to the Earth's axial precession, it will be within 5 degrees of the north celestial pole in 10,000AD, making it the brightest star near the NCP. At that time, our southern sky will be wheeling around the false cross and the spectacular Carina Milky Way.

Vega is a rapid rotator with its equatorial diameter 23% larger than its polar diameter. It was the near northern pole star around 12,000BC and it will be again in about 14,000AD. When Vega is just 4 degrees from the NCP in 14,000AD, Canopus will be 8 degrees from the SCP. Due to its relative motion, Vega will be the brightest star in the sky in about 210,000 years.

The average distance of all naked eye stars is roughly 600 light years. However, this figure can be misleading. In that radius, there are an overwhelming number of low-mass **red dwarfs** and not one of them is anywhere near visible to the naked eye. On the other hand, the brightest stars can be seen from across the Galaxy. If Deneb were the same distance as Vega, 25 light years away, it would be fifty times as bright as Venus at her best.

The **spectral class** (OBAFGKM) of a star is an indication of its surface temperature and apparent colour. O-class stars have the highest surface temperature, while M-class stars have the lowest.

The supergiant star **Naos** (zeta Puppis, spectral type O5, Vmag 2.22) is the bluest naked eye star. However, it can be difficult to distinguish blue from white in stars.

The following table gives the properties of the most commonly recognized stars:

Star Name	Designation	Vmag	Spectral Type	Description	Distance Light Yrs	Diameter x Sun
Sirius	alp CMa	-1.44	A1	Main-sequence	8.58	1.8
Canopus	alp Car	-0.62	F0	Giant	309	65
Rigil Kent	alp Cen	-0.30	G2/K1	Main-sequence pair	4.36	1.3 & 1
Arcturus	alp Boo	-0.05	K1.5	Giant	36.7	25
Vega	alp Lyr	0.03	A0	Main-sequence	25	2.8Eq, 2.3Po
Rigel	bet Ori	0.28	B8	Supergiant	860	70
Betelgeuse	alp Ori	0.56	M1-M2	Supergiant	500	650
Hadar	bet Cen	0.63	B2/B2/B?	3 stars	390	13
Acrux	alp Cru	0.81	B1/B1	Main-sequence pair	320	7.8 & 7.8
Aldebaran	alp Tau	0.87	K5	Giant	67	44
Spica	alp Vir	1.05	B1	Spectroscopic Binary	250	7 & 4
Antares	alp Sco	1.06	M2	Supergiant	550	400
Mimosa	bet Cru	1.28	B0.5	Giant	279	8.1
Deneb	alp Cyg	1.33	A2	Supergiant	1,400	110
Regulus	alp Leo	1.40	B7	Main-sequence	79.3	3.5

Compare the diamond white of Sirius or Rigel in the eyepiece with the yellow of alpha Cen A or the yellow-orange hue of alpha Cen B, orange Betelgeuse, and the red of a carbon star. A child's good eyes can see a blue tint to Spica's light.

Betelgeuse is the brightest of the red supergiants. It has one of the largest diameters of any star and is one of the more luminous stars known. If placed at the centre of our solar system, its outer perimeter would extend as far as Jupiter's orbit.

Zeta 1 Scorpii (spectral type B1, shining at Vmag 4.76 from a staggering 6,300 light years away) is classified as a **hypergiant** with an estimated 60 solar masses. The luminous blue variable and binary **eta Carinae** is the second most massive (>100 solar masses) and luminous systems known behind HD 93129A, also located in the Carina Nebula.

Some bright red carbon stars are **U Ant** (Vmag 5.5) and **X TrA** (Vmag 5.6). Both of them look great in binoculars. An easy telescope find is the carbon star **DY Crucis (Ruby Crucis)**. At magnitude 8.8, it is just 145 arcseconds from Mimosa in Crux and is one of the reddest known stars. **Carbon stars** appear quite red due to their relatively cool surface temperature (< 4,000 degrees Kelvin) and high concentration of molecules containing carbon in their atmospheres. We must remember, even here, that the stellar envelope is still overwhelmingly made up of hydrogen gas.

Carbon stars are important. If a star is too small, carbon, a product of nucleosynthesis, never gets mixed into the envelope from the core via convection, and the carbon is not released via a planetary nebula into interstellar space. The carbon, so important to life, will stay for eternity locked inside the white dwarf. If the star is too massive, the C-O core will burn into oxygen, neon, and magnesium. Statistically, this is where the carbon atoms in you and me have come from.

As a general rule of thumb, you can see quite a few DSOs with naked eyes, and down to visual magnitude 7.5 just with 8x50mm binoculars under a dark sky. However, extended objects at magnitude 7.5 or fainter will have a lower surface brightness and can be difficult targets.

Open Clusters

An open cluster is a group of up to a few thousand stars that are bound together loosely. Their randomly scattered stars form very irregular patterns. Open clusters are largely found in the spiral arms of galaxies where gas densities are highest and most star formation occurs. Young clusters tend to have more hot blue stars, while in older clusters those more massive stars have evolved into red giants and beyond, leaving an increasing number of less-massive cooler stars. In fact, this is how we can tell the age of a cluster – by studying the stellar population. Because the stars are weakly bound together they will disperse over a period of a few 100 million years. Our Sun would have originated in a cluster that has probably long since dispersed.

There are over 1,000 known open clusters in our galaxy but there may be as many as 10,000.

The following table gives the properties of some of the more commonly viewed open clusters:

Open Cluster Name	Title	Cons	Vmag	Size	Distance (ly)	No. of stars
Southern Pleiades	IC 2602	Car	1.6	100’	530	50
Wishing Well Cluster	NGC 3532	Car	3	50’	1,600	300
Gem Cluster	NGC 3293	Car	4.7	7’	7,600	80
Pearl Cluster	NGC 3766	Cen	5.3	12’	5,500	100
Beehive	M44	Cnc	3.1	120’	610	1,000
Jewel Box	NGC 4755	Cru	4.2	10’	6,400	100
Ptolemy’s Cluster	M7	Sco	3.3	40’	980	70
Butterfly Cluster	M6	Sco	4.2	35’	1,600	120
Wild Duck Cluster	M11	Sct	5.8	15’	6,000	500
Pleiades (Seven Sisters)	M45	Tau	1.5	90’	430	1,000

One of the most famous is the **Pleiades**, mentioned several times in the Bible (e.g. Job 9:9, Amos 5:8). The Pleiades is one of the closest open clusters. The **Beehive** is best seen with binoculars. Carina has several spectacular clusters. The **Southern**

Pleiades (IC 2602) is best seen with binoculars. The **Wishing Well Cluster (NGC 3532)** is perhaps the most spectacular of all clusters: large, rich and speckled with many bright stars (about 50 stars brighter than magnitude 9).

Globular Clusters

A globular (or spherical) cluster has tens of thousands to millions of stars that are bound together tightly. They do not show any active star formation and are thought to be the oldest objects in the Galaxy, some as old as 12.7 billion years, or even older. The nature of these objects is very difficult to understand, and can be quite contentious among astronomers. What follows are indications of current, mainstream thinking.

Generally, GCs consist of similar, low metalicity, older, low mass stars. Because of the high stellar density in a globular, there is more chance of stellar collisions, leading to so-called **blue stragglers**, formed from the collision of two stars that merge to form a more massive hotter star. Planets are unlikely to form around stars in a globular due to the high tidal forces of stellar interactions. Also, globulars have a lower abundance of the heavier elements (e.g. silicon, iron, magnesium) necessary to form terrestrial-type planets.

There are about 158 known Milky Way globular clusters, the number constantly being debated and fine-tuned in the journals. Randomly distributed in a spherical halo, they move about the centre of the galaxy in elliptical orbits separate to the rotation of the galaxy.

The average distance of Milky Way globular clusters from the Sun is about 50,000 light years. The closest globulars to the Sun are **M4** and **NGC 6397**.

The brightest globular clusters are **omega Centauri** and **47 Tucanae**. Both are naked eye objects. Omega Centauri is the brightest and most massive globular cluster orbiting the Milky Way. It has a diameter of about 175 light years. It is speculated that omega Centauri may be the core of a dwarf galaxy stripped of its outer stars as it was disrupted and absorbed by the Milky Way.

47 Tuc has a diameter of about 120 light years. It has at least 21 blue stragglers near its core and 23 known millisecond pulsars (fast spinning neutron stars).

NGC 2419 (Vmag 10.4) in the constellation of Lynx, but only 7 degrees from Castor in Gemini, is one of the furthest Milky Way globular clusters at a distance of 300,000 light years or nearly twice the distance of the Large Magellanic Cloud. It has similar absolute brightness to omega Centauri and is known as the "Intergalactic Wanderer".

The globulars in this table are easily visible in 8x50mm binoculars under darker skies:

Globular Cluster	Cons	Vmag	Size	Distance (ly)	No. of Stars
Omega Centauri	Cen	3.7	36'	17,000	5,000,000
47 Tucanae	Tuc	4	31'	15,000	1,000,000
M22	Sgr	5.1	24'	10,000	500,000
NGC 6752	Pav	5.4	20'	13,000	>100,000
NGC 6397	Ara	5.7	26'	7,500	400,000
M5	Ser	5.8	17'	24,500	500,000
M13	Her	5.8	17'	23,000	300,000
M4	Sco	5.9	26'	7,200	>100,000
NGC 2808	Car	6.2	14'	31,000	1,000,000

Diffuse Nebulae

A diffuse nebula is an interstellar cloud with no well-defined boundary. The cloud consists of dust, hydrogen, helium and other gases. There are three broad categories, emission, reflection, and dark nebulae.

Emission nebulae emit radiation from ionised gas (ionised Hydrogen) and are often called HII regions. The most common power source for the ionisation are hot stars within the nebula itself, providing UV radiation that energizes the nebula (reminiscent of a florescent tube). HII clouds are regions of star-formation.

Reflection nebulae are clouds of dust that just reflect light off nearby stars. Several reflection nebulae appear around the brighter stars in the Pleiades, although these clouds are just passing by, and are not otherwise connected to the individual stars at all.

Dust clouds can also block light from stars that are behind them and are called **dark nebula**. The source of this stuff, the dark lanes across the Milky Way, are the above-mentioned red giant stars loosing their envelopes to space. The **Trifid Nebula** in Sagittarius exhibits all three: reflection, emission and dark nebulae. Its dark nebula divides the emission nebula into three parts giving it its name.

The nebulae in this table are visible in 8x50mm binoculars under darker skies:

Nebula	Designation	Cons	Vmag	Size	Distance (ly)
Carinae Nebula	NGC 3372	Car	1	120'x120'	10,000
Orion Nebula	M42	Ori	4	85'x60'	1,400
Tarantula Nebula	NGC 2070	Dor	5	40'x25'	160,000
Lagoon Nebula	M8	Sgr	6	90'x40'	4,300
Swan Nebula	M17	Sgr	6	46'x37'	4,200

The **Orion Nebula (M42)** is the closest region of massive star formation to the Earth. The **Trapezium** is a young star cluster in the heart of the nebula. M42 is naked eye and spectacular in a telescope. Theta-1 Orionis-C, one star of the Trapezium, ionizes 100 solar masses of hydrogen out to over 10 light years away, and is the principle power source of the Nebula.

The **Tarantula Nebula** is a large HII region in the LMC. It is the largest known star-forming region in the Local Group. If it were as close as the Orion Nebula, it would be twice as large as the constellation of Scorpius and cast shadows on the Earth.

The **Carina Nebula (NGC 3372)** is one of the largest and brightest in the sky. It is also one of the largest HII regions in the Milky Way. It can be seen easily naked eye. Central is the Keyhole Nebula, a darker cloud near eta Carinae. Around eta Car itself is a small nebula called the Homunculus, formed by an outburst of the star in 1838-45.

The **Lagoon Nebula (M8)** is naked eye under darker skies. In a telescope, it is seen as a large cloudy region cut by a curved dark lane, the lagoon. It is about 115 light years across.

Galaxies

There is no accepted definition of a galaxy to distinguish them from the globular and open clusters mentioned above. Nor is there a clear distinction between those later two clusters either. However, we can say: A galaxy is a massive, gravitationally bound system of stars and their by-products, interstellar gas and dust, and perhaps dark matter. They range in size from dwarf galaxies as small as 10 million stars to giant galaxies of 100 trillion stars. Galaxies are classified as elliptical, lenticular, spiral or irregular. **Elliptical galaxies** show little structure and are sub-typed from E0 (almost spherical) to E7 (elongated). **Spiral galaxies** are either unbarred Sa, Sb, Sc or barred SBa, SBb, SBc with “a” indicating tight spiral arms and “c” loose spiral arms. A **lenticular S0 galaxy** is intermediate between elliptical and spiral, with an elliptical halo of stars and a disk with ill-defined spiral arms.

The closest galaxies, both naked eye objects, are the **Large Magellanic Cloud** and the **Small Magellanic Cloud**. The LMC is approximately 10.8 by 9.2 degrees and is about 157,000 light years away. It contains the Tarantula Nebula, the most active star-forming region in the Local Group. The SMC is approximately 5.2 by 3.4 degrees and lies some 200,000 light years away. It contains several hundred million stars. Previously thought to be satellite galaxies, new observations by the Hubble Space Telescope indicate both galaxies are moving too fast to be bound to the Milky Way. They are just passing through our galactic neighbourhood!

At 2.5 million light years, the **Andromeda Galaxy (M31)** is our biggest neighbour. The Milky Way is thought to have 200-400 billion stars but the Andromeda Galaxy is estimated to have one trillion stars. Evidence indicates that the stellar disk of M31 may have a diameter as large as 220,000 light years, which makes it twice the size of our galaxy. Due to their relative motions, the two galaxies are expected to collide in roughly 4.5 billion years. At magnitude 3.4, M31 is one of the most distant naked eye objects. It is, however, more than 3 by 1 degree in dimensions and only the core is visible. M31 has about 460 known globular clusters.

The **Triangulum Galaxy (M33)** is the third largest in the Local Group. With an estimated diameter of about 60,000 light years, it is home to maybe 40 billion stars, about average for spiral galaxies in the universe. Reportedly glimpsed naked eye, it is a tad further than the Andromeda Galaxy. M31 can be observed more easily with binoculars. It has a low surface brightness.

Centaurus A is the fifth brightest galaxy in the sky and visible in binoculars. It is a lenticular galaxy (intermediate between elliptical and disk types). It has a bright central bulge and a huge superimposed dust lane. Its peculiar morphology is the result of a two-galaxy collision and merger.

The table below summarises some of the properties of the galaxies mentioned:

Galaxy	Title	Cons	Type	Vmag	Dim	Dist (Mly)
LMC	LMC	Dor	SB	1.3	650’x550’	0.16
SMC	NGC 292	Tuc	SB	2.3	310’x204’	0.2
Andromeda Galaxy	M31	And	Sb	3.4	190’x60’	2.5
Triangulum Galaxy	M33	Tri	Sc	5.7	70’x40’	2.8
Centaurus A	NGC 5128	Cen	S0 pec	6.8	26’x20’	11
Sculptor Galaxy	NGC 253	Scl	SBc	7.2	29’x7’	11
Southern Pinwheel	M83	Hya	SBc	7.5	13’x11.5’	16
Sombrero Galaxy	M104	Vir	Sa	8	8.6’x4.2’	29

The **Sculptor Galaxy (NGC 253)** or **Silver Coin Galaxy**, was discovered by Caroline Herschel (sister of William Herschel) in 1783. Rather edge on and about the apparent width of the Full Moon, it can be seen with 8x50mm binoculars and is quite spectacular in a telescope. Its diameter is estimated to be 70,000 light years.

The **Southern Pinwheel (M83)** is a face-on barred spiral galaxy with a diameter of of a face-on barred spiral galaxy with a diameter of 100,000 light years. Barely seen in binoculars, it is a nice target for larger apertures and astro-imaging.

The **Sombrero Galaxy (M104)** has a bright core and large central bulge. The disk has a prominent dust lane, best seen with a 10 or 12 inch scope. Perhaps 140,000 light years in diameter, it is estimated to contain 1,200 to 2,000 globular clusters.

Planets and Moons

Under the International Astronomy Union definitions of 2006, there are now 8 **planets** in our solar system, four inner terrestrial planets and four outer gaseous giants. Pluto was demoted from a planet to a **dwarf planet**. It is only 2/3 the size of the Moon by diameter but it is massive enough to have formed a spheroid (rounded body) through gravitational pressure. However, it has not cleared its orbit of other bodies. Smaller than Pluto, Charon is classified as a moon of Pluto. However, their barycentre (centre of orbital rotation) does not lie within Pluto's surface, so some argue that the pair should be considered binary dwarf planets. Asteroids and comets are classified as **small solar system bodies** (previously called **minor planets**). **Ceres**, in the asteroid belt between Mars and Jupiter, has been upgraded to a dwarf planet due to its spherical shape.

Planets and moons can be seen visually because they reflect the Sun's light. The two inner planets **Mercury** and **Venus** show different phases as they orbit the Sun, much the same as the Moon does in its orbit around the Earth. The **Moon** (diameter 3,474km) is the fifth largest satellite in the Solar System. Its distance is about 384,400km. It is hypothesised to have accreted from ejected material after a proto-Earth collided with a Mars-sized body. It is debatable whether most of the Moon came from the impactor or the proto-Earth.

Planets further out take progressively longer to orbit the Sun. This is a direct consequence of **Kepler's third law**: "the square of the orbital period is directly proportional to the cube of the semi-major axis of its orbit". The "semi-major axis" can be roughly translated as the distance from the Sun. In reality, Kepler's law does not give a completely accurate description of the orbit as it does not take into account the mass of the planet nor gravitational perturbations that result when planets pass near each other in their orbits. Unexplained changes in the orbit of Uranus led to the conclusion that there was another planet affecting its orbit. As a result, in 1846, Neptune was the first planet discovered by a mathematical prediction of its location.

Jupiter is the largest planet in the Solar System, composed primarily of hydrogen with a quarter of its mass being helium. To be a star, in which nuclear fusion of hydrogen could occur in its core, it would need to be 75 times bigger in mass. Many consider Jupiter as “the cosmic vacuum cleaner”, absorbing comets or deflecting them away from their Sun-bound trajectories, protecting the Earth from many impacts. However, objects that collide with each other in the asteroid belt can be perturbed and nudged by Jupiter into a course headed for the Earth. A one-kilometre body is considered the threshold between a locally damaging and a globally damaging event. The speed of the body is also important, as a “local” asteroid might have more mass but wouldn’t be travelling as fast as a comet.

Jupiter has over 60 confirmed moons. Four of these are easily seen in a telescope: Io, Europa, Ganymede and Callisto. The four are larger than 3,100km in diameter, with **Ganymede** being the ninth largest object in the Solar System and bigger than the planet Mercury. The others are less than 200km in size, with most in the range from 1km to 10km. These are too small to have formed spheroids and are irregular in shape.

Due to axial rotation, spherical bodies tend to bulge more at the equator and flatten at the poles. For this reason, the Earth is not a perfect sphere but an oblate spheroid. **Saturn**’s equatorial and polar diameters differ by almost 10%. Its diameter is about 120,000km but its dense main rings extend out to a diameter of about 280,000km or about 2.3 times the main body of the planet. The inner dense B ring and the outer dense A ring are separated by the Cassini division, which is about 4,700km wide. The rings are incredibly thin at an estimated 10 metres in thickness.

Saturn has over 60 confirmed moons, eight of which where discovered between 1655 and 1848 by direct observation using optical telescopes. Of the eight (see table below), all except Hyperion are spheroids. Hyperion has a diameter of 270km and is irregular in shape. Saturn's largest moon **Titan** is marginally smaller in diameter than Ganymede but it is also larger than Mercury. Titan has a wide orbit. From the Earth, it can reach an angular distance of 10 Saturn diameters (just over 1.2 million kilometres) or about 4.3 times the diameter of its rings as seen in your scope.

Jupiter, Uranus and Neptune also have rings, as witnessed by the Galileo and Voyager2 spacecraft. They are, of course, too tenuous to be seen in amateur scopes. The **Roche limit** is the distance at which a celestial body, held together by its own gravity, will disintegrate due to the tidal forces of another body. Some of the theoretical ways rings can form are: from the material of the protoplanetary disk around a star as that material falls within the Roche limit; from the debris expelled by a moon after a large impact with another body; from the debris of a moon stripped of its surface when it passes through the Roche limit.

Uranus and **Neptune**, while still composed largely of hydrogen and helium, appear bluish in colour due to the higher proportions of ammonia and methane gases in their atmospheres.

An **extrasolar planet**, or **exoplanet**, is a planet around a star outside our Solar System. As of June 2012 the number of exoplanets discovered is in excess of 700.

Some of the properties of the planets are tabled below:

Planet	Distance in klms	Diameter in klms	Angular Size (arcseconds)	Orbital Period	Apparent Magnitude
Mercury	58 million	4,880	4.5" to 13"	88 days	5.7 to -2.6
Venus	108 million	12,100	9.7" to 66"	225 days	-3.8 (full)
Earth	150 million	12,742	N/A	1 year	N/A
Mars	228 million	6,800	3.5" to 25"	1.88 years	1.6 to -3.0
Jupiter	779 million	140,000	30" to 50"	11.9 years	-1.6 to -2.94
Saturn	1.4 billion	120,000	14.5" to 20"	30 years	1.5 to -0.24
Uranus	2.9 billion	51,000	3.3" to 4.1"	84 years	5.9 to 5.3
Neptune	4.5 billion	49,000	2.2" to 2.4"	165 years	8 to 7.8

The brightest and largest of Jupiter's moons:

Moon	Orbital radius In kilometres	Diameter in kilometres	Orbital Period	Apparent Magnitude
Io	422,000	3,640	1.8 days	5.0
Europa	671,000	3,120	3.6 days	5.3
Ganymede	1,070,000	5,260	7.2 days	4.6
Callisto	1,883,000	4,820	16.7 days	5.6

The brightest and largest of Saturn's moons:

Moon	Orbital radius In kilometres	Diameter in kilometres	Orbital Period	Apparent Magnitude
Mimas	185,000	396	0.9 days	12.9
Enceladus	238,000	504	1.4 days	11.7
Tethys	295,000	1,060	1.9 days	10.2
Dione	377,000	1,120	2.7 days	10.4
Rhea	527,000	1,530	4.5 days	10.0
Titan	1,222,000	5,150	15.9 days	9 to 8.2
Hyperion	1,481,000	270	21.3 days	14.1
Iapetus	3,561,000	1,470	79.3 days	11.9 to 10.2

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