HOW TO OBSERVE THE PLANETS

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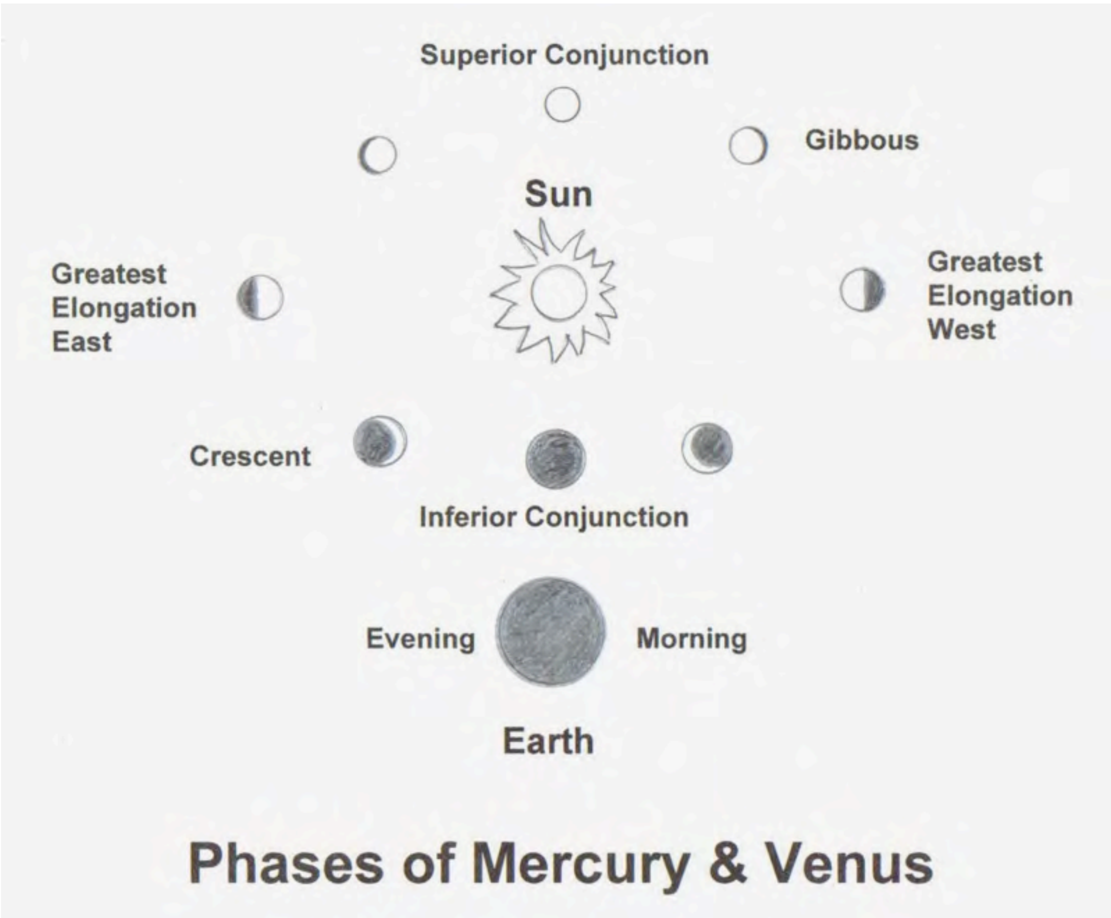
Mercury………………..1
Venus………………….3
Mars…………………...4
Jupiter………………..10
Saturn………………...13
Uranus & Neptune…...15

MERCURY

Mercury is considered one of the five bright ancient planets along with Venus, Mars, Jupiter, and Saturn because it has been followed since antiquity. It is visible to the unaided eye and is as bright as Saturn, but it is the most neglected of the five. The problem with Mercury is that even under the best conditions it can only be observed low in the twilight sky where atmospheric turbulence from the cooling evening causes blurring. Mercury provides a rewarding challenge for the patient observer especially since legend has it that Copernicus never saw Mercury.

Under the best conditions Mercury never appears more than 12 arcseconds in diameter, but can shine as bright as magnitude –2 which makes it easy to locate given a clear western horizon on a spring evening, or eastern horizon on an autumn morning. During those times of the year, the path the planets follow, the ecliptic, is nearly perpendicular to the horizon. This places Mercury higher above the horizon than at other times of the year. Half the fun is locating and following Mercury each evening. A small telescope will increase the fun by resolving the phases as Mercury goes from a small, nearly full disc to a larger, thin crescent in the evening and from a larger, thin crescent to a small, nearly full disc in the morning. Unfortunately, even the most experienced observers only give Mercury a quick glance, forgoing a chance to potentially observe surface detail.

Is it possible to see any surface detail on Mercury? I have only vaguely seen a hint of a faint marking on only two occasions and only by using an orange filter while Mercury was near half phase. In both cases the suspected markings were so faint and elusive that it is doubtful if they really were seen. To increase the chances of observing detail it is best to use a magnification of at least 180x to resolve the phases. Then use an orange (Wratten #21) filter to help steady the image and to darken the bright background. Viewing Mercury high up in the daytime will increase luck and might allow for a tantalizing glimpse of Mercury's delicate markings. Great care must be taken not to accidentally expose the eye to the dangerous rays of the Sun. Crisp blue sky is mandatory, as any haze or high clouds will decrease the contrast. One phenomenon that might be visible is the blunting of the southern cusp since this is Mercury's duskier region. The challenge of seeing any detail is highly rewarding, as Mercury will always be close to the Sun and never visible in a truly dark sky.



Top

VENUS

Venus can be the closest planet to Earth (25 million miles), but in spite of its closeness, Venus reveals very little detail because it is completely covered by thick carbon dioxide and sulfuric acid clouds. There is no hope of seeing the towering mountains, rolling plains, or majestic canyons. But there is still much to see and sketch!

The Phases: Since Venus orbits the Sun closer than the Earth, it passes between the Sun and us. It can never appear very far from the Sun in our sky and therefore can never be seen all night. As Venus swings from the far side of the Sun towards us, it grows from a small disc to a large, but thin crescent. It can range in size from 10 to 64 arcseconds across and blaze at a magnitude of –4.7. The crescent becomes sliver thin as Venus drops out of the evening sky and passes between the Sun and us. It then appears in the morning sky shrinking in size as it goes from a thin crescent to a disc as it heads for the far side of the Sun again. The phases can be seen with a small telescope while the crescent can be seen with binoculars. In fact, a few people claim that the very large and thin crescent phase of Venus can be seen with the unaided eye! If you have 20/15 vision or better, give it a try! Otherwise, simply enjoy the changing phases through the telescope.

Schroter's Effect: The almanac states when Venus is at half phase (dichotomy), but is it? Do not be surprised if it is already a crescent. Try to observe Venus as much as possible around the time that Venus is predicted to be at dichotomy to determine on which night Venus really is at half phase. This anomaly is called Schroter's effect after the astronomer who observed it. The planet's thick clouds may cause it. Do not use a filter since this has an affect on the sharpness of the terminator. In 1991 I coordinated an experiment on the Schroter's effect with five other members of the Mohawk Valley Astronomical Society. Half phase was predicted to be June 12, but after analyzing the data collected over a period of one month, I calculated it to be June 7. The method and formula were that of the Association of Lunar and Planetary Observers to whom I sent the results. The MVAS and I were given credit in the January 1992 issues of *Astronomy* and *Sky and Telescope* for our work!

Dusky Markings: These are elusive and I have yet to see them. I am now using a rich blue (W38A) filter to try and see them, but no luck as yet. Try using this filter to see if you can see any faint streaks in Venus's clouds. They are best seen near the terminator and when Venus is around half phase or a thick crescent. A violet (W47) filter on large telescopes is also helpful. You can use an ultraviolet (W18A) filter if you can find one or a special Venus filter, but these are strictly used for photography.

Cusp Caps: I may have observed this during February 1977. This is where one of the crescent's horns appears unusually bright or blunted. Usually it is the southern horn. Often the cap is bordered by a dark (dusky) collar. This event can last for weeks and should be watched closely as it is most likely caused by the strong circulation patterns in the clouds of Venus.

Ashen Light: When Venus is a large, thin crescent there may be a glow on the night side. The cause is not understood, but it is not Earthshine since the Earth is too far away. It may be caused by airglow, thunderstorms, or perhaps even the intense surface temperatures. Ashen light often appears reddish or violet. I have never seen it.

Cusp Extensions: Venus has a thick atmosphere and when the crescent becomes sliver thin, the horns can appear greatly prolonged like those on the Turkish Flag. Sometimes there can be tiny, detached points of light at the tips of the horns. Even more beautiful is when the horns unite to form a delicate ring of light around the night side. Try watching for all of these phenomena whenever Venus is near inferior conjunction, a time when Venus is nearly between the Earth and Sun and at its closest and largest. I have seen the prolonged crescent many times. What a beautiful sight to behold! I have yet to see any points of light or the delicate ring.

Terminator Deformations: I saw this during August and September 1978. Frequently the terminator will display a serrated edge that can affect the curvature. Use a red (W23A or W25) filter and you will be surprised to see that the terminator has a soft contrast at times. There is a recurring notch near the southern cusp cap that can be dramatic along with a smaller notch in the north. These are what I saw in 1978. A rich blue (W38A) filter also gives the terminator a soft hue and may enhance the dusky notches. This is also most likely caused by the strong circulation patterns in the clouds of Venus.

It is surprising that a cloudy planet has so much to offer. Of course, you can go one step further and try to observe Venus in the daytime! It is bright enough to find with binoculars or a telescope. (Be careful of the Sun!) Or, you can try ultraviolet photography, which can capture elusive cloud detail. Infrared photography is new, but is advancing rapidly. The clouds are transparent to infrared allowing the blazing hot surface and coarse topography details of Venus to be seen! The hotter lowlands shine brighter than the cooler highlands in these photos. Observing Venus need not cease around inferior conjunction. Why not follow it into the morning sky? When you look at that bright star on a cool evening (or morning), just remember that you are looking at a world that has 900ºF surface temperatures, sulfuric acid mist, lightning storms, and an atmosphere 100 times heavier than our own! That should inspire you enough to observe, sketch, and photograph Venus!

Return to Top

MARS

Mars is the only object in the universe besides the Moon where detail can be seen on a solid surface. It is not an easy planet to observe because it is usually too small to see any detail. It is the next planet outwards from the Earth, but it is a small world at 4220 miles in diameter. Opposition is a time when a planet is closest to Earth and therefore at its largest, brightest, and up all night. Unfortunately the speed of both Mars and Earth around the Sun are not much different with Mars being the slower of the two, which means that oppositions occur roughly every 26 months. This is quite a long wait compared to the other outer planets. Even after the long wait, not all oppositions are decent due to Mars' highly elliptical orbit. The result is that Mars can come as close to Earth as 34.6 million miles and be as large as 25.2 arcseconds across, while at other times it is as much as 63.0 million miles and barely 13.8 arcseconds across. The rest of the time Mars is on the far side of the Sun, barely 4 arcseconds across, featureless, and no larger than Uranus through a telescope. Here are several techniques to help maximize each viewing session with Mars:

1. Observe Mars as much as possible at least one to two months before and one month after opposition. By viewing Mars enough times before opposition the eyes will become trained to see finer detail and it will also be possible to become familiar with the varying features on the different sides of the planet. This will make the observing sessions closest to opposition more pleasurable.

2. Do not be afraid to max out the telescope by using the highest power possible that seeing will allow. If it is too turbulent, then nothing much can be done, but on good nights a minimum magnification of 100x is suggested, but 200x to 300x is preferred. This will depend on the atmospheric conditions and the telescope, but the moments of steady seeing will be rewarding.

3. Observe Mars when it is highest in the sky. In order to minimize the blurring from atmospheric turbulence, it is best to observe through the least amount of atmosphere, therefore viewing near the horizon is less ideal since haze will wash out detail. It is best to allow Mars to climb higher for at least two hours after rising.

These simple rules will assure a decent view of the Red Planet, but there is one more important technique that is often overlooked. A color filter is a vital accessory to an eyepiece, just as an eyepiece is a vital accessory to a telescope. A set of color filters should be considered mandatory for every telescopic observer. Features on a planet reflect sunlight in varying colors. A filter absorbs a specific color of reflected sunlight, such as red. Absorbing red light will reveal detail of a contrasting color such as green. The filters actually alter color in such a way as to increase contrast and enhance the details on a planet. The slight reduction of glare from a bright planet also reduces eyestrain, which helps in detecting finer detail. Planetary filters are labeled with the same Kodak Wratten number as in photography. With Mars revealing a solid surface of rock and desert, ice caps, dust storms, clouds, and hazes, filters of every color are capable of revealing something:

Red (#25): The dark surface features will be enhanced as a red filter cuts through the haze and steadies the Earth's turbulent atmosphere. This filter is dark and is best for larger telescopes at lower powers.

Orange (#21): This is the best all-around filter for Mars and for any planet. Since it is not as dark as a red filter the contrast will be dramatic between the dark areas and the brighter deserts as it subdues the brilliance of the reddish areas and reveals finer detail. An orange filter is considered the best to use in order to steady the Earth's turbulent atmosphere. It also darkens a bright background if viewing in twilight.

Yellow (#15): A yellow filter is generally used for penetrating the atmosphere and enhancing the fine particles associated with dust storms. If Mars is experiencing a dust storm, this filter will help define them. If the storms are unusually intense, it might be possible to see some texture in the dust clouds.

Green (#58): An excellent filter for increasing the contrast of the polar ice caps and for studying details within them. Green also enhances the dark band that is often seen surrounding the ice caps. This filter can also be used for detecting dust storms and other clouds as it makes brighter areas and white areas stand out more clearly against the reddish surface.

Blue (#38A): Water ice clouds in the upper atmosphere and hazes, particularly along the limb, will stand out better with this filter. A lighter blue filter (#80A) will have the same effect and may be better for smaller telescopes.

Violet (#47): This is a very dark filter best used for larger telescopes and is useful for detecting polar hazes and structure in the high altitude clouds. Surface detail is washed out with this filter, but it can suddenly become sharply visible on rare occasions. This unexplained phenomenon is known as "violet clearing".

It is important to keep in mind that the enhancement a filter provides will be subtle and cannot substitute for the regular observing of Mars, which is necessary to train the eye to see any detail to begin with. The mind must also overcome looking at an odd-colored Mars with a filter and simply concentrate on detail instead of aesthetics. A filter cannot make features magically appear out of nowhere. If a feature is not visible without a filter, then it might at best only be faintly visible with a filter, even if it is normally the most prominent feature.

Mars will give an impression of a world like Earth with dark patches appearing like continents among an ocean of pink deserts, polar ice caps, clouds, and dust storms. There is plenty to observe in telescopes as small as a 3-inch refractor.

Dusky Features. The most obvious feature on Mars is the overall bright, peach-like hue that is actually a vast global desert. The ruddy hue is due to iron ores in the soil similar to red clays on Earth and causes Mars to appear as a reddish star in the night sky. The ancients feared this unusual bloody-looking, bright star and since they associated blood with war they named it in honor of the "God of War". The darker features on Mars are often referred to as maria, but are actually vast rocky outcrops that have been blown free of brighter dust. These areas appear tan or brownish, but may appear greenish due to the brighter, redder hues that dazzle the eye and create a greenish after-image on the retina. This trick on the eye was so convincing that generations of astronomers were convinced that the dark areas were actually covered with simple plant life such as lichen and moss.

The darkest regions on Mars include a vast triangular area known as Syrtis Major and a pipe-shaped area complete with a bowl and stem called Sinus Meridiani and Sinus Sabaeus. The Solis Lacus region appears like a dark spot and is called the "Eye of Mars" since it resembles the pupil of an eye. This particular feature has been known to undergo dramatic changes; it can grow larger and darken, or shrink and fade. All of these dark regions should be watched carefully for any sudden change in shape or color. There is a seasonal wave of darkening as spring advances in either hemisphere, but this has never been fully understood and may be caused by local winds scouring the terrain clear of brighter dust. These dark features are visible during steady seeing in the smallest telescopes when Mars is closest to Earth. It is fascinating to follow them as Mars rotates during the course of a night reminding us how similar Mars is to Earth.

Polar Ice Caps. These are the brightest features on Mars and it is interesting to follow the changes in size as the Martian year progresses. The north polar cap is made of water ice overlaid with carbon dioxide ice, also known as dry ice. The south polar cap is completely composed of dry ice. As spring advances, the ice cap will steadily shrink and is noticeable to the dedicated observer. The northern ice cap never completely vanishes, but the southern one does. This is because Mars is closer to the Sun during the southern summer and without oceans to moderate the temperature as on Earth, the southern hemisphere warms enough to melt the ice cap.

Another enjoyable observation is to look for details within the ice caps. Sometimes the ice caps may not melt evenly or may break away, leaving tiny white specks along the perimeter that will eventually melt. This phenomenon along the south polar cap is referred to as the Mountains of Mitchell even though it is not a true mountain range; brief moments of excellent seeing are needed to see them. Around the perimeter of the receding ice cap is a dark belt called the melt line that looks like damp sand deposited by melting ice, but it is most likely caused by winds blowing off the ice cap and sweeping the immediate region free of brighter dust. Liquid water cannot exist under the low atmospheric pressure on Mars. Therefore the ice, especially dry ice, sublimates, or changes from solid to gas without ever being liquid.

Atmospheric Phenomenon. White clouds are seasonal, consist of water ice, and usually form during the warmer seasons. They become more numerous and cover a larger area of the poles as the ice caps melt or grow. These clouds occur close to the surface and are probably fogs. They are also seen along the morning terminator as a haze and dissipate after sunrise. White clouds also form near the largest volcanoes: Olympus Mons, Pavonis Mons, Ascraeus Mons, and Arsia Mons and appear as bright spots. These volcanoes are close together and if the clouds grow large enough they can merge into a giant “W”. These types of clouds are caused by relatively moist air being uplifted over the peaks of the volcanoes. Unlike the fogs and morning hazes, these clouds can continue to grow all day beneath the heat of the Sun, but quickly dissipate during the cold night. Clouds can confuse the inexperienced observer into believing they are polar ice caps.

Yellow clouds are the ominous signs of a dust storm. Not all of these clouds develop into dust storms, but some do explode rapidly into a global storm. Such storms occurred during 1971 and 2001 and obscured all the surface details for months. Yellow clouds that often appear in the Hellas Basin and the Solis Lacus region are caused by dust that is stirred up by solar heating of the Martian surface and develop into clouds that may turn into storms. The discovery of dust devils by the Mars Global Surveyor Orbiter strengthens the theory that surface heating is capable of creating strong winds that spin up into dust devils. They are a weaker form of a tornado and are not formed by thunderstorms, but can suck up large quantities of dust high into the atmosphere. Dust storms are the most dynamic weather phenomenon on Mars because they develop and move rapidly, often with winds over 200 miles per hour! If one monitors carefully, one can watch them grow, move, and eventually dissipate.

Mars is an exciting planet to observe when the conditions are perfect, which can create many memorable views of Mars. If no detail can be seen on Mars after days of trying, then it is possible that a dust storm is hiding all of the surface features, which is what happened during the 2001 opposition. Hopefully the dust storms will stay away around the oppositions and permit a dedicated observing program. This will assure getting the most out of an opposition of Mars.

Whenever Mars is at opposition, especially when it is unusually close to Earth, there may be a desire to do something that will make the long nights of observing forever memorable. One way to capture the moment is to sketch Mars as often as possible. Even a simple sketch will be a cherished record of what Mars looked like at any given moment on any given night. The best opportunity to observe Mars is always around opposition.

When observing detail on Mars, bigger is better; it is best to observe Mars when it is over 10 arcseconds across. When sketching any planet, especially Mars, any visible detail will be delicate and often fleeting. Patience is required and will be rewarded with moments of perfect seeing that reveal a crisp image. Use a template of circles and get ready to have fun by using the following tips:

1. On a clean, white sheet of paper use a template or compass to draw several circles of the same size. They should not be more than two inches in diameter. These will be used at the eyepiece during sketching, but do not worry if dew should bother the paper, as this will not be the finalized sketch.

2. Take along a red flashlight that is not too bright along with a soft pencil, eraser, and a clipboard (or something hard to write on).

3. A watch is important in order to note what was seen at a given time.

4. A comfortable chair will help and it is always best to dress warmly even if it has been a hot day. Long hours without moving much can chill the body especially if dew starts forming.

5. With the highest power that seeing will allow, sketch the phase first. Mars is usually full, but can appear gibbous within a few months before and after opposition. During those times Mars can appear as little as 84% lit. Drawing the phase is as simple as drawing a curved line within the disc.

6. Sketch the polar ice cap(s) in the correct position on the disc if visible. If any detail can be made out on the ice cap(s) then sketch it carefully since these are one of the most challenging features.

7. Crudely sketch the darkest and most obvious areas. It is important to do this first in order to make it possible to become easier oriented with the finer details that will follow.

8. Sketch the finer dusky areas such as any streaks or spots even if they are fleeting. Mars rotates steadily in 24 hours, 37 minutes, so sketch quickly because the features will shift

positions. Several minutes of studying Mars may be required to see that rare instant of steady seeing, but do not strain the eye.

9. Sketch the position of any clouds or dust storms by using dashed outlines to mark the area. Be sure to label them accordingly to distinguish them for the final sketch that will be made later. Clouds usually appear white while dust storms appear yellowish.

10. If Phobos and/or Deimos are visible, mark their position with a tiny dot with respect to Mars and label them.

11. Write down the date, time, eyepiece and any filters used, and any personal impressions that may have made the observing session special. This could mean the beautiful placement of Mars among the stars, a nearby aurora, or perhaps Mars casting a faint shadow, or maybe a coyote howled in the valley below creating some real chill to the chilly night! Nothing is minor or insignificant, so jot it down!

12. If the night is enjoyable and staying up late is possible (even all night), make additional sketches throughout the night as Mars rotates. Since Mars rotates on its axis in 24 hours and 37 minutes, the surface features will shift throughout the night. The rotation rate from Syrtis Major to Sinus Meridiani is six hours. From Sinus Meridiani to Solis Lacus is another six hours. If Solis Lacus is visible, then it will be another twelve hours before Syrtis Major returns to view.

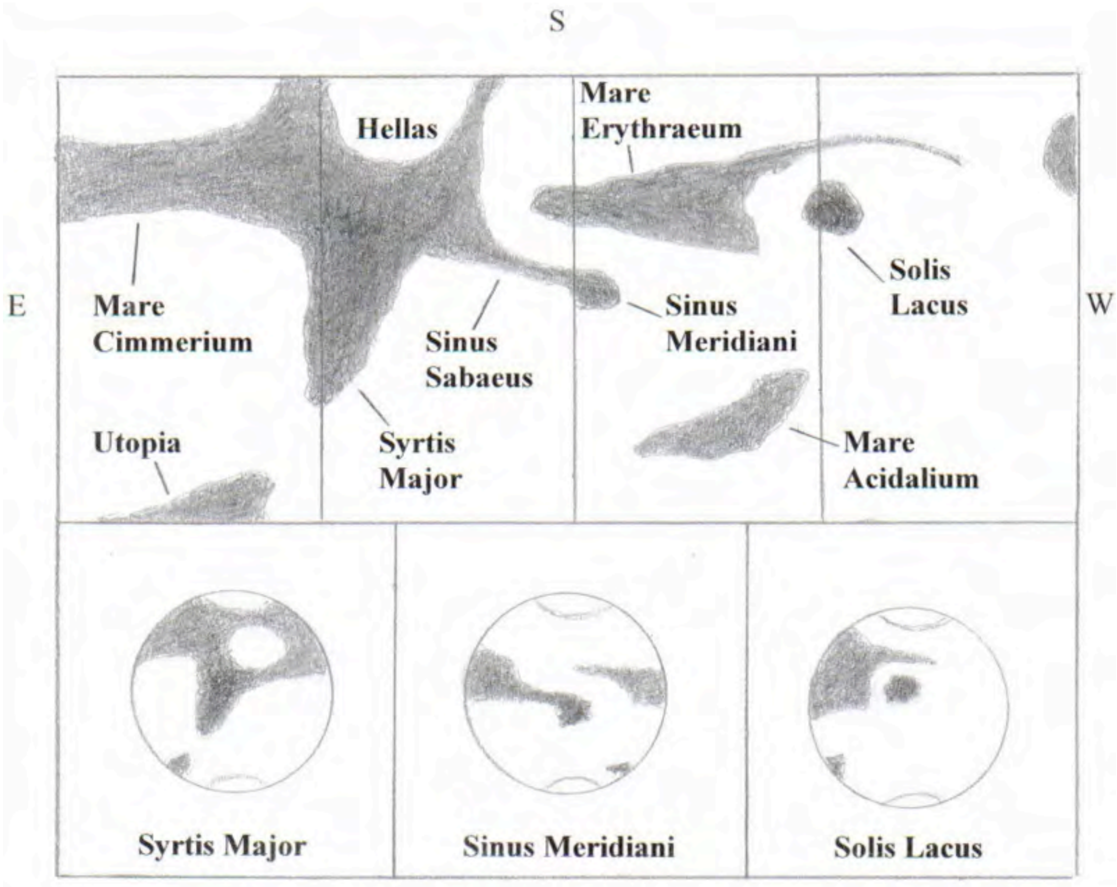
13. When observing is over go inside and get comfortable. Avoid any distractions and get out the official logbook where the final sketches will be made. Draw a circle no larger than two inches in diameter and sketch everything into that circle from the crude sketch made at the eyepiece. Syrtis Major is the darkest feature if it was visible and makes a perfect standard for shading all of the other features. Any clouds or dust storms must still be sketched as dashed lines and properly labeled.

14. Transfer all of the pertinent information and notes into the logbook. This should include everything mentioned earlier including: weather conditions, wind, atmospheric steadiness, the magnitude and size of Mars, the percent of Mars illuminated, the location of Mars, which includes the constellation and its position among any brighter stars, clusters, galaxies, planets, or the Moon.

This is all that is necessary for a great sketch, but even the crude sketch at the eyepiece is a masterpiece and can be left at that. A colored sketch of Mars is nice, but the true color is peach, not red. Use a light stroke of orange, then a lighter stroke of red, but even this might be too much color. Use filters to help make seeing detail on Mars easier.

Sketching helps train the eye to see finer detail, and exceeds what any camera can capture. With patience, practice, and dedication, a beautiful book of sketches can be made that will become a treasured chronicle of Mars.

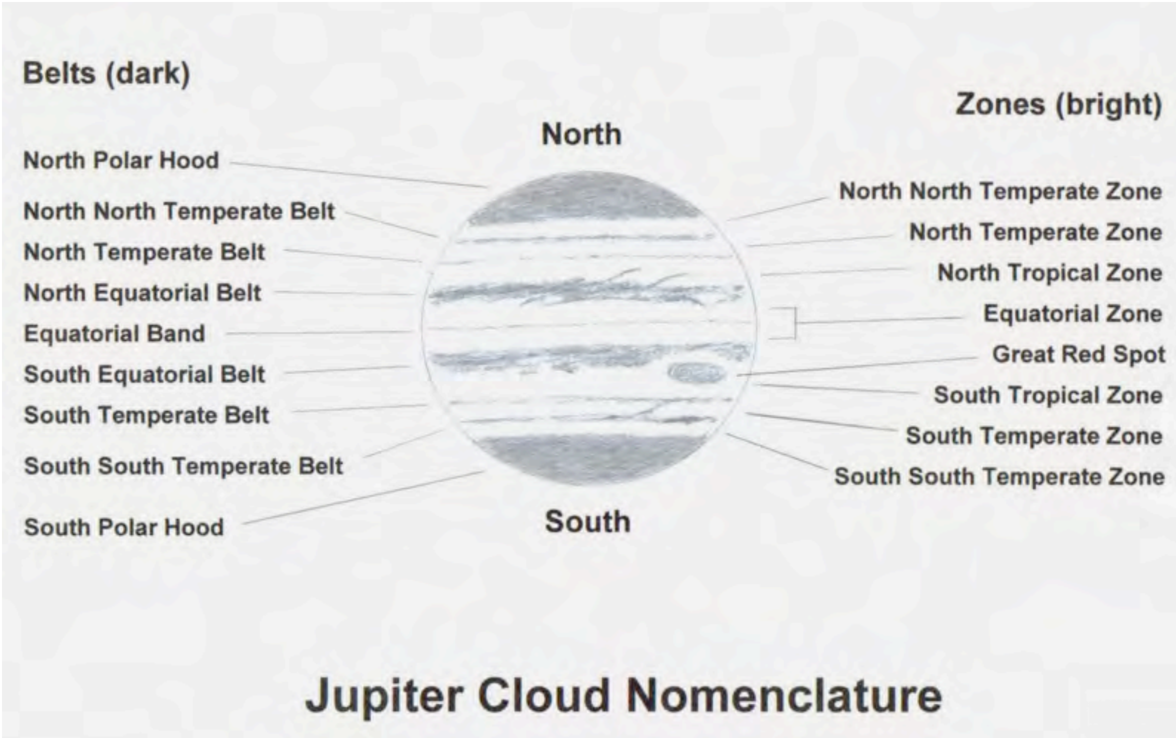
Surface Features of Mars



Return to Top

JUPITER

Jupiter is the best planet to observe as it consistently displays a wealth of detail with even the smallest telescopes. Even when Jupiter is at its smallest, farthest from Earth, detail can still be seen because Jupiter is such a large planet. Since it rotates in just 9 hours and 55 minutes, the changing features provide an excellent opportunity to practice observing and sketching skills. Jupiter is a completely cloudy world with no visible solid surface so the only details visible are its distinct cloud features. Becoming familiar with these cloud features will provide better understanding of what is being seen and a deeper knowledge of Jupiter's weather. The following are the most common features:



Belts, Zones, and Hoods. These are the most prominent features on Jupiter and even the smallest and cheapest telescopes can reveal them. The dark bands are called belts and run parallel across Jupiter due to its strong winds and rapid rotation. The belts are areas of cool sinking air that is warming up and drying out, revealing a clearing into the darker depths. The lower, yellowish-tan clouds are composed primarily of sulfur compounds and water droplets. The bright stripes are called zones and are areas of rising air that condense into billowing whitish clouds consisting primarily of ammonia ice. The dusky cloud caps at both poles are called hoods and are usually not as prominent as the equatorial belts. Slight clearing near both poles reveals some of the deeper, darker clouds below, similar to the belts, but are somewhat obscured by ammonia haze. The North and South Equatorial Belts, which are the darkest belts, are located on either side of the equator. Larger telescopes will reveal additional belts and zones.

Festoons, Garlands, and Rifts. All of these are usually thin delicate extensions of the belts that finger out into the brighter zones. A festoon bridges the entire width of a zone by connecting two belts. A garland does not connect, but instead forms a hook and may curve all the way back to form a closed loop. Another feature, known as a rift, is a bright bridge of cloud spanning from one zone to another across a dark belt.

Ovals, Spots, and Knots. Ovals are noncircular patches that are usually very bright and fairly large. Spots are rounder and more sharply defined, but small. Knots are thickenings or a darkening found in parts of the belts. The most famous spot of all is the Great Red Spot. It is a huge storm of towering clouds similar to a hurricane that is colored red possibly from phosphine being churned up from far below. The Great Red Spot is over twice the size of Earth and sometimes grows redder and at other times fades to a pale salmon hue. Sometimes the Great Red Spot becomes so faint that only a dent remains in the South Equatorial Belt, within which it resides. This dent is known as the Great Red Spot Hollow. In recent years the Great Red Spot has become prominent enough to reveal some finer detail within it. A smaller red spot, known as Red Junior, recently formed and has become quite prominent.

Jupiter is a world of weather where the clouds can change nightly. Sometimes a belt may split or even disappear completely such as was the case for the South Equatorial Belt during 1989-90. In this instance the Great Red Spot appeared vivid and obvious even in smaller telescopes as it did not have to compete with the darker belt in which it always resides. Many other features can be seen such as the shading along the entire edge of Jupiter's globe. This is due to the Sun's slanting angle into the deep atmosphere. The most defining feature of Jupiter can often be overlooked at first, which is the fact that it is not truly round. It appears slightly squashed at the poles due to its rapid rotation and the shape is known as an oblate spheroid. Most of the time Jupiter will appear 100% illuminated because it always orbits far beyond Earth, but at certain times it can appear about 98% lit which will give one edge of the globe more pronounced dusky shading.

Filters are valuable when observing any planet as they can bring out fainter detail that would otherwise be invisible. The best filter for Jupiter is green (Wratten #58) as it enhances the cloud belts and especially the Great Red Spot. It also reveals the limb shadow along the edge of the planet more readily and will make it easier to see a moon passing in front of the darker clouds.

The Moons. Four large moons can easily be seen orbiting Jupiter, but all the other roughly sixty moons are too small and too faint. These four large moons known as the Galilean Moons: Callisto, Ganymede, Europa, and Io, were named after the famous astronomer who discovered them, Galileo Galilei. It is fun to watch them change positions from night to night. It is possible to determine how long it takes each to orbit once around Jupiter by plotting their positions nightly. Other interesting activities include watching the moons disappear and reappear from behind Jupiter or its shadow, watching them cross in front of Jupiter, and watching their tiny shadows cross the face of the planet. It is possible on nights of excellent seeing to be able to distinguish the varying sizes of each moon. During nights of superb seeing with a larger telescope it might even be possible to detect faint detail on Ganymede, although it will be a challenge. If a moon can be seen in front of Jupiter, it might be possible to detect some color. Callisto is the darkest moon and will appear ruddy. Ganymede may appear dusky gray. Europa is an icy world and probably will appear white. Io is a sulfur-stained volcanic world and may have a yellowish tint. These colors will all be subtle, so try to observe them against Jupiter in order to cut down their contrasting glare against the blackness of space.

Jupiter provides a wealth of detail for even the smallest telescope. With regular observing, more detail will pop into view. After a few hours, it will be easy to see changes as a new area of the planet comes into view. The Great Red Spot varies in intensity and stays in view for only a few hours, which gives a great sensation of Jupiter's swift rotation.

Sketching Jupiter is easy and fun. Try this:

1. Start with circles of a few inches in diameter.
2. Roughly sketch in the darker belts.
3. Sketch any spots and fainter details along the belts.
4. Add the shadows along Jupiter's edges and any shadows of the four moons: Io, Europa, Ganymede, and Callisto.
5. Note the time and date of the sketch and any filter used.
6. Re-sketch in the comfort of your home within 24 hours.

Jupiter is slightly squashed at the poles from the rapid rotation. Unless you have a template or want to frame a sketch, or submit it to a magazine, then a circular disc will do fine. Keep in mind that the eye always sees more than any camera. A good project would be to make a strip sketch of Jupiter. This is the globe of Jupiter unrolled into a long strip. By sketching only the details near the center of a line running from the north and south poles every half-hour, a remarkably detailed map can be made. Do this on a night when ample time is available. Filters are very helpful to increase contrast. My favorites are: very light blue (#82A), yellow (#12), and green (#58). A green filter really does the trick; it makes the Great Red Spot easier to find, makes it easier to see limb darkening and moons passing in front of Jupiter. When it comes to observing, sketching, and photographing the planets, Jupiter is the most interesting of them all.

Return to Top

SATURN

The most beautiful sight in a telescope has to be Saturn. The golden globe surrounded by the razor sharp, icy white rings set against the blackness of space is a sight to behold and is a satisfying sight in itself. Dedicated observers scrutinize Saturn closely in order to see detail on the globe and rings. There is actually much more to be seen than is apparent. The following is a guide to what to look for.

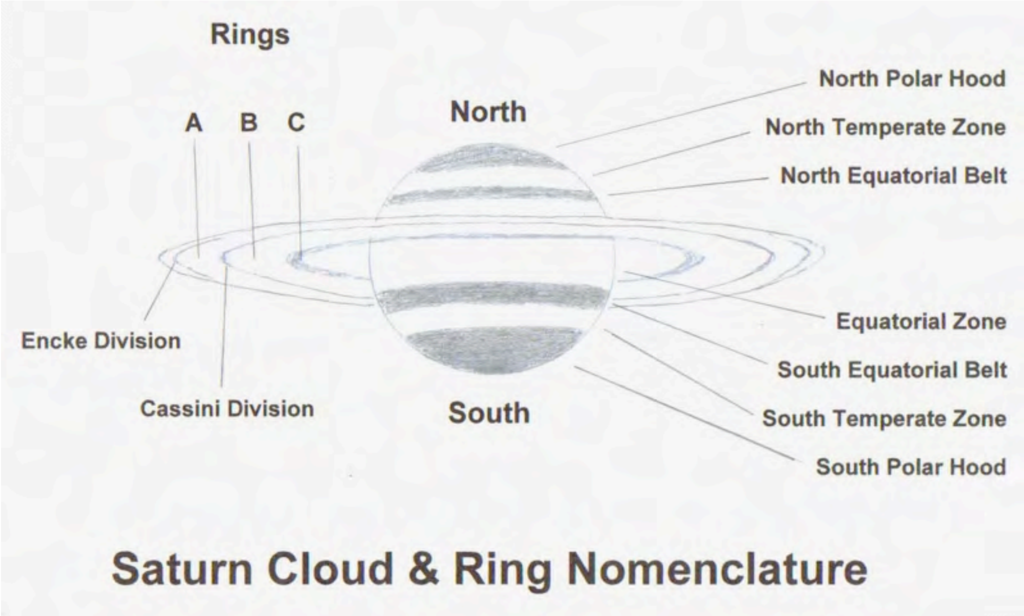
The Globe. Saturn's globe is noticeably oblate and can be easily observed when the rings are edge-on. The diameter through its poles is about 10%, or about one Earth diameter less than through the equator. This is due to its low its density, less than water, and rapid rotation of about 10 hours, 38 minutes. Saturn is a completely cloudy world with no visible solid surface and the only details visible are subtle cloud features. The most prominent features are the Equatorial Zone, Equatorial Belts, and the Polar Hoods. The nomenclature for the cloud features is similar to Jupiter, but most of the features are not visible all at once and are very subtle, so a good telescope with steady seeing are essential. The belts are areas of cool sinking air that is warming up and drying out, revealing a clearing into the darker depths. The darker yellow and yellow-tan clouds are composed primarily of sulfur compounds and water droplets. The zones are areas of rising air that create billowing whitish clouds consisting primarily of ammonia ice. Saturn's rapid rotation and strong winds stretch the clouds out into long belts that wrap completely around the planet.

The Equatorial Zone is a wide, bright whitish band that wraps around the equator and is usually partially obstructed from view by the rings, but fully visible when the rings are edge-on. The Equatorial Belts are the darkest features and usually appear tan against the golden globe. These are the easiest features to see with a small telescope but usually only one belt is visible with the other being hidden by the rings. The Polar Hoods are dusky tan and quite large. They appear to grow darker towards the poles.

Larger telescopes may reveal thin extensions of the belts that finger out into the brighter zones. A festoon is like a dark bridge that connects two belts across a zone. Garlands hook out from a belt and may hook far enough to close off into a loop. A rift is a bright cloud that bridges two zones across a belt. Ovals may be visible as brighter, noncircular patches in the belts. Knots are darker thickenings within the belts while spots are rounder and more sharply defined. White spots are subtle, but once in a rare while they can be seen with a small telescope. The Great White Spot erupted in 1933 and was seen again in 1990. This was a huge, temporary feature that rapidly elongated within the Equatorial Zone within weeks and stretched around the entire planet. The Great White Spot rivaled the polar ice caps of Mars in brightness and was most likely a huge thunderstorm that erupted and billowed high into the atmosphere. Ammonia gas from the warmer depths froze into brilliant white crystals high up.

The Rings. These are the showcase features of Saturn and the most beautiful planetary feature in the Solar System. They are large, but thin and there is plenty to see. When the rings are wide open, look for the dark Cassini Division; it will look like a thin, dark line within the rings. It is hard to believe that this gap is as wide as the Atlantic Ocean! The outer, A ring is not as bright as the inner, B ring and it is important to take note if there are any variations in brightness within the rings. The innermost ring, the C ring or Crepe Ring, is dark and nearly transparent, but may be glimpsed when the rings are widest open as a narrow, dusky band across Saturn's globe. There is a very thin gap known as the Enke Division located near the outer edge of the A ring and is a challenge to see even in larger telescopes. The famous spokes that the Voyager and Cassini spacecraft have seen are worth looking for as amateur equipment becomes more advanced. Take notice that at certain times when the rings are sufficiently open it is possible to see the shadow of the globe on the rings and the shadow of the rings on the globe.

The edge-on rings are also interesting to observe and great care should be taken to note if the rings reveal any brighter clumps when nearly edge-on. It is also interesting to note the dark line that crosses Saturn when the rings appear to be missing. Try to determine if the line is smooth or clumpy, but do not confuse any of the moons for a clump. With the rings nearly gone it will be easier to see the fainter inner moons. It is also the time to observe the transits, eclipses, occultations, and shadow transits of the moons.



The Moons. Up to eight moons can be seen orbiting Saturn: Mimas, Enceladus, Tethys, Dione, Rhea, Titan, Hyperion, and Iapetus, but Mimas and Hyperion will require a large telescope as both are very dim. The easiest moon to see is Titan as it is the brightest at about magnitude +8.3. If it can be seen transiting Saturn, it might be possible to detect an orange color that is due to its smoggy, organic atmosphere. Iapetus is the odd, two-toned world that has one side bright as snow and the other as dark as coal. This makes it easier to see when it is on one side of Saturn than the other as its magnitude ranges from +10 to +12. Rhea is closer in than Titan, but rather easy to see at 10^{th} magnitude. Still closer to Saturn is Dione followed by Tethys and both are a little dimmer than Rhea. Enceladus is a little closer to Saturn than Tethys, but at a dimmer magnitude of about +11 it is a challenge. It can be seen with a high-quality 4” refracting telescope. Mimas is the closest and very dim at magnitude +13 while Hyperion orbits just a little beyond Titan and is very faint at magnitude +14. Observing these two moons is regarded as a major accomplishment.

Filters are valuable when observing any planet as they can bring out fainter detail that would otherwise be invisible. The best filter for Saturn is yellow (Wratten #12) as it enhances the cloud belts and polar hoods. It also increases the contrast of the rings against the globe and the limb shadow along the edge of the planet. No matter what year it is, Saturn is always the most beautiful of all the planets and reigns supreme when observing alone or in the company of others.

Return to Top

URANUS & NEPTUNE

Uranus and Neptune are often overlooked because they are dim and considered too remote to seriously observe; however, under clear, moonless nights away from city lights, and with good finder charts it is surprisingly easy to find and track these nearly forgotten worlds.

Uranus and Neptune are dim because they orbit the Sun at a distance of 1.8 and 2.7 billion miles, respectively. In the dim depths of the outer Solar System, daytime sunlight is no brighter than a clear evening sky on Earth shortly after sunset. Both planets are about four times larger than Earth, slightly over 30,000 miles in diameter, and have thick atmospheres that are completely cloudy. The small amount of methane (2%) in Uranus' atmosphere absorbs the red component of sunlight and scatters the blue creating a turquoise hue. Neptune appears even bluer since it is not as hazy and has more methane (3%). These colors are dramatic whenever they are near stars of contrasting colors.

Given a night of steady seeing, a small telescope should be capable of resolving the discs and revealing the colors of these remote worlds; however, both planets are too far away to observe cloud detail or moons unless the telescope has an aperture of at least 16 inches. Uranus is generally 3.7 arcseconds across and shines around magnitude +5.7 and Neptune is generally 2.3 arcseconds across and shines around magnitude +7.8. The planets appear distinctly different with Uranus having a rich turquoise hue while Neptune is a chilly, icy-blue disc.

In a large telescope of at least 16 inches Uranus appears as a true turquoise globe instead of a tiny disc and two moons, Oberon and Titania, can occasionally be seen within its glare. The other three rather large moons of Uranus: Umbriel, Ariel, and Miranda, are more difficult to see and all five moons shine dimmer than Pluto at magnitude +14 to +15. Neptune appears like a tiny bluish globe at magnitude +13.5 with Triton shining dimly nearby.

There are several fun projects for each planet, which include photographing each on every clear night possible to determine if there is a fluctuation in brightness. This could reveal evidence of bright clouds or dark spots. Neptune is notorious for rapidly changing cloud belts and spots and now Uranus is growing active as sunlight shines more directly on its equator. No actual cloud detail can be seen, or can it? Recent amateur photography has improved to the point where some large features, such as a bright polar hood on Uranus, have been photographed. A magnification of at least 500x for Uranus and 900x for Neptune along with a yellow-green (Wratten #11) filter are required in order to have a chance at photographing any detail.

Uranus and Neptune do not reveal the riot of detail that Jupiter displays nor do they have vivid, icy white rings like Saturn, but both are beautiful and mysterious in their own right. Neither one of these worlds should be passed up during a planetary observing session when they are visible.

Return to Top