Naked Eye, Binocular, or Small Backyard Telescope Night Sky Observing Guide

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A good, basic online resource for currently visible night sky objects, e.g., stars, constellations, planets, and the Moon, that is updated on a weekly basis is provided by skyandtelescope.com: http://www.skyandtelescope.com/observing/sky-at-a-glance/

Planets:
There are 5 Solar System planets visible to the naked eye in the night sky as seen from Earth. However, which of these planets are visible at any give time changes based on the season and the location of each planet in its orbit relative to the orbit of the Earth. The website earthsky.org keeps a monthly updated article on which planets are visible during what part of the night with useful descriptions and reference images for finding the planets. Please check here to find this information prior to your stargazing event: http://earthsky.org/astronomy-essentials/visible-planets-tonight-mars-jupiter-venus-saturn-mercury

Interesting and Historical Stars:
Information and finding charts for all of these stars can be found here:
http://freestarcharts.com/stars-guides

- All year from Ohio (known as circumpolar stars):
    - Mizar and Alcor: These two stars appear as a double star system in the handle of the Big Dipper (Ursa Major), which can be resolvable by eye in dark sights if you have very good eye sight, but they are certainly resolvable with binoculars. When pointing a telescope at this system, you will find that it's actually a triple system because Mizar can further be resolved into its two stars, Mizar A and B.
    - Mu Cephei – Herschel's Garnet Star: This star, located in the constellation of Cepheus, is one of the reddest of all known stars in the Milky Way. It has evolved off the main sequence and is an extremely luminous red supergiant.
- Spring:
    - Albireo: A double star system with striking color contrast (blue and yellow). It is resolvable with a small telescope and located in the constellation Cygnus (the swan's head/eye or the bottom of the cross).
    - Algol (Beta Persei) – The Demon Star: a triple star system where two of the stars (A and B) form an eclipsing binary system. This system is located in the constellation Perseus. In the A and B double (binary) star system, one star passes nearly directly behind the other star, so that the brightness of the system changes by a factor of a little more than 3 for about 10 hours every 2-3 days.
    - Epsilon Lyrae – The Double Double: This double star system of almost identical white colored stars in the constellation Lyra will be very difficult to resolve into two stars with the naked eye, though it is certainly possible with binoculars. However, point a 4-to-6-inch telescope at this system with high magnification, and you will be amazed as each of these two stars are again resolved into double stars of their own, hence the name of this system as a double, double.

- Summer:
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- Fall:
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- Winter:
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Messier Objects:
These are generally relatively brighter night sky, though non-Solar System, objects compiled into a catalogue in the 18th century by Charles Messier. We have included here some of the more spectacular objects that can be observed with the naked eye, binoculars or a small (4-8-in) telescope. Wikipedia has a complete list of Messier Objects (http://en.wikipedia.org/wiki/List_of_Messier_objects) with spectacular (typically *Hubble Space Telescope*) images of each object (Note: they will not look like this from your small, backyard telescope). The website freestarcharts.com has helpful finding charts for all the Messier objects (http://freestarcharts.com/messier), and additional information on some of the objects is found below with each target:

- Spring:
    - M44 (in Cancer): Beehive Open Cluster (binoculars or wide 32mm eye piece)
    - M13 (in Hercules): Great Globular Cluster in Hercules (http://www.telescopes.com/findherculescluster_lp.cfm)
    - M35 (in Gemini): Open cluster near Castor's Foot (toward Orion's raised elbow/arm).

    - M101 (in Ursa Major): The Pinwheel Galaxy, a grand design spiral galaxy (http://www.telescopes.com/findpinwheelgalaxy_lp.cfm)
- Summer:
    - M28 (in Vulpecula; South of Cygnus in the Summer Triangle): The Dumbbell Nebula, a planetary nebula (http://www.telescopes.com/finddumbbellnebula_lp.cfm)
    - M57 (in Lyra): The Ring Nebula, a planetary nebula (http://www.telescopes.com/findringnebula_lp.cfm)
    - M8 (in Sagittarius): The Lagoon Nebula, a planetary nebula (http://www.telescopes.com/findlagoonnebula_lp.cfm)
    - M101 (in Ursa Major): The Pinwheel Galaxy, a grand design spiral galaxy (http://www.telescopes.com/findpinwheelgalaxy_lp.cfm)
- Fall:
    - M45 (in Taurus): The Pleiades, or the Seven Sisters, a young, open star cluster (http://www.telescopes.com/findpleiades_lp.cfm)
    - M31 (in Andromeda): The Andromeda Galaxy, our nearest neighbor galaxy – not counting the dwarf galaxies, the Large and Small Magellanic clouds, observable from the Southern Hemisphere (http://www.telescopes.com/findandromedagalaxy_lp.cfm)
    - M1 (in Taurus): The Crab Nebula, the remains of a supernova explosion (http://www.telescopes.com/findcrabnebula_lp.cfm)
    - M101 (in Ursa Major): The Pinwheel Galaxy, a grand design spiral galaxy (http://www.telescopes.com/findpinwheelgalaxy_lp.cfm)
- Winter:
    - M42 (in Orion): The Orion Nebula (http://www.telescopes.com/findorionnebula_lp.cfm)
    - M45 (in Taurus): The Pleiades, or the Seven Sisters, a young, open star cluster (http://www.telescopes.com/findpleiades_lp.cfm)
    - M31 (in Andromeda): The Andromeda Galaxy, our nearest neighbor galaxy – not counting the Large and Small Magellanic clouds, which are dwarf galaxies that are observable from the Southern Hemisphere (http://www.telescopes.com/findandromedagalaxy_lp.cfm)
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Other Objects:

- Double open cluster in Perseus – good for binoculars or wide field telescope lenses. To the north soon after sunset (if dark enough). Located between Cassiopeia and Perseus.
- The Milky Way – best visibility is during the Summer. Visible from dark sky locations in, e.g., the constellations of Cygnus, Lyra, Cepheus, Cassiopeia, and Perseus.

Constellations:
The celestial sphere (think of the grid of latitude and longitude we use on Earth projected into the night sky around our entire planet) is divided into 88 areas known formally as the constellations (http://www.astro.wisc.edu/~dolan/constellations/constellation_list.html). The following is not an all-inclusive list, but some of the more well-known constellations with more easily visible groupings of relatively brighter stars that are not as difficult to find include:

- Spring: Leo, Ursa Major (including the Big Dipper* asterism), Ursa Minor* (the Little Dipper), Bootes, Cepheus*, Cassiopeia*
- Summer: Libra, Corona Borealis, Scorpius, Lyra, Sagittarius, Cignus, Aquila, Draco*, Hercules
- Fall: Pegasus, Cetus, Aries, Triangulum, Perseus
- Winter: Orion, Taurus, Auriga, Canis Major, Canis Minor, Gemini

(Note: Many constellations are visible either all year – circumpolar constellations, denoted above by * for Ohio – or for more than one season, so there will be some overlap depending on what time of night and from where you are stargazing.)

Basic Scientific Content Information about what you can see in the night sky with your naked eye, binoculars, or a small telescope:

1.) The Moon – The Moon is the only natural satellite of the Earth. Its formation is believed to be the result of a large collision between the Earth and another "planetesimal" (a clump of dust, gas, and rock formed early in the formation history of the Solar System that may have eventually grown into a dwarf planet or planet through collisions with other bodies). One main observable characteristic of The Moon is that it goes through phases: the amount of illumination we see from Earth varies over the orbital period of The Moon around the Earth because The Moon is only illuminated by reflected light from the Sun. The amount of light we see reflected at any time depends on the angle between the Sun, The Moon, and Earth. A full moon is seen when the Earth is between the Sun and The Moon, a new moon is seen when The Moon is between the Earth and the Sun, and the other phases occur in between these configurations. The other characteristic easily noticed about The Moon is that it is covered with craters. This is because The Moon does not have an atmosphere (its gravity isn't strong enough to keep air-borne gas particles from escaping into space). Rocks from space (mainly meteoroids or ejecta from comets passing through the inner Solar System) thus bombard the surface of The Moon, forming craters (pits in the surface). The craters on The Moon can stay undisturbed for billions of years. In contrast, the Earth's atmosphere burns up most meteoroids or cometary debris, creating light shows in the sky known as meteors, or shooting stars, before they reach the earth's surface, thus preventing craters from often forming (meteor showers are the result of the Earth's orbit crossing the orbit a comet once took; the comet left behind debris that the Earth intercepts the same time each year). Even when a crater is created on Earth, surface processes on Earth, such as wind and rain cause erosion and weathering that relatively quickly erase most of Earth's craters, though the left over remains of the meteoroid – a meteorite – can often still be found.

2.) **Planets** – There are eight planets in our Solar System. In order from closest to farthest from the sun, they are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Pluto and four other named Solar System bodies in either the asteroid belt between Mars and Jupiter or the Kuiper belt outside the orbit of Neptune have been designated dwarf planets. (See here for more information on the differences: https://solarsystem.nasa.gov/planets/whatisaplanet.cfm). The five nearest planets to the Earth are visible to the naked eye (Mercury, Venus, Mars, Jupiter, and Saturn). However, they are only visible by the light of the Sun reflecting off of them. Planets do not produce their own light and can only be seen at visible light wavelengths by our eyes by the reflected light from the Sun. In contrast, stars produce their own light by fusing Hydrogen or other elements in their cores, which produces extreme amounts of energy, much of which we see as light. Planets are not large enough to have gravity strong enough at their cores to be able to do this. Planets can be distinguished from stars in the night sky because planets don't "twinkle", but a star does. The reason for this is atmospheric turbulence and the apparent size of planets compared to stars: Stars appear to twinkle (the technical term is scintillation) because of turbulence in our atmosphere (a dramatic example of air turbulence is the "wavy" pattern of objects observed through the air above, e.g., the hot highway, a heat vent of a building, or even hot asphalt roofs in the summer). The light from the star is slightly bent by this turbulence as it travels through the atmosphere, which makes it twinkle. Try comparing a star close to the horizon with one high in the sky; the one near the horizon will twinkle more than the one high in the sky because when one looks along the horizon, one is looking through more atmosphere. Planets do not twinkle because they are so much closer to us than stars: Stars (besides the sun) are so far away that we see their light as a "point source" – just a pinprick of light. Planets, on the other hand, are much closer, so whether our eyes can distinguish it or not, we are actually seeing them as a disk of light, not just a point source. You can tell this in a telescope – you will see a planet as a disk, but even the most powerful optical telescopes that currently exist cannot resolve stars into disks; they remain point sources. The observed size of one of these five Solar System planetary disks – its diameter - is larger than the amount the light is bent by the turbulence in the air, so the bending of light, or the effects of scintillation, are not noticed by our eyes. Interesting characteristics of the five nearest planets to observe with a small telescope:

   a. **Jupiter** – The largest planet. This gas giant planet is observed to have broad and distinct reddish and white bands of clouds covering it. Jupiter also has at least 63 known moons. The largest four of these, specially named the Galilean moons because they were first discovered by Galileo, are visible with a small telescope. Look for these moons, visible as small points of light in the vicinity of Jupiter. They have relatively short orbital periods around Jupiter, so they can easily be observed to move over the course of days.
   b. **Saturn** – Saturn is famous for its amazing rings, which are made of small dust and ice particles and easily seen around this gas giant (the 2nd largest planet) through a small telescope. Saturn has 53 known moons, and a couple of Saturn's largest moons may also be visible with a small telescope on clear, dark nights.
   c. **Mars** – Mars, known as the Red Planet, can be observed to be reddish in color by the naked eye and is distinctly so when viewed through a telescope. Also look for Mars'

polar ice caps. Mars has separate seasons in each hemisphere just like Earth. As the seasons for a particular pole change, these permanent ice caps shrink (summer) and grow (Winter). These seasonal changes can be observed (over the course of Mars' seasons, not Earth's) even through a small telescope. Unlike the Earth's polar ice caps that are made of water ice, Mars' caps are made from carbon dioxide (dry ice).

d. **Venus** – Venus is the brightest object in the sky, besides the Sun and The Moon. It doesn't have any characteristic surface features like Jupiter, Saturn, or Mars, and it doesn't have any moons, but because Venus's orbit is located inside the orbit of the Earth (and as a planet, we can only see it by the light reflected from the sun), Venus is observed to go through phases. Similarly to our Moon, the observed phase depends on the angle between Earth, Venus, and the Sun.

e. **Mercury** – Mercury also goes through phases, but because its orbit is so near the Sun, it is only visible very near sunset or sunrise. This combined with its featureless appearance as seen from a small telescope and its relative faintness compared to Venus, means that it does not make a very interesting target for amateur stargazing.

3.) Stars and Constellations – All the individual stars you can see with your naked eye live in our Milky Way galaxy, which is home to hundreds of billions of stars. These stars range in properties, such as size, mass (how much stuff they're made of), age, and temperature. We observe stars with our naked eye to be different colors; this is because they are different temperatures. We also observe stars to be different brightnesses; this can be due both to the distance the star is from earth, the size of the star, and the mass of the star. The celestial sphere – a projection of a sphere onto the night sky surrounding the entire earth – is broken up into 88 areas called constellations. Many of these formally defined constellations correspond with the constellations defined by ancient civilizations, such as the Greeks and Romans – groupings of stars that (very abstractly, in some cases) represent a pattern or picture when seen from Earth. However, there is no actual physical connection between the stars in a constellation, i.e., the stars forming a constellation are not physically grouped near one another in space. In many cases, we also find patterns or pictures from only some of the stars that form a constellation; for example, the "Big Dipper" is only part of the constellation Ursa Major. These smaller grouping of stars that only include part of a constellation are called asterisms. There are many stories and myths that are often fun to tell when finding constellations in the sky. A collection of such stories and other information about the constellations can be found here: http://www.dibonsmith.com/constel.htm (Note: the accuracy of the content on this site has not been verified by the author of this work.)

4.) Double Stars – Double stars are stars that are physically associated with one another; they formed together in what is known as a binary star system. Many times, with high enough resolving power of a telescope, double stars are further discovered to be triple star systems – a binary star system in a binary system with a third star, or even quadruple systems, a binary of two binaries, or a double, double. For example, the double star system in Ursa Major – Mizar and Alcor – is actually a triple system. Double stars can be particularly interesting to observe in small telescopes (compared to looking at a single star, which will always just look like a point of light) because the two stars can often be found to be distinctly different colors – due to the different temperatures of the two stars.

5.) **Star Clusters** – There are two types of star clusters observable with small telescopes:
   a. **Open Star Clusters** are clusters of stars that were all born from the same material, known as a giant molecular cloud, within a galaxy. Therefore, these stars all live physically near one another (not just apparently like constellations) and are of approximately the same age. Open clusters usually contain on order hundreds of stars, are irregularly shaped, and form anywhere in galaxies where there is enough cold, dense gas – like the spiral arms of spiral galaxies. The Pleiades is a famous, nearby, bright open cluster, many members (at least seven) of which can be seen separately with the naked eye, which is why this cluster is also known as "The Seven Sisters".
   b. **Globular Clusters** are very old, very compact compared to open clusters, and much larger than open clusters, usually containing thousands to hundreds of thousands of stars. Globular clusters are gravitationally bound in more or less a spherical distribution. Globular clusters are also typically only found in the outskirts of galaxies, and require binoculars or a small telescope to see, but even then, most will appear only as a fuzzy patch, though some stars in the outer edge may be able to be separately resolved.

6.) **Nebulae –** A nebula is gas and dust lit up around an area of active star formation. This light can come from the gas being heated up by the star and emitting its own light (an emission nebula; a famous example of this is the Orion Nebula, M42) or by light simply reflecting off of dust – a reflection nebula. Nebulas can appear different colors, depending on the chemical makeup of the gas and the reason for emission; since Hydrogen is the most common element, emission nebulae are most often more red than any other color, while a reflection nebula is more like to appear blue because blue light scatters more than red light (same reason the sky is blue). Unfortunately, when observing nebulae through a small telescope, our eyes are unlikely to be able to distinguish much or any of this color because the light receptor cells in our eyes that are predominantly at work in low-light conditions are not color-sensitive.

7.) **Planetary Nebula –** Even though these are also called nebulae (whose word root simply means "cloud"), and have the word planet in them, they have nothing to do with planets or the birth of anything (like the other type of nebula above). Instead, a planetary nebula is a type of emission nebula signifying the end of a relatively low-mass star's lifetime; the death of our own sun will eventually lead to a planetary nebula. The star blows off the gas in its outer layers, creating rings and shells of gas that lights up due to energy emitted from the remaining stellar core.

8.) **The Milky Way –** The Milky Way is the name for our own galaxy because the patch of sky we see in the summer from dark sky sites (those without much light pollution) was thought to look to the ancient Greeks like spilt milk. We now understand this area of the sky – still referred to at the Milky Way – to be the disk of our galaxy, which contains billions of stars as well as cold dust that blocks starlight. The reason it appears as a band that almost looks more like a cloud than lots of stars is because we're seeing it edge-on, so there are so many stars packed so closely together from our point of view, and they are too far away for our eyes to resolve them as individual stars. In very dark skies, one will also notice the Milky Way to be much darker through the very center; this is not because there are fewer stars here but because there is a lot of dust blocking the starlight from getting through.