To Infinity and Beyond – Study Guide

Further information about the event.

Observational Test

This half of the event will be done in the planetarium or (if the planetarium is not operational or unavailable for some reason) in a classroom using planetarium software projected onto a screen, in the dark. Each team of two will be given a pencil, an answer sheet on a clipboard, and red flashlight. Teams will not be allowed to use notes, charts, electronic devices, or any other reference materials. One of the team members will hold the flashlight, the other will hold the clipboard and write the answer. These duties should be assigned ahead of time. Please do a dry run on this before the day of the event. The purpose of the flashlight is to light up the answer sheet. If the student who is writing is right handed, the person with the flashlight should sit on their left side. They should hold the flashlight steady and point it ONLY at the paper. Teams who shine the flashlight on the dome or on other teams may have points subtracted from their score. The proctor will darken the lights and allow a brief time for the students' eyes to adjust. During that time, students should quickly orient themselves, locating North, South, East, and West, along with any bright stars or planets that may be visible.

For 2nd-4th grades, The sky will be set to April 15th, 2020 at 9:15 pm (to allow practice outside for some teams in the month or two coming towards the event). For 5th grade, <u>the dome may be set to any date, at roughly 9pm.</u> The 5th graders will be expected to recognized constellations from across the year, and will be asked what season the planetarium is set to, given that it is evening and the constellations that are up.

The test itself will be given in the following manner:

The proctor will use a laser pointer to point to an object in the planetarium sky (or on the screen). For example, the proctor might say, "This is question number 1. Please identify its name and the constellation it is in." or "This is question number 5. Please correctly name the current phase of the moon and the approximate time of the day"

The teams will then be given a brief time to look at the object, discuss their answer, and write it down. If they do not know the object, they should leave the answer blank. They can come back to it later.

There will be several types of questions:

i) Name a star and its constellation

ii) Name a constellation

iii) Name a non-stellar object and the constellation it is in tonight.

iv) Name a planet and the constellation it is in.

v) Name the phase of the Moon and the approximate time of the day.

vi) What direction am I pointing the laser pointer in?

vii) *5th grade only* – given that it is the evening (~9pm), what season is it based on the visible constellations?

For Moon phase questions, it may be necessary to change the date and time in the planetarium. There may be two or more Moon phase questions, each on a different date and time.

There will be approximately 15 questions in the Observational Test.

After all of the questions have been asked, students may request that the proctor go back and repeat a question. Repeats will be allowed until the testing time is up. The planetarium/room lights will be turned on, students will be given a few minutes to fix up their writing and spelling, and the tests will be collected. Note that accurate spelling of the constellations or star names is not required, beyond being able to recognize that the students got the correct answer.

Be prepared to identify the following stars and their constellations:
All grades:
- Arcturus in Bootes
- Capella in Auriga
- Castor and Pollux in Gemini
- Regulus in Leo
- Sirius in Canis Major
- Polaris in Ursa Minor
- Procyon in Canis Minor
- Aldebaran in Taurus
- Spica in Virgo
- Betelgeuse in Orion
- Rigel in Orion

4th and 5th grades only:
- Alphecca in Corona Borealis
- Alcor and Mizar in Ursa Major

5th grade only:
- Mirfak in Perseus
- Deneb in Cygnus
- Altair in Aquila
- Vega in Lyra
- Fomalhaut in Piscis Austrinus
- Antares in Scorpius

Be prepared to identify the following constellations:
All grades:
- Cepheus
- Cassiopeia
- Perseus

4th and 5th grades only:
- Coma Berenices
- Corvus
- Hercules
- Cancer

5th grade only:
- Andromeda
- Pegasus
- Pisces
- Delphinus
- Sagittarius
- Pegasus

Be prepared to identify the following non-stellar objects and their constellation:
All grades:
- M42

4th and 5th grades only:
- M44
- M31

Be prepared to identify the following objects and the constellation they are in at 9:15 pm on April

15, 2020:

- Venus (in Taurus)

Be prepared to answer questions about the Moon and its phases.

Phases to be remembered by 2nd grade:

- new, first quarter, full, third quarter

Phases to be remembered by 3rd-5th grades:

- new, waxing crescent, first quarter, waxing gibbous, full, waning gibbous, third quarter, and waning crescent

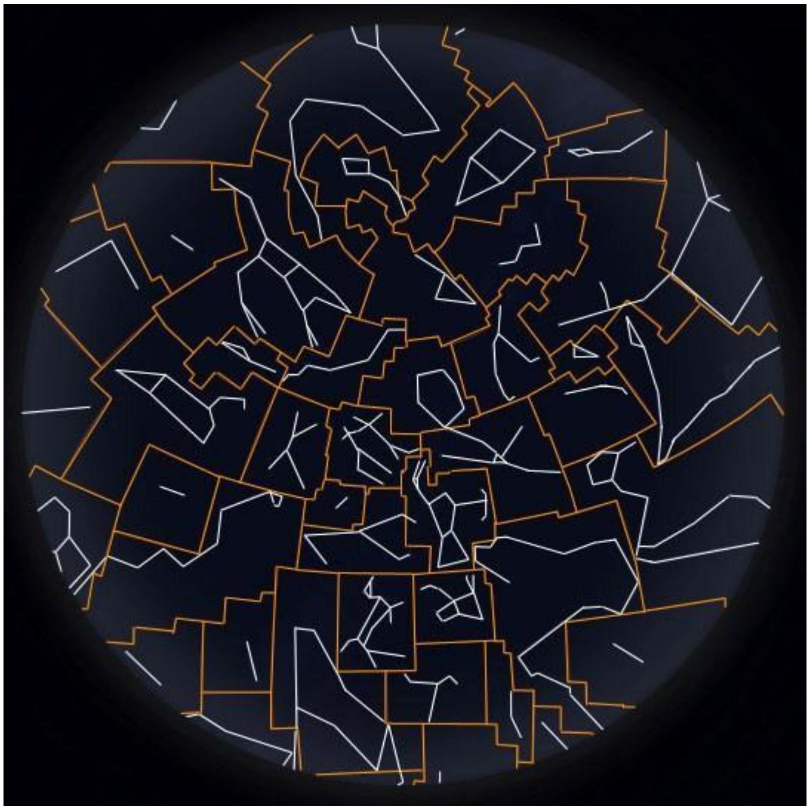
Study Guides relevant to the Observational and Written Tests

For the Observational test, it is likely that we will be able to use the Argus Planetarium inside Pioneer High School. If the Planetarium is unavailable or not operational, we will instead use a computer-based planetarium program and project it onto a flat screen. Either method allows all of the event's topics to be displayed and tested.

1. Constellations This section addresses basic knowledge about the constellations.

1a) When you look at the starry sky, your eyes automatically look for patterns and recognizable shapes. Because there are so many stars in the sky, there are many patterns and shapes to be found. Every culture we know of since the beginning of recorded history has done this. We have cave drawings that go back tens of thousands of years that show events that happened in the sky. These patterns and shapes were all called constellations.

1b) When people look at the sky they see shapes and patterns. They often name them and make up stories about them. These shapes are called constellations. Because people have done this for thousands of years in many different countries speaking many different languages, there are hundreds of these pictures. When scientists tried to organize what they were seeing in the sky, they found that many of the pictures overlapped and shared stars. They also found places that had no constellations at all. This made it complicated for the scientists, so they decided that they would pick just some of the pictures, ones that didn't overlap, and make sure that all of the sky had pictures in it. They needed just 88 pictures to fill the sky, and called these 88 pictures the official constellations. All of the other pictures were then called asterisms.



Any modern star chart or planetarium program should be able to show the boundaries between each picture, as well as the picture itself. By learning these pictures, you can find things in the sky. Here are some lists of planetarium apps:

http://astronomyonline.org/astronomysoftware.asp

and here are the few most popular options (with some comments). I recommend Stellarium, as it is free and the sky looks quite realistic. Free options include :
Worldwide Telescope is excellent and has a web browser and Windows app
Google Sky
SkyChart / Cartes du Ciel
Stellarium – really fiddly to use, but the sky looks quite realistic, so good for training.
Celestia

Paid options (range is usually a basic sky simulator at the low end, telescope or planetarium controller at the high end)
Starry Night ($50 - $250)
TheSky ($50 - $350)
SkySafari - iOS version 6 ($0.99 - $20), Android version 5 ($0.99 - $20) , or Mac version 5 ($5 - $30)
SkyGuide iOS ($2.99, add-ons available for $9.99)

1c) There are 88 official constellations.

1d) We can see about 60 of them from Ann Arbor. To see the rest of them, you would have to go further south.

1e) The stars in any constellation are not necessarily near each other. That is because some stars are much closer or farther away than others. Some planetarium programs can show this by letting you look at a constellation from different sides. Here is a youTube video that shows this using the constellation of Orion: http://www.youtube.com/watch?v=4d4FxC2ohcM

Two of the best constellation books ever published were written by H.A.Rey (the author of the Curious George series). They are available in most libraries and in paperback for about $10; there are some excellent constellation books available at libraries and online resources. In addition, there is an excellent introduction to the ideas in Parts 3-5 of the study guide at an Astronomy – the open source astronomy textbook, section 2.1 (https://cnx.org/contents/LnN76Opl@13.89:jFCByizp@3/The-Sky-Above).

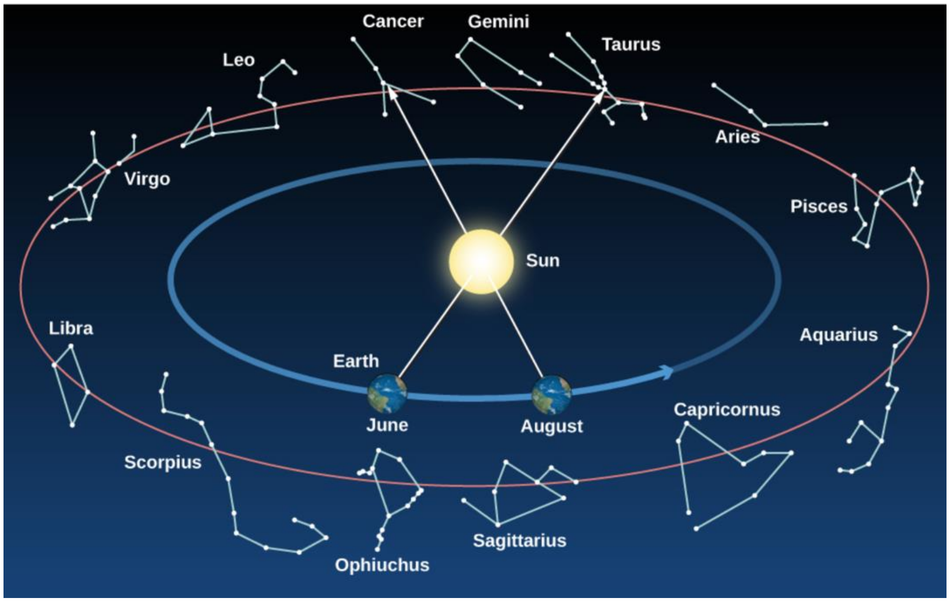
2. Zodiac This section addresses basic knowledge about the zodiac.

2a) As the Earth travels around the Sun, from Earth it appears that the Sun is traveling around us. If we record the apparent path of the Sun against the background of constellations, we see that the Sun draws a line called the ecliptic. The Sun draws this line through the same 12 constellations each year. These 12 constellations are called the zodiac. In ancient times, people used these 12 constellations like months, saying that the Sun was in a different constellation every month. This is not actually true, because some of the constellations are bigger or smaller than others. People just divided up the sky into 12 equal parts and made sure that one of the zodiac constellations matched up with each month.

2b) When modern astronomers divided the sky into 88 official constellations, the zodiac didn't quite match up any more, so now there are 13 constellations that cross the ecliptic. The extra constellation is called Ophiuchus.

2c) The 12 constellations of the zodiac make a complete circle around the Earth. On a clear night, you can only see half of the sky (the other half is on the other side of the Earth – underneath you!). This means you can only see 6 zodiac constellations at once.

2d) The zodiac follows the path of the Sun. Draw a line from East to West while facing South. The line should be about 45° above the horizon in the South. The zodiac should be roughly along this line. Here is what Wikipedia says about the zodiac: http://en.wikipedia.org/wiki/Zodiac
In addition, there is an excellent introduction at an Astronomy – the open source astronomy textbook, section 2.1 (https://cnx.org/contents/LnN76Opl@13.89:jFCByizp@3/The-Sky-Above); the below Figure is taken from that source (their Figure 5)



3. Constellation Groups

3a) Some constellations never set. They are called the circumpolar constellations. They are the constellations that are close to the North Star.

3b) Although all stars move, they are so far away we cannot see their motion with our eyes. When we look at the sky and seem to see the stars move, we are actually seeing the Earth move. As the Earth rotates around its axis once each day, it makes it look like the stars are going around the Earth once each day. The Earth's axis is an imaginary line that connects the North Pole and the South Pole. If we extend this line out into space, it points at a star we call the North Star or Polaris. Because the Earth turns around the axis, the axis doesn't move. It always points at the same star which makes it look like that star doesn't move. All of the other stars seem to go in circles around the North Star. Stars close to the North Star go in small circles. They never set. They are called the circumpolar stars. Stars that are far away from the North Star go in big circles. They do rise and set.

In this picture, which is a time exposure of about 6 hours, you can see the stars going in circles around the North Star. You can also see that the North Star itself is not exactly in the center – it makes a bright arc closest to the center.

To find out more about this picture, visit this website: http://www.astropix.com/IMAGES/SHOW_DIG/Circumpolar_Star_Trails.JPG

The angle between the horizon and the North Star is always equal to the latitude of the observer. In Ann Arbor, our latitude is about 42°. This puts the North Star 42° above the horizon. If we went north to Canada, the North Star would be higher in the sky and there would be more circumpolar stars. If we went south to Mexico, the North Star would be lower in the sky and there would be fewer circumpolar stars.

Finding the North Star is not hard but requires some practice. Go outside after it gets dark and try it for yourself. Remember, it is always in the north. It is NOT the brightest star in the sky. Many people use the Big Dipper as a

guide. Try using a sky chart, planetarium program, or *platisphere* to find it.
http://analyzer.depaul.edu/paperplate/

When we talk about the circumpolar stars in this competition, we will be using the United States as our reference. This means that the important circumpolar constellations are: Ursa Major, Ursa Minor, Cassiopeia, Cepheus, and Draco.

The rest of the stars and constellations rise in the east and set in the west. Most people look at the sky before they go to bed, so when we talk about the seasonal constellations, we are talking about the constellations you can see during that season just after sunset. Learning these constellations takes practice. The more often you see them, the easier they are to find. It also helps to see them from different angles and locations. If you only look from one place, you will tend to include things like houses and trees as points of reference.

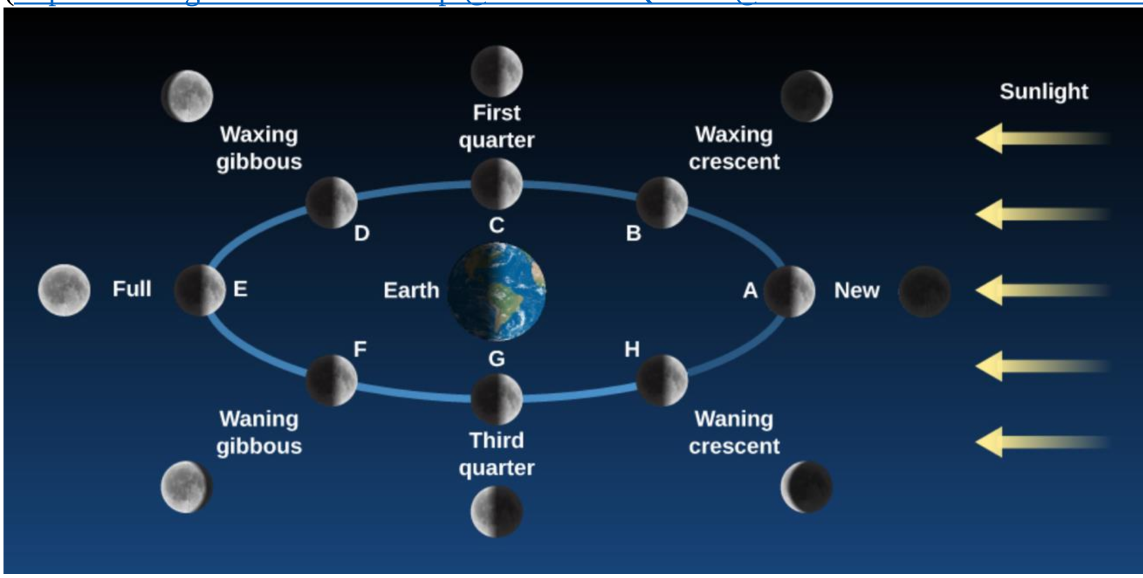
There are many books, websites, and computer programs that can help you learn the constellations. Don't overlook the stories that go with them. The stories help you learn the names and locations, plus they are a lot of fun! http://www.astromax.org/con-page/con-88.htm In addition, there is an excellent introduction to these ideas an Astronomy – the open source astronomy textbook, section 2.1 (https://cnx.org/contents/LnN76Opl@13.89:jFCByizp@3/The-Sky-Above).

Some star chart programs (e.g., Sky and Telescope's, you need to register for a free account) http://www.skyandtelescope.com/interactive-sky-chart/ can show you the sky as it would appear on May 11, 2019 at 10pm, or Heaven's above : http://www.heavens-above.com/skychart2.aspx?lat=42.2808&lng=-83.743&loc=Ann+Arbor&alt=264&tz=EST

Study Guides for the Written Tests

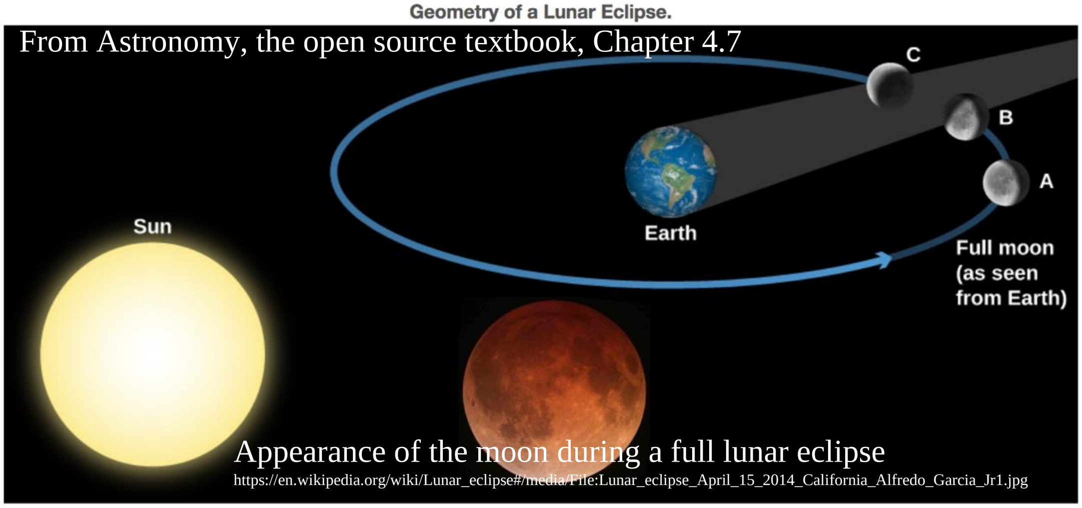
4. Phases of the Moon and Seasons

a) The phases of the moon are caused by our changing perspectives on the sunlit and shaded part of the moon as it goes around the Earth. For example, sometimes we see the entire sunlit phase (full moon), sometimes we only see half of it lit up (first quarter or last quarter, sorry for the confusing names, Astronomy is an *old* science). Look at this diagram from [Astronomy, section 4.5](https://cnx.org/contents/LnN76Opl@13.89:T9HQmc8H@3/Phases-and-Motions-of-the-Moon) (https://cnx.org/contents/LnN76Opl@13.89:T9HQmc8H@3/Phases-and-Motions-of-the-Moon)



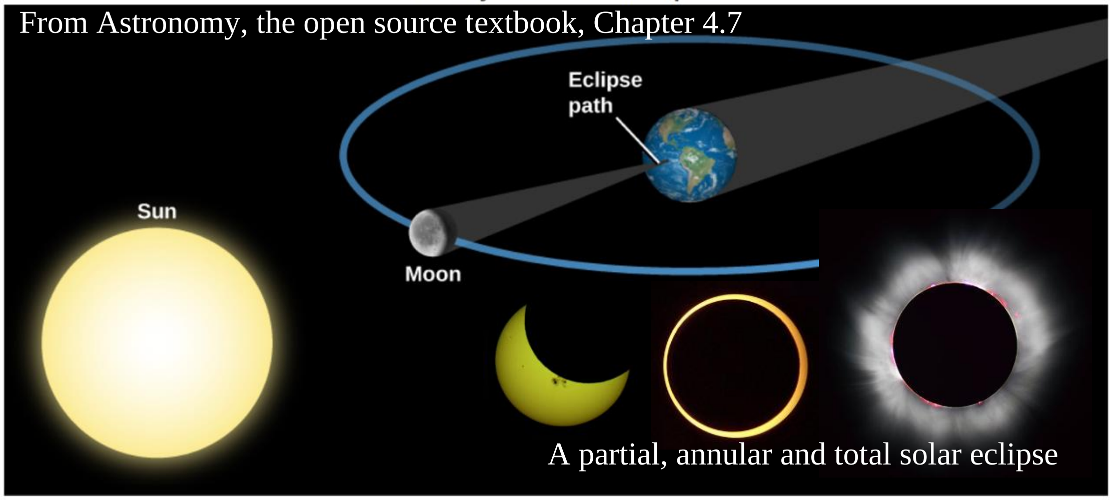
b) At full moon, the Earth can get directly between the Sun and the Moon, and the Moon goes into the Earth's shadow. This appears to us as a *lunar eclipse*. Because the orbit of the moon isn't quite aligned with the orbit of the Sun, a lunar eclipse doesn't happen every full moon.

Geometry of a Lunar Eclipse.

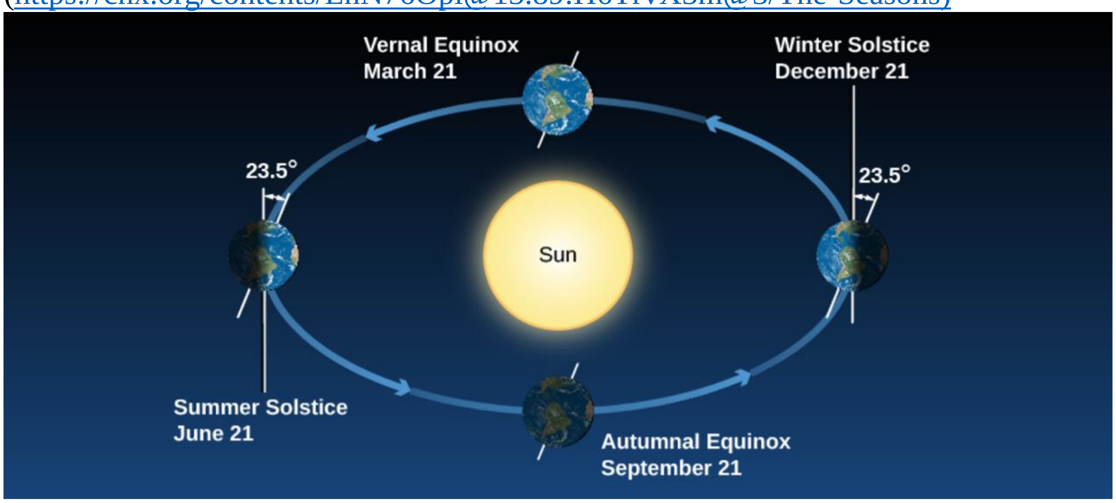


c) At new moon, the Moon can get directly between the Sun and the Earth, and the Moon casts its shadow on the Earth. This appears to us as a *solar eclipse*. If the Sun is only partly covered, it is called a partial solar eclipse. If the Sun is completely covered, it is called a total solar eclipse, and you can see the corona – the outer atmosphere of the Sun. The Moon can be too far away sometimes to cover the Sun completely, and leave a ring of light – this is called an annular solar eclipse.

Geometry of a Total Solar Eclipse.



d) The seasons are caused by the tilt of the Earth's axis compared to the plane of its orbit. As viewed from Ann Arbor, when the Sun is further north in the sky, this lengthens days and gives more direct sunlight, causing more heating and warmer temperatures. In the winter, when the sun is further south in the sky, days are shorter and sunlight is less direct, leading to less heating and colder temperatures. There is an excellent discussion, with diagrams, in Astronomy, chapter 4.2 (https://cnx.org/contents/LnN76Opl@13.89:H6TrvX3m@3/The-Seasons)



e) The Sun is about the same distance from the Earth all the year, and so appears the same size to us all year long.

f) The Earth spins once a day, making it appear that the Sun, Moon and stars move across the sky.

g) During a given day, the Sun appears to rise in the East, and from a moderate latitude Northern Hemisphere site like Ann Arbor appears high in the South at noon, and then appears to set in the West. (for 4th and 5th graders – think about what direction the Sun would be in at noon as seen from the Southern Hemisphere!).

5. Stars This section addresses basic knowledge about what we are seeing when we look at the night sky.

All Grades:

5a) To the eye, a star is always a point. All stars (with the exception of the Sun) are too far away to see as anything bigger than a point. Even the most powerful telescopes in the world see almost all stars as points. The Sun is much brighter than other stars because it is very close to us. Most stars appear faint to us because they are so distant. Our measurements tell us that stars are hot round balls of gas, similar to our own Sun, but we cannot see this directly.

5b) The Sun and all stars shine because they are extremely hot. The source of their energy is nuclear reactions going on deep inside the stars. In most stars, like our sun, hydrogen is being converted into helium, a process which gives off energy that heats the star. The inside is actually millions of degrees! That warms the outer layers of the star, which gives off heat and light. (from https://www.scholastic.com/teachers/articles/teaching-content/all-about-stars/ which also has much more excellent kid-friendly information about stars).

5c) Stars are everywhere in the sky, during the night and during the day. We can't see them in the daytime because light that is scattered from sunlight makes the whole sky appear much brighter than the stars, but they are still there. Look here for more : https://spaceplace.nasa.gov/blue-sky/en/

5d) We see the stars when it is dark. This is usually at night, but it can be other times as well. If there is a solar eclipse in the daytime, it gets so dark we can see the stars in the sky. If we fly a jet very high above the Earth, we can see stars – the bright blue of the sky is below us and the sky is dark. If we go into space we can see stars all of the time.

4th and 5th Grades:

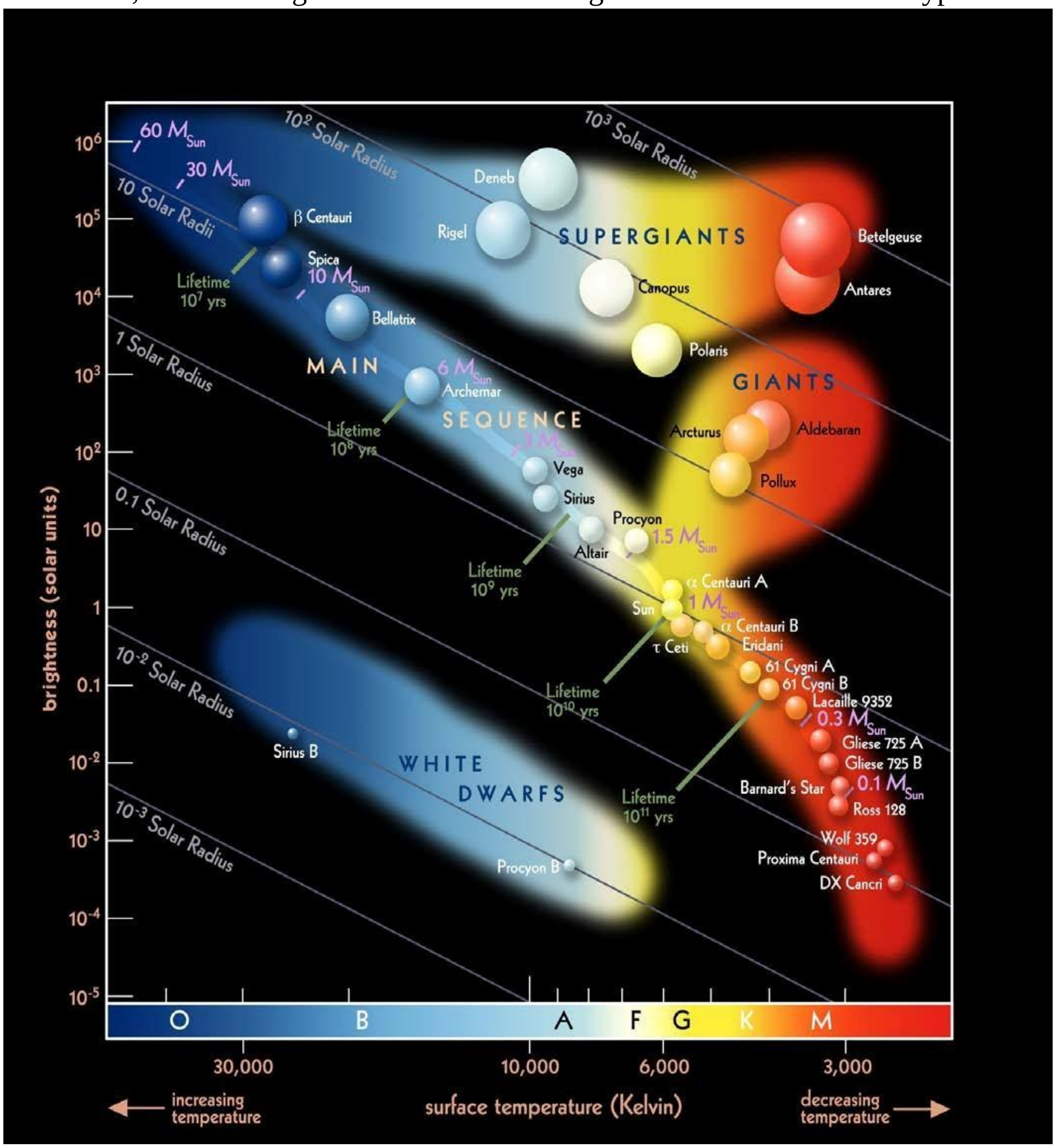
5e) How bright do stars appear (apparent magnitude)?: We measure the brightness of a star using a scale called magnitude. It is a backwards scale, where a bigger number is not as bright as a smaller number. On this scale, the brightest star in the sky are around 1st magnitude, while the faintest star you can see from a dark site is a 6th magnitude star. A telescope can let you see even fainter stars. The bigger the telescope, the fainter you can see. Something that is even brighter than the brightest star (like the Sun or Moon) has a negative magnitude. The noon Sun has a magnitude of -26.8 in Ann Arbor.

5f) The apparent brightness of an object depends on how far away it is from you. Yet, we can understand much more about an object if we know its luminosity. Because the brightness of a star spreads out over a larger area as it moves away from you, the brightness varies proportionally to 1/Distance^2. This is called the inverse square law, and if you study astronomy you will meet it again (gravity is also an inverse square law, for similar reasons!). If a star were to move 2 times farther away it would be 1/4 as bright (twice as far away, so four times as much area for the same light to spread out into; 1/(2 x 2) = 1/4). If a star were to move 3 times further it would be 1/9 as bright. If a star were to move 4 times farther it would be 1/16th as bright. This (and a lot more!) is discussed in section 5.1 of Astronomy – the open source astronomy textbook (https://cnx.org/contents/LnN76Opl@13.89:utu6tFTq@3/The-Behavior-of-Light)

5g) Where they are in the sky: To help locate objects in the sky, scientists image that the sky is a giant ball, or sphere, just like the Earth. They call it the *celestial sphere*. They draw imaginary lines in the sky called *Right Ascension (or RA)* and *Declination (or Dec)*. These lines look just like the lines of latitude and longitude we draw on the Earth. Using these lines, people can describe the location of any object in the sky as seen from Earth. This is described helpfully in Astronomy – the open source astronomy textbook, sections 2.1 and 4.1 (https://cnx.org/contents/LnN76Opl@13.89:jFCByizp@3/The-Sky-Above and https://cnx.org/contents/LnN76Opl@13.89:ITd1b7up@3/Earth-and-Sky) an interactive demonstration at http://astro.unl.edu/naap/motion2/motion2.html .

Because the lines are imaginary, they are not much help when we are outside trying to find an object in the sky. In this case, we use the patterns of the stars in the sky, called constellations or asterisms (these two words do NOT mean the same thing). If you learn how to find these pictures, you can use them to locate specific objects.

5h) What color they appear to be: During the last few centuries astronomers focused on subtlety of color, using color names like peach, aquamarine, and gold to describe what they saw through their telescopes. A more precise method of spectral typing was developed by the famous astronomer Annie Jump Cannon in the early 1900s, represented by letters O, B, A, F, G, K, and M. These spectral types tell you the temperature of the star, with O being the hottest and M being the coolest. Our sun is a type G.



5i) One of the most important visualizations of star properties is the *Hertzsprung-Russell Diagram* (or H-R Diagram for short). Stars form distinctive patterns on this diagram, depending primarily on their mass (how much gas they have) and where they are in their lives. The x-axis is temperature, going from hottest on the left to coolest on the right. You can see how the color changes with temperature. The y-axis is brightness, going from brightest on top to dimmest on the bottom. Most of the known stars can be plotted on this diagram.

Many of the stars are along the diagonal line from the top left to the bottom right. This is called the *Main Sequence* because so many stars fit on that line. The main sequence is very simple. If a star is hotter it is brighter. If a star is cooler it is dimmer.

Some stars are not very hot, but they are still very bright. That is because they are very large. We call these stars *giants* and *supergiants*. You can see they are on the top right. Some stars are very hot and not very bright. That is because they are very small. We call these stars *white dwarfs.* While students won't need to know more than what we've discussed, this diagram and what it tells us is described in more depth in Section 18.4 of Astronomy (https://cnx.org/contents/LnN76Opl@13.89:EVgehrPG@8/The-HR-Diagram).

5k) All stars are **much** farther away than the Sun or our planets. We measure their distance in light years or parsecs. A light year is a distance, not a time. Because the speed of light does not change in the vacuum of space, we can calculate that in one year a beam of light will travel 5,878,897,915,661.71 miles. We can round this off to about 6 trillion miles. So, if a star is about 6 trillion miles away, we say it is about 1 light year away. If it is twice as far away, 12 trillion miles, we say it is 2 light years away. Because light travels at the speed of light(!), the distance in light years tells us how long it takes for light from that star to reach us. If a star is 150 light years away, it means the light from that star takes 150 years to reach Earth. When we look at that star, we are not seeing what it looks like now, we are seeing what it used to look like 150 years ago. If we want to know what it looks like today, we have to wait 150 years for the light to get here. While you don't need to know this, it is interesting to note that the oldest light you can see with your unaided eye (in a dark sky) is the light from the Andromeda Galaxy, 2.5 *million* light years away.

The Sun is the closest star, it is only 8 light minutes away. That means it takes 8 minutes for the light from the Sun to reach the Earth.

The next closest star you can see with the unaided eye is Alpha Centauri. This is actually a triple star system, of which the bright one that you can see is the blended light from two stars. Their average distance from Earth is 4.37 light years. This means that it takes 4.37 years for the light from Alpha Centauri to reach our eyes. If Alpha Centauri were to explode (it won't, we think), we would continue to see it for 4.37 years, even though the star no longer exists. Then, 4.37 years later, we would see the explosion.

The rest of the stars we see in the sky are even farther. Without a telescope, most of the stars we see in the sky are between 4 and 1,000 light years away.

We sometimes measure the distance to stars using *parsecs*. One *parsec* is the same as 3.26 light years.
http://en.wikipedia.org/wiki/Parsec

5l) From the H-R diagram, we see that stars come with a wide range of colors. But, be careful because stars emit **all** colors. This can confuse our eyes and make some colors, like green, difficult or impossible to see. If a star were a "green" star, it would also give off red, orange, yellow, blue, indigo, and violet. When we look at that star, it mostly looks white (which is all colors mixed together).
5m) The brighter stars were given many different names by many different cultures. Scientists have tried many methods to name stars. One early method had them pick the brightest star in each constellation and call it *alpha*,

which is the letter A in the Greek alphabet. So, the brightest star in the constellation of Ursa Major is called alpha Ursa Major. The brightest star in the constellation of Orion is called alpha Orion.
The second letter of the Greek alphabet is *beta*, so the second brightest star in each constellation is called beta. This works well for the brightest 24 stars, but there are more than 24 stars in each constellation. Many other methods have been used, most of which involve assigning numbers to each star. The numbers often have letters before or after them to tell the reader which numbering method was used. There are many different lists or *catalogs*.
For example, the North Star has names (don't worry – you don't have to remember them!) that include: Polaris, Lodestar, Navigatoria, Alpha Ursae Minoris, 1 UMi, HR424, HD8890, SAO308, BD+88 8, HIP11767, TYC 4628-0237-1, and ADS1477.
All of these names are correct names. None of them are "better". Each is useful to someone.

5n) There are many "special" types of stars. These include black holes, neutron stars, white dwarfs, novae, variable stars, and binary stars. For the written test, you are expected to know what these are and have a very rudimentary idea of how they form or happen, no more.

a) Black holes – these are objects that are so dense that light cannot escape from them. A black hole with the mass the same as the Sun would be about 3km in radius. They are thought to be formed at the end of some high mass stars' lives. The radius of an Earth-mass black hole would be 9mm.
b) Neutron stars – are objects that became so compressed that they collapsed into essentially a giant atomic nucleus, they are so dense that many of the protons and electrons combined into neutrons. A neutron star the mass of the Sun is about 10km in radius. They form at the end of the lives of most high-mass stars, in a supernova explosion.
c) White dwarfs – are objects that are still very dense, but less dense than neutron stars. Their atoms are pressed together as tightly as nature allows, meaning that a white dwarf the mass of the Sun would have a size comparable to the Earth. These objects form at the end of low mass stars' lives – the Sun will become one in around 6 billion years from now.
d) Novae – happen for a number of reasons, but most happen when hydrogen and helium collect on the surface of a white dwarf – when there is enough of it, it explosively ignites across the surface of the white dwarf, brightening it dramatically, appearing as a *nova* (new star, in Latin) to us.
e) Variable stars – are stars that vary in brightness. Many of them pulsate, changing their brightness in a regular way. Some stars vary in brightness because other stars pass in front of them (e.g., Algol). Polaris is a variable star, at a level that is hard to notice with the naked eye.
f) Binary stars – are stars that are in a pair orbiting each their common center of mass. Many stars are in binaries or multiple star systems. These are important as the best studied binary stars can give the only measurements we have of the masses of stars.

6. Planets This section addresses basic knowledge about the planets in our Solar System.

6a) When seen with the unaided eye, a planet looks almost exactly like a star. It is a point of light with no visible features. Like a star, a planet can come in different colors and different brightnesses.

So how do you tell them apart? It is easy with a telescope, as stars remain points and planets increase in size and detail. But without a telescope you need to look for the following clues:

i) Some planets, like Venus and Jupiter, are brighter than the brightest stars.
ii) All planets are found near the *ecliptic*, an imaginary line that goes from East to West through the southern sky. The *ecliptic* is both the path of the Sun and the plane of the Solar System.
iii) The planets travel through 12 constellations, called the zodiac. (They actually pass through 13 constellations, but the 13^{th} constellation is often ignored. It is called Ophiuchus.)
iv) The planets move across the constellations very slowly. If you use the internet or Stellarium to locate them, their position will only change a tiny bit each day.
v) If you know what a constellation looks like and there is a new, unknown star in it, it may be a planet.

6b) Planets do not make their own light. They reflect the light from the Sun. Lots of things influence how bright a planet appears to you: its distance from the Sun, how large it is, and how reflective a planet is.
If a planet is close to the Sun, like Venus, it is bright. If it is far from the Sun, like Neptune, it is not very bright.
If a planet is very large, it reflects more light that a small planet. Jupiter is the biggest planet in the solar system. Even though it is far from the Sun, it is still very bright because it reflects lots of light from the Sun.
Mercury is made of bare rock. Rock is usually dark, so Mercury does not reflect much light from the Sun. Venus is covered with clouds that reflect lots of light from the Sun. So even though Mercury is closer to the Sun than Venus, Venus looks brighter. When scientists measure how much a light a planet reflects, they call it *albedo.*

6c) For many of the planets, you cannot just look at a planet and tell which one it is. If you have been keeping track of their movements, you might know that Venus is in the West and Jupiter is high overhead. But if you haven’t been keeping track, it is sometimes quite hard to tell.

6d) The first scientists to measure the Solar System could not measure how far away the Sun or planets were. They could only compare the distance from the Sun to the Earth to the distance from the Sun to a planet. These scientists decided to call the distance from the Sun to the Earth one *astronomical unit*. They used the abbreviation *au*. Using this scale, they learned that Mercury was about 0.4 au from the Sun, Venus was about 0.7 au from the Sun, Mars was about 1.5 au from the Sun, Jupiter was about 5 au from the Sun, and Saturn was about 10 au from the Sun. More distant planets move slowly around the Sun, and take a long time to orbit the Sun. Saturn, with a distance of 10 au, takes just over 29 years to orbit the Sun. If you lived on Saturn, you would be less than 1 year old, and your parents would be around or a little over 1 year old ☺

It was many years later that scientists were able to measure the distance from the Sun to the Earth (the length of an au). This distance is 149,598,000 kilometers, or 92,955,807 miles.

6e) The color of a planet depends on the part of the planet we see. When we look at Venus, we see clouds. They are yellowish grey. Scientists sometimes call this color *ashen*. When we look a Mars, we see dirt. There is lots of rust mixed up with the dirt. This makes the dirt look red. We sometimes call Mars the red planet. The colors tell us a lot about the planet.

6f) Planets come in so many different sizes it is difficult to compare them. You can compare the diameter, the size of the circle, the volume of the sphere, the mass, and many other traits. By comparing and/or combining these measurements scientists can learn many things. There are many tables that list all of these traits. A good resource is Astronomy – the open source astronomy textbook, section 7.1 (https://cnx.org/contents/LnN76Opl@13.89:ySOb2aRL@3/Overview-of-Our-Planetary-Syst).
The National Earth Science Teachers Association has a rudimentary website:
http://www.windows2universe.org/our_solar_system/planets_table.html

6g) The planets are found near the ecliptic and zodiac. Use a planetarium program or star chart maker to become familiar with these.

6h) To early cultures, the planets were five special stars that wandered across the background of fixed stars. The word planet comes from the Greek word planetai (wanderer), or asters planetai (wandering star). They were often given the names of gods or goddesses because they seemed special. Each culture gave them different names (you don't need to remember these, we just thought you might be interested!). There was no standard name of each planet.
Venus, for example was named Shukra in Sanskrit, Kinsei in Japanese, Sao Mai and Sao Hom in Vietnamese, Jinxing in Chinese, Zib/Zig in Sumerian, and Istar in Babylonian.
When the telescope was invented and pointed at the planets, scientists realized they were not stars. Because the telescope was invented in Europe, where scientists spoke Latin, the Latin names were used in most of their writings. As these writings spread around the world, the names stuck and scientists everywhere started to use them.
There were arguments along the way. When Uranus was discovered by William Herschel, he wanted to name it "Georgium Sidus" after King George III. Astronomers from other countries disagreed, and it was later decided that all planets should be named after mythological gods or goddesses. Today, all decisions about naming things are made by the International Astronomical Union.

6i) The International Astronomical Union has many responsibilities, including writing the rules for being a planet. A number of years ago, they changed the rules, which meant that Pluto is no longer called a planet. The IAU has a website which explains their rules and why they did it. It is at:
http://www.iau.org/public/pluto/

6j) **4th and 5th grades:** 6 out of the 8 planets (all but Mercury and Venus) have at least one moon circling them. Students will be expected to know about our Moon, the names and distance order of the 4 large moons of Jupiter (Io, Europa, Ganymede and Callisto), and the existence of the largest moon of Saturn (Titan). If students want to learn more about Jupiter's large satellites, please look here : https://cnx.org/contents/LnN76Opl@17.1:C_IbXlkV@6/The-Galilean-Moons-of-Jupiter and about Titan please look here : https://cnx.org/contents/LnN76Opl@17.1:vcQfWPhp@6/Titan-and-Triton . All of these moons are truly fascinating objects – for example, Titan has clouds, rain and lakes, but made (largely) of liquid ethane instead of water!