On T.R.A.C.K.S.

Teaching **R**esource **A**ctivities and **C**onservation to **K**ansas **S**tudents

Vol. 20, No. 1 **Kansas Wildlife & Parks** **Winter, 2010**

INSIDE...

Don't Miss Our Next Issue:

Climate Change

It is easy to forget that above us on every clear night, stars and planets grace the night sky."
--NPS Exploring the Night

It is easy to forget this. Unfortunately, 85% of people in the U.S. can no longer see the Milky Way due to light pollution. Our understanding of our Earth begins with a clear understnding of our place in the Solar System and just what makes us so special. This issue of ON TRACKS will focus on the night sky, the solar system, constellations, and light pollution.

Cosmic Address

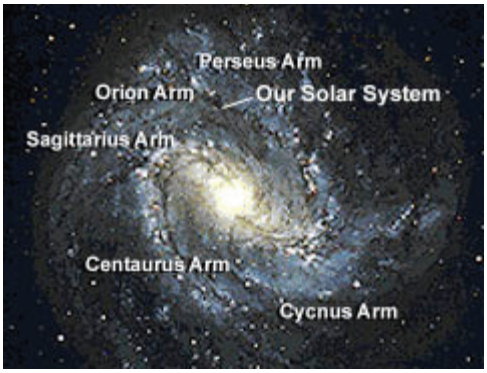
We should all know our address by the time we go to school. For those of us in the United States, our address consists of our state, city, and street number of our house. But, what would our address be on a cosmic scale? Starting from small to big or going from known to unknown our address in the universe would look something like this:

Billy Smith
11504 Orchard Rd
Junction City, KS
USA
Planet Earth
Solar System
Milky Way Galaxy
Local Group
Virgo Supercluster
Observable Universe

Let's start with the fifth line of our address: PLANET EARTH. Earth is the third planet orbiting the sun and this part of the address distinguishes our planet from the seven other planets orbiting the same star. Our solar system consists of all the bodies in orbit around the sun.

Our sun is just an ordinary, insignificant star. There are millions like it. From just 6 billion miles away, we wouldn't be able to see the Earth with telescopes any more so we must also give the address of our sun.

Our solar system is situated in the outskirts of the Milky Way galaxy, in a part that is poor of stars. (The name galaxy originates from the Greek word "gala" which means "milk".) The shape of the galaxy is that of a spiral with arms of stars extending out from the center and our sun is located on the edge of the Orion arm. The whole galaxy includes around 150 billion stars and our sun is located about 26,500 light years away from the center of the galaxy. It takes our sun about 225 million Earth years to complete the circular orbit it makes around the center of the galaxy. All other stars also rotate with different speeds on different orbits around the center of the galaxy, just the way planets rotate around the sun.



The Milky Way galaxy is not alone in the universe. In fact, another spiral galaxy is located around a million and a half light years from us. It is called the Andromeda Nebula because it can be seen in the Andromeda constellation. The Milky Way is one of 30 galaxies in a "cluster" of galaxies called the Local Group. And the local group is just one cluster within a "supercluster" called the Virgo Supercluster. The Virgo Cluster is a tiny part of the entire Universe.

Science is still unable to tell us what and how many superclusters the universe consists of, whether they become bigger or smaller, or how far away they are from us. But, all together, they build the ever-changing and endless Universe.

How Many Stars in the Milky Way Galaxy? ***About 200 Billion!***

How many is 200 BILLION stars? Imagine a football field surrounded by a wall four feet high. Fill the football field to the top of the wall with BIRDSEED. That's 200 billion seeds representing the 200 billion stars in the Milky Way. Using this same scale, the solar system would be about the size of a half-dollar coin. That would make the Milky Way as wide as the United States! Can you imagine throwing a half-dollar coin into a field in Montana and leaving Kansas to try to find it?

Copy this postcard and create your own cosmic address:

Name _____

Street _____

City, State _____

Country _____

Planet _____

Solar System _____

Galaxy _____

Group _____

Supercluster _____

Observable Universe _____

An Atlas of The Universe

Please visit Richard Powell's "An Atlas of the Universe" *www.atlasoftheuniverse.com* for some very good visualizations of our Cosmic Address, as well as a host of other basic astronomical information

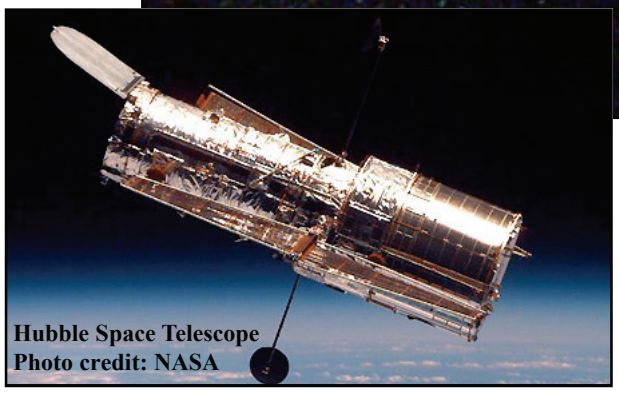
Measuring Vast Distances

On Earth, we measure long distances in miles. The distances in space between stars is so great that measuring that distance in miles wouldn't be practical. Would you want to measure the distance from New York to Los Angeles in inches? Probably not! So, scientists had to come up with another way to measure distances in space. **Light-years** are the units used to measure distances in space. This sounds like a unit of time, but a light-year is actually a distance: the distance that light travels in one year.

Light travels at a speed of 186,000 feet per second and it always travels in a straight line! We know there are 60 seconds in a minute, 60 minutes in an hour, 24 hours in a day, and 365 days in a year, so the distance light travels in one year is about 6 trillion miles! (5,850,000,000,000 miles).

The moon is the closest heavenly body to the Earth. Light from the moon reaches the Earth in just 1.3 seconds. The light from our sun reaches the Earth in about 8 minutes so we could call this distance 8 light minutes. It would take 180 years for you to drive that same distance (93 million miles) in a car at 60 mph! For the space shuttle to travel one light year, it would take about 37,200 years!

The nearest star to our sun, Proxima Centauri, is 4.2 light years away. So, the light we see from Proxima Centauri is already 4 years old when it reaches Earth. What was happening 4 years ago? Sirius is the brightest star in the sky but the light from Sirius takes 8.6 years to reach Earth. What were you doing almost 9 years ago? When we look at the night sky, we are really looking back at the history of the universe!



Hubble Space Telescope
Photo credit: NASA

Galaxies seen by the Hubble Telescope

These are some of the farthest galaxies ever seen. We see some of them as they looked billions of years ago, before the Earth even existed.

Information from Understanding the Universe from the American Museum of Natural History

school.discoveryeducation.com.

The Solar System

Our solar system is made up of the sun, eight major planets and their moons, one dwarf planet, and all other satellites of the sun such as comets and asteroids. There are four small, rocky planets near the sun---Mercury, Venus, Earth, and Mars---and four giant, gaseous planets that are farther out--Jupiter, Saturn, Uranus, and Neptune. The dwarf planet Pluto is the farthest from the sun.

The Sun

By far, the most important object in our solar system is the sun. It is a fiery ball giving off heat and light as the result of a continuous nuclear reaction changing hydrogen to helium.The sun contains 99.85 % of all the matter in the solar system and it is 109 times larger than the Earth, but it is still just an average star.

The Planets

Planets can be distinguished from stars because they wander through the heavens, moving in relation to the stars and each other. The Greeks were the first to call these bodies "planets" which actually means "a wanderer". Planets do not travel around the sun in a perfect circle- instead their orbit is elliptical. Johannes Kepler first described this in the early 1600's. Planets make up 0.135% of the matter in the solar system.

The four innermost planets are similar in size and composed of rock and iron. **Mercury** is the closest planet to the sun and has little in the way of atmosphere. It is also the smallest of the planets. Mercury was thought to be two different planets by the ancients because of its quick rotation around the sun. When Mercury lies behind the sun we see it near the western horizon in the evening sky; when it precedes the sun we see it in the eastern sky near dawn. Several spacecraft have visited Mercury and Messenger is due to visit in 2011.

Venus is almost a physical twin of the Earth--about the same size and composition. It is the brightest object in the sky except for the Sun and the Moon and it shows phases when viewed with a telescope from Earth. It has been visited more than 20 times by spacecraft and while it may seem Earth-like, it is probably the least hospitable place in the solar system. The atmosphere on Venus is heavy and exerts the same pressure as being 3,000 feet underwater. It is also composed of mostly carbon dioxide so Venus experiences the ultimate greenhouse effect. And, if that is not enough, the clouds are composed of sulfuric acid.

Earth, of course, is the most familiar planet in the solar system and the only one whose name does not derive from Greek/Roman mythology. Earth is from Old English and Germanic. The Earth is the fifth largest planet, the densest major body in the solar system, and the only one we know with liquid water on its surface. In fact, 71% of the planet is covered in water.The Earth is about 4.5 to 4.6 billion years old, but, the oldest rocks are just 4 billion years old and it is rare to find rocks over 3 billion years. The oldest fossils of living organisms are less than 3.9 billion years old. The Earth has one natural satellite-the Moon.

Mars is the fourth innermost planet and the seventh largest. Because of its high iron oxide content, it is also called the Red planet. Several spacecraft have visited Mars and the two Mars expedition rovers that landed in 2004 are still operating. From their surveys, we have found that Mars has the largest mountain in the solar system, rising 78,000 feet above its surface! There is very clear evidence of erosion in many places on Mars including large floods and small river systems. At some time in the past there was clearly some sort of fluid on the surface. Liquid water is the obvious fluid but other possibilities exist. Mars has two tiny satellites which orbit very close to the Martian surface.

Jupiter is the fifth planet from the Sun and the largest. Jupiter is more than twice as massive as all the other planets combined (the mass of Jupiter is 318 times that of Earth). Like all the gas giants, it does not have a solid surface.What we see when looking at these planets is the tops of clouds high in their atmospheres. Jupiter is the fourth brightest object in the sky (after the Sun, the Moon and Venus). It has been known since prehistoric times as a bright "wandering star". But in 1610 when Galileo first pointed a telescope at the sky he discovered Jupiter's four large moons Io, Europa, Ganymede and Callisto (now known as the Galilean moons) and recorded their motions back and forth around Jupiter. Jupiter is about 90% hydrogen and 10% helium (by numbers of atoms, 75/25% by mass) with traces of methane, water, ammonia and "rock". This is very close to the composition of the primordial Solar Nebula from which the entire solar system was formed. Jupiter has 63 known satellites, some that do not even have names yet.

Saturn is the sixth planet from the Sun and the second largest. Saturn's interior is hot and radiates more energy into space than it receives from the Sun. Its composition is similar to that of Jupiter with 75% hydrogen and 25% helium and reminds us of the solar nebula from which all the planets condensed. The most unique feature of Saturn through the telescope are its very obvious rings. Galileo saw these rings but was unable to explain them. Rings have now been discovered around Neptune, Uranus, and even Jupiter. The ring particles seem to be composed primarily of water ice, but they may also include rocky particles with icy coatings. Saturn has 34 named satellites.

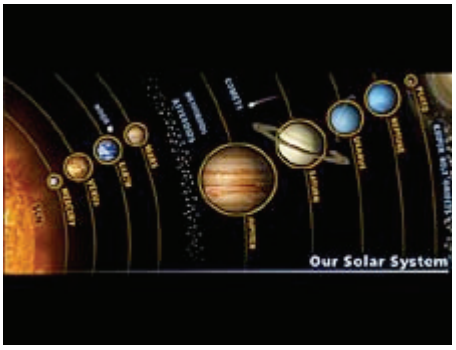
Uranus is the seventh planet from the Sun and the third largest (by diameter). It has been visited by only one spacecraft, Voyager 2, on Jan 24, 1986. Voyager discovered that Uranus rotates on its axis on essentially its side--its south pole was pointed directly at the sun during Voyager's pass. Uranus is composed primarily of rock and various ices, with only about 15% hydrogen and a little helium (in contrast to Jupiter and Saturn which are mostly hydrogen). It has 21 named moons and six unnamed ones.

Neptune is the eighth planet from the Sun and the fourth largest (by diameter). Neptune's discovery was based on a prediction that another body must be perturbing the orbit of Uranus, since Uranus' orbit was out of place according to Newton's laws. Neptune has been visited by only one spacecraft, Voyager 2, on Aug 25, 1989. Much of we know about Neptune comes from this single encounter. Neptune's composition is probably similar to Uranus': various "ices" and rock with about 15% hydrogen and a little helium. Neptune has 13 known moons; 7 small named ones and Triton, plus four discovered in 2002 and one discovered in 2003 which have yet to be named.

Pluto is much smaller than any of the official planets and now classified as a "dwarf planet". Pluto is smaller than seven of the solar system's moons (the Moon, Io, Europa, Ganymede, Callisto, Titan and Triton). Pluto was discovered in 1930 by a fortunate accident. Calculations (which later turned out to be in error) had predicted a planet beyond Neptune, based on the motions of Uranus and Neptune. Not knowing of the error, Clyde W. Tombaugh (a Kansan) at Lowell Observatory in Arizona did a very careful sky survey which turned up Pluto anyway. Pluto rotates in the opposite direction from most of the other planets. Pluto has not yet been visited by a spacecraft. A spacecraft called New Horizons was launched in January 2006. If all goes well, it should reach Pluto in 2015.

Much of the information on the planets was taken from ***www.nineplanets.org.***

Additional Solar System Ideas



There are some wonderful songs about the planets created by some very creative people. I am aware of this song called “Family of the Sun” by Foster Brown from his album, *Foster Brown's Naturally: Children's Nature Songs.* It is available from www.songsforteaching.com/fosterbrown/planetsfamilyofsun.htm.

Family of the Sun

by Foster Brown

Have you ever noticed in the sky
A billion stars in the dark, dark night?
The family of the sun in our Milky Way,
Nine planets spinning night and day

Mecury, Venus, Earth and Mars:
The first four planets amidst the stars.
Jupiter, Saturn, Uranus too,
Neptune and Pluto are the last two.

Mercury’s the closest to the sun,
No water or air and not much fun.
Moving to Venus would be a big mistake,
Full of poisonous gases and lava lakes.

The Earth we know is the best of all,
with water and air on the big blue ball.
Mars is windy and full of dust,
Iron in the rocks give it the color of rust.

Mecury,Venus, Earth and Mars:
The first four planets amidst the stars.
Jupiter, Saturn, Uranus too,
Neptune and Pluto are the last two.

Jupiter’s huge and made of gas
With hurricane storms that never pass.
Saturn’s known for her many rings
made up of ice and rock and dusty things.

Uranus spins upon her side,
Neptune has winds that drive you wild.
Pluto’s the smallest and furthest out,
So now that you know them, sing them, don’t shout.

Mecury,Venus, Earth and Mars:
The first four planets amidst the stars.
Jupiter, Saturn, Uranus too,
Neptune and Pluto are the last two.

The Thousand Yard Model or The Earth As A Peppercorn by Guy Ottowell

This is a classic exercise for visualizing just how BIG our Solar System really is. Both the relative size and spacing of the planets are demonstrated in this outdoor exercise, using a mere peppercorn to represent the size of the Earth. In this model, one yard (36 inches or **one pace**) represents a whopping 3,600,000 miles!

First, collect the objects you need. They are:
Sun-any ball, diameter 8.00 inches ; **Mercury**-a pinhead, diameter 0.03 inch; **Venus**-a peppercorn, diameter 0.08 inch
Earth-a second peppercorn; **Mars**-a second pinhead; **Jupiter**-a chestnut or a pecan, diameter 0.90 inch
Saturn-a hazelnut or an acorn, diameter 0.70 inch; **Uranus**-a peanut or coffeebean, diameter 0.30 inch; **Neptune**-a second peanut or coffeebean; **Pluto**- a third pinhead (or smaller, since Pluto is a dwarf planet)
The three pins must be stuck through pieces of card, otherwise their heads will be virtually invisible. If you like, you can fasten the other planets onto labeled cards too.

You will have found in advance a spot from which you can walk a thousand yards in something like a straight line. This may not be easy. Straightness of the course is not essential; nor do you have to be able to see one end of it from the other. You may have to "fold" it back on itself.

Put the Sun ball down, and march away as follows:
10 paces. Call out "Mercury, where are you?" and have the Mercury-bearer put down his card and pinhead, weighting them with a pebble if necessary.
Another 9 paces. Venus puts down her peppercorn.
Another 7 paces. Earth
Another 14 paces. Mars Now come the gasps, at the first substantially larger leap:
Another 95 paces to Jupiter From now on, amazement itself cannot keep pace, as the intervals grow extravagantly:
Another 112 paces. Saturn
Another 249 paces. Uranus
Another 281 paces. Neptune
Another 242 paces. Pluto. You have marched more than half a mile! (The distance in the model adds up to 1,019 paces. A mile is 1,760 yards.) You can find a complete version at: www.noao.edu/education/peppercorn/pcmain.html

The Moon


Image credit: Lunar and Planetary Institute

Our Moon is the only natural satellite of Earth and the only other body in the solar system to be visited by mankind. It is much smaller than the Earth but is approximately the same age--about 4.6 billion years old. Earth is about 81 times heavier than the Moon and the Moon is only a little smaller than the planet Mercury (the diameter of Mercury is only 1,000 miles larger than the moon).

It would be strange to visit the Moon as there is no atmosphere and no air to transmit sound. Clapping your hands or shouting would not produce any noise on the Moon! Its gravity is very weak and you would weigh only 1/6th your weight on Earth. A rock thrown on the Moon would fall to the ground much slower than on Earth and you could jump much farther on the Moon than on the Earth. The temperature could be above the boiling point of water (reaching 260°F) or drop below -280°F at night.

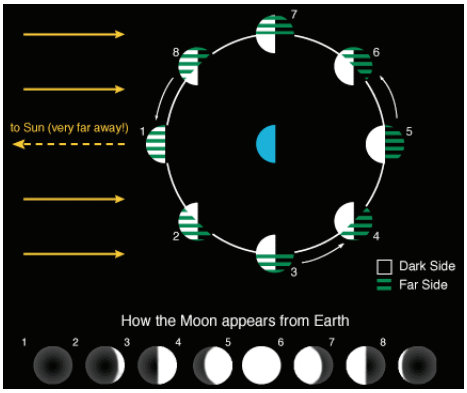
Try This!
To figure your weight on the moon, multiply your current weight by 0.165.
weight x 0.165 = weight on moon

Did you know that the word "month" comes from the rotation of the Moon around the Earth? It takes 27 days, 7 hours, and 43 minutes for our Moon to complete one full orbit around Earth. This is called the **sidereal month**, and is measured by our Moon's position relative to distant "fixed" stars. However, it takes our Moon about 29.5 days to complete one cycle of phases (from new Moon to new Moon). This is called the **synodic month**. The difference between the sidereal and synodic months occurs because as our Moon moves around Earth, the Earth also moves around our Sun. Our Moon must travel a little farther in its path to make up for the added distance and complete the phase cycle.

The Moon is the brightest object in the night sky, however, it does not produce any light of its own. The light we see from the moon is being reflected from the sun. Just as the sun shines on the planets, it shines on the Moon. However, because the Moon is rotating around the Earth and the Earth is rotating around the sun, the shape of the moon seems to change. Starting with the dark new Moon, we see the light part of the Moon "grow" from a sliver to a half to a full Moon — and then the illuminated part decreases, becoming thinner until there is no visible Moon in the sky and we are at the new Moon part of the cycle again.

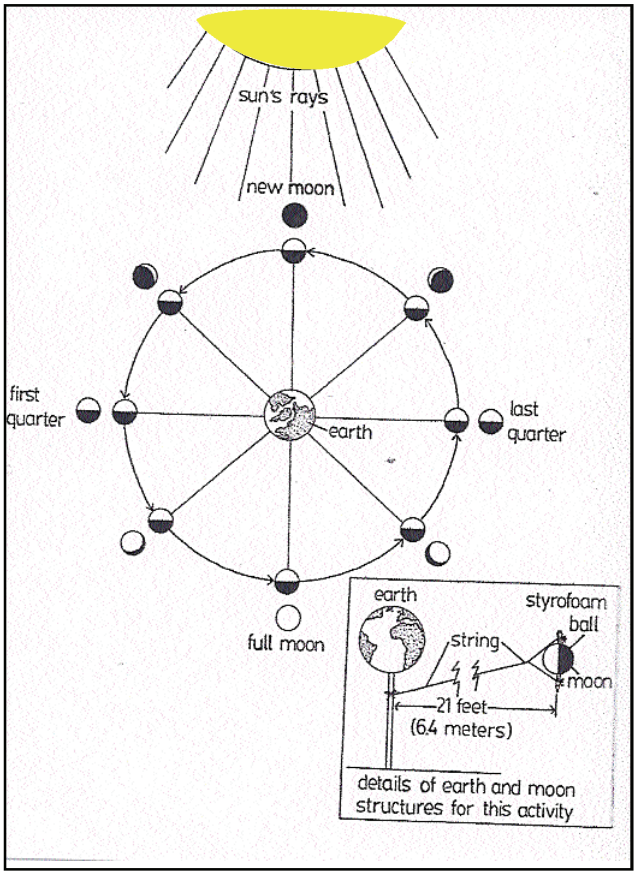
We have a "new Moon" when our Moon's orbit around Earth moves it between Earth and the Sun. From Earth, the Moon's surface looks dark because the illuminated side is facing away from Earth. As our Moon continues its orbit counterclockwise around Earth (viewed from above the north pole), more and more of the illuminated part of the Moon becomes visible to us, until it reaches the "full Moon" stage. A full Moon occurs when the Moon has moved in its orbit so that Earth is "between" the Moon and the Sun.
Between the new and full Moon, the amount of Moon we see grows — or waxes from its right side toward its left side. As it passes the full Moon stage, the amount of illumination decreases — or wanes — from right to left. Finally, the Moon returns to its position between the Earth and the Sun, and on Earth we observe the new Moon again.

In the southern hemisphere, illumination of the Moon increases from the left to the right side in the waxing phase and the dark part increases in coverage from left to right in the waning phase, which is opposite of the northern hemisphere. No matter where on Earth an observer is, however, the phases of the Moon occur at the same time.



It may appear that the Moon has a "dark side" and a "light side" but this is not really the case. The Moon is rotating on its axis just as the Earth is, however, a "day" for the moon (one complete rotation) is 27.3 Earth days! It takes our Moon the same length of time to turn once on its axis as it takes it to go once completely around the Earth! This means that Earth observers always see the same side of the Moon (called the "nearside"). The side we do not see from Earth, called the "farside," has been mapped during lunar missions.

Despite the moon's relatively weak gravitational force, the moon is close enough to Earth to produce tides in Earth's waters. (The distance from the Earth to the Moon is 238,856 miles). Since the Moon is so close to the Earth, its gravitational pull is double that of the sun. Ocean water is drawn toward both the sun and moon and builds in places, rising along the shore to form high tides. When the sun, Moon and Earth are in a line, such as during full moon and new moons, the pull on the oceans is the greatest and causes the most extreme high and low tides.



Moon Walker

from Keepers of the Night by Michael Caduto and Joseph Bruchac

Materials: styrofoam ball 2.3 inches painted black on one side, blue balloon blown up to 8.4 inches with continents drawn in green marcker, 21 feet of string plus a 1-ft piece of string, broom handle of other stick 3 foot long, yellow paper for sun.

Procedure: Insert pencil through the styrofoam ball from top to bottom along the edge of the black and white zones. Be sure the ball turns freely on the pencil and attach the ends of the 1 foot piece of string to the ends of the pencil (forming a loop). Drive the wooden stake into the ground in the center of an open area, then tape the "Earth" (blue balloon) on top of it. Tie one end of the long string loosely around the stake without winding onto it. Tie the other end to loop on the moon.

Explain that the size of the moon and Earth are accurate compared to one another but they are scaled down to 1 in = 945 mi. (The sun would have to be 75 feet in diameter and 1.6 miles away at this scale!)

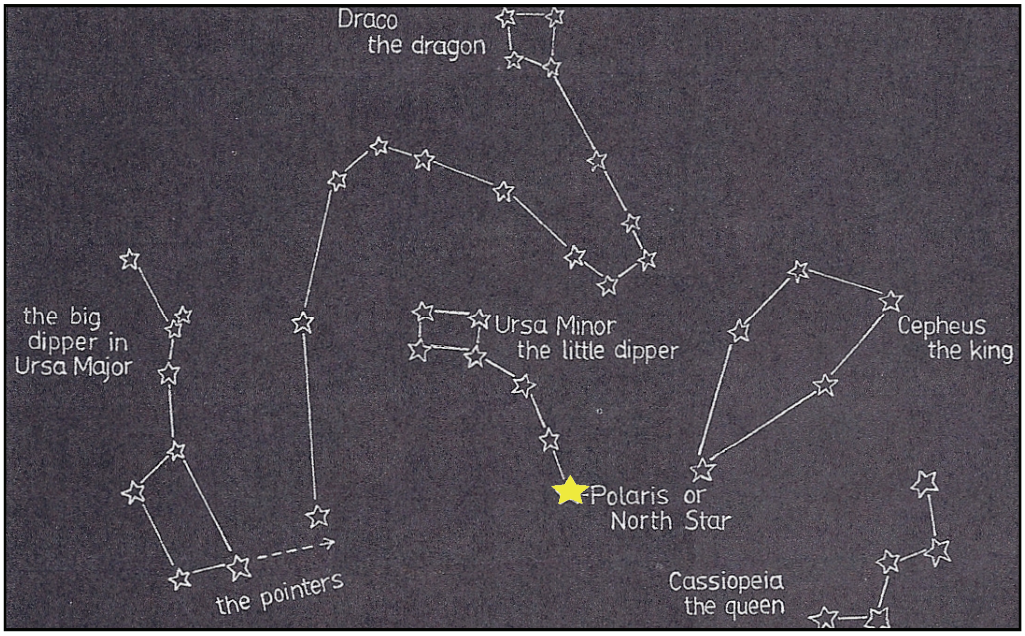
Have the children sit near Earth at the center stake. Walk the moon around Earth while keeping the light side toward the sun and the dark side (shadow) facing away from it. You will have to turn the moon on the pencil as you walk. From Earth, the children will see that the moon looks full when it is farthest from the sun and new when it is closest to the sun.

Here is a great moon cycle challenge game. Try to place the missing phase in the blank. Check out www.sciencenetlinks.com/interactives/moon/moon-challenge/moon-challenge.html

Circumpolar Constellations

Constellations are formed of bright stars that cover certain areas in the sky. Virtually all cultures created their own patterns in the sky based on stories and people that were important to them. Most of the constellations with which we are familiar come from ancient Greece. There are 88 constellation of which 41 can be seen from the Northern Hemisphere.

Because of the rotation of the Earth and its orbit around the Sun, we divide the constellations into two groups. Some constellations never rise or set, and they are called **circumpolar**. All the rest are divided into seasonal constellations. Which constellations will be circumpolar or seasonal depends on your latitude.

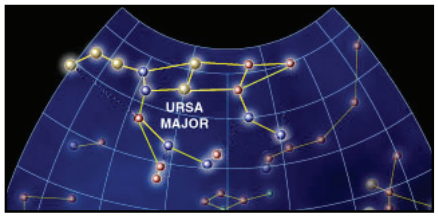


Circumpolar Constellations in the Northern Hemisphere

Creating Constellations

Make a map of the circumpolar constellations by gluing "stars" such as dried beans or grains, onto a cardboard sky. Use a different kind of dried pea, bean, or rice for each constellation, with all the stars in any specific constellation being marked with the same kind of bean, etc. Tell a story about each constellation as you glue on the stars.

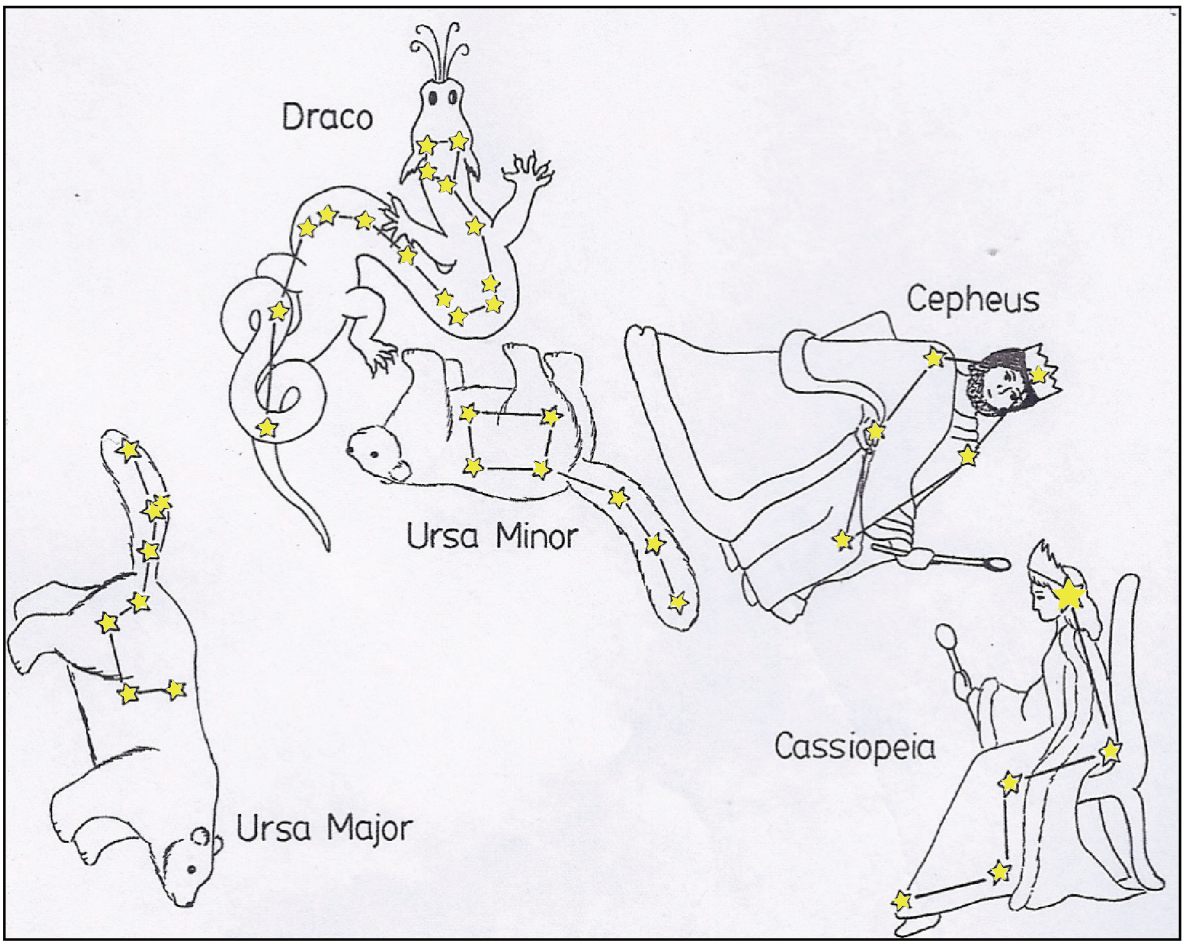
The most well-known star in the night sky (for those of us in North America) is **Polaris** or the North Star. It is the closest star to the celestial north pole, hence, the name North Star. Polaris is really a triple star system 430 light years away. Because it is always visible and "above the north pole" , this star can be used to guide travelers north. Many escaped slaves traveled at night and followed the North Star to find their way to freedom. The **Big Dipper** is, without doubt, the most famous constellation. It is actually only a part of the constellation **Ursa Major**, or the **Great Bear**. Interestingly, several different cultures saw a bear in this constellation, though some saw a dog. The Native Americans knew the great bears lived in the north and described this constellation as a bear. The Greeks told the version that Hera discovered Zeus having an affair with Callisto and turned her into a bear. Zeus put her in the sky along with her son, Arcas, who became the Little Bear. If you connect the stars on the outer edge of the "bowl" of the Big Dipper in a straight line, they will point directly to Polaris. Polaris is actually the last star in the handle of the **Little Dipper** or **Ursa Minor** (**Little Bear**)



Cassiopeia has a very distinct shape. She looks like a "W" or "M" in the sky, depending on where she is. Cassiopeia was the wife of King Cepheus, the king of Ethiopia. She was very pretty, and would often brag that she and her daughter were more beautiful than the sea nymphs, the Nereids. They complained to Poseidon, who sent a monster to Cepheus' land. In order to save their country, the king and queen sacrificed their daughter, Andromeda. Just before the monster, named Cetus, ate the princess, Perseus saved her. All five figures are represented in the sky as constellations. *(Editor's note: For an easy and funny play based on this story developed by National Park Rangers at Bryce National Canyon, contact me.)*

Cepheus looks like a house. The point on top is a special star called a cepheid or a pulsating variable. Cepheids are extremely important to astronomers because their periodic changes in brightness can be used to figure out how far away they are.

Draco is only present in the Northern Hemisphere, so those living in the Southern Hemisphere will never see this long constellation.Its name is Latin for dragon.The easiest way to spot Draco is by finding his head. It consists of four stars in a trapezoid. From there, the tail slithers through the sky, ending between the Big and Little Dippers. There are many stories regarding this dragon, however, the most widely told involves the eleventh feat of Hercules. According to legend, Hercules was to steal the golden apples of Hesperides guarded by Ladon (the dragon). Hercules used music to put the beast to sleep and walk away with the apples. Hera took pity on the beast and put it in the sky.



The images of the circumpolar constellations as they are imagined in the night sky. *From Keepers of the Night by Michael Caduto and Joseph Bruchac*

Why the North Star Does Not Move (Paiute Story)

Long, long ago, when the world was young, the People of the Sky were so restless and travelled so much that they made trails in the heavens. Now, if we watch the sky all through the night, we can see which way they go.

But one star does not travel. That is the North Star. He cannot travel. He cannot move. When he was on the earth long, long ago, he was known as Na-gah, the mountain sheep, the son of Shinoh. He was brave, daring, sure-footed, and courageous. His father was so proud of him and loved him so much that he put large earrings on the sides of his head and made him look dignified, important, and commanding.

Every day, Na-gah was climbing, climbing, climbing. He hunted for the roughest and the highest mountains, climbed them, lived among them, and was happy. Once in the very long ago, he found a very high peak. Its sides were steep and smooth, and its sharp peak reached up into the clouds. Na-gah looked up and said, "I wonder what is up there. I will climb to the very highest point."

Around and around the mountain he travelled, looking for a trail. But he could find no trail. There was nothing but sheer cliffs all the way around. This was the first mountain Na-gah had ever seen that he could not climb.

He wondered and wondered what he should do. He felt sure that his father would feel ashamed of him if he knew that there was a mountain that his son could not climb. Na-gah determined that he would find a way up to its top. His father would be proud to see him standing on the top of such a peak.

Again and again he walked around the mountain, stopping now and then to peer up the steep cliff, hoping to see a crevice on which he could find footing. Again and again, he went up as far as he could, but always had to turn around and come down. At last he found a big crack in a rock that went down, not up. Down he went into it and soon found a hole that turned upward. His heart was made glad. Up and up he climbed.

Soon it became so dark that he could not see, and the cave was full of loose rocks that slipped under his feet and rolled down. Soon he heard a big, fearsome noise coming up through the shaft at the same time the rolling rocks were dashed to pieces at the bottom. In the darkness he slipped often and skinned his knees. His courage and determination began to fail. He had never before seen a place so dark and dangerous. He was afraid, and he was also very tired.

"I will go back and look again for a better place to climb," he said to himself. "I am not afraid out on the open cliffs, but this dark hole fills me with fear. I'm scared! I want to get out of here!"

But when Na-gah turned to go down, he found that the rolling rocks had closed the cave below him. He could not get down. He saw only one thing now that he could do: He must go on climbing until he came out somewhere.

After a long climb, he saw a little light, and he knew that he was coming out of the hole. "Now I am happy," he said aloud. "I am glad that I really came up through that dark hole."

Looking around him, he became almost breathless, for he found that he was on the top of a very high peak! There was scarcely room for him to turn around, and looking down from this height made him dizzy. He saw great cliffs below him, in every direction, and saw only a small place in which he could move. Nowhere on the outside could he get down, and the cave was closed on the inside..,

"Here I must stay until I die," he said. "But I have climbed my mountain! I have climbed my mountain at last!

He ate a little grass and drank a little water that he found in the holes in the rocks. Then he felt better. He was higher than any mountain he could see and he could look down on the earth, far below him.

About this time, his father was out walking over the sky. He looked everywhere for his son, but could not find him. He called loudly, "Na-gah! Na-gah!" And his son answered him from the top of the highest cliffs. When Shinoh saw him there, he felt sorrowful, to himself, "My brave son can never come down. Always he must stay on the top of the highest mountain. He can travel and climb no more.

"I will not let my brave son die. I will turn him into a star, and he can stand there and shine where everyone can see him. He shall be a guide mark for all the living things on the earth or in the sky."

And so Na-gah became a star that every living thing can see. It is the only star that will always be found at the same place. Always he stands still. Directions are set by him. Travellers, looking up at him, can always find their way. He does not move around as the other stars do, and so he is called "the Fixed Star." And because he is in the true north all the time, our people call him Qui-am-i Wintook Poot-see. These words mean "the North Star."

Big Dipper Star Clock

Originally developed by Dennis Schatz and Andrew Fraknoi for Family ASTRO. The Star Clock pattern was adapted from the book *Astro Adventures* by Dennis Schatz and Doug Cooper, 1994 by the Pacific Science Center. This version is from Astronomy from the Ground Up.

You don't need a watch to tell what time it is at night as long as you can find the Big Dipper. Long before digital watches or even grandfather clocks, people used the sky to tell time at night.

1. Carefully cut out the two circles from the pattern (page 14).
2. Punch a hole in the middle of each circle.
3. Put a brass fastener through the two holes. the black circle with the notch and the words "THE TIME IS" should be on top.
4. Make sure the wheels can turn smoothly around the fasteners. You may have to make your holes a little bigger if they don't.

Using the Star Clock

Do this when the sky is relatively clear. Have participants **face north** and see if they can find the pattern of seven stars that make up the Big Dipper or the five that make up Cassiopeia. They can look at the star clock to see how this group of stars looks. **HINT:** In the fall, you can see the Big Dipper in the northwest after the sun has set (and it seems to be upside down). In the winter, it is low on the northern horizon and somewhat harder to see in the evening especially if hills, buildings or trees block your view of the horizon. In the spring, you can see it standing on end toward the northeast in the evening sky.

Participants should then go through the following steps to read the time:

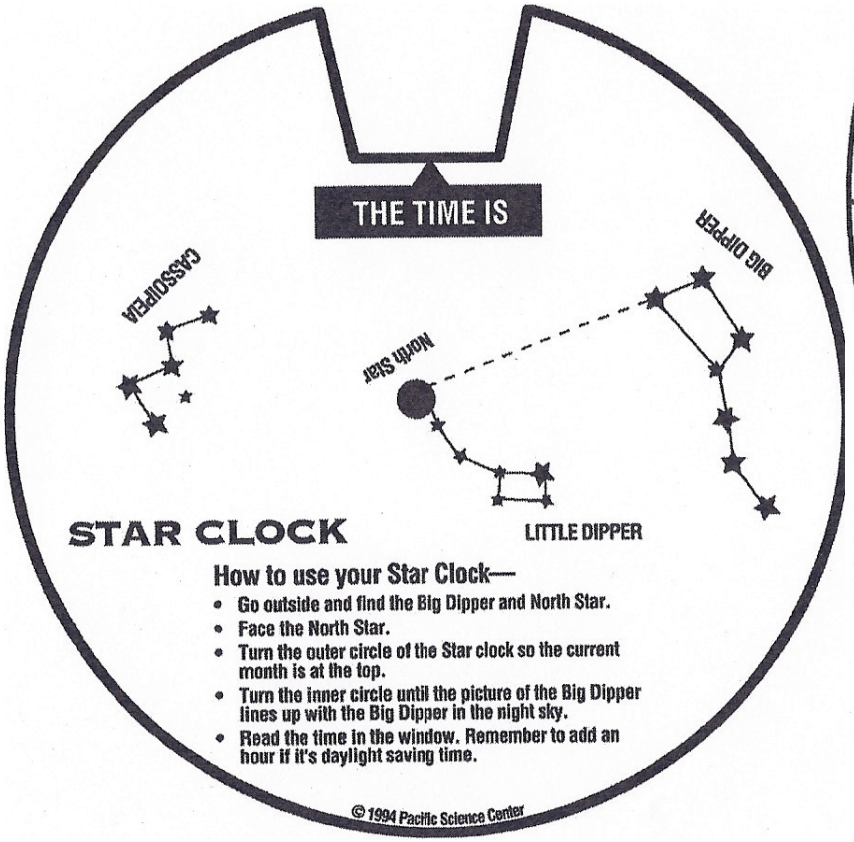
1. Turn the outer circle of the Star Clock so that the current month is on top.
2. Turn the inner circle until the picture of the Big Dipper on the star clock lines up with the Big Dipper in the real sky. To check if you are right, see if the Little Dipper and Cassiopeia are lined up the right way too.
3. Now read the time in the window. That's roughly the time, provided that you are on standard time. Add an hour if you are on daylight savings time.
4. Check your "star time" against a modern watch or clock. How close did you come?

If you need a light to read your clock, remember to use a red light. See the *ABC's of Stargazing* on pg 18.

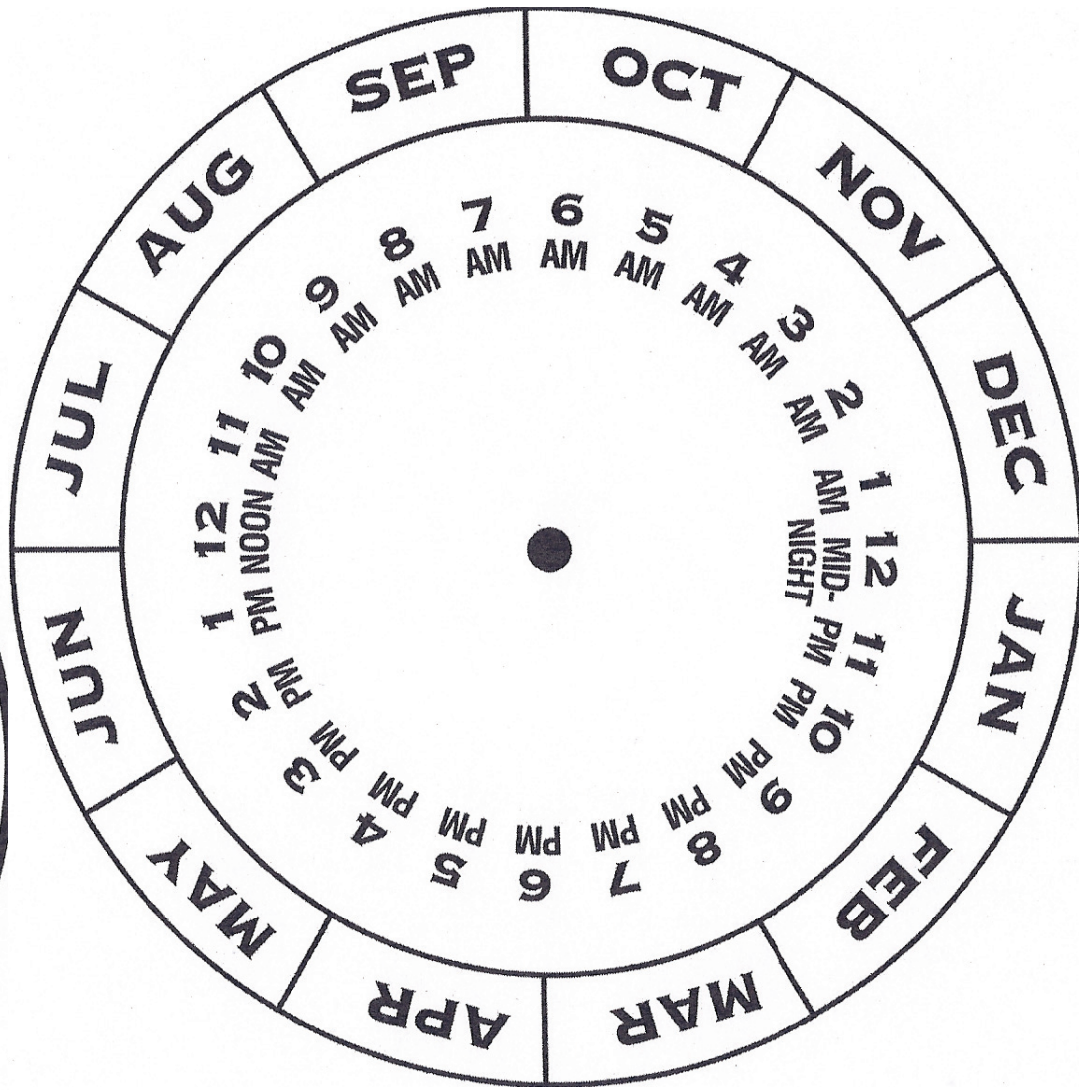
Practicing the Use of the Star Clock Indoors

If you do this activity inside and/or during the daytime, participants can still practice the use of their star clocks. Copy the pattern of stars from the Star Clock onto a large piece of paper or, for something more permanent, onto a circle of plywood. Rotate this large diagram to a certain position and hang it on the wall at the front of the room. Have participants practice using the star clocks by the process outlined above. Stress that this is not the actual time and it is just a way of practicing.

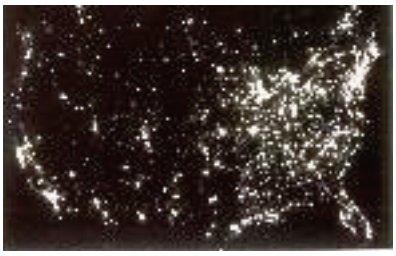
Star Clock Inner Wheel



Star Clock Outer Wheel



Light Pollution



The U.S. at night. Photo from International Dark Sky Association

Here's a kind of pollution I bet you haven't given much thought to--light pollution. **Light pollution is excessive and inappropriate artificial light.** It is an increasing problem threatening astronomical facilities, ecologically sensitive habitats, all wildlife, our energy use as well as our human heitage.The four components of light pollution are often combined and overlapping:

Urban sky glow- the brightening of the night sky over inhabited areas
Light trespass - light falling where it is not intended, wanted, or needed
Glare- excessive brightness which causes visual discomfort. High levels of glare can decrease visibility.
Clutter- bright, confusing, and excessive groupings of light sources, commonly found in over-lit urban areas. The proliferation of clutter contributes to urban sky glow, trespass, and glare.

There are many problems surrounding excessive lighting. Some problems are obvious but some are not.

Light Pollution is Wasteful

In one word, light pollution is wasteful!Lighting is responsible for one-fourth of all energy consumption worldwide. Just in the U.S., light pollution wastes billions of dollars annually. Some figures measure the cost of this waste at 5-10 billion dollars. The generation of electricity to power the wasted light uses hundreds of thousands of tons of coal or hundreds of millions of barrels of oil not to mention this creates additional air pollution from the burning of these fossil fuels. There are many ways to improve lighting quality while reducing energy use and greenhouse gas emissions as well as lowering costs.

Light Pollution Harms Wildlife

According to the IDA guide *Effects of Artificial Light at Night on Wildlife*, "Light pollution has been shown to disorient migratory birds and hatchling turtles, disrupt mating and reproductive behavior in fireflies and frogs, and interfere with communication in species from glowworms to coyotes." As pointed out in the brochure, climate characteristics vary from year to year; it may not be uncommon to experience cool summers, dry springs, or slow falls. However, a season's photoperiod is the only consistent factor in the natural environment. Many species of plants and animals rely on the length of the day to indicate the proper season for mating, molting, and other activities. Some species are even able to discern a discrepancy in natural light as short as one minute! So, enter artificial lighting.

Reproduction cycles are the most likely cycle to be interrupted by artificial lighting. Trees can bud early, flowers can quit blooming, squirrels and robins mate out of season, and frogs, toads, and salamanders may be unable to return to home ponds to breed. One of the most dramatic disruptions of reproduction has been demonstrated with sea turtles. Female sea turtles like to nest on remote and very dark beaches. Coastal light interfere with their ability to find a safe nesting area for their eggs. Newly hatched sea turtles crawl instinctly toward the ocean because of the reflection of the moon and the stars on the water. For centuries, this reflection was the brightest point of light on a beach. Artificial lights can

Hatchling sea turtles photographed in infrared. Photo by US Fish & Wildlife Service.

confuse hatchlings and cause them to crawl away from the oceans and onto roads or into communities. They may become too exhausted or too dehydrated to find their way back to the ocean. Learn more about local and regional action to save sea turtles by visiting **www.seaturtle.org**

Lights on tall structures can disorient migrating birds. Estimates by the U.S. Fish and Wildlife Service of the number of birds killed after being attracted to tall towers range from 4-5 million per year to double that. The Fatal Light Awareness Program (FLAP) works with building owners in Toronto, Canada and other cities to reduce mortality of birds by turning out lights during migration periods. Similar disorientation has also been noted for bird species migrating close to offshore production and drilling facilities. New lighting techniques are reducing bird mortalities in many cases.

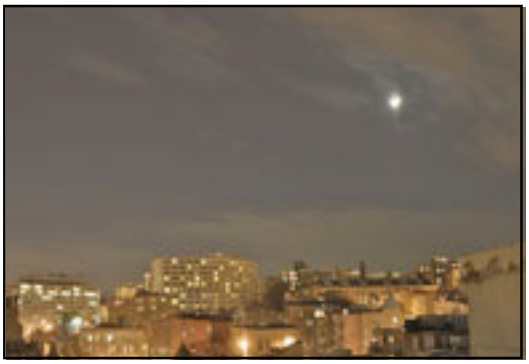
Moths and other insects are attracted to artificial lights and may stay near them all night. This causes populations to fall because it interferes with mating and migration and it makes them unnaturally easy prey for bats and other nocturnal predators. It also can disrupt pollination of night blooming flowers (such as certain cactus) which depend on certain species of moth for proper pollination.

Light Pollution May Harm Human Health

Medical research on the effects of excessive light on the human body suggests that a variety of adverse health effects may be caused by light pollution or excessive light exposure. Health effects of over-illumination or improper spectral composition of light may include: increased headache incidence, worker fatigue, medically defined stress, decrease in sexual function and increase in anxiety. Several published studies also suggest a link between exposure to light at night and risk of breast cancer, due to suppression of the normal nocturnal production of melatonin.The effects of excessive light on human health can be thought of much like the issue of second hand smoke in the 1970's. Researchers were just starting to look into the effects of second hand smoke back then. Many people laughed at the idea that one person could smoke and another person could be harmed. Today, we know that this is in fact the case.

Light Pollution Robs Us of Our Natural Heritage

Light pollution destroys the views of the heavens that man has enjoyed since the beginning of time. Ninety percent of all Americans live under skies that are "negatively impacted" by light pollution, while over half can not even see the Milky Way from their homes. This is a shame. Mankind has throughout history looked to the stars to try to understand events around them.



Light pollution over Washington, D.C. Photo coutesy of International Dark Sky Assoc.

There is growing awareness of this problem and more information can be found at several sites. National Geographic magazine recently published an article on light pollution in the Nov 2008 edition. This can be found at: **ngm.nationalgeographic.com/2008/11/light-pollution/klinkenborg-text.** The International Dark Sky Association (IDA) is in the forefront of combating this problem. Many of their brochures and pictures were used as sources for information in this article.The mission of the International Dark-Sky Association is to preserve and protect the nighttime environment and our heritage of dark skies through environmentally responsible outdoor lighting. More information can be found at **www.darksky.org**

Ways to Combat Light Pollution

Of all the pollution we face, light pollution may be the easiest to remedy. Reducing light pollution means reducing sky glow, reducing glare, reducing light trespass, and reducing clutter. It must be stated clearly that no organization that advocates reducing light pollution advocates eliminating all light at night! Instead, groups focusing on light pollution emphasize the need to **reduce** light pollution. The method for best reducing light pollution depends on exactly what the problem is in any given instance.

Possible solutions include:

***Shield your outdoor lighting.**

Example of unshielded light where much of the light is going to the side or up. Photo from Dark Sky International.

Example of shielded light where the light is directed down. Photo from Dark Sky International.

A full cutoff fixture, when correctly installed, reduces the chance for light to escape above the plane of the horizontal. A shielded light uses less wattage and saves you money.

***Only use the light when you need it.**
***Use timers and dimmers**
***Shut off lights when you can**
***Use only enough light to get the job done**
***Use long wavelength light with a red or yellow tint to minimize impact**

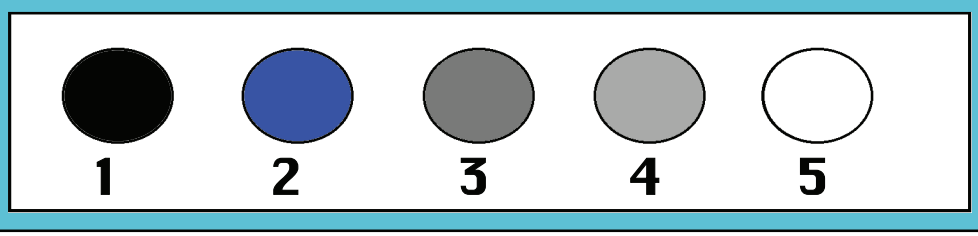
Look for the seal of approval for dark sky friendly lighting fixtures.

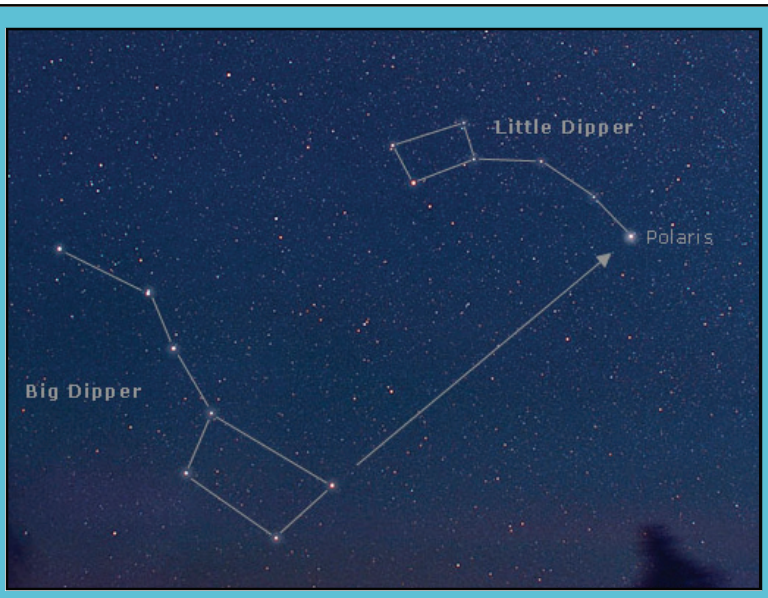
How Light Pollution Affects the Stars: Magnitude Reader

Use a penny to trace five circles on a piece of thin cardboard about 1" x 5" (example: cereal box)
The circles should make a straight line and be evenly spaced apart. Cut out each circle.

Tape or glue a piece of cellophane (clear plastic wrap) across the back of your cardboard, covering all holes. Make sure not to get glue or tape on any of the holes. It will obstruct your view later.

Next tape or glue a piece of cellophane over the last four holes, once again avoiding glue or tape on the holes. Repeat this step covering the last three holes, then two, then the last hole. The result should be that each hole should have one more piece of cellophane than the previous hole. You now have a tool for measuring the magnitude of stars. Label the hole with one piece of cellophane 5, the second one 4, and so forth, until you get to 1.
When viewing a star, the number you can see the star faintest through (i.e. you can't see the star in hole 2 but you can faintly see it in hole 3) is the magnitude of the star. Remember: the lower the number, the brighter the star





Find the constellation of the Big Dipper in the night sky. Use your magnitude reader to view each star in the Big Dipper. On a drawing of the Big Dipper, write down which number you can see the star faintest through. Do this for each star in the drawing. You now have a magnitude for each star in the constellation. Record the lighting situation where you viewed the Big Dipper. Are the lights bright? Are they dim?

Class Discussion: Compare your results to the rest of the class. How did each star compare to the other students data in each of their lighting situations? In brighter lights,were the stars dimmer or brighter? How accurate is this data?

The ABC's of Stargazing

Choose a clear, dark night. Do not choose a night when the moon is full. In fact, the first quarter moon (right half illuminated) and full moon are the worst times for evening viewing. A new moon or third quarter moon are the best times for stargazing in the evening. The moon even looks better through binoculars or a telescope when it is not full.

Find a place that is as dark as possible, away from house lights or street lamps. Light pollution has become a serious problem for stargazing, and in most places, it is getting worse.Unless you live in one of the mega-cities, just driving 15-25 miles into the country can make a big difference. Since much of the sky's action takes place in the southern half of the sky, it's good to try to find a viewing location south of your city.

Give your eyes time to adjust to the dark. It takes our eyes 20-30 minutes to adjust to seeing in the dark. (This is called **dark adaptation**. Your pupils will open wide, letting in more light, and chemical changes will occur, making your eyes more light sensitive.) *White light is taboo when stargazing***.** Any white light such as a flashlight or headlights on a car can immediately reverse your dark adaptation and you must wait again for your eyes to adjust.

Use a red flashlight. Since red light enables us to see while preserving our dark adaptation, a red flashlight is an essential part of stargazing equipment. Any flashlight can be converted by covering the light with red cellophane (red plastic wrap) or painting the glass with a red marker. Even red light, if it is too bright, will affect dark adaptation, so it's best to keep the light subtle. And please don't shine even a red flashlight in someone else's face.

Lie on your back if possible and hold very still. You may want to bring a reclining lawn chair for this or at least a blanket to lay on. If you have binoculars, you may try and use them but be sure to hold them steady (which is why you may want to lay down for this).

Dress for the weather and bring some snacks. It is always cooler when you are not moving around so plan as if it is 20°F cooler than it really is. Snacks are good but not around telescopes!

How Children Observe the Universe

Several interesting studies involving children's perceptions of the solar system have been conducted. One was conducted in 1998 in New Zealand by John Dunlop. Children ages 7-`14 years were surveyed before and after visits to the Auckland Observatory and some shocking misconceptions were common Several children indicated that the Earth orbited the Sun daily or the Moon blocked the sunlight to cause night when asked about what causes night and day. Even after teaching, only 20% mentioned the Earth spinning as the cause of night and day. Furthermore, three of eight 13-year olds believed that the Moon orbits the Sun and two held that belief after teaching.

Moon phases was the concept least understood in this study. Nobody correctly showed how the change in Sun-Earth-Moon angle caused particular phases. The idea of the Earth, clouds or something else blocking the light from reaching the Moon as the cause of Moon phases was popular. These results clearly indicate that this is a difficult concept for children and more time probably should be spent with clearly shaded scale 3-D models of the Earth and Moon.

Explaining why summer and winter happen was a very hard question for children to answer, with a quarter not even trying before their visit and 19% not answering post-test. Some misconceptions found in other studies was found in this one as well. Clouds as the cause of winter was a choice made by some. The combination of Earth's tilt and yearly orbit producing the changing day length and sun angle, which, in turn, causes seasons is a concept considered too difficult by some for primary school children. Seasons scored the worst, with just 19% achieving a 'scientific understanding' of this concept.

Some other concepts that are involved in a correct understanding of the way things behave in space are force and motion. Most high school students did not correctly understand that all objects exert a gravitational force. Most thought of gravity as holding down something and thought of it as being connected with air pressing down and an atmospheric shield that prevented things from floating up. Another concept that affects understanding is the nature of light. Most young children do not use the scientific model (that light is either produced by something like the Sun or reflected from a non-luminous object such as the Moon.) About 1/3 believe that some kind of light travels from the eye to the visible object. A year later, half the group still stated that something was emitted from the eyes during the seeing process. Children aged 10-14 rarely expressed the idea of light moving through space, often thought it stayed near objects, sometimes did not associate diffused daylight with the Sun, and often attributed the eye with the power to send out light. Another common misconception found in several studies was that light did not travel very far in the daytime.

Adults are not immune to misconceptions either. A survey of 1,120 American adults found that 45% believed the Sun was not a star. Over one-half of students in an introductory geology course at the University of Illinois could not explain the causes of seasons. All the studies reviewed suggested that adults retain misconceptions common among children. Thus, it is not surprising that most children and adults are unable to explain Sun-Earth-Moon concepts. The importance of adult misconceptions increases significantly when they become teachers.

What does this mean for teaching?

* Present children with realistic models of the Earth-Moon-Sun system or they may well incorporate the inaccuracies of teaching aids into their mental models.
* Beware of written test results--they may grossly under-report real understanding, especially in younger children. Try comparing children's before and after drawings instead.
* Listen to children and take their ideas seriously, or they will probably squeeze bits of adult explanations into their own unique view of how the Universe is.

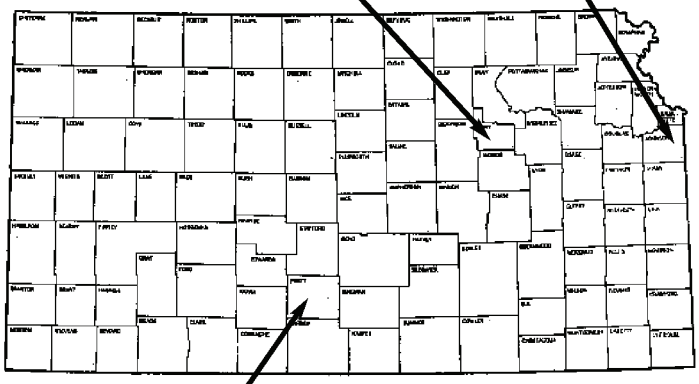
www.atnf.csiro.au/pasa/17_2/dunlop/

On TRACKS is published by the Kansas Department of Wildlife & Parks several times during the school year.

The purpose of On TRACKS is to disseminate information and educational resources pertaining to the natural, historic, and cultural resources of the prairie, emphasizing Kansas ecology. Information is presented from the perspective of current scientific theory.

Pat Silovsky
Milford Nature Center
3115 Hatchery Dr.
Junction City, KS
(785) 238-5323
pats@wp.state.ks.us

Alaine Neelly Hudlin
The Prairie Center
26325 W. 135th St.
Olathe, KS 66061
(913) 856-7669
alaine@wp.state.ks.us



Mike Rader
Pratt Headquarters
512 SE 25th Ave
Pratt, KS 67124
(620) 672-0708
miker@wp.state.ks.us

Editor:
Pat Silovsky

Contributing Authors:
Pat Silovsky

Editorial Assistant:
Shelby Stevens

KANSAS WILDLIFE & PARKS

Wildlife Education Service
512 SE 25th Avenue
Pratt, KS 67124

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