

ST[EMpower]



SCIENCE, TECHNOLOGY,
ENGINEERING, AND MATH
COLORADO STATE UNIVERSITY
EXTENSION

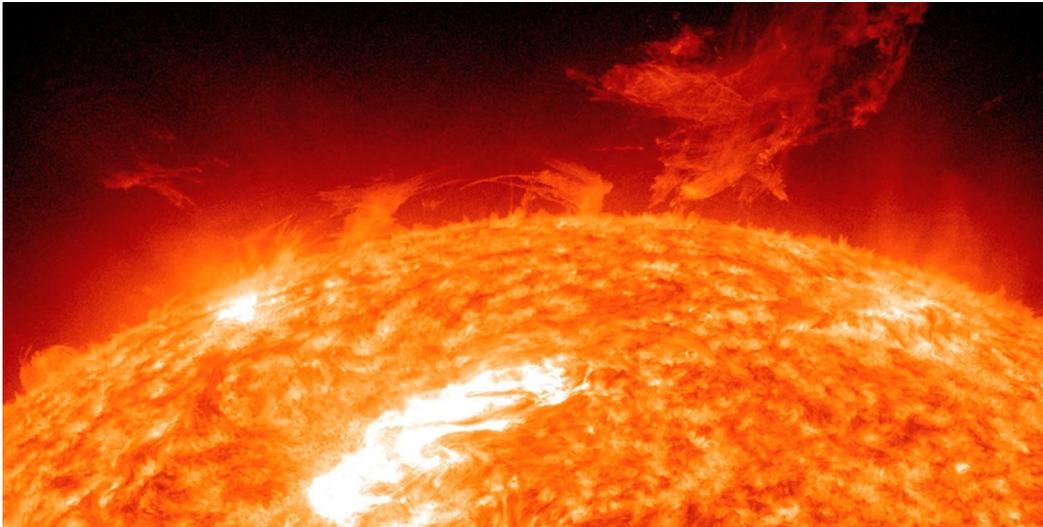
HERE COMES THE SUN!

Issue 47
Dec 2018

CAREERS

Page two lists more than 30 careers related to Solar Science. Before we start looking at these careers, let's pause to consider how you want to live when you are on your own.

- This month's career section is going to explore a bit about the lifestyle you want when you are on your own.
- January's career section will explore education options (2 year Associate's Degree, 4 year Bachelor's Degree, or advanced degree (Master's Degree or Ph.D.).



BACKGROUND

Our Sun is a mid-sized yellow star. Nothing remarkable about our star when comparing it to the other ~100,000,000,000 (estimated one hundred billion) stars in the Milky Way Galaxy.

Our star, however, is home to the only known solar system to harbor life. Our star is fairly stable, an important component for life. The Earth falls in the **habitable zone**, the range surrounding a star which could support liquid water. Water is the one component every lifeform on Earth needs to survive. Not too bad for an average star!



The Sun is 109 Earths in **diameter** (864,000 miles), and it could fit 1.3 million Earths inside it! The image on the right has 1,300,000 blue marbles representing the Earth inside the transparent sphere representing the sun!

The Earth's **orbit** around the sun is not a perfect circle around the sun, but **elliptical**, or oval shaped. The Earth's average distance is 93 million miles, but that varies from 91



Your lifestyle has several factors to consider (these are in no particular order):

- Family
 - Your father, mother, siblings
 - Your extended family
 - Starting your own family
- Friends
- Religious beliefs
- Your health
- Your community
- Activities you enjoy
- Your values
- Your job
 - Career
 - Income

These are factors that influence who you are. Over the past two years, these ST[EMpower] issues have been focusing on your interests and the activities you enjoy to

direct you towards a satisfying career. Your values are shaped by the important people in your life, starting with your family.

This issue is going to explore what you envision for your lifestyle. This will help you determine how much money you would like to make.

Let's make some assumptions:

- You are 25 years old, or 30 years old if you select a doctorate degree (People working on doctorate degrees are usually in their late 20s or early 30s.).
- You are living in the county you are living in right now (a bit easier for getting the information you need).
- You have a high school diploma.
- You have (pick one):
 - No additional education
 - Two-year Associate's Degree (includes technical schools and community colleges)
 - Four-year Bachelor's Degree
 - Master's Degree
 - Doctorate degree (i.e. Ph.D. (doctorate in philosophy), M.D. (medical doctorate), E.D. (educational doctorate), D.V.M. (doctorate in veterinary medicine), etc.)
- You are single.
- Do you have a roommate or spouse?
- If you do, the roommate or spouse contributes equally.
- You do not have children.

The basic amount of money you need to live varies with

million miles, called the **perihelion** (January) to 94.5 million miles (in July) called the **aphelion**. The winter in the Northern Hemisphere has nothing to do with how far the Earth is from the sun! That is when we are the closest! Light travels at 186,282 miles per second. If you could travel at that speed, you could circle the Earth 7.5 times in one second! It takes light from the sun 8 minutes 20 seconds to travel to the Earth.

There are many careers related to solar science: Astronomy, Astrophysics, Atmospheric Chemistry, Atmospheric Dynamics, Biogeochemistry, Climatology, Computer Science, Education, Emergency Management, Engineering (Aerospace, Civil, Environmental, Mechanical, and Software), Environmental Science, Geography, Geology, Hydrology, Hydrometeorology, Land-Use Planning, Mathematics, Meteorology (Agricultural, Global-Scale, Mesoscale, Microscale, Physical, Satellite, and Synoptic-Scale), Oceanography, Physics, Sociology, and Weather Forecasting. That's a plethora of interesting careers! Check the yellow side bar starting on page 1. This month is exploring your lifestyle. Having a better grasp of what you envision for your future is also a factor in career exploration.

Objectives—you will:

- Have fun!
- Build the model of the sun by layers.
- Discuss what happens in each layer and at each interface of the sun.
- Eat your way through the sun!
- Build a pinhole projector to safely view the sun.
- Record your observations and truth-source them to NASA SOHO Satellite information.
- Explore concepts of microclimates through an experiment how temperature varies around your house.
- Map your yard and determine the microclimates that exist.
- Design a native garden, researching different plants that will thrive in the different microclimates.
- Build a 3D topographic map.
- Experiment albedo's reflecting and absorbing properties.
- Examine the topographic map to identify how solar **radiation** varies.
- Examine the topographic map to identify how landscape blocks or funnels the wind.
- Examine the topographic map to identify watersheds.
- Build a topographic map of Colorado challenge.
- Build a solar oven challenge.
- Explore careers related to solar science.
- Envision your future lifestyle when you are out on your own.

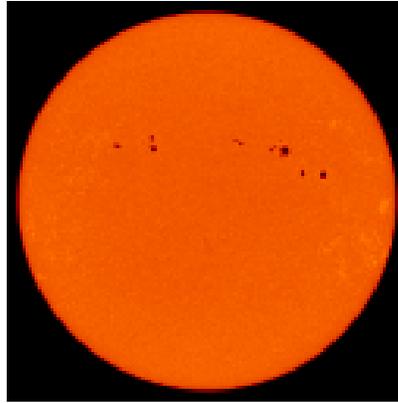


NASA Atmospheric Chemist Andreas Beyersdorf holding a wing-mounted cloud instrument

THE SUN CAKE!

DO

“What is a sun cake?” you ask in all innocence. Well, it is perhaps the best (and most delicious) model of the sun that has ever been developed! This model of the sun is enormous, so plan to make it for a party! You will need about 3 hours to make all the components, and you could make it over several days, if you cover with plastic wrap to keep it fresh. The cake will serve about 30 people.



SOHO Michelson Doppler Imager
Stanford University – NASA

Materials:

- Oven
- 1 metal mixing bowl about 8-10 liters (32-40 cups) referred to as “large”
- 2 metal mixing bowls about 4-5 liters (16-20 cups) referred to as “medium”
- 2 metal mixing bowls about 2.5-3 liters (10-12 cups) referred to as “small”
- Hot pads
- Cooling rack
- Large serrated knife
- Large mixer
- 2 angel food cake mixes
- 2 gingerbread cake mixes (you can substitute spice cake)
- 1 brownie mix
- Oil (amount as specified on the brownie mix directions)
- Extra oil for brownie and gingerbread bowls (to prevent sticking while baking)
- Eggs (amount as specified on the mix directions)
- Water
- 3 cans cream cheese or white frosting
- 1 can chocolate fudge frosting
- About 1 oz yellow food coloring
- Toothpicks or bamboo skewers (to test for doneness)
- 1 small package chocolate chips
- 1 small package red whip licorice (you want the thinnest licorice)
- Aluminum foil
- Platter – larger than the opening of largest metal mixing bowl (or as an alternative, get a large cardboard box, cut it down and cover with aluminum foil.)
- Birthday candles
- Matches

Directions for Cake:

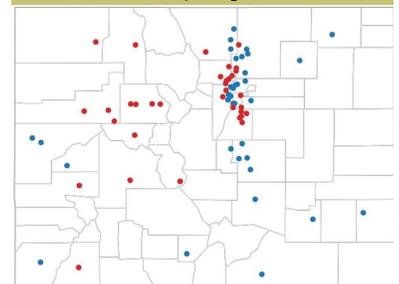
1. Angel Food Cake: If you have two ovens, see step 3 first. If not, start here.
2. Set the two racks in your oven: one rack for the cake, and another rack above it to steady the “medium” mixing bowl. This mixing bowl

where you live (state, county, city/town). In Colorado, Vail comes in as the most expensive place to live. The other 9 most expensive places to live are:

2. Aspen
3. Steamboat Springs
4. Carbondale
5. Avon
6. Eagle
7. Glenwood Springs
8. Gypsum
9. Rifle
10. Durango

On the flip side, here are the ten least expensive places to live in Colorado (out of 71 cities/towns), starting with the least expensive:

1. Lamar
2. La Junta
3. Pueblo
4. Trinidad
5. Alamosa
6. Fountain
7. Colorado Springs
8. Woodland Park
9. Cortez
10. Manitou Springs



This map indicates the most expensive (red dots) and least expensive (blue dots) places to live in Colorado. The map was generated by calculating only the necessities:

- Housing
- Food
- Health Insurance
- Utilities
- Transportation, including gas

Materials:

- Local newspaper (Sunday edition usually has the most classified ads)
- Computer with internet
- Notebook
- Pencil
- Eraser
- Tape
- Worksheets pages 31-33
- Optional colored pencils
- Optional markers

The worksheets for this activity (pages 31-33) will guide you through the steps. To complete the worksheet, you will need the internet and a newspaper from the county. You can either go to your community library to use the local newspaper and a computer with the internet, or buy the paper if you have internet access at home.

To enhance this activity, buy an inexpensive notebook. Label the notebook, "On My Own." You can look through magazines or the computer to find pictures and descriptions of things you like, copy/print (if you are in the library) or tear out the image (make sure that is okay with your parents/guardians), and tape them in your notebook. If you are artistic, you can also sketch your ideas into your notebook.

Include the cost of the items. This can include anything that you like or interests you. If you really want that 2019 Porsche 718 Cayman sports car, include pictures, cost, find out how much insurance will cost. This is a dream book of the material items you would like in

will create a well in the angel food cake batter as it rises around the "medium" bowl. (See the photograph of the oven. The yellow arrows point to the bottom rack and the angel food cake pan. The green arrows point to the upper rack and the bowl set in the angel food batter to make the indentation that will nest the next layer.) Preheat your oven according to the cake package directions. Even though you have two cake mixes baking in the "large" mixing bowl, the "medium" mixing bowl acts like a bunt cake pan, and this cake will do just fine at its regular temperature. It may increase the amount of time it takes to bake, but only 5-10 minutes.



- You can use the "large" mixing bowl as the mixing bowl.
 - Add both packages of angel food cake mix, and follow the directions on the back of the box, remembering to double everything you add. Mix well.
 - Do NOT oil the "large" mixing bowl. Egg whites will not whip up if any oil or egg yolk traces get into the batter.
 - When the oven has reached temperature, set the "medium" mixing bowl in the middle of the "large" mixing bowl on top of the angel food cake batter. Do NOT oil the bottom of the "medium" bowl. It will not stick on the angel food.
 - Bake the time specified on the box, and check with the toothpick or skewer. If it comes out clean, your angel food cake is done. If not, bake for an additional 5 minutes at a time until done. Take out of the oven and cool on the rack.
2. Gingerbread Cake: Begin to make this cake about the time the angel food cake is supposed to come out. You may need to adjust the oven temperature, depending on the mix you are using. You need to adjust the rack by raising the bottom rack up one notch. Even though you have two cake mixes baking in the "medium" mixing bowl, the "small" mixing bowl will act like a bunt cake pan, and this cake will do just fine at its regular temperature. It may increase the amount of time it takes to bake, but only 5-10 minutes.
 - Use the "medium" mixing bowl as the mixing bowl. Add both packages of gingerbread cake mix, and follow the cake directions on the back of the box, remembering to double everything you add. Mix well.
 - Oil the bottom of the "small" bowl. Set the "small" mixing bowl in the middle of the "medium" mixing bowl on top of the gingerbread cake batter.
 - Bake the time specified on the box, and check with the toothpick or skewer. If it comes out clean, your gingerbread cake is done. If not, bake for an additional 5 minutes at a time until done. Take out of the oven and cool on the rack.
 3. Brownies take a long time to bake in a low heat oven. If you have two ovens, you can start the brownies with your angel food cake. If not, time mixing the brownies about the time the gingerbread cake is

supposed to come out of the oven.

- Reduce the oven temperature 25°F from the temperature stated on the brownie directions (i.e. if the package said to bake at 350°F, set the oven to 325°F). You need to slow down your oven to allow the inside of the brownies to cook without burning the outside. It will increase the time it takes to bake them.
- Use the “small” mixing bowl, and you can use it to mix your brownies. Add the brownie mix and follow the directions on the back of the box. Mix well.
- Bake the time specified on the box, and check with the toothpick or skewer. It won’t be done. Continue to bake for an additional 10 minutes at a time until done, being careful not to over bake. If you are concerned that the outside is baking too fast, turn down the oven an additional 25°F.
- When the toothpick or skewer comes out clean, take out of the oven and cool on the rack.

4. Cool overnight.



REFLECT

To assemble the sun cake:

1. Start with the brownies. Set them upside down in the center of your platter or cardboard covered with aluminum foil. To get out of the bowl, I use a rather flexible knife, and just keep working it a little further down the sides until it finally is free from the bowl. This is the core of the sun.
2. Next, the radiative zone is the ginger bread. By spinning the “small” mixing bowl gently in the center of the ginger bread, it will work free from the top of the batter. Use the same knife technique until the gingerbread is free. It is more delicate than the brownies, so work it free, and have it gently drop on the brownies, lining up the indentation in the gingerbread with the brownies.
3. Frost the gingerbread with the 2 cans of chocolate frosting to represent the interface layer. This represents the area where the magnetic fields are generated.
4. The angel food cake, the convective zone, will then need to be placed on top of the frosting on the gingerbread. Remove the medium bowl on top of the angel food cake by gently spinning, like you did with the gingerbread. Great care must be taken in order to free the angel food cake, and not mess up the chocolate frosting too much! Set the angel food cake on top of the gingerbread, seating it in the indentation.
5. In one of the small mixing bowls add the 4 cans of white frosting and add yellow food color until it is the perfect shade of sun yellow. Too much and it looks orange. Not enough, and it just doesn’t look sunny. Frost the outside of the angel food cake. Make peaks in the frosting (very important for our model.)

your life. If you are absolutely crazy about dogs, include the kinds of dogs that you love. If you love architecture and landscaping, include those images. It is totally up to you what you include.

Occasionally look through your notebook. Looking specifically for items that resonate with you will give you a better idea of how you would like to live. Do you have pictures of cabins in the mountains and all your furnishings are log furniture? That is a clue.

The point of the notebook is just a place to keep the ideas of what you like, not what you will ultimately acquire. You may later wonder why you taped a specific picture in your notebook.

Time to get started! The worksheet includes the instructions. Have fun. Envision your future with what is important to you.

Final note: as you explore careers, consider the two aspects of a career: income and job satisfaction.

Sometimes the highest paying jobs would be a terrible fit with your interests. Every single day would be spent doing something you don’t love. On the other hand, you should be able to make a decent living doing what you love.

Sometimes, those two align. For examples, one of the highest paid professions is an engineer. Engineers generally

have extremely high job satisfaction. Win/Win.

You may decide that job satisfaction is much more important than a huge paycheck. You would be willing to earn less (but still enough to have a good life) to do what you love. Classroom teachers fall into this category.

Okay! You are ready to start. One more assumption: you are moving out on your own for the first time. That means there will be additional costs, that are included in the worksheets. Even though this lists the basic items you need for your own place, once those have been purchased, you will continue to purchase additional items. The costs will probably not go down, even after you purchase your first bed or buy plates, pots, and pans.

When you have completed your worksheets and optional notebook, check out this website for a quick assessment to double check your calculations for how much money you need to earn for the lifestyle you would like. It also includes careers and amount of education. <https://www.jumpstart.org/what-we-do/support-financial-education/reality-check/>.

Are the careers listed interesting to you? What kind of education do you need?

Next month, we will look a little closer at education beyond high school.

- Add chocolate chips for **sunspots** and red licorice for the solar flares. For solar flares, push the licorice into the cake until it sticks out satisfactorily. For solar prominences, push both ends of the licorice into the cake to create arcs.
- Add the candles. Before serving, light the candles.

APPLY

Directions for Serving:

Cut the cake in half, and open so that everyone can see the interior and exterior of the cake.



- **Core** (brownies) It can be 15 million degrees at the core of our sun. It is so hot because of the tremendous pressure exerted by the total mass of the sun pressing down on it. This hot, dense zone is where nuclear fission occurs. The sun takes some of its mass and changes it into energy – light energy. (Be sure to understand the difference between mass and weight and density. Definitions are at the end of this section.)
- **Radiative Zone** (gingerbread) Light, after it has been converted from matter, reaches the radiative zone. It can spend millions of years passing through this section of the sun, because it gets bounced all around like a pin ball.
- **Interface Layer or Tachocline** (chocolate fudge frosting) Until very recently, not much was known about this layer. It is thought that the tremendous magnetic field of the sun is generated in this layer, and there are sudden changes in both the fluidity and the chemical composition of this area.
- **Convection Zone** (angel food) The outer layer of the sun is hotter towards the interior and cooler at the surface. This creates huge cells of rising hot plasma. Remember, hot air rises and cold air sinks; hot water rises and cold water sinks. Same with plasma. Hot plasma rises and cold (relatively speaking) plasma sinks. Go to weather at <http://tra.extension.colostate.edu/stem-k12/stem-resources/> page 3 for a demonstration of this concept.
- **Chromosphere** (surface of the angel food) An invisible layer of plasma at the edge of the sun is the end of the convective zone and the beginning of the photosphere.
- **Granules or Supergranules** (peaks in frosting) The surface of the sun has a granular look from the hot plasma rising in California-sized bubbles and the cool plasma sinking.

- **Photosphere** (yellow frosting) This is what we see. It is “only” 10,000 degrees, but it is so bright that we cannot see either the chromosphere or the corona.
- **Sunspots** (chocolate chips) The sun is blemished with cool, darker spots known as sunspots. Not only are they cooler, but they have very strong magnetic fields associated with them. And for every sunspot, there is a mate. Like any magnet, one spot is the “north pole,” and its mate is the “south pole.” There is an 11 year cycle associated with sunspots. They peak in number. During that time, we can see more aurora borealis or aurora australis (southern lights). Then they subside, and the sun can appear with almost no spots, as it currently is in 2018. The 11 year cycle is not constant. About 300 years ago, there was no peak for about 75 years. No one knows why that happened.
- **Solar Flares** (licorice whips sticking straight out) Solar flares are explosions from the sun that are not pulled back by the strong magnetic fields.
- **Solar Prominences** (licorice whips that make arcs) Sometimes the far end of a solar flare is pulled back to the sun by the strong magnetic field. They make beautiful arcs.
- **Corona** (candles) During a total solar eclipse, the corona is the illuminated halo that surrounds the sun. It can be millions of miles for the surface, and is about 2 million degrees. Astrophysicists can explain why the surface of the sun is so much cooler (10,000 degrees compared to 2,000,000 degrees), but it is very hard to understand.

ENJOY!

POWER WORDS

- **aphelion**: the point in the orbit of a planet, asteroid, or comet at which it is furthest from the sun.
- **albedo**: the proportion of the incident light or radiation that is reflected by a surface, typically that of a planet or moon.
- **Aurora Borealis**: a natural electrical phenomenon characterized by the appearance of streamers of reddish or greenish light in the sky, usually near the northern or magnetic pole.
- **Australis Borealis**: a natural electrical phenomenon characterized by the appearance of streamers of reddish or greenish light in the sky, usually near the southern magnetic pole.
- **calibrate**: correlate the readings of (an instrument) with those of a standard in order to check the instrument's accuracy.
- **camera obscura**: a darkened box with a convex lens or aperture for projecting the image of an external object onto a screen inside. It is important historically in the development of photography.
- **cardinal point**: each of the four main points of the compass (north, south, east, and west).
- **chromosphere**: a reddish gaseous layer immediately above the photosphere of the sun or another star. Together with the corona, it constitutes the star's outer atmosphere.

- **circumference:** the distance around something.
- **contour:** an outline of a natural feature such as a hill or valley.
- **convection zone:** outermost layer of the interior of the Sun; energy is transported by convection in this region. The surface of the convection zone is where light (photons) is created.
- **core:** gravitational forces create tremendous pressure and temperatures (27 million degrees Fahrenheit) at the sun's center; hydrogen atoms are compressed and fuse together, creating helium in a process called nuclear fusion.
- **corona:** the rarefied gaseous envelope of the sun and other stars. The sun's corona is normally visible only during a total solar eclipse when it is seen as an irregularly shaped pearly glow surrounding the darkened disk of the moon.
- **coronal mass ejections:** significant release of plasma and accompanying magnetic field from the solar corona, often follow solar flares and are normally present during a solar prominence eruption; plasma is released into the solar wind.
- **corrugated:** shaped into alternate ridges and grooves.
- **diameter:** a straight line passing from side to side through the center of a body or figure, especially a circle or sphere.
- **elliptical:** oval, egg-shaped, elliptic, ovate, ovoid, oviform

SOLAR SUNSPOTS BY CAMERA OBSCURA

DO

The first time I saw this style of **Camera obscura** was on a Saturday morning TV program called *Beakman's World*. We would race to the couch and watch mesmerized for 30 minutes of crazy, wacky science fun. *Beakman*, *Josie the assistant*, and *Lester the Lab Rat* pictured. **Camera Obscuras** are a very safe way to observe the sun.



NEVER LOOK DIRECTLY AT THE SUN!

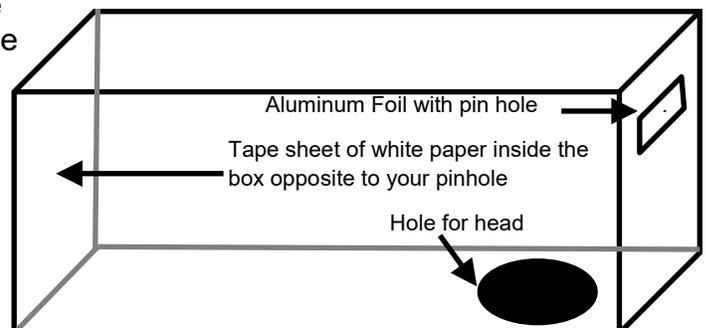
Materials:

- Large and long cardboard box (about the size of a microwave)
- Scissors
- Tape
- Duct tape
- Aluminum foil
- Pin or thumbtack
- Paper cutter
- Adult supervision
- Sheet of white paper
- Bath towel



Directions:

- **NEVER LOOK DIRECTLY AT THE SUN!**
- **Ask an adult to help you with cutting the box.**
- Optional: You can tape 2 boxes together to make a long box. The longer the box, the larger the projected image.
- With the box cutter, cut a rectangular hole at the end of the box. The rectangle doesn't have to be big—3" x 4" works.
- Using the scissors, cut a piece of the aluminum foil 4" x 5", slightly larger than the rectangular hole. Make sure the foil is completely flat and not crinkled.
- Tape the foil over the rectangular hole in the box. Be sure that you tape down all four sides of the aluminum foil.
- Use the pin or thumbtack to poke a tiny hole in the center of the foil.



- Tape a sheet of white paper on the opposite side of the foil, inside the box.
- With the box cutter, cut a hole in the bottom of the box, on the end closest to the foil. You will put your head through this hole. Try to make the hole just large enough to slip your head through.
- To use your **camera obscura** to observe the sun, put a towel around your shoulders to block as much sunlight coming in around your neck.
- **NEVER LOOK DIRECTLY AT THE SUN!**
- Stand with your back toward the Sun. Place the box over your head with the pinhole towards the Sun. Adjust your position until you see the sun projection which is a reversed image. If you look at a tree, you will see an upside down, backwards tree. Very cool. When you line the pinhole up with the sun, you will see the image of the sun on the screen in front of you. Look for **sunspots**, prominences, solar flares, and the roiling of the sun's surface. You can even see Mercury and Venus **transit** across the sun. Mercury is schedule to cross in front of the sun next year, November 11, 2019 at 8:20 A.M. Mountain Standard Time. The next Venus' transit won't be until 2117!



NEVER LOOK DIRECTLY AT THE SUN!

Image inside a **camera obscura**. The image will be upside down!



- **granule**: a small compact particle of a substance.
- **habitable zone**: In astronomy and astrobiology, is the range of orbits around a star within which a planetary surface can support liquid water given sufficient atmospheric pressure.
- **hardscape**: the hard stuff in your yard: concrete, bricks, and stone.
- **helispherical**: large, roughly elliptical region of space around the Sun through which the solar wind extends and through which the Sun exerts a magnetic influence.
- **indigenous**: originating or occurring naturally in a particular place; native.
- **insulate / insulating**: protect (something) by interposing material that prevents the loss of heat or the intrusion of sound.
- **interface layer**: just above the radiative zone there is a thin **layer** called the **interface layer** or overshoot zone which makes the transition between the radiative and convection zones.
- **microclimate**: the climate of a very small or restricted area, especially when this differs from the climate of the surrounding area.
- **miniscule**: extremely small; tiny.
- **native garden**: the use of native plants, including trees, shrubs, groundcover, and grasses which are

indigenous to the geographic area of the garden.

- **orbit**: the curved path of a celestial object or spacecraft around a star, planet, or moon, especially a periodic elliptical revolution.
- **penumbra**: the less dark outer part of a sunspot, surrounding the dark core.
- **perihelion**: the point in the orbit of a planet, asteroid, or comet at which it is closest to the sun.
- **perimeter**: the continuous line forming the boundary of a closed geometric figure.
- **photosphere**: the luminous envelope of a star from which its light and heat radiate.
- **plasma**: a state of matter; ionized gas consisting of positive ions and free electrons in proportions resulting in more or less no overall electric charge.
- **radiation**: energy.
- **radiative zone**: section of the solar interior between the innermost core and the outer convective zone; energy generated by nuclear fusion in the core moves outward as electromagnetic radiation.
- **reflective**: providing a reflection; capable of reflecting light or other radiation.
- **rotate/rotation**: pass to each member of a group in a regularly recurring order; the action of rotating around an axis or center.
- **solar flare**: a brief eruption of intense high-energy radiation

REFLECT

Sunspots

Well, wouldn't you know it: an entire activity on **sunspots** and currently there are no **sunspots** on our Sun. It has been awhile since we have spotted any **sunspots** (as of November 7, 2018, 20 days since the last **sunspot** disappeared). Weird but true!

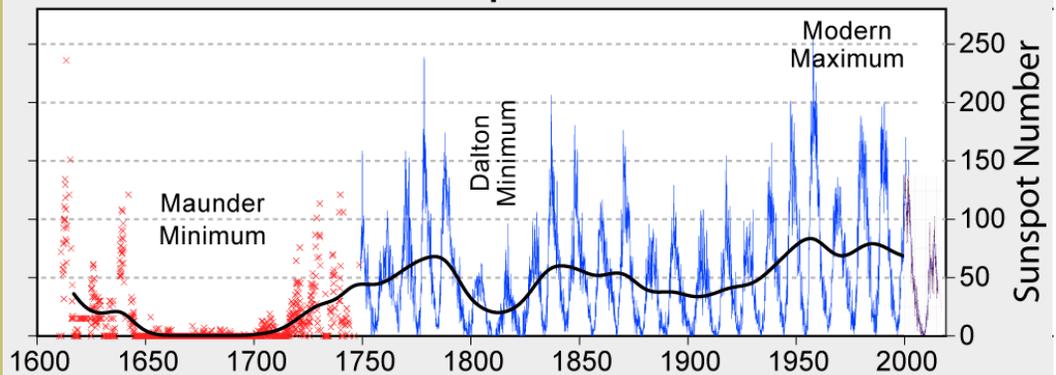
Sunspot activity is usually a 11-year cycle: peak to minimum and back to peak number. We are currently at the **solar minimum**. That means there is very little in **sunspot** activity. With your **camera obscura**, you can begin recording the number and length of time between appearance to disappearance of the **sunspots** during a time that they are easy to count. It will require patience:

On November 7, 2018, there have been 20 straight days without a **sunspot**. So far this year, we have had 186 days with no **sunspots**, and 60% of the days have had no **sunspots** this year.

Do **sunspots** have any impact on the Earth?

There is a weak relationship between **sunspot** activity and the Earth's climate. The best example is called the Maunder Minimum. **Sunspots** were exceedingly rare between 1645 to 1715. The Maunder Minimum coincided with a period of lower-than-average temperatures in Europe known as the Little Ice Age (LIA). During a 28-year period in the middle of the Maunder Minimum, there were fewer than 50 **sunspots** (1672-1699). Compare that to the average activity over a 25-year period: 40,000-50,000 **sunspots**!

400 Years of Sunspot Observations



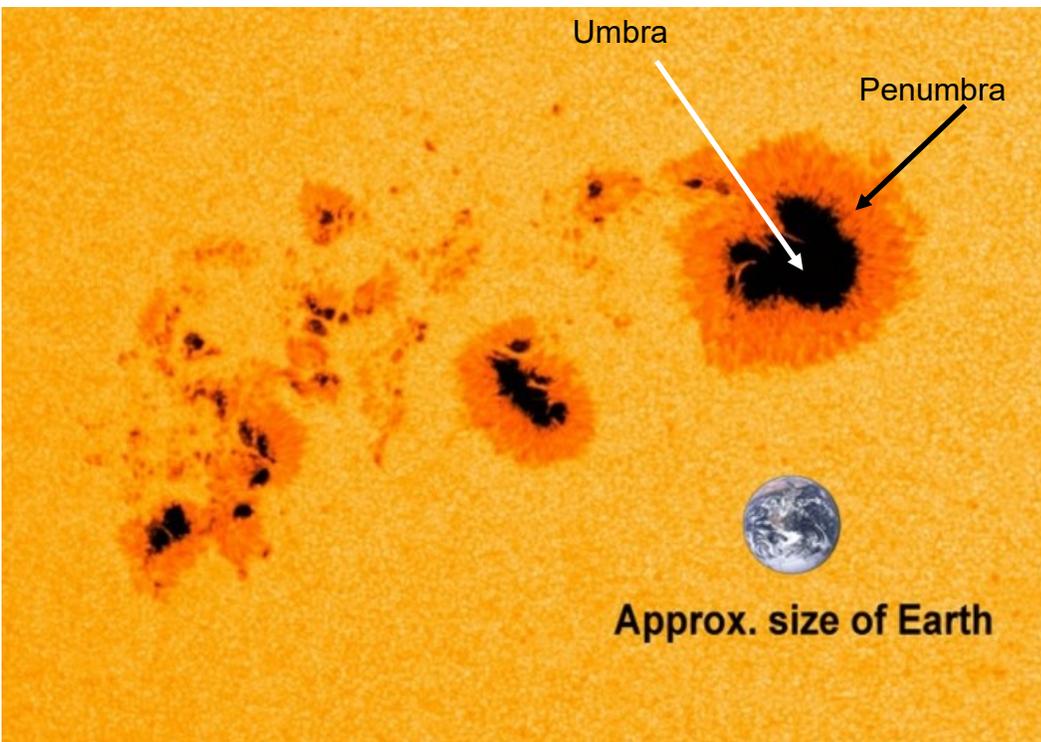
Materials:

- Computer with internet access
- https://sohowww.nascom.nasa.gov/data/realtime/hmi_igr/512/
- **Camera obscura**
- **Sunspot** Datasheet—1 copy per week
- Pencil
- Ruler

NEVER LOOK DIRECTLY AT THE SUN!
Only use your camera obscura to observe the sun.

Directions:

- The Sun **rotates** on its axis, just like the Earth. Use your **camera obscura**, and check before and after school (you will see different areas of the sun at different times of the day). By the time you read this, there may be **sunspots**. You may have to check for several weeks before seeing anything since we are at a **solar minimum**.
- When you see a **sunspot**, there will probably be a second **sunspot**. A **sunspot** is interference with the sun's magnetic field (the chocolate frosting between the gingerbread and angel food cake layers on your model of the sun). Like any magnet, there is a north and south pole, meaning that the **sunspots** usually appear in pairs. On your datasheet, record the number of **sunspots** you see and sketch their position. Include notes, e.g. the time and place of your observation.
- On larger **sunspots**, you can differentiate between the **umbra** (the very dark center of the **sunspot**), and **penumbra** (lighter area outside the umbra). The image below is a **sunspot** group taken by NASA's Solar and **Heliospheric** Observatory (SOHO) on January 2014.



NEVER LOOK DIRECTLY AT THE SUN! Only use your Camera Obscura to observe the sun.

- Verify your results with the Current Conditions (be sure that the date is correct): <https://sohowww.nascom.nasa.gov/sunspots/>
- Can you determine how long it takes the sun to **rotate** on its axis? (Earth's rotation is 24 hours). How long does it take the sun to make one rotation on its axis? It depends on the location! Common states of matter on Earth are solid, liquid, gas, and **plasma**. The sun is in the plasma state, the same state as fire, with almost no friction. The result is that the Sun's poles **rotate** much slower than the equator. Your answer will vary depending on the **sunspot** location!
- You will need to make observations of your **sunspot**, watching it

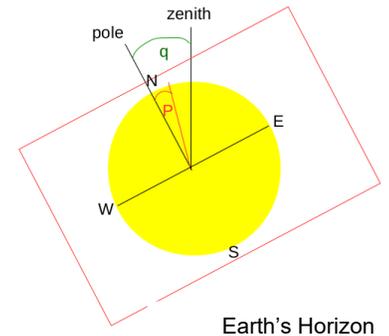
from the sun's surface, associated with sunspots and causing electromagnetic disturbances on the earth, as with radio frequency communications and power line transmissions.

- **solar maximum**: the period in the sunspot cycle when solar activity is highest and sunspots are most abundant.
- **solar minimum**: the period in the sunspot cycle when solar activity is lowest and sunspots are least abundant.
- **solar prominence**: large, bright, gaseous feature extending outward from the Sun's surface, often in a loop shape; they are anchored to the Sun's surface in the photosphere, and extend outwards into the Sun's corona.
- **stabilize**: make or become unlikely to give way or overturn.
- **sunspots**: a spot or patch appearing from time to time on the sun's surface, appearing dark by contrast with its surroundings.
- **tachocline**: transition region of the Sun between the radiative interior and the differentially rotating outer convective zone. It is in the outer third of the Sun.
- **topographic / topography**: relating to the arrangement of the physical features of an area.
- **treatment**: in an experiment, the variable (black paper or white paper covering the canning jars).

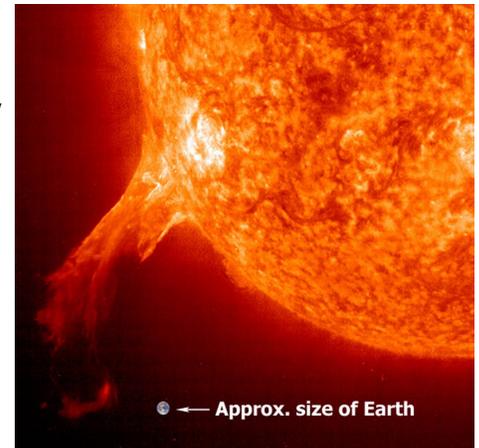
- **umbra**: the dark central part of a sunspot.
- **variable**: able to be changed.
- **watershed**: an area or ridge of land that separates waters flowing to different rivers, basins, or seas.

travel across the sun, disappear, and hopefully return back to its original position. **Sunspots** can last from hours to several months. The average is two weeks.

The sun and Earth's equators are not aligned. When you look at the **sunspots**, they will move in a northeast direction. The Earth is tilted on its axis 23.5 degrees to the plane of our solar system. The sun is tilted 7.25 degrees to the solar systems' plane. That means the **sunspots** will slant as they move across the face of the sun. The sun **rotates** counterclockwise, same as the Earth. When we view **sunspots** from Earth, they appear on the left side of the sun, and travel to the right side of the sun. The opposite view happens in the **camera obscura**.



- The **sunspots** are darker because they are cooler than the surface of the sun. The **photosphere** (yellow frosting on the outside of the model of the sun) has a temperature of 5,527°C (9980°F). **Sunspots** are about 2,000 degrees cooler (about 3,600 cooler in the Fahrenheit scale). They look dark compared to the brighter and hotter regions around them.
- **Sunspots** can be very large, and up to four Earths could fit inside them. Scientists still do not understand how they work, but there is a disruption with the Sun's magnetic field. The **sunspot** can act like a cap on a pop bottle. Shake up the pop, and you can cause the pop to erupt from the bottle. The same thing can happen on the Sun. **Sunspots** are often the locations of intense magnetic activity forming **solar flares** and even **coronal mass ejections (CME)**. As the **sunspot rotates** on the edge of the sun, you can occasionally see one of these eruptions. Keep your eyes peeled at your **camera obscura** screen! If the solar flare or CME is directed at the Earth, our magnet field protects us. It can disrupt electrical facilities, radio transmissions, and cause beautiful **Aurora Borealis** or **Australis Borealis** (northern and southern lights).



APPLY

Explore Solar Weather forecasting with these websites:

- **NASA's SOHO** (Solar and **Heliospheric** Observatory) website: <https://sohowww.nascom.nasa.gov/home.html>
- **NOAA's Space Weather Prediction Center**: <https://www.swpc.noaa.gov/>
- Solar Influences Data Analysis Center, part of the Royal Observatory of Belgium: <http://sidc.oma.be/index.php>

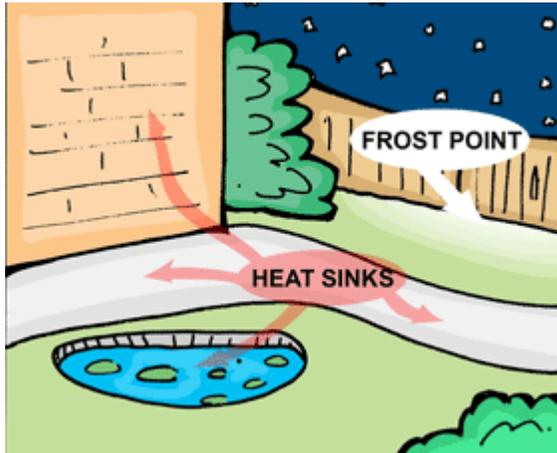
Microclimates

DO

Microclimates are variations in temperature and moisture within a small area. These variations can provide habitat niches for small organisms, like insects, mice or bacteria. The reason for **microclimates** is simple: the sun. What geologic, architectural, or biological formations provide access or create barriers to sun, wind, and moisture? Why do you think those three factors are so important in **microclimates**?

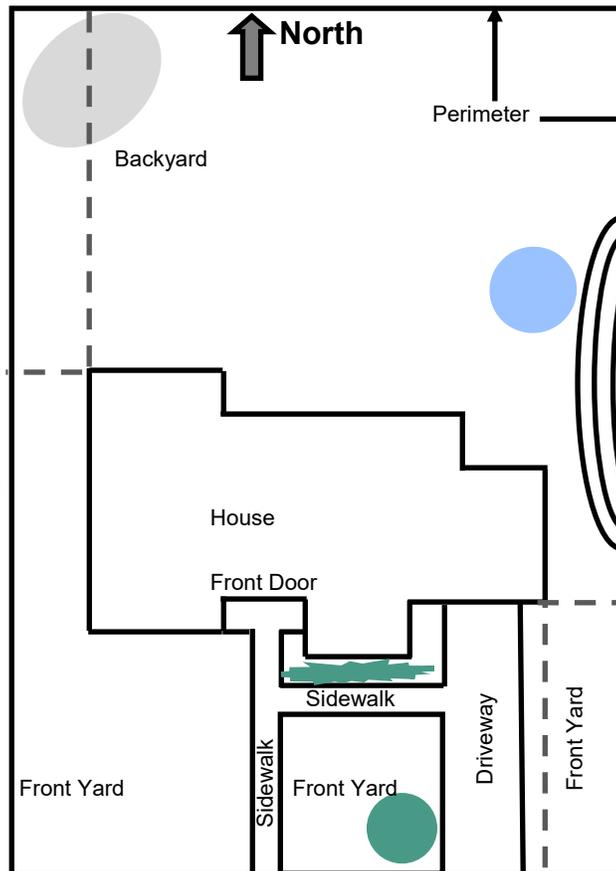
Materials:

- Color pencils
- Paper
- Tape measure
- Ruler
- Magnetic compass
- 4 Outdoor thermometers
- Large bowl
- Water
- Permanent marker
- **Microclimate** Datasheet
- Pencil
- Flashlight (temperature reading after dark)



Directions:

- Make a map of your yard. If you live on a large piece of land or acreage, use a smaller area just around your house.
- Measure the **perimeter** of your yard. If your yard is not straight lines, for this activity, assume that they are straight lines.
- Measure the **perimeter** of your house. To find the location of the house to the edge of the yard, measure the corners to two adjacent edges of the yard. For example, in the diagram on the right, a back corner of the house is measured to the north and west edges (grey dashed lines) of your yard perimeter, and a front corner is measured to the south and east edge of your yard's **perimeter**.
- Insert vegetation (shrubs and trees indicated in green) rocks or boulders (indicated in grey), and water (indicated in blue).



FASCINATING FACTS

The following facts on the sun were taken from the website: <https://space-facts.com/the-sun/>

Age:	4.6 Billion Years
Type:	Yellow Dwarf
Diameter:	1,392,684 km
Equatorial Circumfer-	4,370,005.6 km
Mass:	1.99×10^{30} kg (333,060)
Surface	5,500 °C

- At its center the Sun reaches temperatures of 15 million °C.
- The Sun is all the colors mixed together, this appears white to our eyes.
- The Sun is mostly composed of hydrogen (70%) and Helium (28%).
- The Sun is a main-sequence G2V star (or Yellow Dwarf).
- The Sun is 4.6 billion years old.
- The Sun is 109 times wider than the Earth and 330,000 times as massive.
- **One million Earths could fit inside the Sun.** If a hollow Sun was filled up with spherical Earths then around 960,000 would fit inside. On the other hand if these Earths were squished inside with no wasted space then around 1,300,000 would fit inside. The Sun's surface area is 11,990 times that of the Earth's.
- **The Sun contains 99.86% of the mass in the Solar**

System. The mass of the Sun is approximately 330,000 times greater than that of Earth. It is almost three quarters Hydrogen, while most of the remaining mass is Helium.

- **The Sun is an almost perfect sphere.** There is only a 10 kilometer difference in its polar diameter compared to its equatorial diameter. Considering the vast expanse of the Sun, this means it is the closest thing to a perfect sphere that has been observed in nature.
- **The temperature inside the Sun can reach 15 million degrees Celsius.** At the Sun's core, energy is generated by nuclear fusion, as Hydrogen converts to Helium. Because hot objects generally expand, the Sun would explode like a giant bomb if it weren't for its enormous gravitational force. The temperature on the surface of the Sun is closer to 5,600 degrees Celsius.
- **Eventually, the Sun will consume the Earth.** When all the Hydrogen has been burned, the Sun will continue for about 130 million more years, burning Helium, during which time it will expand to the point that it will engulf Mercury and Venus and the Earth. At this stage it will have become a red giant.
- **The Sun will one day be about the size of Earth.** After its red giant phase, the Sun will collapse,

- Indicate if you have any change in elevation (curved lines with hatch marks to indicate the low point in the yard or curved lines with no hatch marks to indicate a rise in the land). See the example map located on page 13.
- Look at your map and determine the shaded and the sunny areas. Which areas of the day are partially shaded? Which areas get the most wind, and which areas are sheltered from the wind?
- **Calibrate** your thermometers: get a large bowl and fill it with ice. Add water, and place all 4 of your thermometers in the water. Allow them to sit in the water for about 10 minutes. The ice water will hover right at 0°C (32°F).
- One at a time, remove each thermometer to find which one is closest to 0°C (32°F). Dry that thermometer off and with the permanent marker, label that thermometer "1." Record the temperature on the Microclimates Datasheet for Thermometer 1. Remove another thermometer, record that temperature for Thermometer 2. Dry it and label it "2" with the permanent marker. Remove another thermometer, record that temperature for Thermometer 3. Dry it and label it "3" with the permanent marker. Remove the last thermometer, record that temperature for Thermometer 4. Dry it and label it "4" with the permanent marker.
- On your datasheet, note the difference between Thermometer 1 and the other three thermometers. For example, if Thermometer 1 is 0°C and Thermometer 2 is 0.5°C, record the calibration as -0.5°C. To correct that thermometer to 0°C, you will need to subtract 1/2 of a degree. If thermometer #3 is -1°C, to correct that thermometer, you need to add 1°C. Example below. That will calibrate each thermometer to thermometer 1.
- Place your 4 thermometers on each side of your house. Thermometer 1 on the north side, Thermometer 2 on the east side,

Time	Thermometer 1	Thermometer 2	Calibrate ± -0.5°C	Thermometer 3	Calibrate ± -1°C	Thermometer 4	Calibrate ± 0
Ice Water Temp	0°C	0.5°C	-0.5°C	-1°C	+1°C	0°C	No dif.

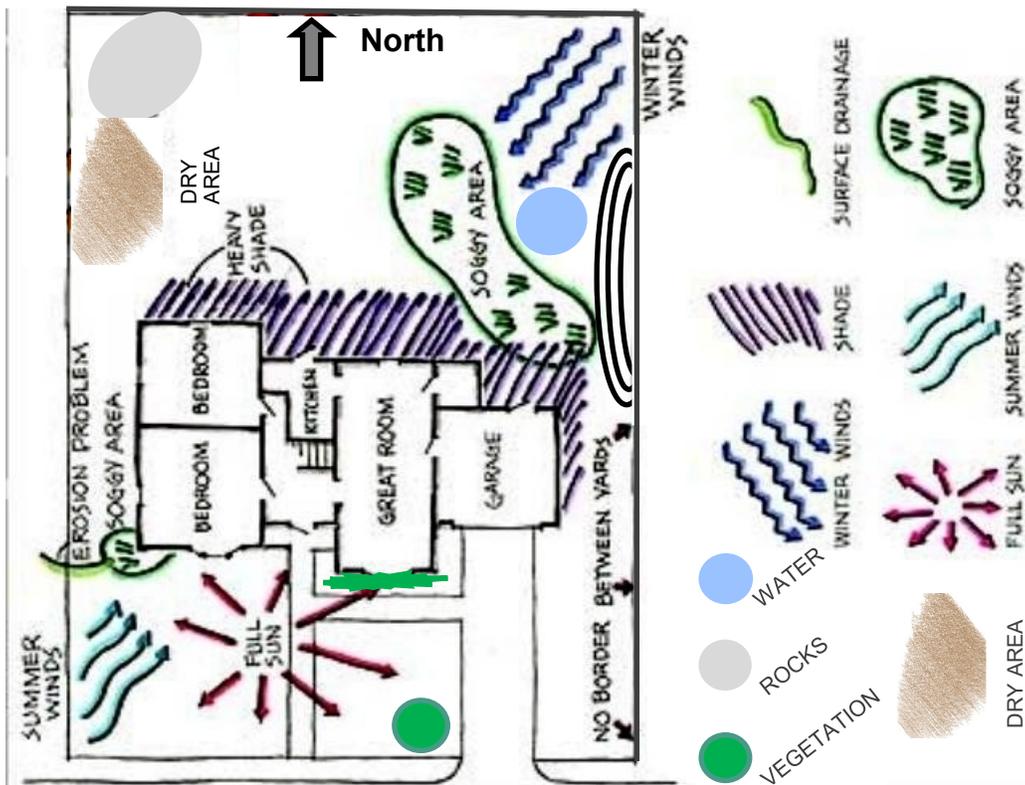
Thermometer 3 on the south side, and Thermometer 4 on the west side. If your house is not aligned to the compass, place each thermometer as close to those **cardinal** points as possible. North will have the most shade, and south will have the most sun.

- Start collecting your temperature data in the morning the following day. You can start recording anytime. For example, if you start at 9:00 AM, do not use the first two rows (7:00 and 8:00 AM), but start at the 9:00 AM row. Continue collecting and recording your temperature once an hour for each of the four thermometers throughout the day.

REFLECT

Microclimates can be **miniscule** (inches for bacteria or other single celled organisms) or large (like the north face of Mount Sneffels). What other impacts produce the microclimates in your yard?

- Examine the map and key on the next page. Use the data you collected with the 4 sides of your house and the temperature readings. Examine your yard, and indicate on your map, using the



symbols above to plot your microclimates in your yard:

- Where are the areas of full sun? What areas are the warmest?
- Where are the shaded areas? What areas are the coolest?
- Which direction does the summer winds blow?
- Which direction does the winter winds blow?
- When it rains, how does the water drain?
- Are there any areas that are soggy? What areas are really dry?
- The green, grey, and blue areas are vegetation, rocks, and water, respectively.

APPLY

Challenge: Design a **native garden** incorporating microclimate data for the needs of each plant. Things to consider: plant needs (sunlight, water, temperature) time of blooming and flower and seed colors. Include flowers, shrubs, trees, a water feature, and **hardscape** in your design. The following are great websites for your research:

- Native Colorado Wildflowers: <http://wildflowersofcolorado.com/>
- USDA's Plant Database: <https://plants.sc.egov.usda.gov/java/>
- CSU Forestry Service Colorado's Major Tree Species: <https://csfs.colostate.edu/colorado-trees/colorados-major-tree-species/>
- More wildflowers: <https://www.swcoloradowildflowers.com/index.htm>

Albedo



retaining its enormous mass, but containing the approximate volume of our planet. When this happens, it will be called a white dwarf.

- **Light from the Sun takes eight minutes to reach Earth.** With a mean average distance of 150 million kilometers from Earth and with light travelling at 300,000 kilometres per second, dividing one by the other gives us an approximate time of 500 seconds, or eight minutes and 20 seconds. Although this energy reaches Earth in a few minutes, it will already have taken millions of years to travel from the Sun's core to its surface.
- **The Sun travels at 220 kilometres per second.** The Sun is 24,000-26,000 light years from the galactic center and it takes the Sun 225-250 million years to complete an orbit of the center of the Milky Way.
- **The distance from the Sun to Earth changes throughout the year.** Because the Earth travels on an elliptical orbit around the Sun, the distance between the two bodies varies from 147 to 152 million kilometres. The distance between the Earth and the Sun is called an Astronomical Unit (AU).
- **The Sun is middle-aged.** At around 4.5 billion years old, the Sun has already burned off about half of its store of Hydrogen. It has enough left to continue to burn Hydrogen for approximately another 5 billion years. The Sun is

currently a type of star known as a Yellow Dwarf.

- **The Sun has a very strong magnetic field.** Solar flares occur when magnetic energy is released by the Sun during magnetic storms, which we see as sunspots. In sunspots, the magnetic lines are twisted and they spin, much like a tornado would on Earth.
- **The Sun generates solar wind.** This is a stream of charged particles, which travels through the Solar System at approximately 450 kilometers per second. Solar wind occurs where the magnetic field of the Sun extends into space instead of following its surface.

Other Cool Facts

The following facts on cameras were taken from the website: <https://www.fotographeer.com/66-fun-facts-photography/>

- The word camera comes from the Latin phrase “**camera obscura**,” which translates to “dark chamber.”
- The first ever camera described in the history was a pin hole camera, dating back to 4th or 5th century.
- The world's first photo was taken by a French scientist, Joseph Nicéphore Niépce with a camera obscura in 1826.

The following facts on maps were taken from the website: <http://www.themaptoeverywhere.com/wp-content/uploads/2015/10/Map-to-Everywhere-Map-Facts.pdf> on 11/29/2018

DO

Albedo is a term to describe the solar **reflective** properties of a planet or satellite (our Moon is a natural satellite). A high albedo means the surface is highly **reflective** (like fresh fallen snow); much of the solar **radiation** is bounced away from the surface. If the albedo is low, like a freshly plowed field, then the solar **radiation** is absorbed into the surface.

Materials:

- 3 outdoor thermometers longer than the canning jars
- Black construction paper
- White construction paper
- Aluminum Foil heavy duty works best
- Scissors
- Tape
- Pencil
- Single hole punch
- 3 pint size identical canning jars
- Cloth tape measurer (or string and ruler)
- **Albedo Datasheet**
- **Albedo Graph**

Directions:

- You need a sunny day and a south-facing, sunny window.
- Measure the height and the **circumference** of the canning jar. If you don't have a cloth tape measure, you can use a string and ruler. Pull the string around the jar's middle, and pinch where the end meets the string. Using the same tension, measure the length of the string with the ruler. You can use this method to find the **circumference** of anything round, like the pumpkin pictured above.
- Use the exact measurement for the height of the jar. Add 1” to the



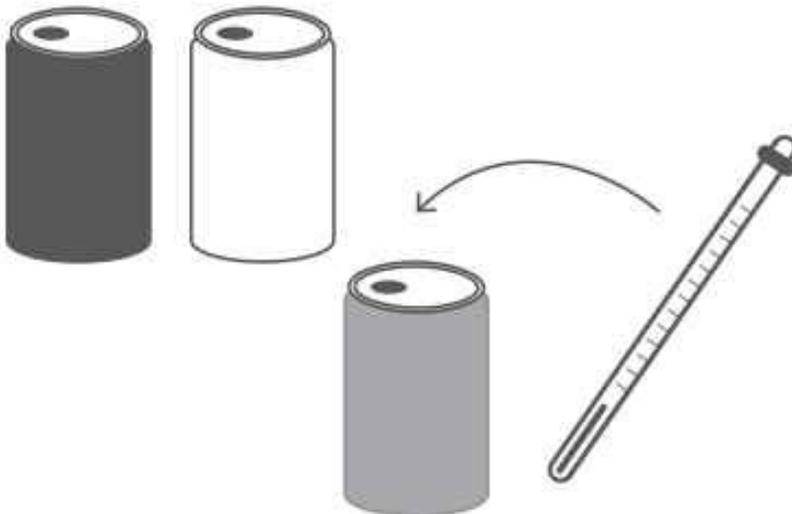
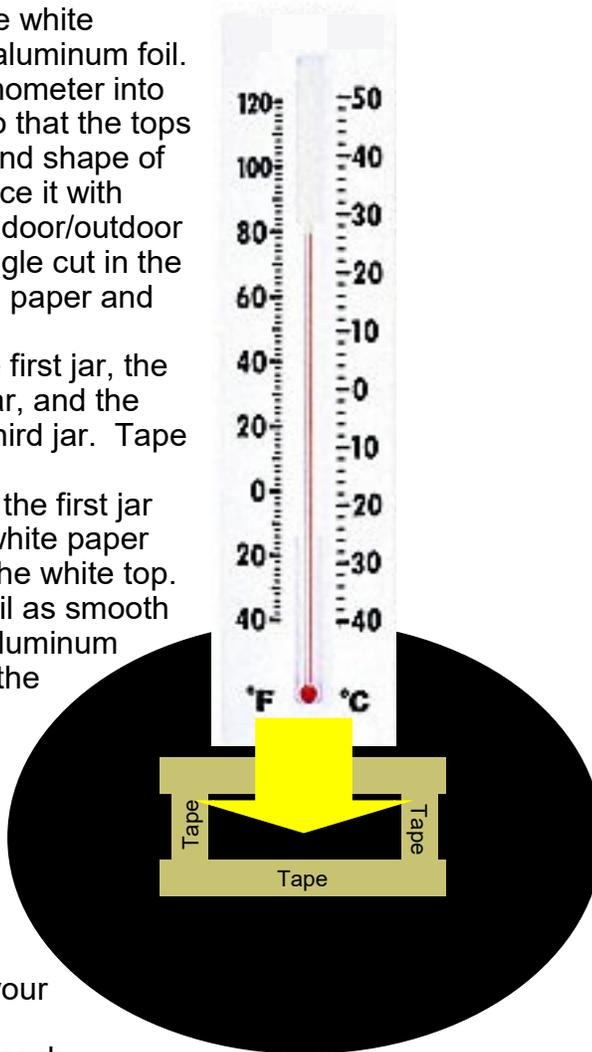
measurement of the **circumference**. This will give you some overlap to tape the paper or foil around the canning jar.

- With a ruler, draw the dimensions of the canning jar on the black and white construction paper and a piece of aluminum foil. Do not press hard on the aluminum foil. It will easily rip. Cut out the black and white construction paper and aluminum rectangles to cover the jars.
- Place the jar top on the black construction paper and trace the circle with your pencil. Cut out the circle. Repeat with the white construction paper and the aluminum foil. Trace the canning jar lid



and cut out the shape for the white construction paper and the aluminum foil.

- You will be inserting a thermometer into each jar through the top. So that the tops don't rip, cut the top to the end shape of the thermometer and reinforce it with tape. Pictured is a typical indoor/outdoor thermometer with the rectangle cut in the top of the black construction paper and reinforced with tape.
- Place the black circle on the first jar, the white circle on the second jar, and the aluminum foil circle on the third jar. Tape securely in place.
- Roll the black paper around the first jar with the black top, and the white paper around the second jar with the white top. Try to keep the aluminum foil as smooth as possible as you roll the aluminum foil around the third jar with the aluminum foil top. Tape the sides to keep the paper and foil secure on the jars.
- Tape the paper and foil to the bottom of their jars so the covers will stay in place.
- Predict which jar will have the largest temperature change and record that on your **Albedo** Datasheet.
- Record the temperature for each thermometer on your **Albedo** datasheet. Carefully insert one



thermometer into the black jar through the slit on the top, one thermometer into the white jar through the slit on the top, and one thermometer into the aluminum foil jar through the slit on the top. Each jar is a **treatment** in the experiment.

- All three jars need full sun, no shadows. Place them in a window

- Cartography is the study of maps and map making. Someone who makes maps is called a cartographer.
- North may be at the top of maps today, but that wasn't always the case. During the middle ages, most Western maps put East at the top instead. In Latin, the word for East is oriens, so to hold the map correctly, you had to "orient" it. That is to make sure that East was on top. That is where we get the word orientation today.
- Modern mapmakers often incorporate fake towns into their maps, known as "paper towns," "phantom settlements," or (for some reason) "bunnies." If they come across another map with the same fake town, they knew it was a copy!
- In 1798, cartographer James Rennell drew the first map of Africa featuring the massive Mountains of Kong, an enormous mountain range that stretched thousands of miles east to west across Africa. The only problem was that the Mountains of Kong didn't exist. Rennell made a mistake. Even so, the Mountains of Kong would be placed on maps of Africa for the next 100 years.
- The first map to use the name "America" was created by the German cartographer Martin Waldseemüller in 1507. It is also one of the most expensive maps in the world—the US Library of Congress bought it in 2003 for \$10 million!

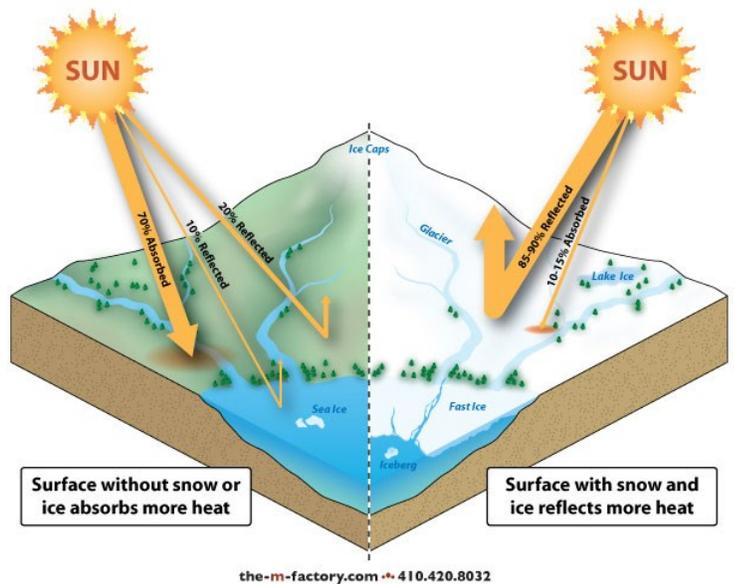
- In 44 CA, ancient Roman thinker Pliny the Elder wrote that every creature on land had a counterpart in the ocean. Because of that, ancient mapmakers would draw sea monsters on their maps to look like aquatic versions of familiar land animals: sea cows, sea serpents, sea pigs, marine dog-pigs, etc. If you've ever seen a sea lion or a seahorse, this is how they got their names!
- During medieval times in Europe, most maps of the world, called mappae mundi, were used by royals and nobles as displays of their wealth rather than as tools for navigation. Only around 1,100 map mundi still survive from that time period.
- There are two Norths: true north and magnetic north. True north is the direction of the geographic North Pole. Magnetic North Pole can actually move up to 25 miles a year, and has even been known to swap places with the magnetic South Pole (don't worry, the last time this happened was 780,000 years ago).
- During World War II, the British game company Waddington PLC, altered several Monopoly games by sealing silk maps into the game boards, shuffling real money with fake, and adding new playing pieces, such as a working compass. These special games were then shipped to prisoner-of-war camps to help prisoners escape!

when the sunlight is coming into that window. Be sure that they are in full sun during the entire experiment.

- Record your temperature every 5 minutes for each of the 3 **treatments**. Carefully remove the thermometer from the top and record the temperature on your **Albedo** Datasheet. If the top tears, you can mend it with tape.
- At the end of 30 minutes, the temperature in each jar should have **stabilized**. Clean up the experiment and put everything away.

REFLECT

- Make a graph of this experiment. Use a different color pencil as indicated in the legend for each treatment. Is your prediction supported? Why or why not? What does it mean?
 - Low **Albedo**: Black Jar
 - High **Albedo**: White Jar
 - Control: Aluminum Foil Jar



- How does **albedo** impact the weather? What happens if it is really cold, snows, and people use their wood burning stoves? Will that make any difference? The soot and ash from wood

burning snows will eventually settle down on the snow, and it makes the snow darker. What happens when the sunlight is directly on freshly fallen snow? What happens when it is directly on snow that has a layer of soot and ash?

APPLY

Some scientists study snow. The CSU Climate Center has lots of information about the importance of snow and high **albedos** and why this is important to Colorado. Check it out! <http://climate.colostate.edu/snow.html>.

Community Collaboration for Rain Hail and Snow (CoCoRaHS) also has information about **albedo**. Check it out! <http://www.cocorahs-albedo.org/about/>

Have you ever considered climate or weather careers? What kind of education do you need? Check it out! <http://catalog.colostate.edu/general-catalog/colleges/engineering/atmospheric-science/#text>

Topographic Maps

DO

Topographic maps are also called **Contour** Maps. How does the **topography** and vegetation impact weather locally?

Materials:



3-D Topographic Map

- Copy **topographic** map template (page 28) possibly several copies
- Sharp scissors
- Box cutter
- Adult supervision
- Sharp pencil
- Metal 12" ruler
- Recycled boxes of **corrugated** cardboard
- Masking tape
- Color pencils
- Paint
- Paint brushes different size bristles
- White glue one 7.625 fl. oz bottle

Optional Papier Mâché additional supplies

- Container for the glue solution (i.e. milk jug cut in half)
- Newspaper
- Water
- White glue (~three 7.625 fl. oz bottles)

Wind and Sun Experiments additional supplies

- Fan
- Flour
- Sifter
- Outdoor spot with no obstructions, but close to an outlet for the fan

Watershed Experiment additional supplies

- Aluminum foil
- Water-based markers
- Squirt bottle

Directions:

- The oldest Globe on record dates back to around 1500, and it is carved on the surface of an ostrich egg. It is also the first time the phrase, "here be dragons" appears on a map (in Latin, "hic sunt dracones").

JOKES

The following facts on cameras were taken from the website: <http://www.solarevents.com/articles/solar-jokes/>

NASA, Full Of Bright People

Three men were in a NASA conference room to decide how to spend \$10 billion. "I think we should put our men on Mars!" said the first man.

"Ooh, good idea," said the other two.

"I think we should put our men on Venus!" said the second man.

"Ooh, good idea," said the other two.

"I think we should put our men on the Sun!"

"How are you going to do that?"
"Easy. We go at night."

Most books now say our sun is a star. But it still knows how to change back into a sun in the daytime.

Some people can tell what time it is by looking at the sun. But I have never been able to make out the numbers.

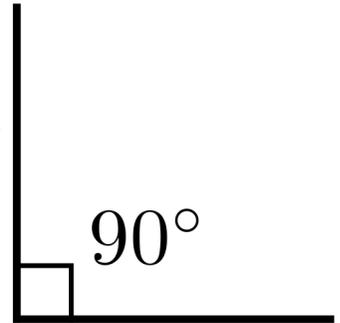
The sun never sets on the British Empire. But it rises every morning. The sky must get awfully crowded.

You Know You're In Alaska When...

... you have to put your sun visor down at 3:00 a.m.

Did you hear about the blonde that stayed up all night to see where the sun went?
It finally dawned on her.

- Your **topographic** map is $7\frac{1}{2} \times 9\frac{1}{4}$ ". Select a side of a cardboard box without creases or folds. Measure $7\frac{1}{2} \times 9\frac{1}{4}$ " with the ruler for the base of your map. Make sure your corners are 90° angles and your measurements are correct. (Measure twice and cut once). Be sure that you have adult supervision while using the box cutter. Be sure your fingers are out of the way.

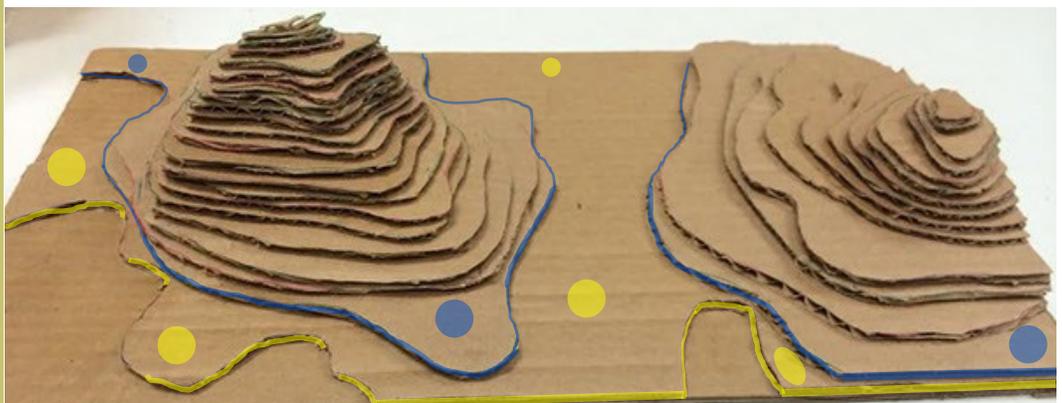


- Line your metal ruler up with one of the lines on your base. Hold the metal ruler securely in place. With your box cutter, press against the ruler and down to cut the first side of the base.
- Align your metal ruler on the next rectangle side, and make your second cut, pressing against the ruler and down.
- Repeat the above steps for the remaining sides of the base.
- Each **topographic** line on the template represents 20, which could be feet or meters

(since there is no unit identified). We will assume feet. Note that there is a darker line on each hill with "100" to indicate that is 100 (feet). The template identifies levels (i.e. 20 foot, 40 foot, etc.) with colored dots. If you do not have a color printer, use your color pencils to color the dots on your copy like the image to the right.



- Cut off your template's margins. Use a few pieces of masking tape (1 or 2" long) to tape down the template on the cardboard. Hint: tape the top and one side of the template to the corner of the cardboard. You won't have to cut those pieces.
- Start with the outside **topographic** line. For example, pictured below,



the yellow level will sit on the base. It is one large piece of cardboard oddly shaped. The next layer, blue, will be in two pieces. They are at the 40 foot level, with a dip to 20 feet between them.

- After you have cut out each piece, identify it with the color coding indicated by the dots of color in the pictures on the prior page.
- Indicate the left side pieces as “A” and the right side pieces as “B” on the cardboard to keep track of where the layers go.
- You will have 18 pieces (including the base) when you are done. The yellow and blue layers include both hills at the 20 foot and 40 foot levels, and are 9¼” wide. See the arrow pointing to the river in the image at the top of page 19 to see how the river will fit into your map.
- Use the template (you can view it on the computer or print another copy) and assemble your **topographic** map. Use the white glue to attach each layer to the layer below. Allow to dry thoroughly (at least overnight).
- If you do not want to papier mâché your map, paint areas to indicate blue water, brown, grey, red rock, green vegetation, white snow. Below are two examples. The image on the left is a painted 3D **topographic** map. The image on the right is a papier mâché map.



Optional Papier Mâché

- You may choose to use the cardboard **topographic** map as a template for a 3-D map. Papier mâché is a great medium to fill out the layers so it looks more like the **topography**.
- This is a very messy project, so protect the table and floor (plastic table cloth or newspapers), or do this outside. You may want to make a “lab coat” from a large plastic garbage bag to protect your clothing. See page 6 of 45. Mad Scientist ST[EMpower] science article for directions located at <http://tra.extension.colostate.edu/stem-k12/stem-resources/>.
- Gather your supplies (your **topographic** map, newspaper, white glue, paintbrush, water, and a container to mix the solution like an empty,

Q: Why do blondes drive cars with sunroofs?

A: More leg room.

The following facts on astronomy were taken from the website: <http://www.astronomytrek.com/astronomy-jokes-and-humour/>

Living on Earth might be expensive but at least you get a free trip around the Sun every year.

Copernicus' parents might deserve some of the credit for his great discovery. Apparently at the age of twelve they said to him: “Copernicus, young man, when are you going to realize that the world does NOT revolve around you.”

The following facts were taken from the website: <https://thecosmiccompanion.com/jokes-about-astronomy/>

Q: Why isn't the Sun still in college?

A: Are you kidding? It already has about 15 million degrees!

Q: Why did the Sun get straight A's in college?

A: Because it was so bright!

CITATIONS

- <https://www.ucsusa.org/global-warming/science-and-impacts/science/effect-of-sun-on-climate-faq.html#.W9ssoOJRfBQ>
- <https://www.nationalgeographic.com/science/space/solar-system/the-sun/>
- <https://www.spaceweatherlive.com/en/solar-activity>
- <https://en.wikipedia.org/wiki/Star>
- <https://scied.ucar.edu/students/careers>
- <https://spaceplace.nasa.gov/sun-compare/en/>
- <https://www.businessinsider.com/image-of-1-million-earths-inside-the-sun-2015-1>
- <https://wiltoday.wordpress.com/2013/07/28/how-big-is-the-sun/>
- <https://www.timeanddate.com/eclipse/box-pinhole-projector.html>
- <https://poke-a-pixel.tumblr.com/post/150882701389/using-a-camera-obscura-to-observe-a-partial-solar>
- <https://www.urbanfoodgarden.org/main/climate/climate--micro.htm>
- <https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=27510>
- <https://eclipse.gsfc.nasa.gov/transit/transit.html>
- https://en.wikipedia.org/wiki/Maunder_Minimum#/media/File:Sunspot_Numbers.png
- https://www.nasa.gov/centers/goddard/images/content/93614main_sun2.jpg

clean gallon milk jug with the top cut off is perfect.

- Tear (not cut) the newspaper into long strips about 1" thick. It is okay if some are wider and some are thinner.
- Pour 2 parts white glue and one part water into your container. If you are using the 7.625 bottle of glue, you can add 2 of the bottles of glue. Fill one of the bottles with water, and divide between the two glue containers. Put on the top, and shake vigorously to get as much glue out as you can. Add the water to glue in the container.
- With a large paintbrush, mix the glue and water solution together until completely mixed and uniform.
- Now comes the REALLY messy part! Dip a strip of newspaper into the mixture. Keep the newspaper flat, and pull it through the glue solution. Remove any excess mixture by sliding the strip between two of your fingers from the top to the bottom of the newspaper strip. Hold the newspaper over the bowl so the glue drips back into the container.
- Lay the strip over the surface of the map. Smooth it out, using either your fingers or a paintbrush. Be sure to get as many of the creases and bumps out as you can. You are aiming to get a very smooth surface for painting and decorating. Since the cardboard is stair-stepped, you have to be careful to produce a smooth appearance.
- Continue to add strips until the entire surface or figure is covered four times over. Put your first layer on horizontally, the second vertically, the third horizontally, and the fourth vertically.
- When complete, set your map aside to dry—at least 24 hours. Check it, and if still damp, leave for another day.
- When your map is completely dry, you can paint it blue water, brown, grey, red rock, green vegetation, and white snow
- Allow the paint to dry completely.



REFLECT

Now that your map is complete, you can do some experiments to observe how the landscape impacts weather. Before you get started, what do you think about:

- What causes the wind? Why does it usually blow from the same direction, or seasonally shift to a different direction?
- How does the sun heat the landscape differently (think **albedo**)?
- Why does it rain where it does? Why are there deserts, forests, and grassland areas in Colorado?

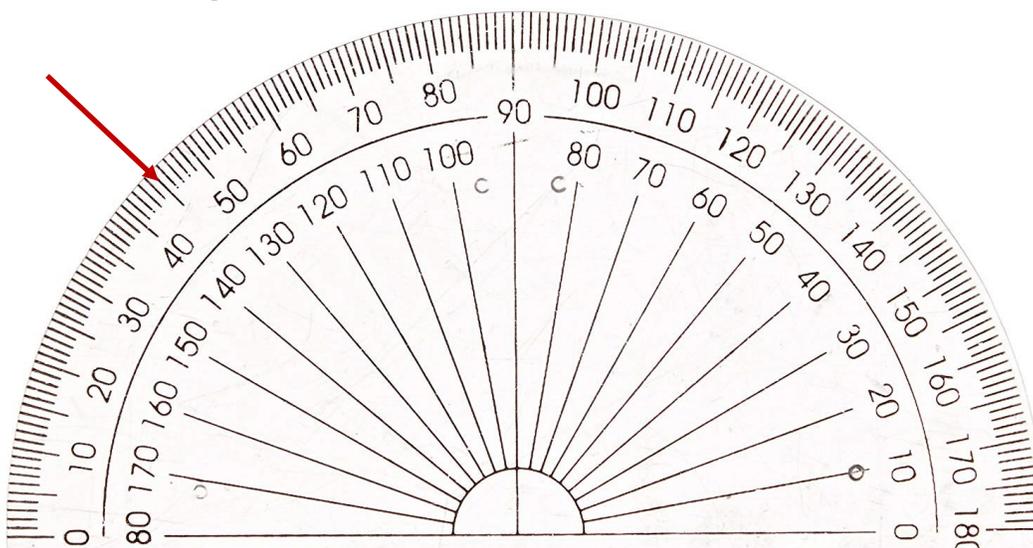
The sun is the main reason we have weather. The sun heats the land differently. The color of the ground and rock, vegetation, and snow

modifies the solar energy. The shape of the land absorbs heat if in direct sunlight, but doesn't in shadows. That temperature difference generates wind as air moves from high pressure (cold air sinks) to low pressure (warm air rises). Like water flowing from high to low, so does air. Air moves from high pressure to low pressure. We call that the wind. The sun's relationship between **albedo**, vegetation, and the **topography** of the Earth that produces weather.

Remember that the sun also is the main energy source for the water cycle. Water evaporates from oceans, rivers, lakes, and even the land. It is warm and rises in the air. As it rises, it cools down. Once cold enough, it condenses into water, or even, when cold enough, freezes into ice, snow, or sleet. Precipitation falls back to Earth, and the cycle begins again.

Albedo Experiment:

- Place your **topographic** map in the sunlight. Observe where the light falls and where shadows exist. Rotate your map 45° and observe how the light and shadows shift. Rotate another 45° and observe how the light and shadows shift. Rotate 45° one more time. How have the light and shadows shifted?



- Place your map back to the original position. The sun rises and sets in a different place every day as the Earth orbits the sun. On your map, how does the sun during the winter strike the Earth differently than the summer sun?
- What areas of your map were always in the sunlight? What areas of the map were always in the shadows?

Wind Experiment:

- Place your map outside in a protected area from the wind, but close to an outlet in your house. Plug the fan in, and place it about 5' from the map.
- Place a small scoop of flour into the sifter, and sift flour evenly across the entire surface of your map. When you are done, you should have a light dusting of flour all across your map.
- Caution: the flour will be blowing off the map. Be sure that you are

- <https://www.nasa.gov/centers/goddard/news/topstory/2003/0313irradiance.html>
- <https://www.nasa.gov/content/goddard/giant-january-sunspots/>
- <https://clipartxtras.com/download/29c9fcb355182404af6978a676359d685dcefb1f.html>
- <http://nurturedbylove.blogspot.com/2012/10/we-live-here-3d.html>
- <https://www.wikihow.com/Create-Papier-M%C3%A2ch%C3%A9>
- <https://scijinks.gov/wind/>
- <https://www.solarpowerrocks.com/solar-basics/3-reasons-the-sun/>
- https://www.emblibrary.com/EL/elprojects/project_images/PR1971_2c.jpg
- <https://www.originenergy.com.au/about/community/energy-for-schools/teachers/black-white-silver-years-7-8.html>
- VanCleave, Janice (1991) *Astronomy for Every Kid: 101 Easy Experiments That Really Work*. John Wiley & Sons, Inc, NY. Pages. 6-7.
- <https://www.giftofcuriosity.com/easy-fall-math-measuring-the-circumference-of-a-pumpkin/>
- <https://www.oneearthdesigns.com/blog/compare-solar-cookers/>
- <https://denver.cbslocal.com/2015/06/23/geomagnetic-storm-brings-northern-lights-to-colorado-another-storm-possible-late-wednesday/>
- <http://www.socoreenergy.com/new->

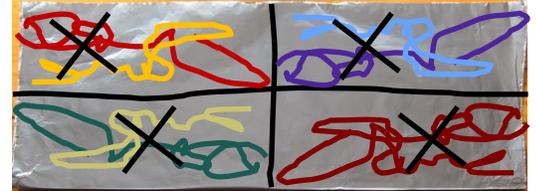
- wind-solar-power-colorado-now-cheaper-existing-coal-plants/
- <https://www.educationquest.org/blog/go-2-year-4-year-college/>
- <https://www.jumpstart.org/what-we-do/support-financial-education/reality-check/>
- <https://www.homesnacks.net/most-expensive-cities-in-colorado-127547/>
- <https://solarsystem.nasa.gov/people/3125/andreas-beyersdorf/>
- <https://space-facts.com/the-sun/>
- <https://www.fotographee.com/66-fun-facts-photography/>
- <http://www.themaptoeverywhere.com/wp-content/uploads/2015/10/Map-to-Everywhere-Map-Facts.pdf>
- <http://www.solarevents.com/articles/solar-jokes/>
- <http://www.solarevents.com/articles/solar-jokes/>
- <http://www.astronomytrek.com/astronomy-jokes-and-humour/>
- <https://thecosmiccompanion.com/jokes-about-astronomy/>

not in the path of the flour. Do not stand in the path of the fan. Make your observations on one side or the other of your map.

- Only use the low setting on the fan and watch your map. How does the flour move? Does it completely blow away? Does it gather in certain areas on your map? Are some areas sheltered? Do you see eddies and dust devils form?
- Repeat this at different angles to the fan. How does this change the wind patters?

Watershed Experiment:

- Tear a piece of foil about 20" long. Use a black marker and draw lines to divide the foil into 4 sections.
- Divide your remaining markers into 4 groups:
 - red and orange
 - yellow and green
 - blue and purple
 - brown
- Draw a picture in each square, using lots of marker color. You can draw anything like doodles or pictures. For example, one section could be a farm scene, one section a city scene, one section a river scene, and one section a mountain scene.
- On each section, draw a large "X" with the black marker. This will represent pollution.
- Carefully mold the aluminum foil over your **topographic** map with the pictures face up.
- Go outside. This is going to get messy!
- With the spray bottle, start squirting the aluminum foil. What happens? As you spray, you are going to find different section colors mixing together. Do you have any places that do not mix? Do you have any places where all the colors mix?
- Each area of color is a **watershed**.
- What happened to the pollution? What does this mean for watersheds? What kind of pollution is produced in cities? What kind is produced in agricultural areas? What kind of pollution is produced in mountains? What kind of pollution is produced around rivers? What happens to pollution in a watershed?



APPLY

The focus of this entire issue is on the sun's energy and how it interacts with our planet. The sun produces enormous amounts of energy, and only the tiniest fraction of that energy strikes the Earth. The rest is **radiated** into space.

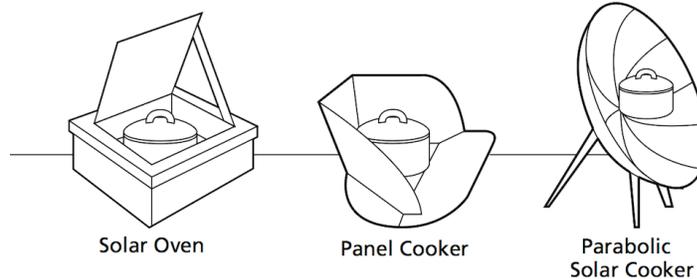
Challenge:

Can you design and build a solar oven to bake a cookie? You will need to incorporate the following components into your oven:

- **Corrugated** cardboard box about the size of 10 reams of paper
- Black (example: paper, spray paint, cloth)
- **Reflective** (example: mirror spray paint, aluminum foil, mirror)
- Something like a window (Plexiglas, plastic wrap)
- Something **insulating** (newspaper, old clothes)
- A smaller box to fit inside the big box (large shoe box)

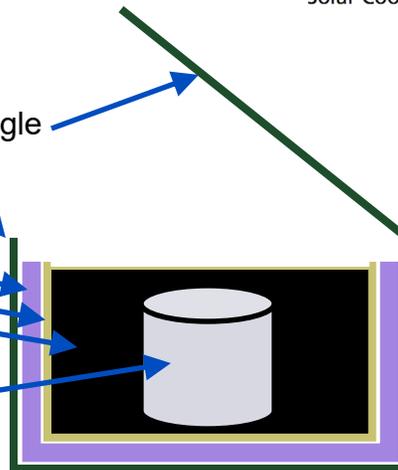
- Large metal can (29 oz or larger) that fits in the smaller box
- Box cutter or sharp scissors (with adult supervision)
- Pencil
- Ruler
- Clear (transparent) tape
- Yummy treat (cookie dough, s'mores, cheese sandwich, you could even bake biscuits or bread, but test it out first with something easier!)

Examples of designs:



Basic design on box solar oven:

- Top of box (green), propped at an angle to **reflect** sunlight into the box interior
- **Corrugated** cardboard box (green)
- **Insulation** (purple)
- Smaller box (gold)
- Dark interior to **absorb** solar energy
- Can (consider darker colors absorb solar energy: could you paint or cover the can with something?)



HAVE FUN!

- Eating Sun Cake
- Observing **Sunspots**
- Predicting Space Weather
- Discovering Microclimates
- Designing a Native Garden
- Making Maps
- Conducting Experimental Observations
- Test Driving Careers in Atmospheric Science and Solar Science!



Solar Energy in Colorado is not cheaper than coal plants! Perhaps this is a career that will be a perfect fit with you! Check it out US Bureau of Labor Statistics for info!

https://www.bls.gov/green/solar_power/



Aurora Borealis image taken in Denver in 2015. It is rare for the auroras to be seen this far south. Cool! Increased sunspot activity correlates with aurora activity. You can learn to predict auroras!

AUTHORS

Dr. Barbara J. Shaw, Colorado State University Extension Western Region STEM Specialist, 4-H Youth Development

Tom Lindsay, retired HS science teacher (AP and IB Chemistry, Physics, Biology, and Calculus) and university instructor (geology and paleontology)

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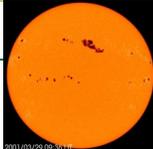
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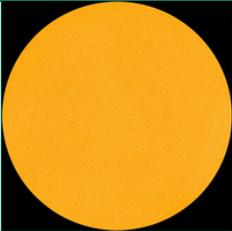
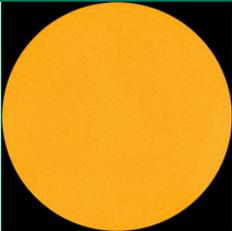
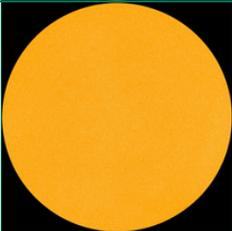
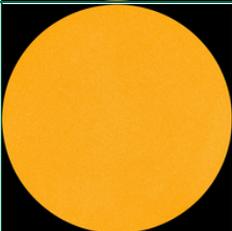
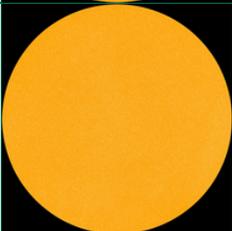
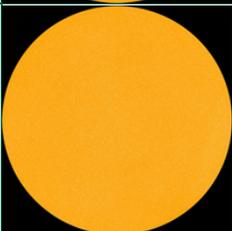
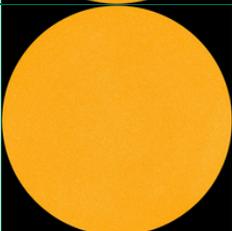
Microclimates Datasheet

Time	Thermometer 1	Thermometer 2	Calibrate ±	Thermometer 3	Calibrate ±	Thermometer 4	Calibrate ±
Ice Water							
7:00 AM							
8:00 AM							
9:00 AM							
10:00 AM							
11:00 AM							
12:00 PM							
1:00 PM							
2:00 PM							
3:00 PM							
4:00 PM							
5:00 PM							
6:00 PM							
7:00 PM							
8:00 PM							

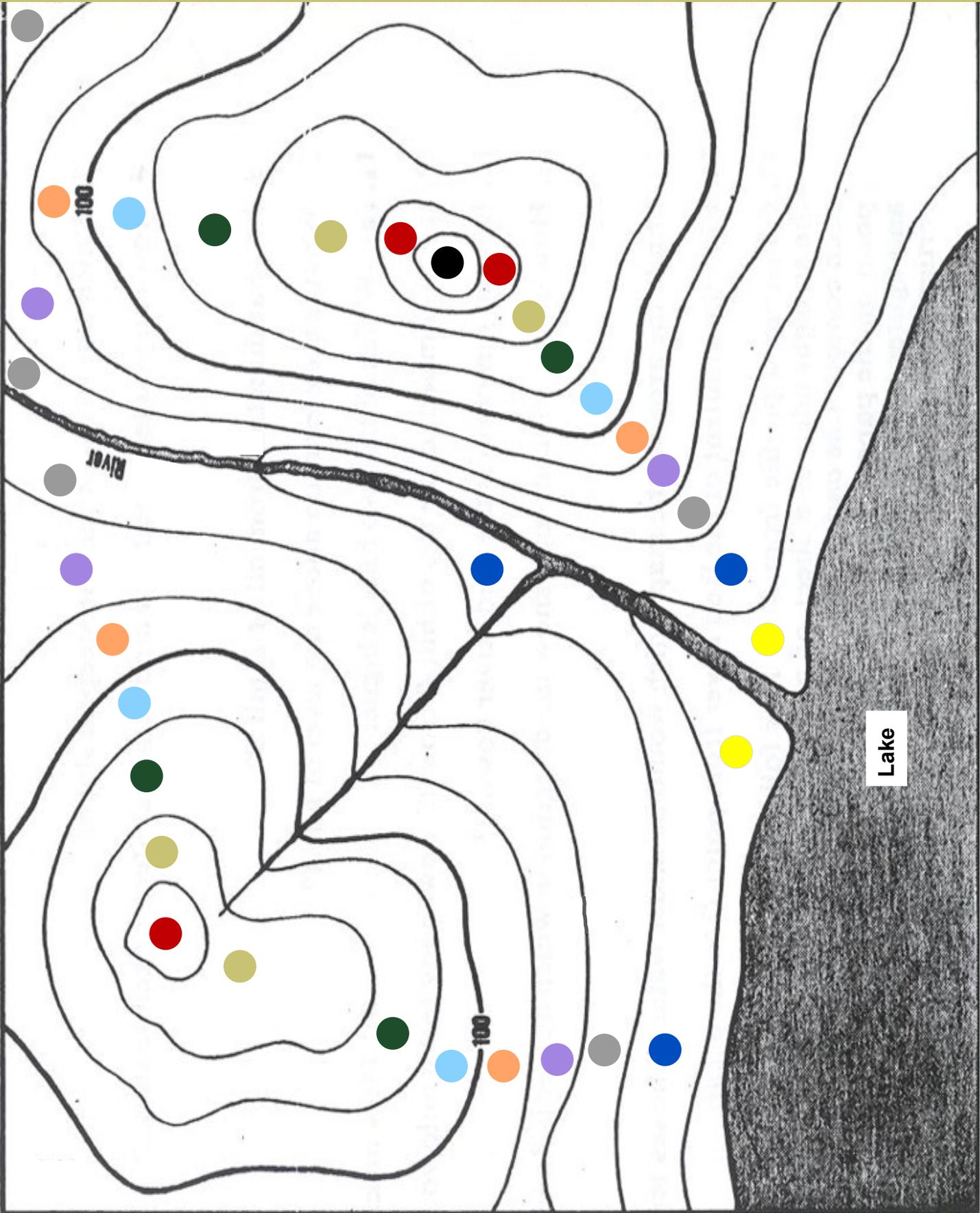
Supplemental Information

Sunspot Datasheet



Day and Time	Number Sunspots	Website Verified	Drawing of Sunspots and Notes	
Sunday				
Monday				
Tuesday				
Wednesday				
Thursday				
Friday				
Saturday				

Supplemental Information



Supplemental Information

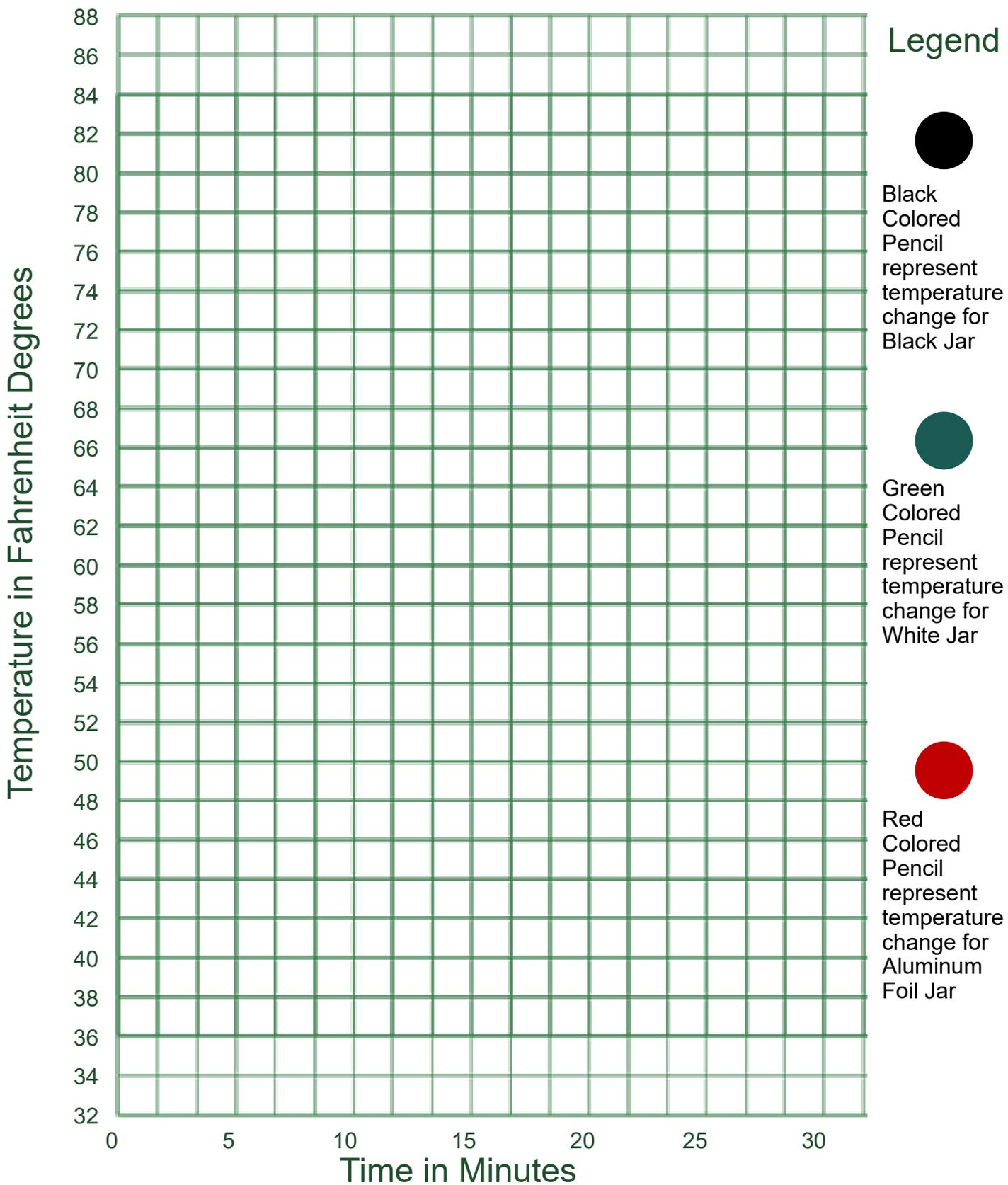
Albedo Datasheet

What is your prediction?

Surface Time	Black Jar	White Jar	Aluminum Foil Jar
Initial Temperature			
5 Minutes			
10 Minutes			
15 Minutes			
20 Minutes			
25 Minutes			
30 Minutes			

Supplemental Information

Albedo Graph



Supplemental Information

Lifestyle Worksheet—Monthly Expenses

For this exercise, use the median or mean (average) cost for each item if appropriate. If the amount is an annual amount, divide by 12 for the cost each month. As you do your research, print information to keep in your notebook. Use the headings: Housing, Food, Health Insurance, Utilities, and Transportation. Add family recipes and tips to your notebook.

Housing

- **Apartment:** what is the medium cost for a rental / month? (Search “average rent for an apartment in (your town), Colorado”). If you have a roommate, divide the rent by 2.

- **Renter Insurance:** varies, but assume \$144/year (\$12/month)
- Divide by 2 if you have a roommate.

Furniture: Start looking online or in magazines for the kind of furniture you would like for your home. You can add the pictures to your notebooks, noting the cost of each item. Talk to your parents. They may have some nice items that they will provide for you, and that would reduce your costs. You can be creative. Maybe a nice crate could substitute for a side table. Assume that the apartment comes with refrigerator, stove, curtains or shades, and laundry facilities. Under desired items, you can include more items for your home like a radio, TV, or computer. Assume a 2 year loan, and add 18% to the total for the total cost of the item. Divide by 24 to get your cost per month. If provided, put a “0” on the line. You will need:

- Bed—Cost x .18 = total. Divide by 24 months
- Dresser—Cost x .18 = total. Divide by 24 months
- Side table—Cost x .18 = total. Divide by 24 months
- Side table—Cost x .18 = total. Divide by 24 months
For living room. Divide by 2 if you have a roommate.
- Lamp—Cost x .18 = total. Divide by 24 months
- Lamp—Cost x .18 = total. Divide by 24 months
For living room. Divide by 2 if you have a roommate.
- Couch—Cost x .18 = total. Divide by 24 months
For living room. Divide by 2 if you have a roommate.
- Table—Cost x .18 = total. Divide by 24 months
For living room. Divide by 2 if you have a roommate.
- Chairs—Cost x .18 = total. Divide by 24 months
(Dining table and chairs may come as a set.)
For living room. Divide by 2 if you have a roommate.

- **TOTAL FURNITURE**

- **Kitchen:** Start looking online or in magazines for the kind of kitchen equipment you would like. You can add the pictures to your notebooks, noting the cost of each item. Talk to your parents. They may have some nice items that they will provide for you, and that would reduce your costs. Assume a 2 year loan, and add 18% to the total for the total cost of the item. Divide by 24 to get your cost per month. If provided, put a “0” on the line. You will need:

- Dishes—Cost x .18 = total. Divide by 24 months

Supplemental Information

- Eating utensils—Cost x .18 = total. Divide by 24 months
- Glasses and cups—Cost x .18 = total. Divide by 24 months
- Pots and pans—Cost x .18 = total. Divide by 24 months
- Cooking utensils—Cost x .18 = total. Divide by 24 months
Include spatula, knife, stirring spoons, measuring cups, measuring spoons, whisk, slotted spoon, etc.)

• **TOTAL KITCHEN**

If you have a roommate, divide the entire amount by 2.

Food

- Probably the easiest way to calculate the cost of food is to work with your family to determine how much money your family spends on the groceries. Go shopping with the parent who does the shopping, and keep the receipts. Include not only food, but all the other items, like cleaning supplies, toilet paper, and toiletries. At the end of the month, add up the total cost of the groceries and divide by the number of people in your household. To get started in your own home, you will need to spend more money to purchase the staples: flour, sugar, etc. Much depends on what your family eats, those famous family dishes. For each family, the staples will be different.

- Week 1 groceries receipt
- Week 2 groceries receipt
- Week 3 groceries receipt
- Week 4 groceries receipt
- Total
- Divide by the number of people in your family including you
- Divide by 4 (to get the average cost per week)
- Times 52 for the number of weeks in the year

• **TOTAL FOOD Divide by 12 cost of food per month**

Health Insurance

- **Assume \$136.** The website **Connect for Health Colorado** (<http://connectforhealthco.com/get-started/individuals-families/young-adults-2/>) states:

Welcome to Connect for Health Colorado®, the **only place** where you can **apply for financial help to lower the cost of your health insurance**. Here you can choose from a broad range of comprehensive health insurance and dental plans – all of which include free preventive services and coverage for pre-existing conditions. **Join the thousands of Coloradans receiving financial who protected their health and finances for just \$136 per month, on average.**

Utilities

- **Assume \$120.** Utilities include water, sewer, garbage/recycling, electricity, and gas. The average cost in Denver is \$116.52 for water, electricity, and heat.

Supplemental Information

Transportation

- What is your dream car? Might as well get that one out of the way. You may not be able to afford that 2019 Porsche 718 Cayman sports car right away. Look for good, reliable transportation. Remember to use your notebook to keep track of not only your dream car, but other cars that you can afford! When you have found the car that best suits your needs, search the internet for the car you would purchase today if you could. Considerations as you look for your car:
 - What is the average city and highway mileage?
 - What will the maintenance costs be?
 - How much will the auto insurance be?
 - What about new tires or snow tires?
 - Do you need the vehicle for more than transportation (i.e. self employed)
 - You are environmentally concerned (i.e. electric car)
 - Typical car loans are 60 months (5 years). Expect to add 18% to cover the cost of interest.

- Car cost:

- 18% to estimate interest
- Car insurance costs (ask your parent's car insurance agent)
- Estimated maintenance (tires, wipers, oil changes, etc.)
- Mileage (the US average is 13,474 miles per year. The average for a gallon of gasoline in Colorado right now is \$2.33 (rounded). Divide 13,474 miles by the average city mileage for your car to determine the cost of how many miles you get per gallon of gas.

13,474 miles / _____ miles per gallon = _____ gallons

Multiply the gallons times the cost of gasoline

_____ x \$2.33 = \$_____ cost of gasoline per year

Divide the cost of gasoline per year by 12 months

\$_____ ÷ 12 months = _____ cost of gasoline per month _____

Example: 13,474 miles / 23 miles per gallon = 585.82 gallons

585.82 gallons x \$2.33 = \$1,365.96 gas per year

\$1,365.96 ÷ 12 months = \$113.75 cost per month

- **TOTAL CAR**

TOTAL MONTHLY LIVING EXPENSE (add the blue boxes)

Other Expenses

- Clothing Estimate a clothing budget
- Purchase a TV or Computer
- Internet, TV, cable
- Entertainment (movies, dates, dining out)
- Savings
- Gifts
- Other?

GRAND TOTAL Add Total Monthly Living Expenses with Other Expenses