

# Innovators

## Discovery Group

For millions of years, plants and animals have innovated to survive Earth's changing environmental conditions. Human innovation has developed fantastic inventions over the last few thousand years. But now society may be faced with the reality of a rapidly changing ecosystem, which we will need to adapt to.

Students participating in the Innovators discovery group will gain an enduring understanding of Earth as a system through investigations of plant design and seed dispersal techniques, the earth-sun relationship, global climate change and renewable and non-renewable energy sources.

To innovate is to create change within a dynamic system. Innovators will visit a field classroom powered by solar and wind energy and assess how they have, as individuals and communities, the power to be innovators for positive change in society, the economy and the environment.

*"I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait until oil and coal run out before we tackle that."*

Thomas Edison, 1931

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Engage in a science concept scavenger hunt

Investigate local plant design

Connect human invention to nature

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Systems game

Build models of earth's seasonal changes

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Discuss resources, global issues  
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## What students learn:

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Climate change role-playing game, Systems game  
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# Innovators for Teachers and Staff

Innovators is designed to teach students how earth's systems work and are interconnected and how plants and animals have innovated over time to take advantage of the power of these systems. Students in Innovators will hike to the Renewable Energy Yurt at High Tor, a unique field classroom, for hands-on activities focused on renewable energy technologies. HTOEC staff will choose activities and content focus appropriate to the age group participating in Innovators and the curricular goals of the school.

## 2010 6th Grade Colorado State Standards Met

Famous inventors	SS1.2, RWC1.1
Science concept scavenger hunt	S1.3, M4.1, RWC1.1
Local plant design investigation	S2.2, RWC4.1
Biomimicry	SS2.2
Innovators Problem Solving Challenges	
Renewable and non-renewable energy sources	S3.2, S3.3
Climate destabilization	S2.1
Earth-sun relationship	S3.1, RWC1.1
Renewable energy trailer and yurt tour	S1.1
Solar activities	S1.1
Wind activities	M3.1
Concluding discussion/sustainability	S3.3, RWC4.3

S = Science (1 = Physical Science, 2 = Life Science, 3 = Earth Systems Science)

RWC = Reading, Writing, Communicating

SS = Social Studies (1 = History, 2 = Geography)

### Materials:

- scientist costumes
- copies of plant investigation research findings and other resource materials
- pencils
- compass
- angle finder
- ruler
- creative challenges materials
- solar materials
- wind materials

# Setting the Role

Students will: discover science, math and engineering concepts in nature.  
Time: 15 minutes

After taking role at the stake, set the stage for an exciting discovery group by asking students,

*What is the greatest invention of all time?*

*Have you thought about some natural inventions...*

- *the brain*
- *the eye* - made the world more competitive about 543 million years ago when a patch of light sensitive cells evolved into a complex eye in a trilobite, who became the first active predator.
- *lungs* - allowed for respiration, dispersing carbon dioxide and taking in fresh oxygen to the blood stream.
- *photosynthesis* - ability to capture energy from sunlight, without it there would be little oxygen.
- *symbiosis* - when two species engage in a mutually beneficial dependency, usually involving food
- *language* - specific to the human brain, allowed humans to develop their own environment, or culture.
- *multi-cellularity* - the change from single-celled animals to more complex animals

After a few students speak up, ask the 4 high school leaders to introduce themselves as one of the famous inventors in the resources pages. Divide students into 4 groups, each with a high school student who has taken on the role of an inventor, to complete the following tasks:

*What is your innovation company name and field (robotics, energy, computers, etc..?)*

*What is your idea for an invention?*

*Complete the Scavenger Hunt.*

Encourage high school leaders and students to identify and observe examples in nature for all the items listed on the scavenger hunt card. Student groups will also use their imaginations to become part of a scientific team working on an invention. After about 15 minutes, debrief the activity by going through the list...what did they find? Have the small groups introduce their company, the idea for a new invention and how it will benefit humans.

## *Science and Math Concept Scavenger Hunt*

solid, liquid, gas  
something that takes advantage of sun's angle  
something shaped to withstand wind or take advantage of the wind  
an atom and an electron  
a natural container  
a pattern in nature  
a light absorbing material  
a light reflective material

an example of:

**friction** (resisting force that opposes motion of an object as it passes by another object)

**transformation** (something that is going through a change or alteration)

**Newton's First Law of Motion** (an object at rest stays at rest and an object in motion stays in motion, unless acted on by an outside force)

**kinetic energy** (energy of motion)

**potential energy** (stored energy)

Find these geometric terms in nature:

**circle**

**parallel lines**

**arc**

# Plant Design and Function - Inventor Research

Students will: compare how organisms interact with each other and their environment.  
Time: 20 minutes

To start this activity, as a whole group, take one minute of silent observation to focus on the plant life surrounding us. Engage students in a discussion about plant design by asking:

*How many species of plants do you see? Do you see any micro-zones within the Montane Life Zone?  
How would you characterize the health of this area?  
Have you ever heard of the Venus Fly Trap? What other cool things do plants do?*

Investigating seed dispersal illustrates perfectly how plants are natural innovators, taking advantage of their surroundings to survive and thrive. Discuss the importance of plant design in surviving particular environments by looking at the Ponderosa Pine and looking at its bark, roots and needles. How plants distribute their seeds is key to their survival. Ask students how seeds move and refer to the dispersal methods below for a short discussion. Be sure to show students at least two examples (feel free to move around and have students find a seed to discuss as a whole group).

Now student groups will search for a plant they think has a unique seed distribution technique. Using the Seed Design and Function Investigation Research Findings page (see Resources) as a guide. After filling out the form, have student groups trade and search for the plant described by the other group. Come together for a quick closing by discussing student findings. They may find something no one else has seen before!

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## Seed Dispersal Techniques - Plants are natural innovators! (and they don't have a brain)

Seed dispersal is the movement of plant seeds away from parent plants and is advantageous for plants for a number of reasons. Seeds that fall near parent plants may end up competing with parent plants, to the detriment of either or both individuals. Also, a well-dispersed population is more likely to persist after disturbances, and more likely to survive as a species.

### Dispersal Methods:

**Water** (seeds designed to float or act as rafts with airtight sac with seeds)  
**Wind** (parachutes, helicopters, and height of trees)  
**Spores** (seeds 'shoot' off plant or are pollinated using cones)  
**Roots and Branches** (sprouting of clones)  
**Animals, adhesion** (spines, hooks, barbs and stickiness help seeds hitch hike or they are ingested)

### Montane Life Zone Examples:

Willow (snaps easily during storms to be carried downstream for replanting)  
Mountain Mahogany, Aspen  
Mistletoe, Ponderosa Pine. Blue Spruce  
Aspen  
Gumweed, grasses

# Biomimicry - Copying Mother Nature

Students will: give examples of how people interact with their environment.  
Time: 10 minutes

While making your way up to the yurt at High Tor, ask students if they have any velcro on them? Did they know that Velcro was designed by a swiss mountaineer in the 1940's after he had burr stuck to his wool socks and his dog after a long hike in the woods? The seed dispersal method of the burdock seed pod led to one of the coolest, simplest and most efficient form of adhering fabrics (better than zippers, snaps and buckles!) A new type of design engineering based on natural inspiration is called Biomimicry...copying mother nature. The simple, elegant mechanics developed by nature often make sense in a human context. More and more scientists are looking to nature to improve efficiency, design systems, and create sustainable products.

Use the following examples by giving students either the invention or part of nature and have them guess the other...

## ***Nature:***

*Woodpecker Skulls*  
*Bird Beaks*  
*Mussels*  
*Whales Fins*  
*How locusts fly in groups*  
*Shark skin*  
*Mountain Goat hoofs*  
*Hair on a Gecko's feet*  
*Lotus Plant leaves*  
*Shape of a tropical box fish*  
*Mobility of Insects*

## ***Human Idea:***

*motorcycle helmets*  
*bullet train design*  
*biodegradable glues*  
*wind/fan turbines*  
*auto accident warning systems*  
*swimsuits*  
*shoe soles*  
*tape/adhesives*  
*water repulsion in materials*  
*efficient car design*  
*robotics*

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## **Creativity Training**

Biomimicry takes a lot of creative thinking! Use these thought provoking but simple group challenges to get small groups having fun while thinking creatively. After completing one or both of the creativity challenges, task students with coming up with a new invention based on something in nature.

**Bandana Game:** Hand a bandana around the group for 2 minutes, come up with 25 different uses for it. Tell the whole group about 3 of the most unlikely uses you brainstormed.

**Stick-figure Stories:** Draw the stick figure pictures (in resources) and ask student groups to take 2 minutes to tell the story behind it. Then give students a blank sheet to create their own stick figure picture for another group to come up with a story for.

**Ants, Bees and Termites:** Present a performance in which you show how you would get rid of ants, bees and termites that have taken over your school. Take 5 minutes to use your imagination and up to 2 minutes to present your performance. You must have a different way of getting rid of each insect.

# Innovators Challenges

Students will: use problem solving skills to creatively complete a hands-on challenge.

Time: 25 minutes

Use this problem solving activity to encourage cooperation and creativity within the small groups. Choose one of the following challenges for the group. These also be used as activities for the All-Day.

## Just Straws

**Task:** to build a tower as tall as possible made only with straws. You will have up to 2 minutes to use your imagination and discuss strategy, and up to 5 minutes to build your tower.

**Materials:** 30 straws, 2 pairs scissors, 2 toenail clippers

## Fetch!

**Task:** to design a tool from the materials provided and anything you find in nature to retrieve items from behind the line. No part of a team member's body may cross over the line.

**Materials to be used for making tools:** yardstick, 4 ft string, ruler, 6 straws, 4 mailing labels, 4 index cards, 4 paper clips, 2 rubber bands, 2 sheets newspaper, 1 envelope, 1 plastic spoon

**Materials to be retrieved:** cork, feather, book, ring, golf ball, crayon, quarter, film container, cup

## Knock It Off

**Task:** remove an item from the top of a pipe and get it outside of the 'danger' area. You will have up to 5 minutes to use your imagination to design strategy and practice and up to 1 minute to remove the item.

**Setup:** in the center of the 'danger area' (roped off by yarn) is a vertical pvc pipe with an item on it.

**Procedure:** use materials to create a way of removing the item from the pipe without knocking the pipe over and a way of getting the item outside the taped area without any group member crossing into the danger zone. You may not throw objects at the pipe or item.

**Materials:** cotton balls, 2 compact discs, 1 index card, 4 straws, 1 fly swatter, 3 mailing labels, 6 packing peanuts, 1 paper cup, 1 yardstick, pipe cleaners

## Mini-Launchers

**Task:** make as many different launchers as possible and use them to send popcorn across a line.

**Materials:** 1 piece duct tape, plastic knife, cardboard tube, 2 pieces spaghetti, 1 rubber band, 1 straw, pipe cleaner, 2 coffee stirrers, 1 index card, 1 clothes pin, 2 paper clips, popcorn

## Mouse Traps

**Task:** create a mousetrap and demonstrate how it works.

**Materials:** 1 paper bag, 2 paper plates, 3 paper clips, 2 mailing labels, 2 rubber bands, 4 paper cups, 4 pipe cleaners, 4 coin rolls

### *Debrief questions:*

*How do you think you did as a team? What did you learn about teamwork by doing this challenge?*

*How well did you manage your time? How might you have used your time more effectively?*

*What were some strengths of your solution? What worked well?*

*If you were to start over, what would you do differently?*

*How well did you utilize the materials provided for you?*

# Energy

Students will: describe how humans are dependent on the diversity of resources provided by the earth and sun.  
Time: 15 minutes

Scientists define energy as the ability to do work. In a more realistic sense for humans, after food and water, energy is our most basic need. Ask students:

*Think about what types of energy it took for their breakfast to be served this morning.*

*Where did the food come from and how did it get to the kitchen?*

*How was it cooked and what processes were needed to clean up after the meal?*

## Energy Sources

*Ask students:*

*What are our major sources of energy?*

*What is the difference between renewable and non-renewable energy?  
Who can name two renewable and two non-renewable energy sources?*

*Who can name a fossil fuel?*

*Why are they called fossil fuels?*

*What needs oil to run?*

*What products are made from oil?*

*How does Colorado Springs get the majority of its electricity?*

*What is one of the cheapest forms of energy? One we use here at camp to heat your cabins...*

Non-Renewable sources cannot be replenished) and account for 85% of global energy use (oil, coal, natural gas).

Renewable Energy are sources that can never be exhausted and are considered 'clean' energy (wind, solar, hydro, geothermal, biomass).

**Oil (petroleum)** - Oil was formed from the remains of animals and plants (diatoms) that lived millions of years ago in a marine (water) environment before the dinosaurs. Over millions of years, the remains of these animals and plants were covered by layers of sand and silt. Heat and pressure from these layers helped the remains turn into what we today call crude oil. The word "petroleum" means "rock oil" or "oil from the earth." Gas, diesel fuel and propane, plastic bags, tires, roofing, crayons, balloons, lipstick and more are all made from oil!

**Coal** - Coal is a combustible black or brownish-black sedimentary rock composed of carbon and hydrocarbons. It is the most abundant fossil fuel produced in the United States. The energy in coal comes from the energy stored by plants that lived hundreds of millions of years ago, when the Earth was partly covered with swampy forests. For millions of years, a layer of dead plants at the bottom of the swamps was covered by layers of water and dirt, trapping the energy of the dead plants. The heat and pressure from the top layers helped the plant remains turn into what we today call coal.

**Natural Gas** - Natural gas was formed from organic materials millions of years ago like oil and coal. It is drilled for below Earth's surface on land or in the ocean. Pipelines are used to bring the gas to the surface, where it is stored or transported elsewhere to create electricity.

### Did you know??

All energy is solar energy! Even coal! Coal, the remnants of plants that lived a million years ago, stored energy in their leaves through the photosynthetic process...capturing the energy of the sun! Wind too! Differences in air temperature, caused by the sun, creates wind!

Energy continued...

**Questions to ask:**

**Have you ever seen a solar powered clothes dryer?** (clothesline)

**Where have you seen solar power at work?**

**Who here has seen a windmill?**

**What were they used for historically?**

**Now?**

**Has anyone seen a dam in Colorado? Where?**

**Who can name the inner layers of the earth?** (crust, mantle, core, inner core)

**What is there deep under the Earth's surface?**

**Solar** - energy from the sun converted into electrical energy using PV (photovoltaic) cells, made of metal and silicon, grouped into panels and arrays of panels that can be used in a wide range of applications ranging from single small cells that charge calculator and watch batteries, to systems that power single homes, to large power plants covering many acres. The silicon used to make PV cells is often found in sand and takes energy to create.

**Wind** - Wind is simply air in motion, a form of solar energy. It is caused by the uneven heating of the Earth's surface by the sun. Because the Earth's surface is made of very different types of land and water, it absorbs the sun's heat at different rates. Wind energy requires wind turbines. Once wind turbines are made, there is no land, water or air pollution associated with wind power.

**Hydropower** - energy generated by moving water. Fast-flowing water and water that falls contains a lot of energy and is harnessed in dams to create electricity. The cost of hydropower lies in building the infrastructure, but is a cheap and clean source of energy emitting no harmful emissions, air or water pollution.

**Geothermal** - heat that comes from within the earth. Extremely high temperatures are continuously produced inside the earth. Pipes are drilled below Earth's surface to access these reservoirs of thermal energy. Geothermal heat pumps transfer heat from the ground in the winter and reverse the process in the summer, transferring heat from the air into the cooler ground.

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## Environmental Impacts

**Question to ask:**

**Can you think of positive and negative consequences for each energy source?**

**How can we make responsible choices about resources we use on a daily basis?**

Oil and coal must be mined, processed, transported and burned to produce their energy, which takes a consistently large amount of energy in itself. When burned, emissions toxic to the environment are released. There is an initial energy cost to harness wind and solar, but it is only a one time cost, not constant like oil and coal production.

### Energy Production in Colorado:

Huge quantities of natural Gas and Oil Shale are drilled for in Colorado. Ten of the Nation's 100 largest natural gas fields and three of its 100 largest oil fields are found in Colorado.

Colorado is also a leader in solar energy technology, with many renewable energy start-up companies making Colorado their base. Colorado has over 300 sunny days a year...optimal conditions for harvesting the power of the sun!

### Debate Questions for more advanced groups:

**'There are enough resources to meet the needs of everyone on the planet'**

**'The US gives more to the world and therefore, can take more from the world'**

**- Supporting statistic: The US/Canada make up 6% of the world's population, but consume 30% of the world's energy, as opposed to Africa, which consumes only 5% for 15% of the world's population.**

# Climate Destabilization

Students will: develop, communicate and justify an evidence-based explanation about how ecosystems interact with and impact the global environment.

Time: 15 minutes

Earth has warmed by about 1°F over the past 100 years. But why? And how? Scientists are not exactly sure. Many leading climate scientists think that things people do are helping to make the Earth warmer (like what?). Plants and animals have been able to adapt in the past to natural changes in climate that occur over long periods of time. However, the rapid changing of the global temperatures poses a problem for living things that may not be able to adapt as quickly.

## Greenhouse Effect and Global Warming

### *The Greenhouse Effect:*

Greenhouse gases make the Earth warmer by trapping energy in the atmosphere. Without the greenhouse effect, the Earth would not be warm enough for humans to live. But if the greenhouse effect becomes stronger, it could make the Earth warmer than usual. Even a little extra warming may cause problems for humans, plants, and animals. The Earth's atmosphere is all around us. It is the air that we breathe. Sunlight enters the Earth's atmosphere, passing through the blanket of greenhouse gases. As it reaches the Earth's surface, land, water, and biosphere absorb the sunlight's energy. Once absorbed, this energy is sent back into the atmosphere. Some of the energy passes back into space, but much of it remains trapped in the atmosphere by the greenhouse gases, causing our world to heat up.

### *Global Warming:*

Global warming refers to an average increase in the Earth's temperature, which in turn causes changes in climate. *What evidence do we have of global warming?*

### *Evidence:*

- ***Melting Glaciers:*** a glacier is a large sheet of ice that moves very, very slowly. Many glaciers in the world are now melting. For example, glaciers are melting in Montana's Glacier National Park.
- ***Rising Sea Level:*** At most shores throughout the world, two high tides and two low tides occur every day. But now the level of the sea is rising, so high tides are higher than they were before. Over the last 100 years, the level of the sea has risen about 6-8 inches worldwide. When the sea level rises, the tide goes farther up the beach.

### **Student activities:**

Climate Change Role- Playing Game

Balance in Systems Game

see Resources for full descriptions...

### *Questions to ask:*

*Is this a problem? If so, whose problem is it? Are there any solutions?*

*What are the potential consequences for human health? ecological systems? crops and food supply?*

*What areas of Earth are most vulnerable to climate change?*

*How might your ecosystem change?*

*How might people benefit from climate destabilization?*

*How do ecosystem changes affect biodiversity?*

# Earth in Balance...An Amazing System!

Students will: understand complex interrelationships exist on earth due to its relationship to the sun.

Time: 20 minutes

The Earth/Sun relationship is what makes conditions possible for life to exist!. Using a student as earth and the teacher as the sun, explain their relationship in terms of rotation, revolution and axis (see image in Resources to clarify terms below. After your explanation students should be able to answer the question..

*‘Why is it hot at the equator all year long?’ or ‘Why are there seasons in the Northern Hemisphere?’ and know why different parts of the earth receive the suns direct rays at different times of the year.*

**Terminology: axis, rotation, revolution, equator, elliptical orbit**

The orbit of the Earth around the Sun is called an Earth **revolution**. This celestial motion takes 365.26 days to complete one cycle. Further, the Earth’s orbit around the Sun is not circular, but oval or **elliptical** (see Figure 6h-2). An elliptical orbit causes the Earth’s distance from the Sun to vary over a year.

The movement of the Earth about its axis is known as **rotation**. One rotation takes exactly twenty-four hours and is called a mean solar day. The angle of rotation is toward the East.

Tilt of the Earth. The Earth’s rotational **axis** is tilted 23.5°. Earth’s axis is what creates seasons, not the ‘closeness’ to the sun while in the elliptical orbit.

Use ‘What if’ questions to follow up:

*What would Colorado’s climate look like if Earth’s axis were 55 degrees?*

*What would your day look like if rotation was slower? What if Earth’s revolution was faster?*

## **Student Activity - Build a model of the earth - sun relationship.**

In small groups, students will illustrate the earth-sun relationship using whatever materials they want to represent the sun and the earth. After 3 minutes of planning they will tell their ‘earth-sun story’ to the group. Students may choose to use natural materials, items from their packs, etc...

## **Infuse the sense of wonder...**

As a whole group, have the students lay on their back looking up at the sky...The sky is one of the most beautiful and mysterious parts of our Earth system.

Can they feel the warmth of the sun? Imagine the atmospheric layers the suns rays travel through to get to the surface of the earth....the ozone, troposphere and stratosphere. These layers are helping us by screening harmful UV rays before they reach us. The sun is 93 million miles away...isn’t it amazing the amount of power and energy the sun has to have such an important effect on us so far away. Light from the sun travels at 186,000 miles/second...it only takes about 8.5 minutes to get here! The sun is the central figure for life as we know it. ***How is the atmosphere connected to the geosphere? How is the hydrosphere connected to the biosphere?***

# At the Yurt

Divide students into 3 groups to participate in 15 minute stations at the Yurt. The three stations are Tours of the Renewable Energy Trailer and Yurt, solar activities, wind power activities. If there is a game you develop around an energy theme, divide students into 4 small groups to rotate through stations.

## Tours of the Renewable Energy Trailer and Yurt

The yurt and renewable energy trailer provide a unique field learning station for students to discover the wonders of solar, wind and recycling and to reinforce learnings from earlier in the discovery group.

### At the Renewable Energy Trailer... (staff or teacher should teach this station)

- Use the posters to guide student learning in terms of wind and solar power.
- Have students investigate the solar pv panels closely.  
*What are they made of? How do they work? Why are they different?*
- Using a compass ask students to determine the direction the trailer is facing. *Why?*
- Using an angle finder ask students to determine the angle of the panels.  
*What angle would you put them if you lived in Alaska? How about in the Amazon?*
- Assess the site selection for the yurt and trailer in terms of wind, sun, shade, etc...  
*Is there a better place for this setup? Where and why?*
- Use the 'Basic Solar Energy System' puzzle cards with student to address the unseen components of the trailer...the batteries, charge controllers and inverter. (see Resources)
- Investigate the trailer for mechanical engineering and 'tools of the trade' such as wheels, which allow the power source to be moved, the stays and guidewires securing the turbine tower, the winch, etc...

This trailer is a small scale model for harvesting solar and wind energy...imagine standing under a giant wind turbine in Iowa or next to an array of over 1000 pv panels...wow! This is a good topic to discuss the concept of scale.

### How solar panels work:

1. Light hits the PV panel and energy particles in the light, called photons, cause the silicon (within the silicon, there is a positive and negative layer, which creates an electric field, like a battery) molecule to release an electron.
2. Electrons are knocked loose and move to the edges of the panel, following the metal guides, producing an electric current.
3. The current flows to the battery in the form of direct current (DC) and is converted to alternating current (AC) by the inverter to be used.
4. Electrons return to the silicone no longer energized.

This process is known as **The Photovoltaic Effect** –  
converting light (photons) to electricity (voltage).

### At the Yurt...

Assess the physics of a yurt.  
*What is the predominating shape?*  
*How is the roof held up?*  
*What is the advantage of having a structure like this?*

# Solar Activities at the Yurt

## Play with Panels:

Students will use small pv panels to invent and run small DC machines and motors using the materials found in the 'solar box' in the yurt. (If the sun is not shining...try using one of the lights in the yurt as the source of power or use the alternate solar activities found in the resources.)

- Challenge students to run panels 'in-series' or 'in parallel'
- Use a voltmeter to determine the output of their panels.
- Try the solar cooker.

## Solar Energy is DARING!!

<b>D - Distributed</b>	Solar Energy is everywhere on the planet.
<b>A - Abundant</b>	1 hour of sunlight that hits the Earth is equivalent to 1 year of all human energy
<b>R - Reliable</b>	The sun shows up for work every day.
<b>I - Inexhaustable</b>	The sun will not run out. It is an infinite (and free) power source.
<b>N - Not Centralized</b>	There are no transmission losses.
<b>G - Green</b>	There is no pollution associated with solar power, no environmental costs.

**Did you know** that 70% of humans have no electricity?

There are major health consequences associated with this level of poverty...

*Can you think of any?*

There are organizations developing solar suitcases and small voltage medical equipment to help communities in need. Talk about innovation!

# Wind Activities at the Yurt

Wind is created by the Earth's rotation and the sun's uneven heating of our atmosphere and the surface of the Earth. Because the Earth's surface is made of very different types of land and water, it absorbs the sun's heat at different rates. (For example, On a planetary scale, the equatorial belt is warmer than the Temperate Zones)

As hot air rises, cooler air moves in to fill the void. Hot air rises and cold air falls. Air flows from a high pressure area to a low pressure area. The closer the high and low pressure areas are together, the stronger the "pressure gradient", and the stronger the winds. Near the surface of the Earth, friction from the ground slows the wind down.

## How wind turbines work:

1. When air flows past the blade, a wind speed and pressure differential is created between the upper and lower blade surfaces.
2. Pressure at the lower surface is greater, which 'lifts' the blade. The amount of energy a wind turbine can produce is determined by the diameter of the rotor blades.
3. Turbines convert wind's kinetic energy to mechanical energy (which drives the generator to produce electricity). Electricity is transmitted through wiring down the tower.
4. The tail keeps the rotor pointed into the wind

## Using Maps...

Compare the US wind map to the US raised relief map...

*Do you see a connection between topography and wind speed?*

Looking at a topographic map, find the best location for a wind turbine.

*Why did you choose that spot?*

## Using Scales...

Using the Beaufort and Griggs-Putnam Scales, estimate the wind potential in the area of High Tor. (See wind supplies in yurt)

## Testing Turbine Blades

Set up the wind turbine motor, fan and give each pair of students a hub. Students can choose from the bag of turbine blades to set up their turbine for the highest amount wind capture. Pre-cut blades, hubs, the tower and motor are in the wind box in the yurt.

## Wind Power Debate

Divide the group and assign roles as representatives from the wind power association and concerned homeowners. The homeowners know wind power is the right thing to do, but don't want the turbines in their backyard. How will the wind power representatives convince them?

# Concluding Discussion

Students will: critically evaluate the advantages and disadvantages of sustainability?

Time: 10 minutes

Thomas Edison said, “*Genius is 1% inspiration and 99% perspiration*”.

*What does this mean?*

Idea development and creative thinking are only steps in the long path to great innovation. Hard work and persistence make ideas a reality. Think about the idea of sustainability for example. Living sustainably means to meet present needs without compromising the ability of future generations to meet their own needs. Sounds like a great idea. Something that all humans should consider in their everyday living...but what are the realities behind living this way?

*What would we, as humans, need to compromise in our present lives to ensure a healthy planet for people in the future?*

There are three key elements in trying to achieve a sustainable lifestyle (as an individual, family, business, etc...)

*Do your actions or product impact the economy in a positive, negative or neutral way?*

*Do your actions or product impact the environment in a positive, negative or neutral way?*

*Do your actions or product impact society in a positive, negative or neutral way?*

Get back into your small groups and re-assess the invention you were thinking of at the beginning of the discovery group and ask these three questions about it. Below is a good list of questions that can be used as a discussion guide. Have students focus on environmental sustainability if short on time. For example, how many resources does my cola-retrieving robot use in its production.

## **Environment:**

*How many resources does the activity use?*

*Does the activity cause damage to plants or animals?*

*Is Biodiversity protected?*

*Does it cause air pollution, water pollution or soil erosion?*

*Does it use resources at a rate that allows the resource to be renewed or regenerated?*

*What happens to the waste created by the activity?*

*Does it generate excessive waste?*

## **Society:**

*Does it contribute to people's quality of life?*

*How does it affect culture?*

*Is it an equitable activity; does it offer more opportunities to certain groups of people than others?*

## **Economy:**

*Does it create meaningful work for individuals?*

*Does it contribute to a community's economic development?*

Now think about your personal life.

*What is your consumption pattern?*

*How can you make compromises to live more sustainably?*

# Innovators All-Day Activities

The innovators all-day is a great opportunity for students to expand their knowledge of solar energy through team and individual projects. Students will build solar cookers and use solar print paper to create art projects.

## Solar Cookers

Using professionally built solar cooker, illustrate concepts needed in building an efficient cooker.

Have you noticed how a car parked in the sun stays warm inside, even on cold days? That's because clear materials like glass and plastic trap the heat from the sun. We can use this principle to make solar power ovens. Here are some other concepts to look for:

**Collection** - how is your cooker angled to the sun? Glazing should be perpendicular to the sun

**Reflection** - use best reflective material available to you at a 60 degree angle (best are mirrors)

**Glazing** - cover of the cooker must be a clear single layer as airtight as possible to minimize heat escape

**Insulation** - walls and floor of cooker should be insulated. Corrugated cardboard and newspaper work well.

**Absorption** - black absorbs the sun's rays. The inside of the cooker should be black.

### Solar Cooker Directions

**Materials:** 1 medium sized pizza box  
black construction paper  
aluminum foil  
1 oven cooking bag (reynolds: you can get several windows out of each bag)  
masking tape, clear tape, glue, ruler  
scissors  
sticks (to hold flap open)  
newspaper for insulation  
cookie dough/peeps to test oven!

#### What to do:

1. Draw a line about 1" from the edges of the box and cut along the line. (don't cut along the top edge where the hinge of the box is!) and gently fold the flap back along the uncut edge to form a crease.
2. Put a piece of aluminum foil on the inside of the flap and fold the edges around the back of the flap. Smooth the foil and tape the edges on the back of the flap. Keep the tape from showing on the front side of the flap. This foil will reflect sunlight into the box.
3. Open the box and put a piece of cardboard or newspaper in the bottom and sides for more insulation. Cover it with black paper to help absorb the sun's energy.
4. Cut a square of Oven Bag that's about 1/2" bigger on all sides than the cutout in the box top. Tape it to the inside of the box top with clear tape. It must be airtight!
5. Use a stick to hold the top flap up. Adjust it to reflect as much sunlight as possible into the box. To hold it in place, stick it about an inch through the top and tape the other end to the box.

## Solar Prints

Making solar prints with solar paper is a fun art activity for students.

**Materials:** solar print paper, random objects, sun

**Directions:**

**Step 1:** Choose a design that you want to print. Some ideas: flowers, leaves, photograph negatives, found objects, etc. This is where you really get to use your imagination. Don't limit yourself. Try anything!

**Step 2:** Remove your blue sunprint material from its UV safe bag and place it on a ridged flat work surface. Make sure to keep the unused materials in there UV safe bag.

**Step 3:** Lay, pin or tape down your design. Keep in mind that you are working with ultra violet light (UV) sensitive material. Stage your initial set-up in your house or in the shade away from UV light.

**Step 4:** Expose your design facing the sun. If it does not face the sun, it will print the shadows of your objects, which can create a very interesting effect. Moving or changing your design around during your exposure time, can give another creative effect.

**Exposure times** Expose sunprint cotton or watercolor paper for 10-20 minutes and sunprint silks for 5-10.

**Step 5:** Rinse the exposed blue sunprint materials in water, after you remove your design. Rinse until the water runs clear. You will see your blue print magically appear and also see why blue sunprints are amazing.

## Solar Smoothies

Thirsty for a refreshing drink made with power from the sun and wind?

**Materials:** Renewable Energy Trailer, blender, cups, fruits, juice, ice, etc...

**Directions:**

**Step 1:** Plug the blender into the trailer and blend away! Have students make 'crazy' smoothie mixtures!

**Step 2:** Enjoy!

## Passive Solar Home Design

The sun can heat and cool your house, reducing energy costs. Using geoblocks or natural materials, challenge the students to build a structure in 2 minutes that embodies the principles of passive solar design listed below. Before students begin, show them which direction is south. After 2 minutes of building, have 1 student of the team visit other structures. Go back and redesign with new knowledge in mind. Encourage students to be creative!

Be sure to build your own model while discussing the principles for students to visualize the challenge.

*How can you maximize the benefits of the sun?*

### Principles of passive solar home design:

- **Orientation:** Is the building facing south?

Longer walls should face toward the south to absorb the heat from the low winter sun. In the summer, when the sun was higher in the sky, long porches helped to shade the buildings and keep them cooler. Areas which are most frequently used should be located on the longer, south side of the building, where sunlight can enter through windows in the south side, high clerestories windows, or skylights. The shorter east/west side reduces the amount of surface area exposed to the sun and cuts down heat gain. Spaces such as garages, storage or laundry rooms can be situated on the house's east/west facing "short side" where they act as an additional thermal (or heat) buffer.

- **Overhangs and shading:**

A good building will have overhangs measured on the south windows that block the extreme summer sun when it is high in the sky while allowing winter sun (sun is low in the southern sky) to heat the home naturally.

- **Landscape Features:**

Landscape features such as trees, rocky outcroppings, small hills or water can impact how your home performs. Become familiar with the prevailing winds and the pattern of air movement on your property - this knowledge will help you use trees and other natural features to direct summer breezes into the house while channeling cold winter winds away from it. Evergreen trees or a sheltering hilly outcropping on the north can buffer winter winds and harsh weather. Deciduous trees placed on the south and east or west can shade your home in the summer before dropping their leaves in the winter to let the sunlight into your home.

- **Insulation:** What is the insulative material?

- **Windows:**

Where are all the windows? Are they operable for proper air flow? Locate the majority of your home's windows and patio doors on the south side. This will allow them to collect warm solar energy when heat is needed and to let in breezes when you need fresh, cool air. Limit the number of east, west and north facing windows to help insulate against winter cold and reduce summer heat gain.

# All-Day Performance Activities

## Climate Control

Create a store that sells things that can control the 'climate' and then present a performance using imaginary props in which you show the group the things that can be found in your store.

You will have 4 minutes to use your imagination to create your store and plan your performance, and up to 2 minutes to present your performance to the group.

**The Scene:** Everyone is talking about the new store that is opening up that will be selling the weather. Yes the weather! Everyone hopes that they will be able to buy the "perfect weather" to share with their friends. And yet, no one knows anything about what's inside the store or how the things that are sold will work. Since this is going to be your store, create a skit that shows the group how the things inside the store work. You must demonstrate 3 kinds of climate control your store will sell. All props must be imaginary.

## Transformation

Identify a new plant that 'transforms' into an animal, and present a funny performance in which you show how the plant can transform into an animal.

You will have up to 5 minutes to use your imagination to create a funny performance and up to 2 minutes to present your performance to the group.

**The Scene:** Your team is on a mission as scientists when you discover a new plant. Everyone is very excited. The next day when you check to make sure that your new plant is okay, imagine your surprise when you find an animal, looking a little like your new plant, sitting exactly in the same spot! What is going on here? How are you to explain your discovery?

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## All-Day Challenge Activities

See Innovators Challenges pages for full write-ups on the following challenge activities:

**Fetch!** - Design a tool to fetch and replace items from across the room

**Just Straws** - build a tower that is as tall as possible made only of straws.

**Knock It Off** - Create a way to remove a funnel from the top of a pipe and get it out of the danger area!

**Making Mini Launchers** - create 5 launchers to shoot popcorn.

**Around the House** - invent a gadget to make your house chores easier!

**Mouse Traps** - create a mousetrap and demonstrate how it works.

# **Innovators Resources**

## High School Leader Intro Biography Cards

**Wilbur Wright** - inventor of the first flying machine. He and twin brother Orville gained much of their inspiration from nature. "The desire to fly, is an idea handed down to us by our ancestors who, in their grueling travels across trackless lands in prehistoric times looked enviously at the birds soaring freely through space, above all obstacles, on the infinite highway of the air." Another source of inspiration for the Wright Brothers was "cycling". The premier of the "safety bicycle" hit America big. In the 1890's, "cycling" became one of the most popular forms of personal transportation in America. Before "safety bicycles," the only type of bicycle that was manufactured was the old kind with one large wheel and one small wheel. The new, "safety bicycle" used two wheels of equal size, meaning there was less distance to fall if you fell off the bicycle. Wilbur lived in a creatively nurturing household where his dad, a preacher, didn't allow card-playing because he believed it was a waste of valuable time and his Mom, whose dad was an engineer, had a strong grasp of physics as a science and encouraged the boys to do kitchen experiments. Neither of the Wright brothers graduated from high school, however Wilbur had dreams of attending Yale until he was hit in the head with a bat during an ice skating game which caused him to have a heart palpitation condition. This single event made him a very serious person, one difference between him and his brother. Another notable creative outlet for Wilbur was his interest in printing. He ran a printing press and delivered a 4-page magazine known as 'The Midgit'.

**Thomas Edison** had very little formal education and actually taught himself much by reading on his own. He began working at an early age, as most boys did at the time, and received his first patent on an electric vote recorder, a device intended for use by elected bodies such as Congress to speed the voting process. This invention was a commercial failure, as were a lot of his 1,093 patents. However, the telegrapher-turned-inventor's greatest invention was his research lab where he first developed the tin foil phonograph, the first machine that could record and reproduce sound. His most famous invention, of course, was the incandescent light bulb. But it wasn't just the light bulb that made Edison a success. It was the entire electric lighting system that contained all the elements necessary to make the incandescent light practical, safe, and economical which ushered in an era of modern utilities in the 1880's, making life easier. Edison also invented the first movie or moving picture recorder; he called it the Kinetoscope.

**Ben Franklin**, son of a soap maker and father of 17, is known for inventing the Franklin stove, swim fins, a musical instrument called the 'armonic', bifocals, the lightning rod, odometer, fire company, daylight savings time, and was the first person to map and study the Gulf Stream over his 8 voyages across the Atlantic Ocean. Ben Franklin, like Thomas Edison with his electrical utility inventions, looked at whole systems in trying to improve societal problems. An example was Franklin's goal of making streets in Philadelphia cleaner and safer for citizens. He invented road building techniques, the gas street lamp, and organized fire companies to achieve that goal. Franklin was also a huge political advocate for the growing population of the colonies in the 1700's. As one of the 'founding fathers', he helped gain independence from Great Britain through his writing, diplomacy and political activism.

**American Indians** were the first people to invent methods to deal with a variety of ecosystems, while living a sustainable lifestyle. The status of Earth was important to the American Indians, and we can see it in their cultural and practical inventions. American Indians can be credited with inventing methods of transportation such as the kayak, and canoe, housing, moccasins, the toboggan, snowshoes, lacrosse, and bows/arrows. The American Indians were true innovators, utilizing the natural world for all their basic needs.

## *Seed Design Investigation Research Findings*

Description of Plant (color, size, texture)

Sketch of Plant

Where found?

North or South facing slope?

Dense or sparsely vegetated area?

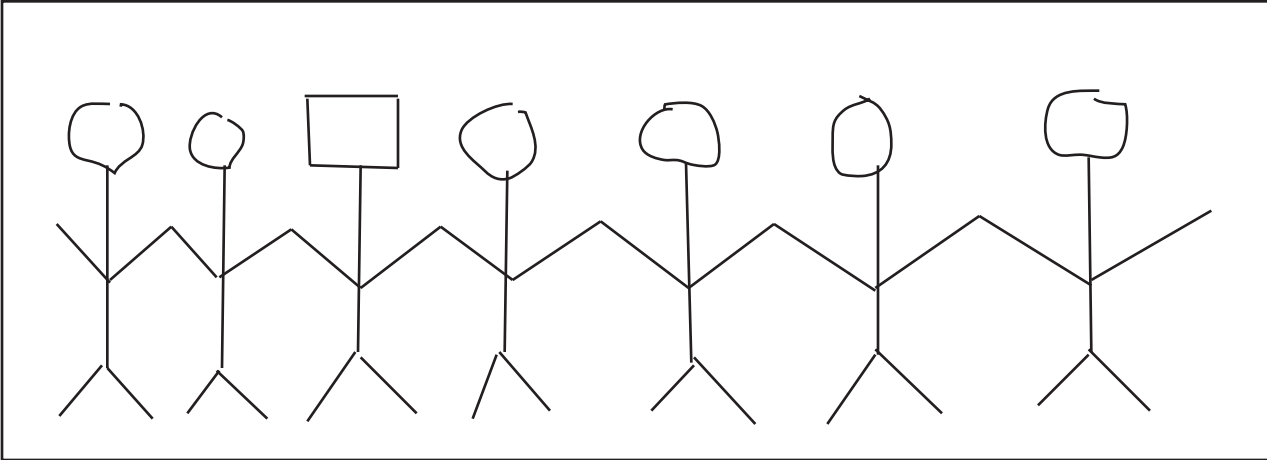
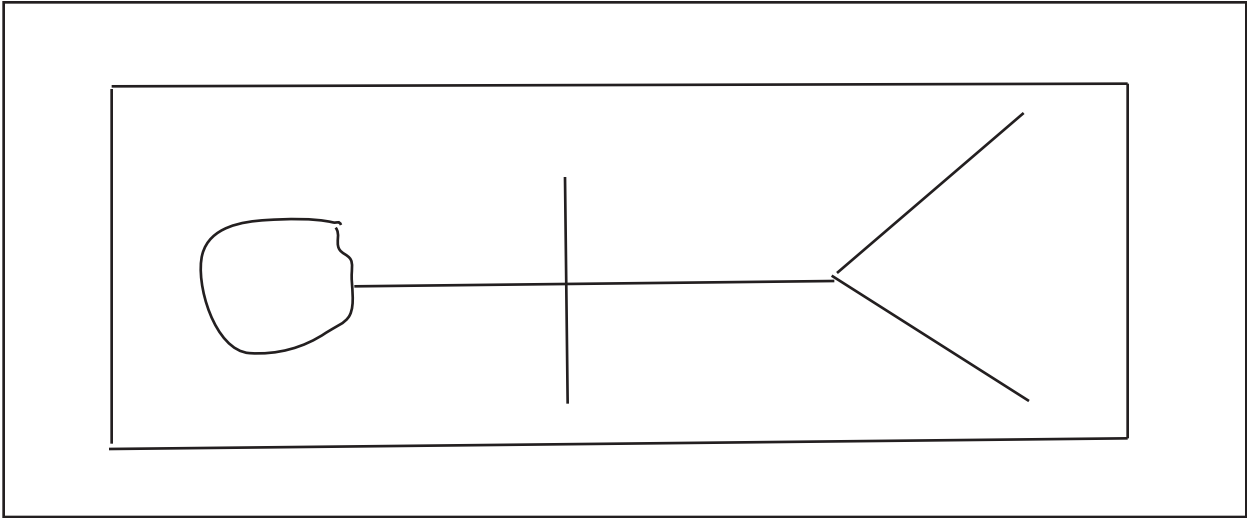
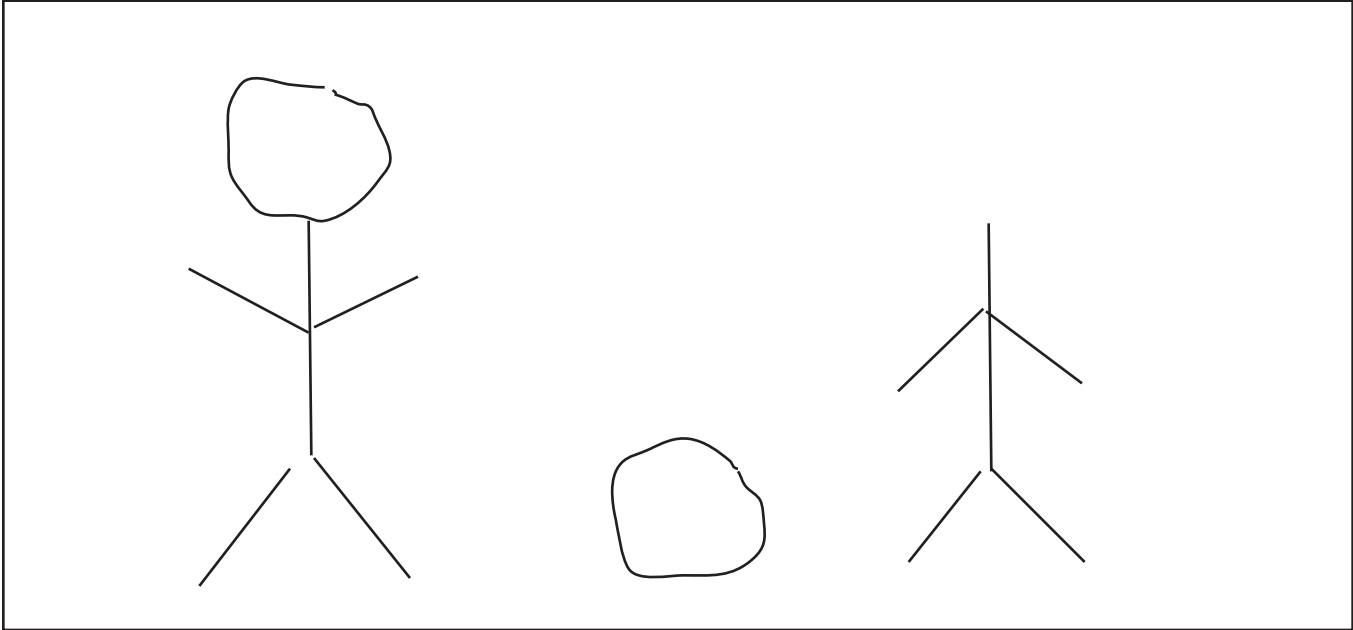
Characteristics of Soil: Rocky, mud, wet, dry?

Suspected Method of Seed Dispersal?

Rationale:

Innovation Company Name:

Stick Figure Pictures



# Games

## Climate Change Role Playing Game

Use to reinforce global climate change discussion.

Directions: Students are each given something in nature (see list for examples). They must think about how a rapid change in global climate may affect them.

*How is their ecosystem affected?*

*How is their food source affected?*

*Is there any way they could benefit from an increase in temp?*

Examples of Roles:

Polar Bear

Sea Turtle

Ponderosa Pine

Human living on a South Pacific Island

Human living in NYC

Mountain Mahogany

Shorebird

Prairie Grass in Nebraska

Student in Colorado

Snow flea

Western Rattlesnake

## Systems Game

Ask students: *What are some features of a system?*

- many parts work together, if you change 1 part it affects other parts, if you remove or add something it can change the whole system, made of interconnected parts, can be something in nature, mechanical or human

The goal of the systems game is to illustrate how systems self-regulate.

### Directions:

**Step 1:** Have students stand randomly in a large open space.

**Step 2:** Give the following 2 instructions:

- Mentally select 2 other people in the group, without telling anyone who they are.

- Move so as to keep an equal distance between you and each of the 2 people at all times. This does not mean simply remaining at the midpoint between them.

**Step 3:** To pursue this objective, students begin to circulate, each movement triggering many others in an active, independent fashion. Movement may speed up, then slow down, but rarely reaches stasis.

**Step 4:** Let the movement continue for 3-4 minutes then have students pause for reflection questions.

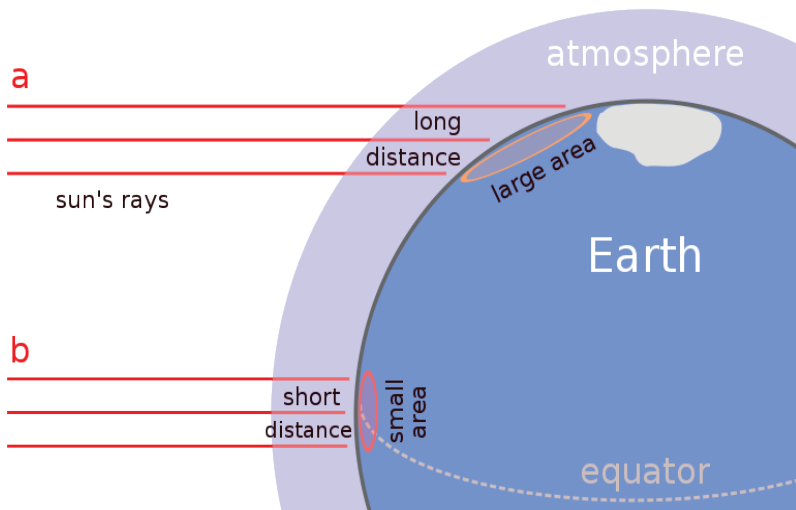
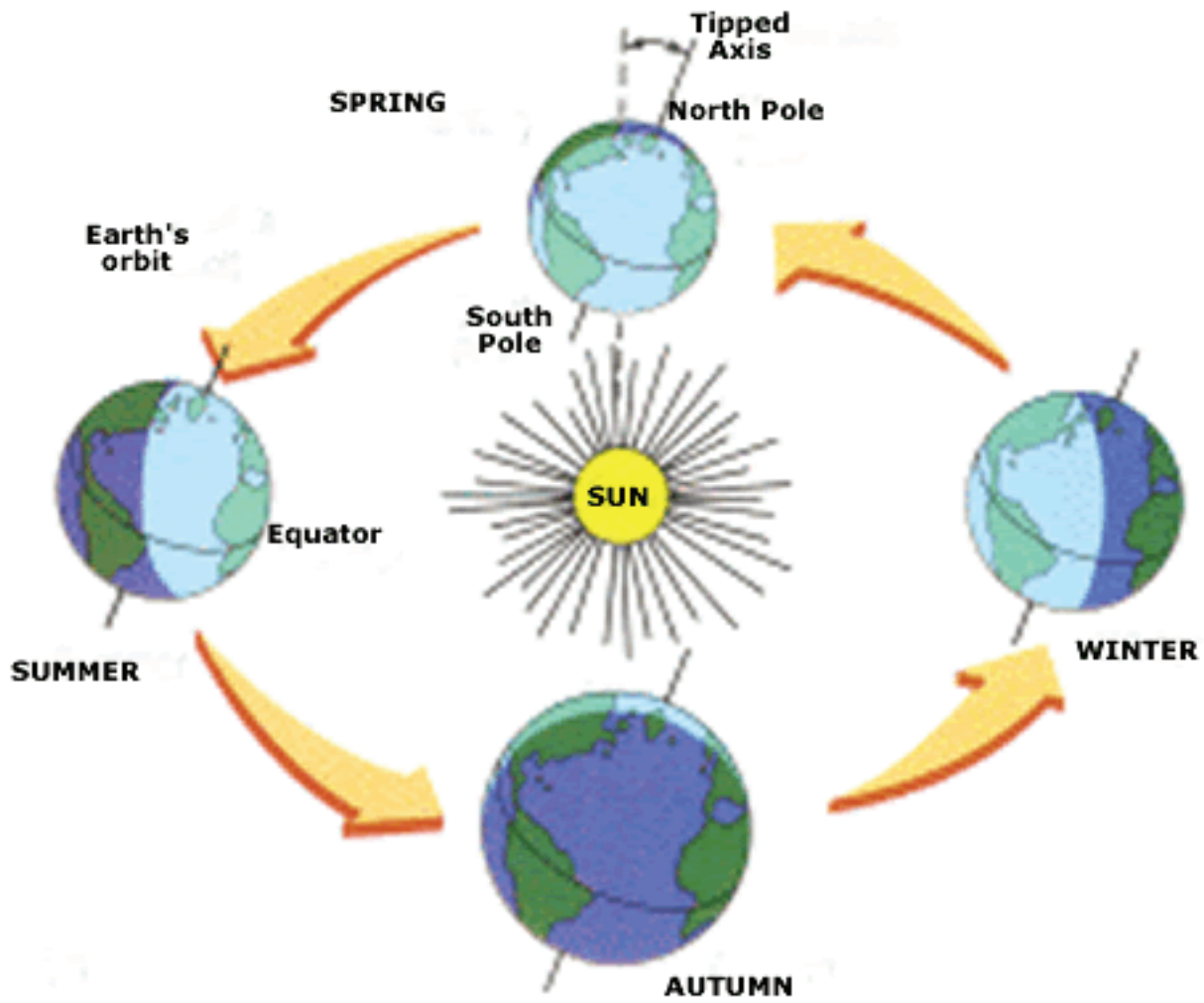
Invite observers to walk through the game, notice it does not disrupt the game.

Reflection Questions: *What did you experience?*

*Where was your attention focused? Were you focused on big picture or details?*

*What other systems can you think of that are interconnected and self-regulating?*

# Earth - Sun Relationship

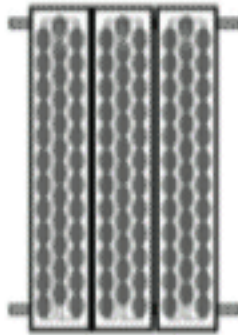


# Basic Solar Energy System Puzzle



## The Sun

sends 1,000 watts of clean, free energy to every square meter of the earth



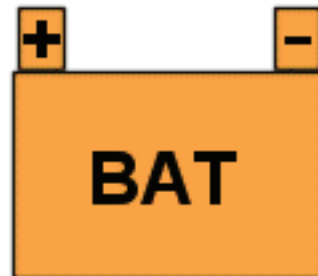
## Solar Panels

can produce up to 100 watts for every square meter. Solar panels do not pollute, and last a lifetime.



## Charge Controller

prevents overcharging of batteries



## Batteries

store the solar energy for use at night or in cloudy weather



## Inverter

Converts DC power in the batteries to AC power for household appliances. Today's inverters are 90% efficient.



## Appliances

You can run just about anything on solar energy!

**BASIC  
SOLAR  
ENERGY  
SYSTEM**  
solarbus.org