CreositySpace
Connecting Kids to STEM Through Entrepreneurship

Sun Catchers

Educator Guide

Solar Energy

Featuring GRID Alternatives

Grade 5

An Overview of the CreositySpace Grade 5 Sequencing Is Provided Below.

CreositySpace—Grade 5 Science—Year-at-a-Glance				
Dates	**September–November**	**December–January**	**February–May**	**June**
Unit Title	*Sun Catchers* (Solar Energy) Theme: What are all the different ways we rely on the power of the sun and what is the evidence of its importance in our lives?	*Battery Builders* (Batteries and Energy Storage) Theme: Exploration of material properties through the applications of batteries and the objects they power.	*Community Designers* (Sustainable Design) Theme: Creating equitable communities that provide opportunities for everyone and use technology in a way that benefit humans and the planet.	
Assessments	See supporting documentation.			
Standards	**5-PS1-1** Develop a model to describe that matter is made of particles too small to be seen. **5-PS3-1** Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun. **5-ESS1-1** Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth. **5-ESS1-2** Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. **5-ESS3-1** Obtain and combine information about ways individual communities use science ideas to protect Earth's resources and environment. **3-5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. **3-5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. **3-5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	**5-PS1-1** Develop a model to describe that matter is made of particles too small to be seen. **5-PS1-2** Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances the total amount of matter is conserved. **5-PS1-3** Make observations and measurements to identify materials based on their properties. **5-PS1-4** Conduct an investigation to determine whether the mixing of two or more substances results in new substances. **5-ESS3-1** Obtain and combine information about ways individual communities use science ideas to protect Earth's resources and environment. **3-5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. **3-5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. **3-5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	**5-LS1-1** Support an argument that plants get the materials they need for growth chiefly from air and water. **5-LS2-1** Develop a model to describe the movement of matter among plants (producers), animals (consumers), decomposers, and the environment. **5-PS2-1** Support an argument that the gravitational force exerted by Earth on objects is directed down. **5-PS3-1** Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun. **5-ESS2-1** Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. **5-ESS2-2** Describe and graph the amounts of saltwater and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. **5-ESS3-1** Obtain and combine information about ways individual communities use science ideas to protect Earth's resources and environment. **3-5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.	

An Overview of the *Sun Catchers* Unit Is Provided Below.

Overarching Enduring Understanding **What are all the different ways we rely on the power of the sun and what is the evidence of its importance in our lives?**	
FLOW OF INSTRUCTION	
5-PS1-1 Develop a model to describe that matter is made of particles too small to be seen. **5-PS3-1** Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun. **5-ESS1-1** Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth. **5-ESS3-1** Obtain and combine information about ways individual communities use science ideas to protect Earth's resources and environment.	**5-ESS1-2** Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. **3-5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. **3-5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. **3-5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
Investigation: Some Like It Hot! (hands-on investigation, occurs during week 1) In this investigation students get their first look at the connection between light and heat. From this they will start building a model to explain their observations based on the fact that matter is made up of particles too small to be seen. They will expand and revise this model throughout the Solar Sleuthing activities. (5-PS1-1) **Investigations: Solar Sleuthing (hands-on investigations, occur during weeks 1, 2, 3, and 4)** In this series of smaller investigations students investigate various attributes of the sun. • In **Light. Heat. Motion!** students continue exploring the connection between light, energy, and particles. (5-PS1-1) • In **Color Creations** students investigate different properties of light, light-blocking materials, and the idea of light-sensitive molecules. (5-PS1-1) • In the short research activity **Follow the Energy** students develop, use, and explain models to describe different ways we use energy from the sun. (5-PS1-1, 5-PS3-1) • In the short research activity **Star Light, Star Bright** students research and report out on evidence that supports an argument focused on the differences in apparent brightness of the sun compared with other stars (5-ESS1-1) as well as the seasonal changes of some stars in the sky. (5-ESS1-2) • In **Solar Circuits** students get some hands-on experience with solar cells. At the end of the series of Solar Sleuthing activities, students must use the knowledge they have gained to develop a model to describe that matter is made up of particles too small to be seen. (5-PS1-1) **Investigation: Solar Solutions (summative challenge, occurs during weeks 5, 6, 7, and 8)** After having discussed and investigated all the different ways the sun plays a role in our lives, students will apply that knowledge toward the development of a *solar solution*. Working in teams of four or five, students must describe three innovations or discoveries that were made possible by our understanding of the sun that have helped to protect the Earth's resources and the environment. (5-ESS3-1) Then students must describe a problem or challenge that could be solved (or improved) with the help of the sun and design a device or test or similar based on that problem. (5-ESS3-1).	**Investigation: WATTs Cooking? (hands-on investigation, occurs during weeks 2 through 6)** Working in groups, students begin this project by researching solar ovens and reporting out on how they work (5-PS-1-1) and their assessment of critical design criteria (3-5-ETS1-1). Groups must then determine their plan for oven construction, build their ovens (3-5-ETS1-2), and determine the plan for testing (3-5-ETS-1-3). Part of their plan must include gathering data (both from reference resources and firsthand) on the sunlight available at different places around the school and throughout the day/year. This includes collecting and tabulating data about patterns in sunlight and shadows (5-ESS1-2). From this data students should finalize and execute their testing plan, reflect on their design, and plan improvements in design or process (3-5-ETS1-3) [Note: Depending on where you are located, it may be fun to perform the testing throughout the year.]

Welcome to CreositySpace

We're glad you're here.

We know our curriculum may look a little different from what you're used to, but it has been developed with the philosophy that students learn better when what they are learning is put into a context that is relevant to them.

With a focus on student-led, inquiry-based discovery, each unit features a variety of real-life STEM entrepreneurs, their personal stories, and details about the businesses they are building and technologies they are developing. With that as our anchor, CreositySpace connects the applications back to the relevant elementary-level science topics and creates lessons that can be delivered in science, ELA, math, social studies, and art classes.

How do we do this?

CONNECT students and their interests, entrepreneurs and their technologies, and the relevant standards through an overarching phenomenon.

ENGAGE students' through a variety of introductory activities designed to spark student interest in, and excitement about, the unit and enable teachers to assess students thinking, interests, and misconceptions.

TRANSFORM students' self-confidence and proficiency with science as they build foundational knowledge through the early lessons and investigations, and then apply and demonstrate their deeper understanding of key concepts through design projects, models, and summative challenges.

Since one can never predict the exact path a student's mind will explore, the CreositySpace team is always available to provide additional support and content should your students' questions take you down an unfamiliar road.

Integrating STEM and CreositySpace into Your Classroom

The CreositySpace *Educator Guide* is your resource to engage your classroom in student-directed inquiry-based discovery. You decide what exact sequencing works best for your classroom. We provide the tools and content designed to leverage your students' natural creativity and curiosity, with extra Background Information and Additional Resources so that you are supported wherever their inquiries takes you.

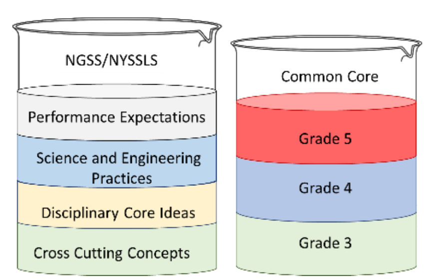
To help with lesson planning options, the Lesson Planning Tools and Pacing Guide Resources sections are there to help with preparation activities, lesson flow and activities, and exit tickets for quick formative assessments. The design projects and summative challenges provide an opportunity for your students to demonstrate their knowledge in a variety of ways.

Informational Icons

<table>
<tr>
<td>Student Questions

The inquisitive monkey represents the portion of the lesson where students should be given the opportunity to voice or revisit their questions.</td>
<td>Student Sense Making

The jubilant tiger represents the portion of the lesson where students should take time to reflect upon and make sense of what they have observed and learned.</td>
</tr>
<tr>
<td>Time Management

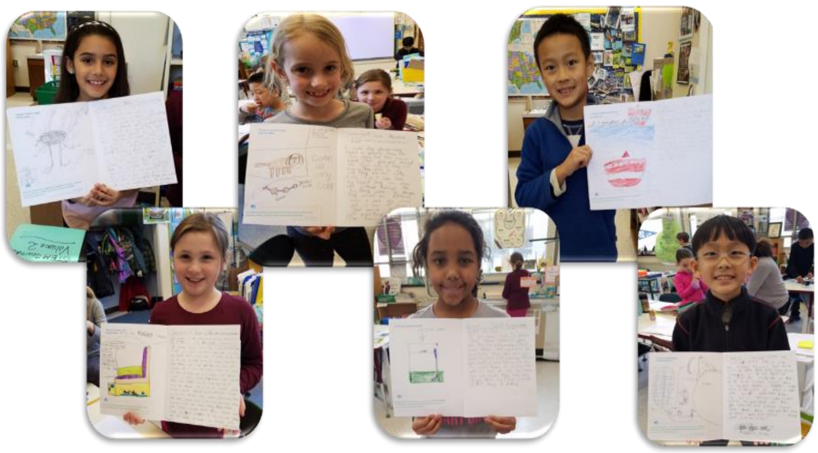
Plug-In (< 30 min) · Investigation (multiple periods) · Challenge (> 1 week)
To support lesson planning, stopwatch icons indicate how much time an activity or investigation is expected to take.</td>
<td>Standards


Multicolored beakers highlight the Common Core (CC) and NGSS/NYSSLS standards supported by a given plug-in, investigation, or challenge.</td>
</tr>
</table>

Using the *Book of Ideas* to Create an Environment of Creativity, Communication, and Collaboration in Your Classroom

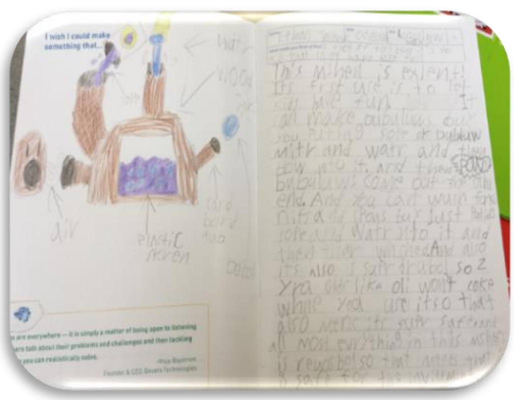
Getting kids to connect to and see value in their ideas is a key ingredient in teaching STEM and to fostering student confidence. This is why CreositySpace created the *Book of Ideas*.

Similar to a real inventor's notebook, the *Book of Ideas* was designed to encourage kids to write down or draw, explore, and discuss their own ideas and inventions. Pages include a title block, quotes from entrepreneurs and innovators, short design prompts and a list of inventions and businesses started by kids.

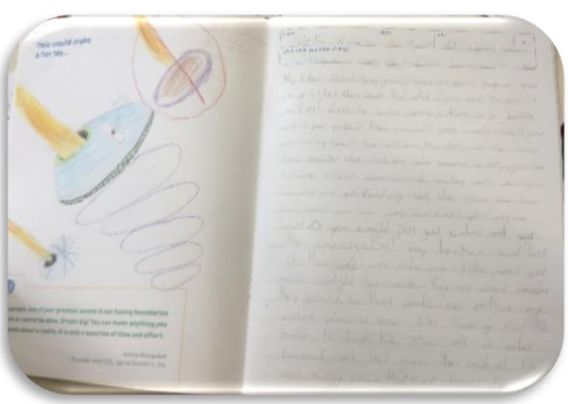


The *Book of Ideas* is NOT about the right answer, perfect spelling, or fitting into a pre-determined box.

The *Book of Ideas* IS about



- Giving students the opportunity to explore and express their ideas in a way that works for them,
- Providing a forum in which students may work independently, as well as collaboratively, and practice giving and receiving respectful feedback, and
- Offering an exciting way for students to show you the ideas, big wonderings, and solutions on their minds and giving you additional insight on how to engage every learner.



There is no wrong way to use the *Book of Ideas* in your classroom. Above all, it should be considered a conversation-starter and a great way to encourage creativity, communication, collaboration, and curiosity in your classroom.

Assessment and Differentiation

Assessments

This Educator Guide provides a number of pre, formative, and summative assessments (a complete list is provided in the Unit Document sub-section of the Appendix) as well as ongoing opportunities for student self and peer assessment. The Appendix also contains an outline for the range of acceptable work for many of the formative assessments (e.g., exit tickets, short research activities, etc.) and expected prior knowledge for the specific investigations (see the *My STEM Stories*™ and *My STEM Explorer Notes*™ sub-sections). A checklist or detailed rubric are provided for the models and summative assessments respectively.

It is not required that students complete **ALL** provided assessments, as there is redundancy built in to give you the flexibility to match assessments to your students' interests and learning styles. However, if your students are struggling with a particular learning objective or concept, unused assessments provide an opportunity for additional practice or alternative perspectives.

Differentiation

Group work and peer discussion is encouraged as a strategy to support students with language and learning challenges. **However, all students are expected to maintain their own records in their *My STEM Stories*™ and *My STEM Explorer Notes*™ notebooks so that educators can assess the learning of individual students.** Drawing and the use of one's native language are acceptable methods to maintain records and demonstrate scientific knowledge. The use of technology to assist challenged learners (e.g., video recording, voice-to-text, Google Translate, etc.) is encouraged if available.

The Detailed Description portion in the Main Investigation section describes extensions for more advanced students. **These extensions are in bold blue text.**

Ongoing Support

Successful implementation of each CreositySpace unit is important to us, and to that end, our company is committed to providing ongoing support to you—from brainstorming ideas and helping with an activity to answering questions around implementation. Don't hesitate to reach out to us via email or phone.

We hope *Sun Catchers* inspires and energizes your classroom to explore the intersection of science with the world around you, and we welcome your feedback on what you like, would like to see, or even change. Feel free to reach out to us at Peg@CreositySpace.com or Kath@CreositySpace.com.

Table of Contents

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Introduction

Sun Catchers: Content Connections

Outlined below is the progression of learning objectives for the *Sun Catchers* unit. The theme of the power of the sun and its importance in our lives invites you and your students to explore how we interact with the sun through three lenses:

- The sun as a critical energy provider to Earth and all its inhabitants.
- The sun as a power source to humans via solar thermal and solar electric energy.
- The sun as a member of the cosmos that helps us to understand the universe.

Example pacing guides are provided in the Pacing Guide Resources section. Blank lesson planning sheets are provided in the Appendix so you can plan out the specific lesson sequencing that works best for your classroom.

Learning Progression

CONNECT students and their interests, the entrepreneurs and their technologies, and the relevant standards through the overarching phenomenon: *How can you use solar energy, or the sun in general, to solve a challenge in your life?*

ENGAGE students with the **Some Like It HOT!** introductory activity and discussions about some of the cool ways entrepreneurs are using the sun to help communities around the world.

TRANSFORM students' self-confidence and proficiency with science as they build foundational knowledge about various forms of solar energy and the sun's role in the universe through the **Solar Sleuthing** investigations and the first half of the **WATTs Cooking?** design project.

Students apply and demonstrate their deeper understanding of all the ways we get and use energy from the sun through the **Solar Solutions** summative challenge, the second half of **WATTs Cooking?** design project and the final version of their **Solar Energy Interactions** model.

Storyline

The sun is more than just the gravitational center of our solar system—it is a critical provider of energy and information to Earth on a number of different levels. Throughout the *Sun Catchers* unit, students are invited to explore and examine the sun from a number of different perspectives: as a critical energy provider to Earth and all its inhabitants, as a power source to humans via solar thermal and solar electric energy, and as a member of the cosmos that helps us to understand the universe. The stories of a variety of solar energy entrepreneurs further help to *personalize* the role of the sun in our lives.

The unit begins with the introductory investigation *Some Like It Hot*, during which students start thinking more critically about the sun and gain some experience examining and quantifying generally understood concepts. In this case these concepts include 'it's hotter in the sun than in the shade' and 'we are hotter when we wear dark cloths versus light clothes'. Students continue their exploration with a series of smaller investigations in *Solar Sleuthing*. These investigations are aimed at helping students form deeper connections between common phenomena they have observed and understanding the science behind them.

In parallel to the *Solar Sleuthing* investigations are the *WATTs Cooking?* design challenge and preparation for the *Solar Solutions* summative challenge. In the *WATTs Cooking?* design challenge students do more than just build a solar oven. Students must research and outline critical design and testing criteria for the solar oven. Part of their plan must include gathering data on the sunlight available at different places around the school and throughout the day/year. For the summative challenge, *Solar Solutions*, students will use the information they have gathered throughout the unit to describe three innovations or discoveries that were made possible by our understanding of the sun that have helped to protect the Earth's resources and the environment. Then students must describe a problem or challenge that could be solved (or improved) with the help of the sun and design a device, test, or similar based on that problem.

General Expected Prior Knowledge

Students coming from grade 5 should have had the following experiences and learnings that they will build upon throughout the *Sun Catchers* unit:

- About matter and interactions—scale, proportionality, and quantity—through 2-PS1-1,2,3 (covered in CreositySpace units *Green Architects* and *Polymer Prodigies*);
- About energy—specifically energy from the sun—through K-PS3-1,2 and 2-LS2-1 (covered in CreositySpace units *Soil Savers* and *Green Architects*);
    - About plants and animals and what they need to survive through K-LS1-1, K-ESS2-2 (covered in CreositySpace unit *Soil Savers*), 1-LS1-1 (covered in CreositySpace unit *Copy Catters*) and 2-LS4-1 (covered in CreositySpace unit *Green Architects*);
- About Earth's place in the universe—including various seasonal patterns—through 1-ESS1-1, 2 (covered in CreositySpace unit *Virtual Tracers*);
- About human impacts on Earth systems—including the development of model systems to help explain various scientific phenomena—through K-ESS3-3 (covered in *Soil Savers*) and 2-ESS2-1, 2LS2-2 (covered in *Green Architects*)
- About asking questions, running experiments, making observations and drawing conclusions through all CreositySpace grade K, 1, 2, 3 and 4 units.
- About generating explanations and communicating conclusions regarding experiments and explorations through all previous science and engineering based activities.

Specific details around prior knowledge expectations, and suggestions on methods to address knowledge gaps, are provided in the detailed investigation description (in the Lesson Planning Tools section) and in applicable locations throughout the Appendix.

Weekly Goals

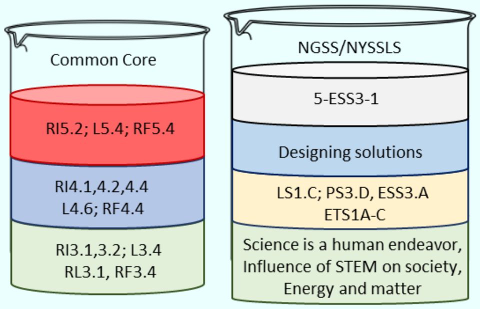
The table below summarizes the weekly learning objectives of the *Sun Catchers* unit.

Week	Goals
1	• Determine student interest and prior knowledge about the role the sun plays in our life. • Generate excitement for the *Sun Catchers* unit with the **Some Like It Hot!** introductory activity. Introduce overarching phenomenon. • Get students thinking about how we derive energy from the sun with their initial **Solar Energy Interactions** model and begin the **Solar Sleuthing** investigations. **(5-PS1-1, 5-PS3-1)**
2–3	• Students continue exploring the different ways we interact with the sun through the **Solar Sleuthing** investigations. Students start compiling evidence for their model that matter is made up of particles too small to be seen and of all the ways we get energy from the sun. **(5-PS1-1)** • Students complete background research and preparation for the **WATTs Cooking?** design project. **(3-5-ETS1-1)**
4–5	• Students continue developing their understanding on the structure of matter and various properties and applications of the sun as they complete their **Solar Sleuthing** investigations and revise their solar interactions model. **(5-PS1-1, 5-PS3-1, 5-ESS1-1)** • Students will begin to gather data around patterns of sunlight intensity (heat and luminosity) and shadows for the **WATTs Cooking?** design project. **(3-5-ETS1-1, 5-ESS1-2)**
6	• Students determine critical design parameters and approach for the students' solar oven. **(3-5-ETS1-1)** • Students solidify their understanding of the sun's role in the cosmos as they begin the **Solar Solutions** summative challenge. **(5-ESS1-1, 5-ESS1-2)** • Students obtain and begin organizing evidence on how advancements in our understanding of the sun and solar energy have helped specific communities and the planet in general through the timeline activity. **(5-ESS3-1)**
7–9+	• Students apply knowledge gained throughout the unit to complete the solar oven construction, testing, and, if desired, process or device improvements. **(3-5-ETS1-2, 3-5-ETS1-3)** • Students complete the **Solar Solutions** summative challenge, both describing how STEM innovations have benefited the community and applying the knowledge gained during this unit to solve an innovation challenge. **(5-ESS3-1)**

Technology Description: Renewable Energy

Time

Standards



Description

The introduction section was initially developed to give you, the teacher, some additional context on the scientific field and focus surrounding the highlighted technologies in this unit. However, we realized that this was also good background and informational text reading for the students. This text, along with a few reading comprehension questions, is included in the My STEM Stories™ *notebooks.*

Increasing pressure to seek alternative energy sources has generated new business opportunities and scientific study. Scientists, engineers, and entrepreneurs alike are interested in how to sustainably harvest our renewable resources—sun, wind, geothermal, tides, rivers, etc.

Solar power involves harnessing energy from the sun's light. This can be done in two ways: either as passive solar thermal or as active solar power. Passive solar thermal uses the heat from the sun's light to increase the temperature of a place or object. Active solar power uses the sun's light or heat in one place to deliver electricity or heat to another place.

Hydropower is energy generated from the energy of falling water or running water. For example, a large dam that is placed in a river forces the water to flow over or through the dam. The falling water has a lot of energy and when it passes through the dam's turbines it generates electricity.

Wind power uses the energy in the movement of the wind. Wind turbines convert the kinetic energy (the energy of motion) of the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water), or it can be converted into electricity to power things like homes, businesses, and schools.

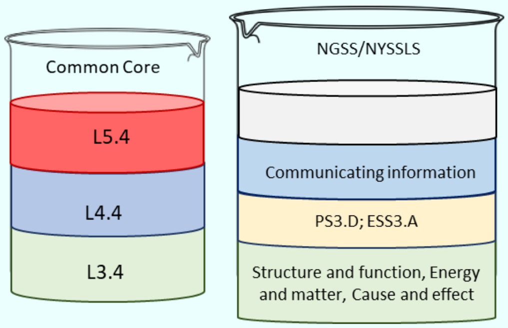
Geothermal energy is heat from Earth. It comes from many places: volcanos, hot water springs, and more. In the United States a lot of the geothermal energy comes from the top 10 feet of ground, that stays between 50°F and 60°F year-round. Heat exchangers use the heat difference between the ground and a home to heat the home in the winter and cool it in the summer.

As we develop new source of energy, there is a need for improved materials and better processes for energy capture and storage. These needs are a source of endless opportunity for new discoveries and inventions.

Vocabulary: Solar Energy

Time

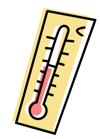
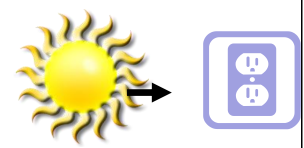
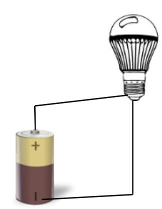
Standards



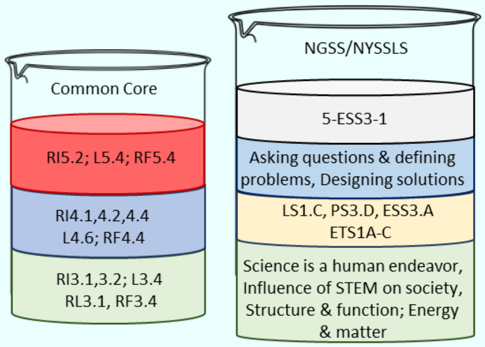
Description

The table below contains key vocabulary words for this unit specifically related to the entrepreneur and application. The My STEM Stories™ *notebook contains the vocabulary table with the Term and Definition columns completed and a blank third column that encourages students to determine a picture or simplified definition. Columns 3 and 4 in the table below are intended to provide you with some examples of simplified definitions or appropriate pictures. (Note: Drawing diagrams is a skill needed in higher level sciences.) Additional unit vocabulary is provided in the* [*Additional Background Information*]() *section.*

Term	Definition	Simpler Definition	A Picture or Simplified Definition
Solar Radiation	Solar radiation is energy given off by the sun.	The energy the sun gives us	Sunlight
Passive Solar Energy	Passive solar energy involves using the sun's energy without any changes to it or the use of mechanical devices.	Don't need machines to get the sun's energy	Our bodies absorb the sun's heat to stay warm
Active Solar Energy	Active solar energy involves using the sun's energy by changing it with a second process or machine.	Need machines to get the sun's energy	Solar cells Solar panels

Solar Thermal Energy	Solar thermal energy involves specifically using the sun's heat to warm things up.	Using the sun's warmth	
Solar Electric Energy	Solar electric energy (also known as solar photovoltaic) is turning sunlight into electrical energy.	How sunlight changes into electricity	
Circuit	A circuit is a path or route for electrons/electricity that will start and return to the same place.	A closed loop in which electricity flows	
Watt	A watt is a unit of power—the amount of energy that is transferred in a second.	How much energy is transferred from one place to another	 

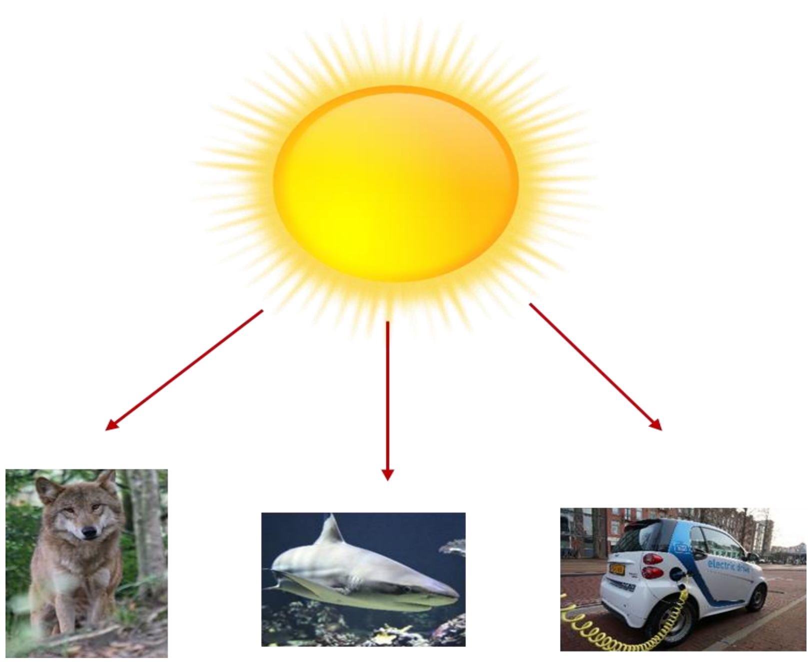
Your Technology: Solar Energy

Time	*Standards*	*Description*
		*This section introduces the entrepreneurs, technologies, and businesses that form the anchor applications and phenomena for this unit. These minibiographies of real people developing real technologies make the elementary concepts covered in this unit current, real, and relevant for the students and answer the "Why are we learning this?" question before it is even asked. Text and additional reading comprehension questions are also provided in the* My STEM Stories™ *notebooks.*

Enduring Understandings

Students will develop a deeper understanding of the structure of matter and the flow of the sun's energy through systems as tools to solve community challenges.

Students will develop an understanding the sun's and Earth's role in the universe and how that role impacts our daily life.



Meet Your Entrepreneur: Erica Mackie, GRID Alternatives

Erica Mackie, PE, is the co-founder and CEO of GRID Alternatives. We asked her to talk a bit about herself and about the solar electricity company she started with Tim Sears.

How would you describe yourself and your career path?

"I think of myself as a social worker turned engineer then turned back to something in between. My path to clean energy included work with survivors of domestic violence, at-risk youth, women's studies, outdoor education, math, and physics. I am an entrepreneur because in the end, in order to have the job and impact I dreamed of having, I needed to create it."

How did you get the idea for GRID Alternatives?

"In 2001, I was working as a professional engineer implementing large-scale renewable energy and energy efficiency projects for the private sector. It was at this job that Tim Sears and I met and thought of the idea for GRID Alternatives. It took us a few years to actually quit our jobs and decide to start our own nonprofit business, but that time we took to create a joint vision and establish a collaborative leadership style has been critical to our success today.

How would you describe GRID Alternatives?

GRID Alternatives is a national leader in making clean, affordable solar power and solar jobs accessible to all communities. By putting people first, GRID Alternatives develops and implements solar projects that serve qualifying households and affordable housing providers and offers solar education and hands-on job training to help people jumpstart their solar careers.

How has GRID Alternatives grown over the years?

"GRID Alternatives has grown a lot over the years. We started out with the idea of installing solar for low-income homeowners with volunteers, like Habitat for Humanity except with solar. As we grew, we kept finding more community needs and opportunities to do more. Today we have a staff of 350 around the United States, and we're installing 1,500 solar electric systems a year, mostly for homeowners but also for renters, affordable housing buildings, and even some community organizations that have goals that are similar to ours. We also do work in Nicaragua, Nepal, and Mexico for communities that either have no access to electricity or for which access is expensive and unreliable. We also train people. We found that many people were volunteering with us because they wanted work experience for jobs in solar, so we started to build out a real workforce development program. We've trained over 35,000 people, both volunteers and solar career aspirants, in solar installation."

What do you think it takes to be a successful entrepreneur?

"Being a successful entrepreneur, whether in the nonprofit sector or in business, is about more than just that initial vision. It's also about being able to adapt and grow as the environment changes and opportunities arise. With a new technology like solar, there's so much opportunity and so much need, and we'll keep working and innovating until we're not needed anymore.

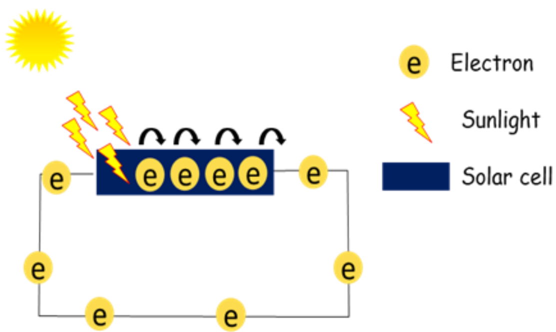
21st Century Context: We Care Solar, Century Solar

We Care Solar (www.wecaresolar.org)

Note: The Additional Resources section contains links to a few videos where Laura talks about her journey and We Care Solar.

About Laura: Laura Stachel studied medicine and lives in California. In 2008 she went to Northern Nigeria to try to figure out ways to make having a baby safer for moms and babies. When she was there, she saw that most hospitals didn't have a reliable and constant source of electricity! While this made things hard during the day, it made having a baby at night very dangerous. Sometimes babies were born in total darkness. Other times mothers and babies had to wait hours for important surgery.

FOUNDATIONAL SCIENCE: *(Note this information also appears in the students' My STEM Explorer Notebooks)* Solar electric (also known as solar photovoltaic) is the action of turning sunlight into electrical energy. This is done with solar cells that are made of materials called SEMICONDUCTORS that have special properties. Semiconductors are a mix between a conductor (like metal) and an insulator (like rubber). When sunlight hits a semiconductor, some of the electrons get pushed out (like too many people sitting on a bench) and they flow through the wires making electricity.



When she got home from Nigeria, Laura joined forces with Hal Aronson, and together they started We Care Solar to help provide hospitals with reliable electricity. Hal created a suitcase-sized solar electric system, which included solar panels, batteries, LED lights, and headlamps, for Laura to show to the Nigerian hospital workers. When Laura returned to Nigeria with the "solar suitcase," her Nigerian colleagues were very excited that everything they needed to bring light and electricity to their clinics was contained in an easy-to-use suitcase. They began using the kit to charge headlamps and walkie-talkies immediately! To date We Care Solar and their partners have distributed almost 3,000 Solar Suitcases around the world.

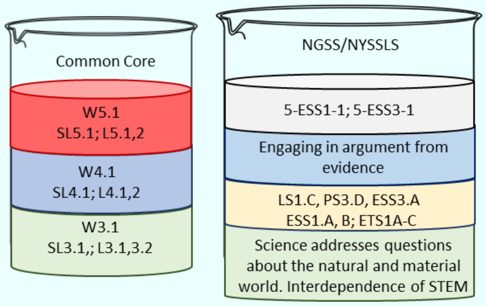
Here are a few more cool companies using solar energy to reduce their impact on Earth. (For complete company URLs see the Additional Resources section.)

1. SolarMill makes consumer products using solar energy and sustainable materials.
2. New Sun Road is a company that is working to provide solar electricity to communities, health clinics, and education centers in remote and challenging environments.

Technology Historical Timeline: Understanding the Sun

Time

Standards

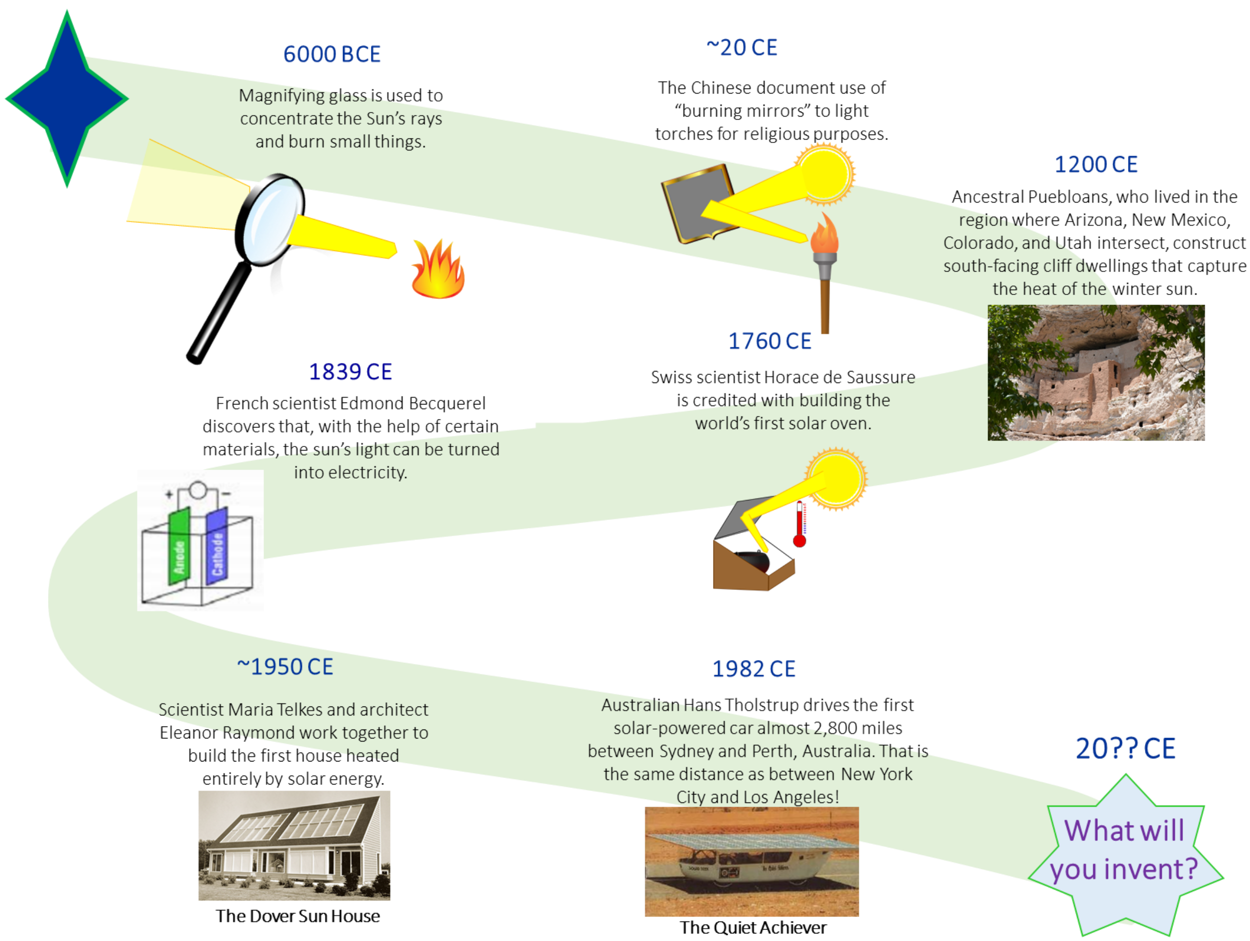


Description

The Technology Historical Timeline is a great tool to use to give your students historical context for what they are learning and to show them how any single scientific discovery or understanding is built from all the discoveries and understandings that came before. In many cases, scientific discoveries only thrived if there was a community need they helped to solve.

The Appendix contains a variety of timelines and suggested activities you can use with your class. Many of these activities are a good opportunity for ***peer-to-peer*** *and* ***teacher-student feedback*** *cycles.*

Note: If you are using Sun Catchers *as a primary curriculum there is a required timeline activity highlighted in the Appendix.*



Background Information

This section contains additional information intended for teachers on the topics of:

- The Engineering Design Process
- Unit equipment and how it works
- Solar energy
- Celestial objects

Links to additional videos, articles, webpages, etc., are provided in the Additional Resources section where they are organized by topic area. Extra copies of the **Follow the Energy** tables can be found in the Appendix.

The Engineering Design Process

Despite what the name might suggest, the **engineering design process** is really no different than any creative or iterative process. You would follow the same basic steps if you were writing a story or painting a picture.

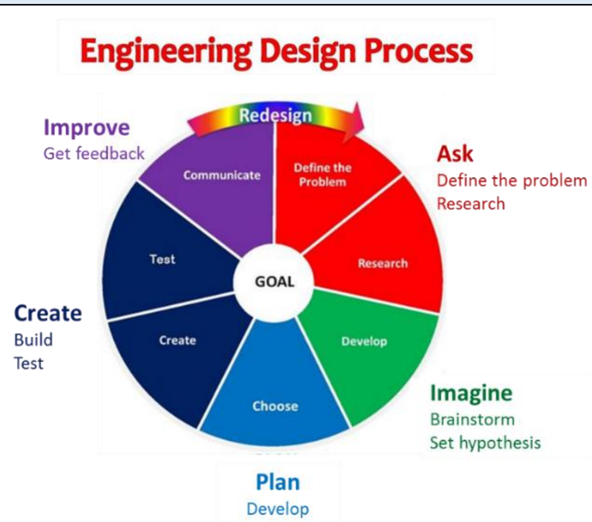
Step 1: Start with a question, problem, or goal.

Step 2: Think about all the possibilities.

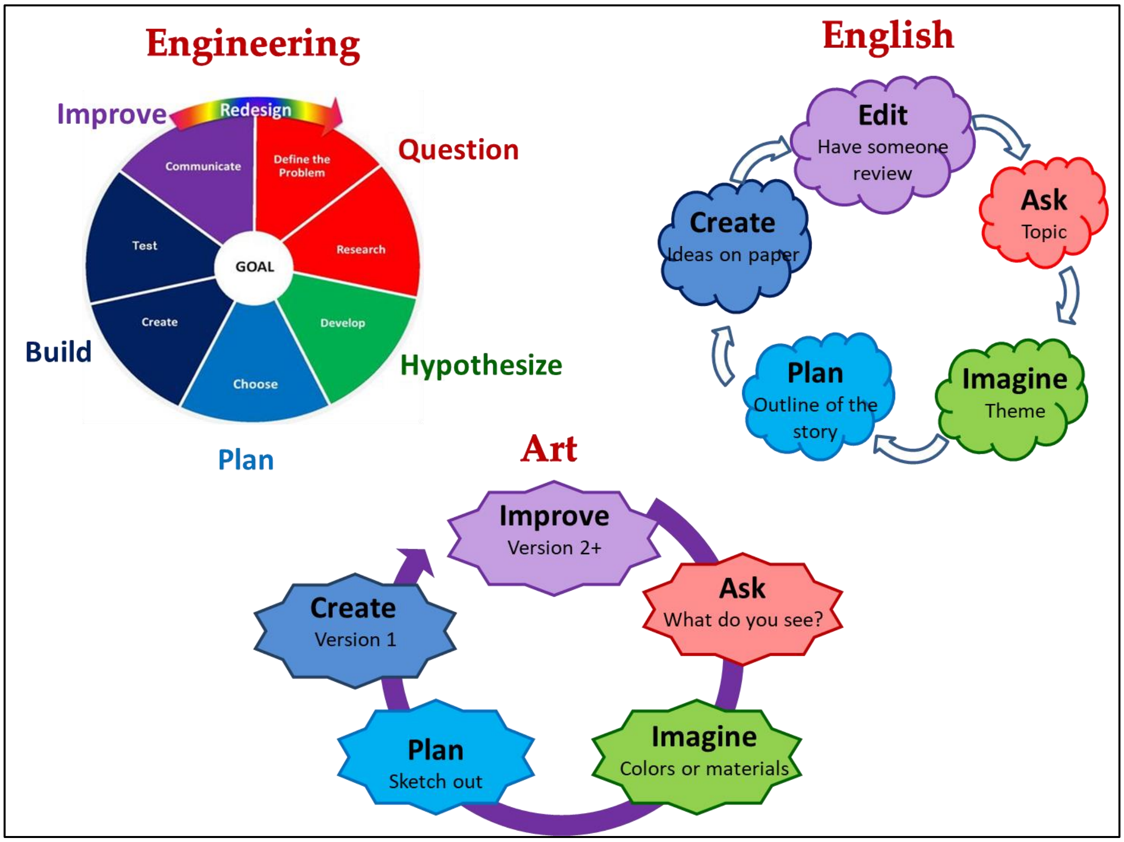
Step 3: Decide which ideas from step 2 you want to use.

Step 4: Create your first draft/prototype/version.

Step 5: Get feedback and improve your design.



Under some circumstances the words used to describe a step might be different, but the general goals of each step are the same.



Additional Vocabulary

Brainstorming	Brainstorming is when a group of people gets together and shares ideas to solve a problem or challenge (coming up with a lot of ideas).
Prototype	A prototype is an early version of an invention. It can't necessarily do everything the invention is supposed to do, but it allows the inventor to see what things will look like.

Unit Equipment

The *Sun Catchers* unit has a fair amount of technical equipment with which you might not be familiar including:

- Radiometers
- IR thermometers
- Light meter
- Solar circuit components (multimeter, breadboard, solar cell, LED, resistor, buzzer, jumper wires)

Radiometers

Radiometers are a cool way to put the concept of differences in heat absorption by different materials into action. The radiometer is also a great model system for a lot of large-scale weather phenomena that result from air currents.

Inside the glass radiometer bulb there is a partial vacuum. What this means is that while there is a bit of air, there isn't a lot, so the gas is free to move around quite a bit without a lot of resistance. The rotor vanes are on a nearly frictionless spindle, or pin, so once they start moving there is very little force to oppose them.

When you shine light on the radiometer, the area near the black side of the vanes heats up much more than the area near the white side of the vanes. That heat difference causes gas to rearrange so that the temperature is evenly distributed. This movement of air is enough to get the vanes spinning quickly.

If there was a total vacuum, then there would be no air to heat up and the vanes would not spin. If there was a normal amount of air, the drag force of the vanes having to push through the air would be much stronger than the force from rearranging gas molecules and the vane would not spin.

The following video gives a decent explanation of what is going on, although the speaker talks quite quickly. It may be more appropriate as teacher background than to show directly to students. https://www.youtube.com/watch?v=llxqNcipTwA (5:02 min, short ad at the beginning)

IR Thermometers

IR thermometers are a fun and easy way to measure temperature.

You simply point the IR thermometer at the object whose temperature you want to measure and pull the trigger. The object's temperature will then appear on the screen.

Before beginning the investigation, students should test out the IR thermometer by measuring the temperature of some objects in the room.

Light Meter

The light meter is a fun and easy way to measure the intensity o the light.

The photodetector (top white portion) senses the illuminance (light intensity) per unit area. The display shows the light level i either *lux*, which is luminous flux (or lumens) per meter, or *foot candle* (fc).

Before beginning the investigation, students should test out the light meter by measuring the light level under different circumstances (e.g., near a window, in a closet, and directly in front of a lamp).

Multimeter

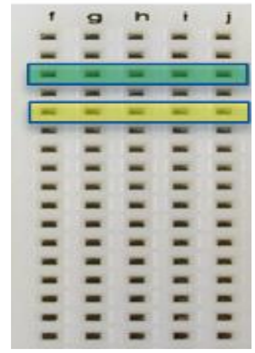
- A multimeter is great tool to help you understand your power supply. In this unit the power supply is a solar cell. Another option for a power supply is a battery. Here are some tips on how to use your multimeter to check the voltage of your power supply:
    - Make sure the dial is turned to 200 mV or 2 V/2000 mV (top left). The readout is the voltage in V.
    - The red lead/wire needs to be hooked into the V/Ω mA port and the black wire/lead into the COM port.

Troubleshooting the multimeter:

- Check dial position.
- Check wire connections (both into the multimeter and on the power source).
- Make sure multimeter batteries are working.
- Use an AA 1.5 V battery to make sure it is working (set the dial on 2 V/2000 mV and the readout should be between 1–2 V).

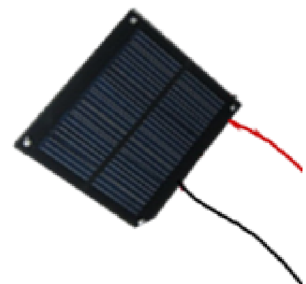
__Breadboard__

A breadboard makes circuit building easier. All the spots in a row are connected to each other but each row is separated from the other rows. For example, the green slots are connected to each other and the yellow slots are connected to each other, but the green slots are not connected to the yellow slots.



__Solar cell__

A solar cell is the power supply for your circuit. When it is exposed to light the solar cell can generate electricity. The wired solar cells can plug directly into the breadboard.

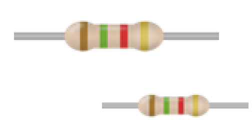


__Jumper Wire__

- Jumper wires conduct electricity and connect different parts of the circuit.
- They are all the same—color doesn't matter—and can be hooked up either way.

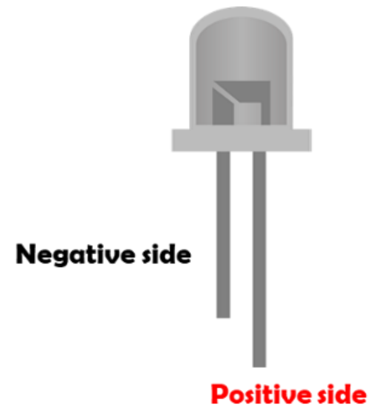
__Resistor__

- A resistor is like a sponge that soaks up extra current. You need one of these to protect the LED.
- Resistors will work the same regardless of how they are plugged in (provided they are in the right spot!).



LED

- An LED is a light source that gets its color from the type of material inside (called a semiconductor).
- An LED must always have a resistor in the circuit to control the amount of current—if not, you will break the connection to the semiconductor material.
- An LED has a positive side (longer) and negative side (shorter). If you plug the LED in backward it won't break but it won't light up either.
- Current only flows one way for an LED.



Buzzer

- The buzzer is just that, a buzzer.
- Similar to the LED it has a specific direction. If you have a circuit that has both buzzers and LEDs, you need to make sure the positive end of both components is on the same side. For the LED, that is the longer wire; for the buzzer, that is the red wire.
- If you plug the buzzer in backward it won't break but it won't work either.

Solar Energy

While a lot of the following information can be found throughout this Educator Guide, we thought it might be helpful to have everything in one place for easy reference.

Introduction

Did you know that in ONE HOUR enough energy from the sun hits Earth to supply all the power we need for things like heating our homes, running our electronics, and powering our schools and hospitals?

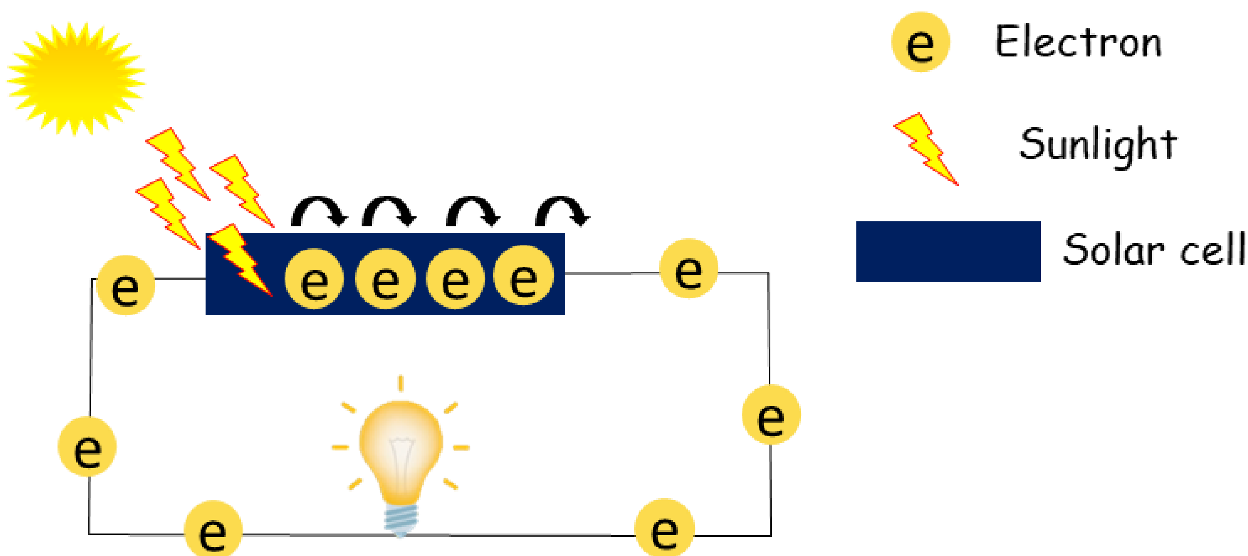
Solar power is all about harnessing energy from the sun's light. This can be done in two ways: either as passive solar thermal or as active solar power. Passive solar thermal uses the heat from the sun's light to increase the temperature of a place or object. A familiar example is a green house. Active solar power uses the sun's light or heat in one place to deliver electricity or heat to another place. Some examples include solar panels or solar heating tubes you see on the roofs of some houses. In the Solar Electric section we will see how solar panels convert the sun's light into electricity.

Active vs. Passive

One cool thing about solar energy is that it can provide power to us in two forms—passive or active. The key difference between an active solar system and a passive solar system is this: **Passive solar** energy uses the **heat** of the sun **directly**, while an **active solar** system uses the sun's radiation (the sun's rays) to generate **electricity** via solar panels or uses some mechanical energy to transfer the heat of the sun to a different location.

__Solar Electric__

Solar electric (also known as solar photovoltaic) is the action of turning sunlight into electrical energy. To do this we need special equipment called solar cells. How do solar cells turn sunlight into electricity? They are made of materials called **semiconductors** that have special properties. Semiconductors are a mix between a conductor (like metal) and an insulator (like rubber). When sunlight hits a semiconductor, some of the electrons get pushed out (like too many people sitting on a bench) and they flow through the wires making electricity. At this point the electricity can be used to run a device (like a light or buzzer) or it can be stored in a battery to use later.

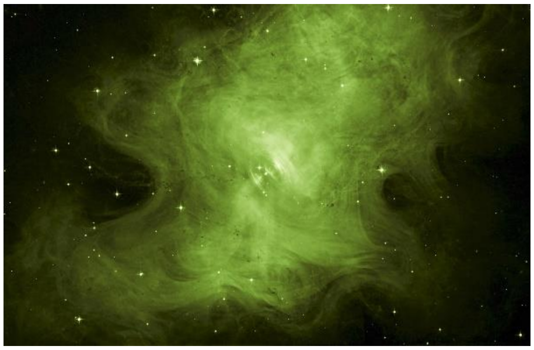


Celestial Objects

In **Star Light, Star Bright** your students are asked to choose a celestial object and compare it to our sun. While there are many phenomena your students can pick from, we've detailed a couple here that are our favorites. The resource books provided with this unit and online links and additional resources suggested in the Additional Resources section provide additional options for your students to investigate.

Nebulae

A ***nebula*** (plural: nebulae) is a cloud of dust and gas. Nebulae can be different colors with their color being determined by how the dust inside the cloud interacts with various sources of radiation. Most stars are created from a nebula, and any given nebula may have a number of small stars that have not fully formed or emerged.



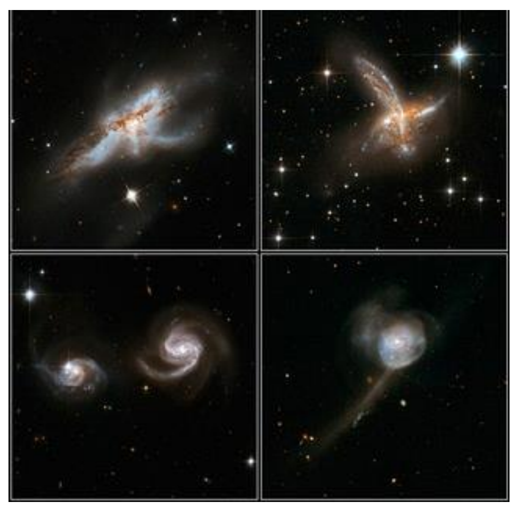
Stars (the universe's other suns)

While the sun is the closest star to Earth (only about 93 million miles away) it is just one of the billions of stars that are in our galaxy and trillions of stars in the universe overall. Stars vary in size, surface temperature, and luminosity (brightness). All stars start as a cloud of dust and gas (specifically hydrogen gas) called a **stellar nebula**. As the gas and dust particles come together, they increase in density until the whole thing collapses on itself forming a star. During the star's life it burns the hydrogen gas that was part of the original **nebula**, producing the radiation and light we see in the night sky. As the star runs out of hydrogen it begins to die. The size of the star determines what will happen to the star upon death. Average-size stars shed their outer layer becoming smaller, dimmer **white dwarfs**. Larger stars explode forming a supernova and then collapse upon themselves forming **black holes**. Pages 212–213, 216–219, and 228–229 in *Space, A Visual Encyclopedia* (included with the activity kit) has additional, simple-to-read explanations on star types and life cycles as well as some examples of the different specific stars you and your students might find interesting.

Binary (and Multiple) Stars

Although it may seem normal to us to have a star (or sun) without any close neighbors, it is actually somewhat rare. Stars are often created in clusters inside the **nebula** and, while they may drift apart from some of their "stellar siblings," they often remain close to one or more other stars. Sets of star pairs that orbit each other are called **binary stars.** Sometimes one star in a binary system will steal material from its neighbor. Other times one star in a binary or multiple star cluster will be so bright that it is hard to see the other stars in the system. This was the case for the **North Star** (Polaris), which has three stars in the system (Polaris A, Polaris B, and Polaris Ab). The third star (Polaris Ab) was so close to Polaris A that it was only recently discovered. Pages 222–225 in *Space, A Visual Encyclopedia* (included with the full unit) has additional information on binary and multiple star systems.

Galaxies



Galaxies are very large clusters of stars, dust, and gas clouds held together by gravity. The universe has billions of galaxies that come in different shapes and contain different numbers of stars. Our galaxy, the Milky Way, contains about 100 billion stars. Galaxies have been classified into three groups based on their shape: spiral, elliptical, and irregular. The Milky Way is a spiral galaxy. The Andromeda Galaxy, another spiral galaxy, is our closest galactic neighbor. Recent data suggests that most galaxies (perhaps all) have a **black hole** at their center, which could provide the gravity necessary to hold the galaxy together.

Black Holes

Black holes are a portion of space where an extremely large amount of matter has collapsed in on itself. What this means is that a very large amount of mass becomes concentrated in a very small volume, creating an extremely large gravitational pull. This gravitational pull is so strong that nothing can escape—including light! Astronomers now suspect the universe is littered with black holes—some small and others quite large. It is thought that very large black holes, called supermassive black holes, can be found at the center of most galaxies. However, since nothing can escape a black hole, they are impossible to see directly and are very hard to study. In fact, most of what we know about black holes comes from studying the things around the black hole and relating the motion of other stars and stellar material to the presence of a very high gravitational object.

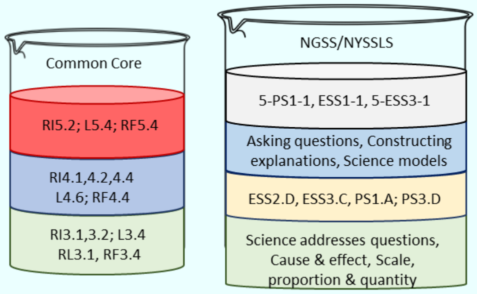
Comets, Asteroids, and Meteoroids

Comets, asteroids, and **meteoroids** are all celestial objects that are too small to be considered planets. **Comets** have a core that is made of ice and dirt. When a comet comes closer to the sun it warms up and starts to release some of its dust and gas. The dust and gas give comets their glow and sometimes result in long tails. Unlike comets, **asteroids** and **meteoroids** have a core made from rocky materials and metals. The major difference between asteroids and meteoroids is size; anything 3.5-feet wide or smaller is called a meteoroid, while anything larger than 3.5-feet wide is called an asteroid. A meteoroid that enters Earth's atmosphere is called a **meteor** and a meteoroid that enters Earth's atmosphere **AND** lands on Earth is called a **meteorite**.

Lesson Planning Tools

Before you begin, we suggest you read through the Unit Overview (p. 3), the Technology Description (p.16) and the Featured Entrepreneur story (p. 21). These three sections are a quick way to get a comprehensive look at the unit before you dive into lesson planning details.

Topic Introduction Tools

Time	*Standards*	*Description*
		*The following few pages outline some topic introduction tools you can use with your students to get them excited to be thinking about the sun and solar energy.* *Pick the tools that work for you!* *You do not need to use all of these introductory tools, but instead pick the ones that enable you to get a feel for what your students know and what they are interested in. These introductory tools and activities are also a good way to check in with your students throughout the unit to see how they are doing, what concepts they may be struggling with, and/or how their interests are developing.*

Phenomenon

How can you use solar energy, or the sun in general, to solve a challenge in your life?

Topic Bundle/Big Idea

In this unit students learn about all the ways the sun provides us with energy and information. They then use that knowledge to determine solutions to a variety of challenges.

Essential Questions/Sub-Phenomena

Topical essential questions are used to help provide the "why" around each concept or standard students are learning. Also included are *bigger wonderings* to inspire deeper reflection and discussion.

Topical Essential Questions

- How do we get energy from the sun? (5-PS1-1, 5-PS3-1)
- How do with interact with the sun every day? (5-ESS1-2, 5-ESS3-1)
- How can we use the sun's energy to power our homes and lives? (5-PS1-1, 5-ESS3-1)
- How does the sun teach us about the universe? (5-ESS1-1)

Big Wonderings

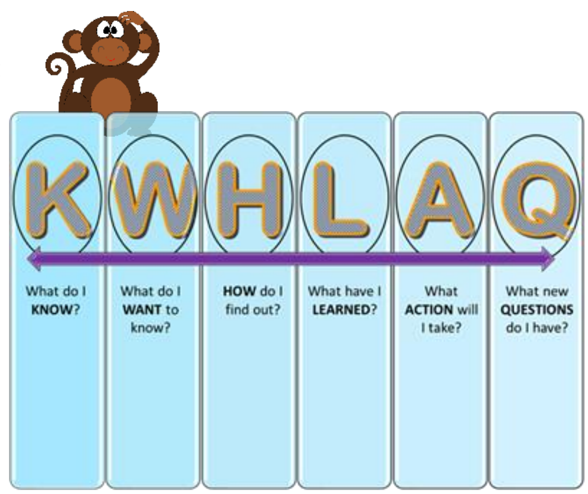
- How can we use the sun's energy to solve new challenges and problems?
- Given Earth's limited resources, how can we use technology to accomplish more with renewable sources of energy?

KWHLAQ Charts and Pictorial Input Charts

KWHLAQ charts (know, want, how, learned, action, questions) and pictorial input charts (PICs)—also referred to as anchor charts—are a great way to get students thinking about a topic area *and give you a chance to see where they are with current understanding and possible misconceptions*. Depending on your students you may choose to complete one or more of these activities with you leading the discussion or have the students work together in small groups.

A few possible starting prompts for KWHLAQ charts are:

- How does the sun help us every day?
- What are different sources of energy?
- What do I wonder about renewable energy?



A couple possible themes for PICs are:

- Develop a model to explain different ways the sun's energy is used by plants, animals, and people.
- Develop a model to show how the sun's energy is turned into electricity.

(Note: A PIC is a great way to create a model of a concept that students can use as a reference throughout the unit.)

What Do You See? What Do You Know? What Do You Want to Know? 

What do you see? What do you know? What do you want to know? is another great way to get the students thinking and excited about a new topic. With this activity each day starts with a picture or object that you share with the class (examples provided in the Appendix). Ask them to write what they see, what they think they know about it, and what questions it sparks in their minds. After a few minutes have the students share out what they've written. This activity not only gives you an idea of their interests and understanding, but also gets them thinking about the topic and gives them practice writing, organizing their thoughts, and speaking to the group.

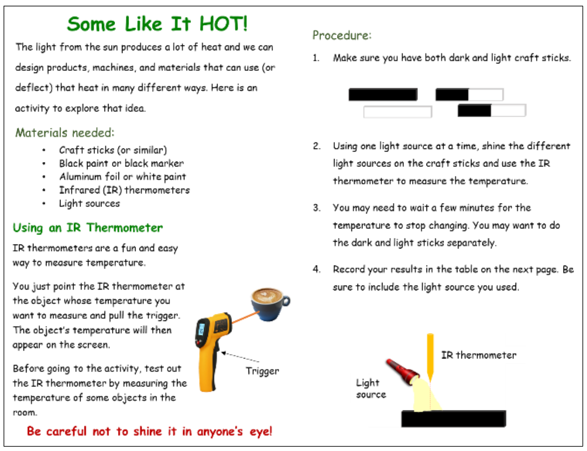
Introductory Videos

- http://video.nationalgeographic.com/video/alternative-energy (2:48 min, no ad) A short introduction to renewable energy (focus on solar energy, biofuels, and wind) by National Geographic.

- https://www.youtube.com/watch?v=x4CTceusK9I (2:04 min) The first 1:25 min of this is a good general introduction to solar energy with a focus on solar electric energy. The last 40 sec is a plug for BEP, so you might want to stop it before that.

Introductory Investigation

The introductory investigations are designed to be activities the students can work on with very little guidance or introduction from you, the educator. The goal is that the students have a chance to think about ideas or concepts independently and in peer groups, without the reliance on the adults in the room. **Your role as the teacher is to help the students stay motivated and on-task, without providing them with the answer.** Often encouragement to explore their line of thinking is all that they need.



Some Like It HOT!

The light from the sun produces a lot of heat and we can design products, machines, and materials that can use (or deflect) that heat in many different ways. Here is an activity to explore that idea.

Materials needed:

- Craft sticks (or similar)
- Black paint or black marker
- Aluminum foil or white paint
- Infrared (IR) thermometers
- Light sources

Using an IR Thermometer

IR thermometers are a fun and easy way to measure temperature.

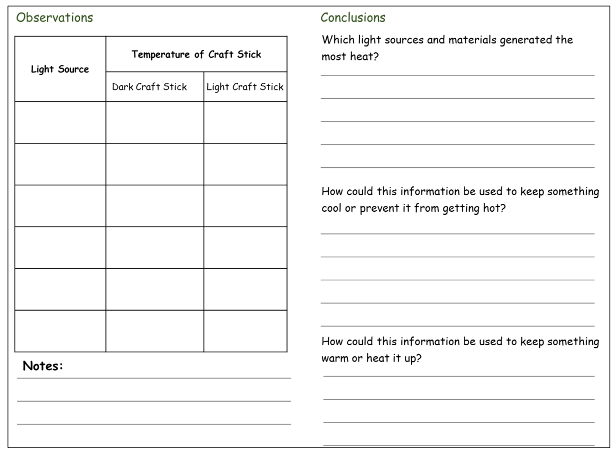
You just point the IR thermometer at the object whose temperature you want to measure and pull the trigger. The object's temperature will then appear on the screen.

Before going to the activity, test out the IR thermometer by measuring the temperature of some objects in the room.

Be careful not to shine it in anyone's eye!

Procedure:

1. Make sure you have both dark and light craft sticks.
2. Using one light source at a time, shine the different light sources on the craft sticks and use the IR thermometer to measure the temperature.
3. You may need to wait a few minutes for the temperature to stop changing. You may want to do the dark and light sticks separately.
4. Record your results in the table on the next page. Be sure to include the light source you used.



Observations

Light Source	Temperature of Craft Stick	
	Dark Craft Stick	Light Craft Stick

Notes:

Conclusions

Which light sources and materials generated the most heat?

How could this information be used to keep something cool or prevent it from getting hot?

How could this information be used to keep something warm or heat it up?

The Some Like It Hot! introductory challenge gets students thinking about how the sun provides heat to the Earth and different ways we might be able to manipulate that process. This challenge will lay the groundwork for many of this unit's investigations. In this exercise, working on and talking about the challenge is more important that the actual completion of the challenge. Once again, this gives you, the educator, a chance to formatively assess student interest and prior knowledge as you watch the group interactions and listen to the conversations. Since the introductory activity is intended (but not required) to be used before the unit begins, the data recording sheet is provided separately from the *My STEM Explorer Notes*™ notebook. A full-sized copy can be found in the Appendix and on the unit website. Printed loose-leaf copies are provided in the activity kits and printed curriculum packs.

Main Investigations

The following pages describe the main investigations in this unit. The Detailed Description section describes extensions for more advanced students. These extensions are in bright blue text.

Safety

Warning: This kit contains materials that may be harmful if used incorrectly. Please read all instructions before beginning. Failure to follow these instructions and warnings could result in serious consequences.

- Kit components are scientific and engineering equipment—not toys. While we have worked to supply the most robust kit components possible, aggressive use can cause damage.
- Electricity in the circuit is generated through the solar cells. While small solar cells generate much less current than batteries, students must be careful not to contact the two ends of the wires attached to the solar cell to each other.
- Remind students to use materials only as instructed by the teacher.
- **IR thermometers should never be pointed at someone's face as the laser may damage the eyes.** The thermometers have a "laser off" position, where they still work but do not shine a guiding red light. You may choose to use the IR thermometers in this mode. We also suggest telling your students that IR thermometers are NOT to be used on people or animals to avoid this problem.

Materials

Component Name and Description	Approximate Cost	Source
Provided equipment and materials		
Infrared thermometer (4)	$60	Click for Amazon link
Radiometers (4)	$60	Click for Amazon link
UV-sensitive beads	~ $10	Click for Amazon link
UV flashlights (5)	$25	Click for Amazon link
Normal beads	~ $5	Craft store
Light-blocking materials	$10	Craft store
key chain rings	~$5	
Cord materials	~ $5	Craft store
Multimeter	$20	Click for Amazon link
Wired solar panels (7)	$50	Click for Amazon link
Mini breadboards (6)	$15	Click for Amazon link
Jumper wires (set of 30)	$12	Click for Pololu link
LED with resistors (class set)	$15	Click for Amazon link
Buzzers (five at 3–24 V)	$20	Click for Amazon link
Light meter	$40	Click for Amazon link
Dowels	$5	Craft store
Trade Books		
National Geographic Kids Everything Space	$15	Click for Amazon link
DK Eyewitness Books: Universe	$12	Click for Amazon link
SPACE: A Visual Encyclopedia	$27	Click for Amazon link
Educator Guide (1) *My STEM Stories™* notebooks (30) *My STEM Explorer Notes™* notebooks (30) Timeline sheets (1 set) Introductory investigation data recording sheets (30) *Follow the Energy* sorting cards	NA	This unit (electronic versions available on unit website)
Common equipment and materials required but not provided		
Light sources	< $10	Hardware store
Cardboard boxes	NA	Collection from homes/school or grocery store donation
Insulation material (newspaper works well)	NA	Collection from homes/school or grocery store donation
Black and white paint	<$5	General classroom supplies
Aluminum foil	<$2	Grocery store
Glue or strong tape	<$5	General classroom supplies
Something to cook (we suggest cookies)	< $5	Grocery store

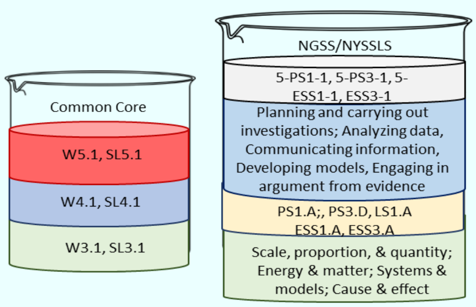
Introduction

Energy from the sun is used directly and indirectly by many of Earth's inhabitants and in many of our daily processes. As students begin this unit, they are asked to select an example of solar energy that is most interesting to them and to draw out a model of how they think energy from the sun is used in that application (**Solar Energy Interactions**, p. 3 in their *My STEM Explorer Notes*™ notebooks). As they progress through the unit's investigations, they should continually reexamine their model to determine if portions need to be modified, removed, or added. At the end of the unit there is space for them to formally revisit their model (p. 39 in their *My STEM Explorer Notes*™ notebooks) and create an updated version. While the details of each model will be different based upon the chosen application, they should all include a discussion involving how the solar energy interacts with particles of matter that are too small to be seen. (5-PS1-1)

Investigation 1: Solar Sleuthing

Time

Standards



Description

*In this series of investigations students will explore various aspects of energy and information from and about the sun. These investigations are a fun way for them to build their understanding toward a successful completion of the solar oven project (**WATTs Cooking?**) and the **Solar Solutions** summative challenge.*

Note: See NGSS/NYSSLS Education Standards section for detailed evidence statements for 5-PS1-1, 5-PS3-1, 5-ESS1-1, 5-ESS3-1.

Materials

Radiometers, infrared thermometers, light sources, UV-sensitive beads, UV flashlights, normal beads, light-blocking materials, cordage, keychain rings, Follow the Energy sheets and cards, reference books, multimeter, wired solar panels, mini breadboards, jumper wires, LEDs with resistors, buzzers, and *My STEM Explorer Notes*™ notebooks.

Heat. Light. Motion!

Note: See NGSS/NYSSLS Education Standards section for detailed evidence statements for 5-PS1-1.

Objective

Students will explore the connection between light, heat, motion, and energy.

Related essential question: How do we get energy from the sun?

Materials

Radiometers, IR thermometers, light sources, *My STEM Explorer Notes*™ notebooks

Detailed Description

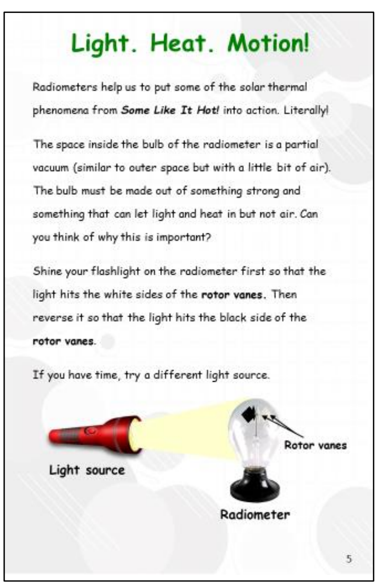
Warm-Up

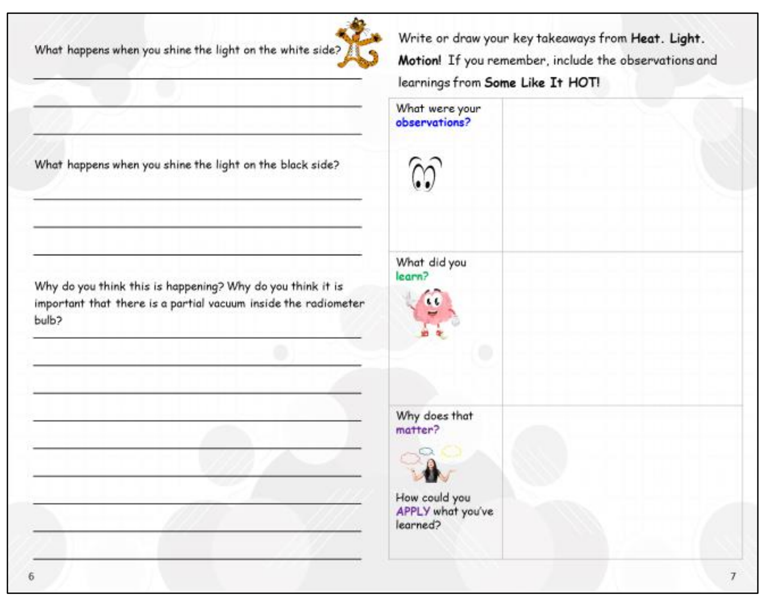
If you haven't completed the *Some Like It Hot!* introductory activity have your students do it now. Otherwise guide your students through a refresher discussion about the heat-generating properties of different light sources and the heat-absorbing properties of different materials.

Main Investigation

(Note: The Additional Background section includes some additional background on radiometers and how they work.)

Guided by the investigation prompts in their *My STEM Explorer Notes*™ notebooks (pp. 5 and 6) have students investigate the central phenomena associated with the radiometers and complete the OLA (observations, learnings, application) table on page 7.





Color Creations

Note: See [NGSS/NYSSLS Education Standards] section for detailed evidence statements for 5-PS1-1.

Objective

Students will use the color-changing properties of the UV-active solar beads to explore solar radiation.

Related essential question: How do we get energy from the sun?

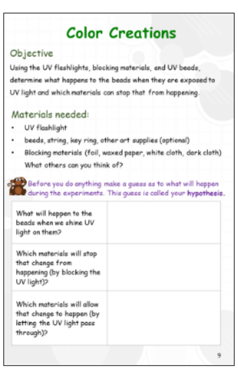
Materials

UV-sensitive beads, UV flashlights, normal beads, light-blocking materials, cordage, keychain rings, *My STEM Explorer Notes*™ notebooks

Detailed Description

Even though people can't see ultraviolet (UV) light, there are a lot of too small-to-see particles (a.k.a molecules) that can absorb the energy from UV light causing them to glow or change color. Some of the beads in this investigation contain those types of particles. Over time these beads revert to colorless when they are removed from UV light (e.g., brought back inside).

For this investigation your students will design a small "creation" using both UV-sensitive beads and regular beads. Materials for necklaces, bracelets, or keychain charms are provided but they can make whatever allows them to investigate the impact of UV light on the beads (i.e., to have some of the beads covered and others exposed). Students can explore how solar beads change colors under different conditions using the conditions described in the *My STEM Explorer Notes*™ notebooks (pp. 9–13), using conditions that you specify, or by coming up with their own scenarios. Make sure they complete the hypothesis section before they begin and the OLA (observations, learnings, application) table at the end.



Color Creations

Objective

Using the UV flashlights, blocking materials, and UV beads, determine what happens to the beads when they are exposed to UV light and which materials can stop that from happening.

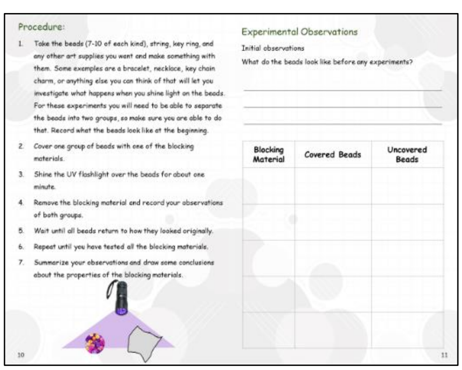
Materials needed:

- UV flashlight
- beads, string, key ring, other art supplies (optional)
- Blocking materials (foil, waxed paper, white cloth, dark cloth) What others can you think of?

Before you do anything make a guess as to what will happen during the experiments. This guess is called your **hypothesis.**

What will happen to the beads when we shine UV light on them?	
Which materials will stop that change from happening (by blocking the UV light)?	
Which materials will allow that change to happen (by letting the UV light pass through)?	

9



Procedure:

1. Take the beads (7-10 of each kind), string, key ring, and any other art supplies you want and make something with them. Some examples are a bracelet, necklace, key chain charm, or anything else you can think of that will let you investigate what happens when you shine light on the beads. For these experiments you will need to be able to separate the beads into two groups, so make sure you are able to do that. Record what the beads look like at the beginning.
2. Cover one group of beads with one of the blocking materials.
3. Shine the UV flashlight over the beads for about one minute.
4. Remove the blocking material and record your observations of both groups.
5. Wait until all beads return to how they looked originally.
6. Repeat until you have tested all the blocking materials.
7. Summarize your observations and draw some conclusions about the properties of the blocking materials.

10

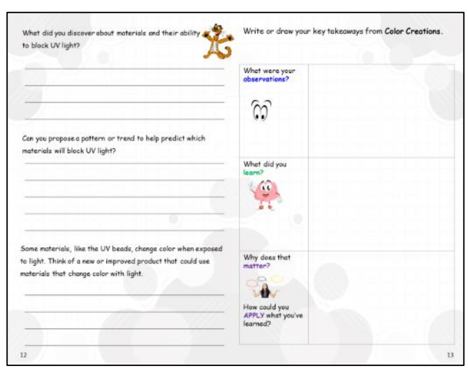
Experimental Observations

Initial observations

What do the beads look like before any experiments?

Blocking Material	Covered Beads	Uncovered Beads

11



What did you discover about materials and their ability to block UV light?

Can you propose a pattern or trend to help predict which materials will block UV light?

Some materials, like the UV beads, change color when exposed to light. Think of a new or improved product that could use materials that change color with light.

12

Write or draw your key takeaways from **Color Creations**.

What were your observations?	
What did you learn?	
Why does that matter? How could you APPLY what you've learned?	

13

Follow the Energy

Note: See NGSS/NYSSLS Education Standards section for detailed evidence statements for 5-PS1-1, 5-PS3-1.

Objective

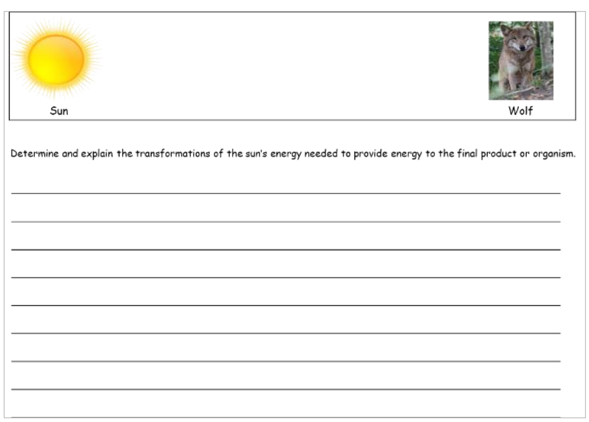
In this game students will explore how different ways energy from the sun can be used by humans, plants, and animals.

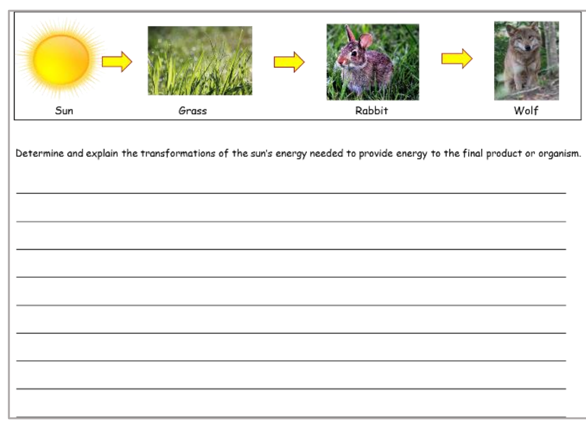
Related essential question: How do we get energy from the sun?

Materials: *Follow the Energy* sheets and cards, *My STEM Explorer Notes*™ notebooks

Detailed Description

In this game students work in groups to model the flow of energy from the sun to various products or organisms. The goal is to reinforce that the energy from the sun can be used directly or indirectly in several ways. Groups are provided with a set of cards and sheets they can use to determine their sequence. In many cases there is more than one way to model the energy transformations. We have provided one example.



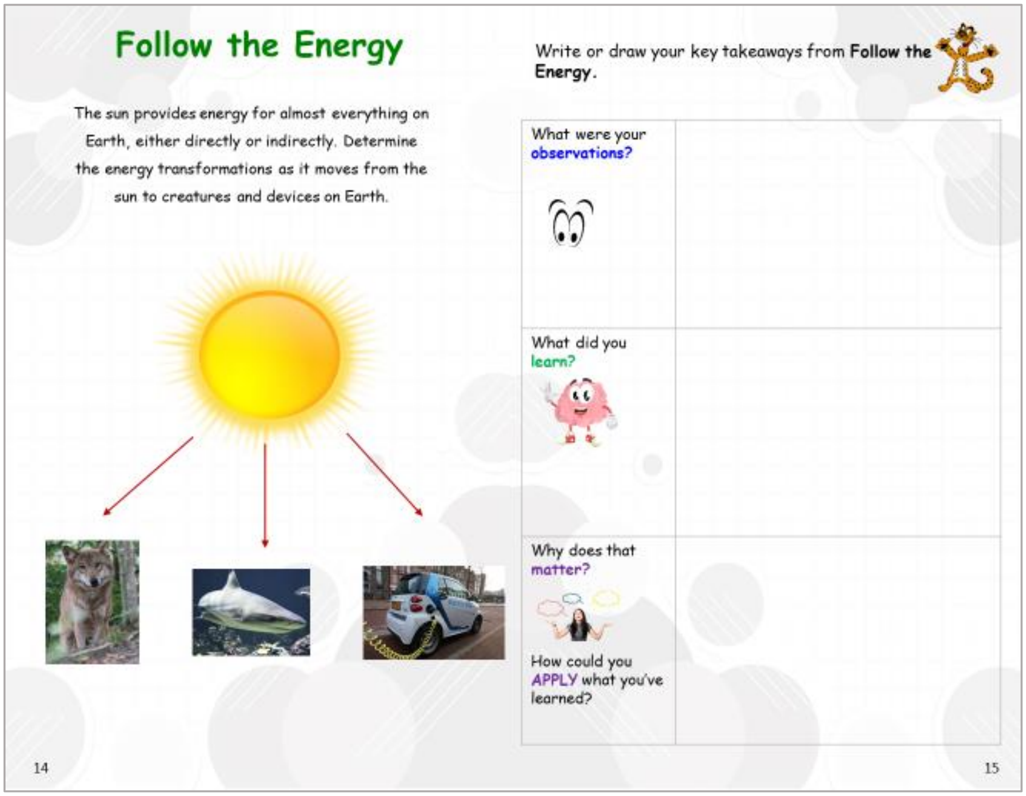


Depending on the independence level and familiarity of your students with this topic you may want to have some initial class-wide discussions that touch on the ideas of active solar energy, passive solar energy, and how plants use the energy directly from the sun to build up their structure. Additionally, the sequences with more or fewer steps may be omitted based on your class's capabilities.

Some extensions include:

- Have the students determine the energy flow without using the cards (i.e., determine the intermediate steps on their own).
- Use the worksheets without the end condition specified and have the groups determine what they want to investigate. (Note: You may want to require a minimum number of transformations for their sequence.)

After this investigation students should complete the OLA (observations, learnings, application) table on page 15 of their *My STEM Explorer Notes*™ notebooks.



Star Light, Star Bright

Note: See [NGSS/NYSSLS Education Standards](#) section for detailed evidence statements for 5-ESS1-1, 5-ESS3-1.

Objective

Students will obtain evidence to support the argument that the sun is a star and that differences in apparent size and brightness of the sun compared with other stars is due to the sun's closeness to Earth.

Related essential question: How does the sun teach us about the universe?

Materials

Provided resource books, online resources, *My STEM Explorer Notes*™ notebook

Detailed Description

In this mini research activity students will perform some research about a star, or celestial object, and complete a comparison between that object and the sun. While students should be free to choose a celestial object that interests them, they should be able to make at least five comparisons between the sun and that object. Some things they might want to compare are:

- Key features (size, composition, color, heat, interesting properties)
- Distance from Earth
- Apparent size from Earth (approximate), visibility from Earth, and how that changes
- Some reason why understanding this phenomenon has helped Earth or could help Earth

When they have completed their analysis, they should fill out the OLA table on page 18. If you are short on time you may want to have students select from a predetermined list of other stars or celestial objects.

As an additional activity, students can share their comparison with you, small groups, the class, etc., via a poster, a recorded video, a short report, a presentation, etc.

Solar Circuits

Note: See NGSS/NYSSLS Education Standards section for detailed evidence statements for 5-PS5-1.

Objective

In this investigation students will investigate the electricity produced with small solar cells. The investigation will also build upon their general knowledge of circuits.

Related essential question: How do we get energy from the sun? How can we use the sun's energy to power our homes and lives?

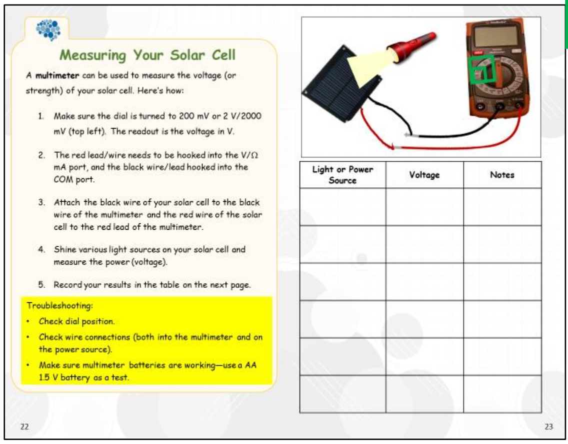
Materials

Multimeter, wired solar panels, mini breadboards, jumper wires, LEDs with resistors, buzzers, *My STEM Explorer Notes*™ notebooks

Detailed Description

<u>Part 1: Measuring Energy</u>

While many students understand that batteries store energy, they may not be familiar with how that energy is measured. Using some batteries (either AA or 9 V is fine), the solar cell panels, and the multimeters, have the students measure the voltage output of the batteries and compare that to the voltage output of the solar cells under different conditions.



Measuring Your Solar Cell

A **multimeter** can be used to measure the voltage (or strength) of your solar cell. Here's how:

1. Make sure the dial is turned to 200 mV or 2 V/2000 mV (top left). The readout is the voltage in V.
2. The red lead/wire needs to be hooked into the V/Ω mA port, and the black wire/lead hooked into the COM port.
3. Attach the black wire of your solar cell to the black wire of the multimeter and the red wire of the solar cell to the red lead of the multimeter.
4. Shine various light sources on your solar cell and measure the power (voltage).
5. Record your results in the table on the next page.

Troubleshooting:

- Check dial position.
- Check wire connections (both into the multimeter and on the power source).
- Make sure multimeter batteries are working—use a AA 1.5 V battery as a test.

Light or Power Source	Voltage	Notes

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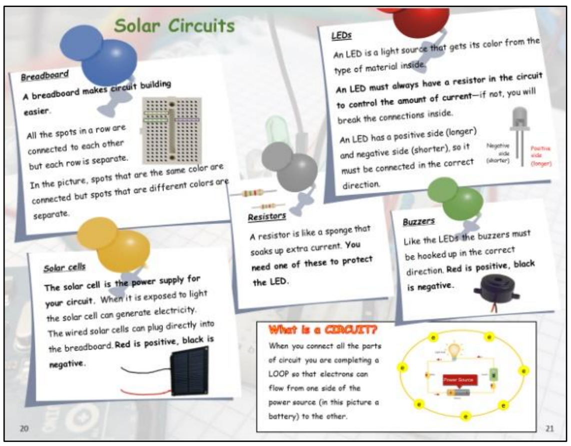
<u>Part 2: Solar Circuits</u>

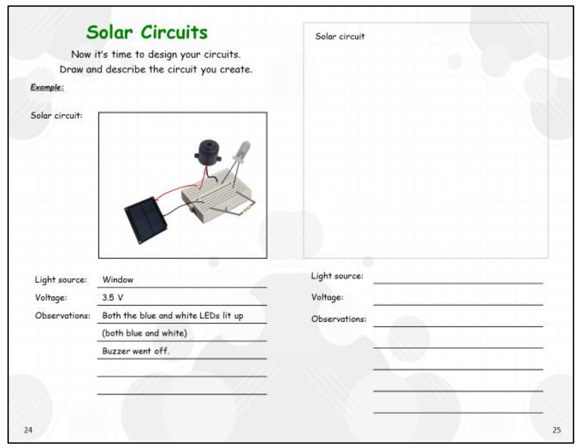
Begin by reminding students what they know about circuits:

1. The circuit needs to be a loop.
2. The key components in this circuit are:
   - The solar cell (power source)
   - LED, resistor, and buzzer (active components)
   - Wires and breadboard (passive components)

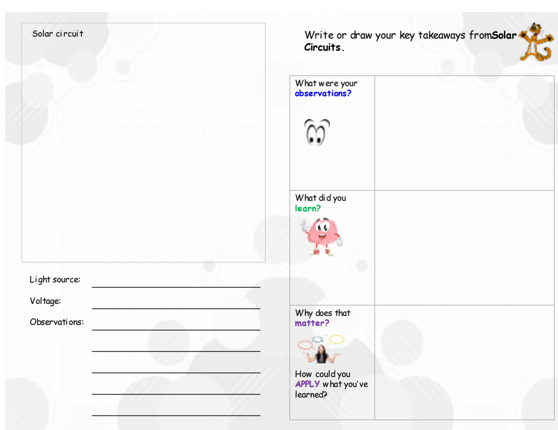
Have students assemble different circuits with their solar panels as the power source. They may need to do some troubleshooting to get the LED to light up.

Hint: If it doesn't light up, first they should make sure the circuit is a loop. Then they may need to switch the direction of the LED since current only flows in one way through an LED.



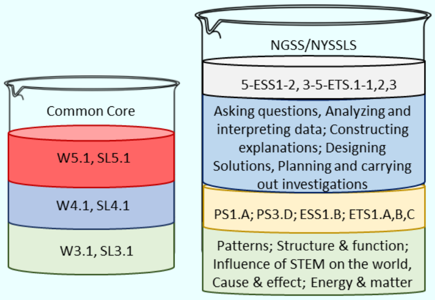


After they've spent some time exploring their solar circuits, have them complete the OLA (observations, learnings, application) table on page 27.



The Appendix contains a short primer on building circuits using a breadboard as well as how to use a multimeter. Both are also discussed in the online How-To videos.

Investigation 2: WATTs Cooking?

Time	*Standards*	*Description*
		*In this investigation students will work in groups to research, design, build, and test out a solar oven. Throughout the investigation they must determine the best location and time of day to run their tests as well as their testing criteria. Depending on your geographical location it may be interesting to run the cooking tests throughout the year to reinforce the seasonal changes.*

Note: See NGSS/NYSSLS Education Standards section for detailed evidence statements for 5-ESS1-2, 3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3

Objective

In this investigation students will **build, test, and evaluate** a solar oven. Prior to testing they will **gather and graph data on sunlight, sun intensity (light and heat), and shadows** around the school to determine daily **patterns** and the best time and location to test their ovens.

> *Related essential questions: How do we get energy from the sun? How do with interact with the sun every day? How can we use the sun's energy to power our homes and lives?*

Materials

Light meter, infrared thermometer, aluminum foil, dowels, carboard boxes, insulation material, black paint, glue or strong tape, something to cook, *My STEM Explorer Notes*™ notebooks

Detailed Description

Warm-Up

Before launching into the solar oven design and construction activity, it's a good idea to get your students thinking about generally about how solar ovens work (passive heating) as well as more specifically about critical design parameters.

Passive Heating: Solar Ovens, Greenhouses, Etc.

One cool thing about solar energy is that it can provide power to us in two forms—passive or active. The key difference between an active solar system and a passive solar system is this: **Passive solar** energy uses the **heat** of the sun **directly**, while an **active solar** system uses the sun's radiation (the sun's rays) to generate **electricity** via solar panels or uses some mechanical energy to transfer the heat of the sun to a different location.

Now that your students have a bit more familiarity with how light can generate heat and how different materials can absorb more or less heat (via the Some Like It Hot and Light. Heat. Motion! investigations), it is time to move on to a more formal passive versus active solar discussion. This discussion can be carried out in a number of ways depending on how your students work best.

1. The *My STEM Explorer Notes*™ notebook (p. 29) has a short quiz on active versus passive solar that students can take and then use as the basis for a class discussion.
2. There is room in the *My STEM Explorer Notes*™ notebook (p. 28) to brainstorm ideas or current hypotheses or understanding around passive versus active solar energy.
3. Below we include some links to kid-friendly videos and websites that they can use to research passive versus active solar and then share the results via a class discussion, a short writing piece, or a poster.
    - https://www.eia.gov/KIDS/energy.cfm?page=solar_home-basics
    - http://scienceprojectideasforkids.com/2010/solar-energy/
    - https://www.youtube.com/watch?v=H-L79SGMiJE
    - https://www.youtube.com/watch?v=AQjVKkIZoj0 This is a more complex video with a lot of elements of green architecture.

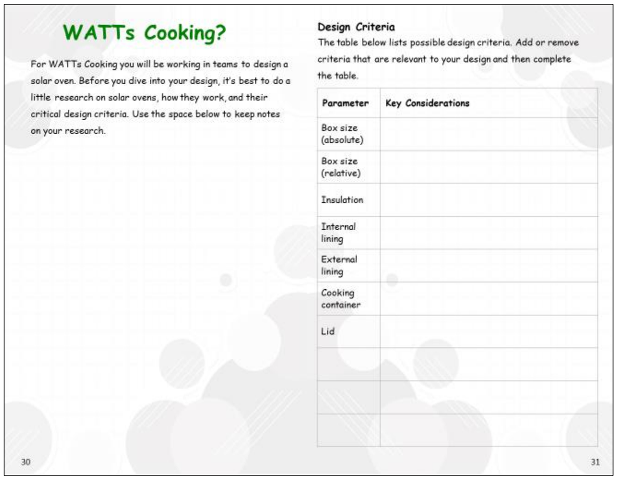
Solar Oven Design and Testing

There are several critical design and operation features for students to consider in their solar oven design including container size, materials of construction, color, and testing location and time of day. For the first few weeks of their solar oven design project students will be researching and planning out their oven design and testing plan. The Additional Resources section contains some useful websites to get your students started researching their design projects and the Appendix contains a "no fuss" solar oven design procedure for your reference.

The general design for a homemade solar oven often includes two nested cardboard boxes with some type of insulation between them, a reflective coating on the inside, and an absorbent coating on the outside. However, your students should be free to explore their own designs and explore key design parameters, including the number of boxes, size of the box/boxes (both the absolute size and the relative sizes), role of the insulation material, function of the lining material (internal and external), and requirements of the cooking container. The following table outlines some key points that should make their way into the discussion.

Component	Design considerations
Box size—absolute	Student should discuss what functional considerations they need to make when thinking about box size. (*You want to make sure you have enough space to cook your material but the bigger the oven the longer it will take to heat up.)*
Box size—relative	Student should discuss what functional considerations they need to make when thinking about box size. *(You want to make sure you have enough of a size difference between the two boxes so that you can add enough insulation but not so much that there is absolutely no heat transfer from the outside.)*
Insulation	Students should discuss the purpose of the insulation. *(The insulation is making sure heat generated in the smaller box doesn't escape to the surroundings.)*
Internal lining	Students should discuss the purpose of the internal lining. *(The internal lining helps to focus the sun's heat into the center of the oven.)*
External lining	Students should discuss the purpose of the external lining. *(The external lining helps to absorb the sun's heat.)*
Cooking container	Students should discuss the key design considerations for the cooking container. *(The less energy it takes to heat up the cooking container the better. As well you want all the energy to go into cooking the food and not the cooking container).*
Lid	Students should discuss the purpose of the lid and if it should be open or closed. *(The lid directs sunlight into the oven. Depending on the material the lid is made out of it could be open or closed).*

During the first few weeks of this investigation students will also be gathering data about daily sun intensity and shadows, so that they can determine the best time and place to test out their ovens. Their *My STEM Explorer Notes*™ notebooks have space for them to record, graph and analyze this data.



WATTs Cooking?

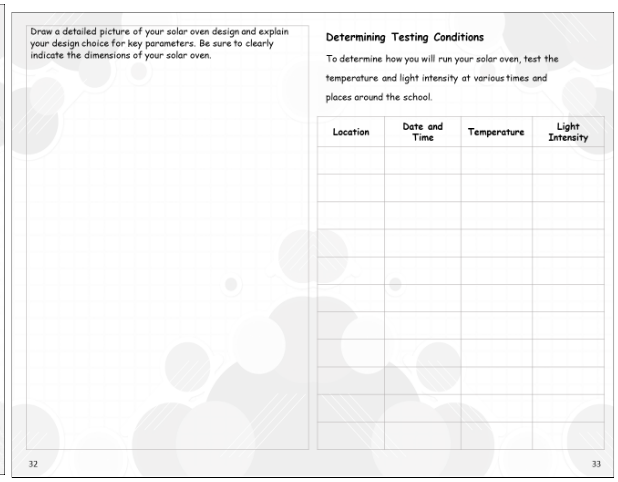
For WATTs Cooking you will be working in teams to design a solar oven. Before you dive into your design, it's best to do a little research on solar ovens, how they work, and their critical design criteria. Use the space below to keep notes on your research.

Design Criteria

The table below lists possible design criteria. Add or remove criteria that are relevant to your design and then complete the table.

Parameter	Key Considerations
Box size (absolute)	
Box size (relative)	
Insulation	
Internal lining	
External lining	
Cooking container	
Lid	

30 31



Draw a detailed picture of your solar oven design and explain your design choice for key parameters. Be sure to clearly indicate the dimensions of your solar oven.

Determining Testing Conditions

To determine how you will run your solar oven, test the temperature and light intensity at various times and places around the school.

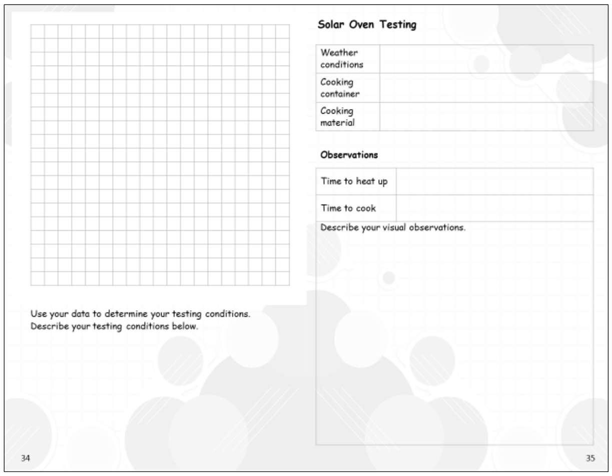
Location	Date and Time	Temperature	Light Intensity

32 33

We suggest each team pick a different location to monitor and around the school and that they evaluate the same place at different times during the day. In addition to recording light and temperature data they should describe the general weather and what they see in their location—such as any shadows or large-scale observable differences. This will help to provide them with context when they are analyzing their data and to help reinforce the learning objectives associated with 5-ESS1-2.

General solar oven assembly procedure

1. Apply the internal and external lining materials. *Note: Students can decide if the internal and external lining needs to be applied to both boxes.*
2. Add insulation and then place the smaller box inside the larger box.
3. Assemble the lid and cooking tray.



Use your data to determine your testing conditions.
Describe your testing conditions below.

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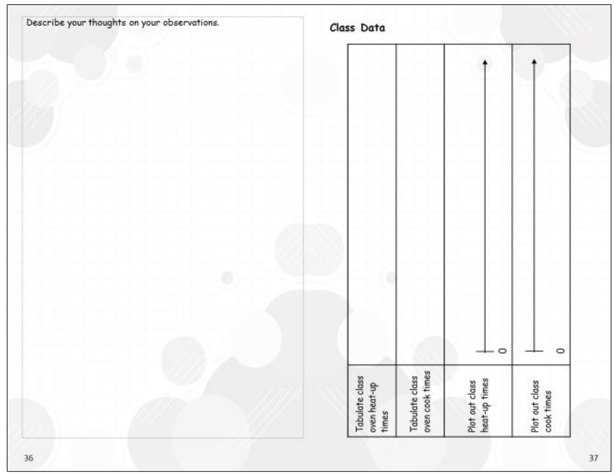
Solar Oven Testing

Weather conditions	
Cooking container	
Cooking material	

Observations

Time to heat up	
Time to cook	
Describe your visual observations.	

35



Describe your thoughts on your observations.

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Class Data

37

General cooking procedure

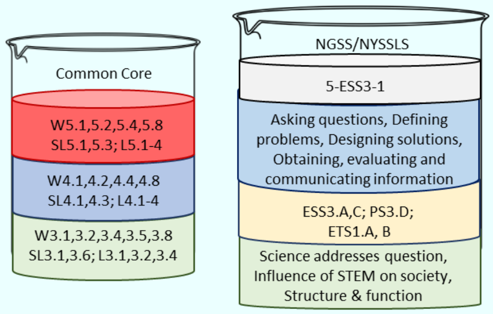
1. Place solar oven on a dry flat surface, in the path of as much sunlight as possible. *(Note: Cooking will likely take many hours.)*
2. Place your food in the solar oven and wait. Monitor the temperature in the oven, and of the food, with an IR thermometer. Observe any visual changes in the food.

Box acquisition suggestions

There are several ways you and your students can gather boxes for this challenge. Larger boxes can be cut open and reassembled if necessary or desired.

- Ask the school office or janitorial staff to put boxes to the side.
- Ask local grocery stores or shops for boxes they would normally throw away or recycle.
- Ask pizza delivery restaurants to donate a stack of boxes.
- Ask local moving or shipping companies to donate a set of boxes to your class.
- Ask students to collect boxes that come to their house or apartment building.

Summative Challenges

Time	*Standards*	*Description*
		*Summative challenges provide students with the opportunity to apply the concepts they have learned and practiced during the investigations to a broader and deeper project. To complete this activity, they must not only* ***know*** *the specific standards but also understand* ***why*** *that knowledge is useful and how they can apply it to a new problem or application. Students should work in teams of three or four to complete one of the following projects and, if time allows, present their findings to the class.*

Solar Solutions

Note: This summative challenge is a required component of the NGSS curriculum. See NGSS Education Standards section for detailed evidence statements for 5-PS1-1. 5-ESS3-1.

After having discussed and investigated all the different ways the sun plays a role in our lives, students will apply that knowledge toward the development of a **solar solution**. To do this, students must:

- Identify and describe three innovations or discoveries that were made possible by our understanding of the sun and that have helped us to protect the environment and/or Earth's natural resources. (A) *Note: Depending on the ability of your students you can let them use innovations described in this unit or require them to research three new discoveries or innovations.*

- Determine or describe a current problem or challenge that may be helped using the sun. (B) *(Note: It's best if your students choose an example that is relevant to their lives, but if they are super stuck some options include providing extra heat when it is cold out, providing extra energy when it is very hot out, purifying water, powering devices in an emergency or when you are outside of the city, etc.)*

- Design and describe an innovation that could be used to solve or improve this problem and that incorporates some property of the sun. (C)

Rubric:

Score	A	B	C	Teamwork
3	Three appropriate innovations identified and described	Well-described problem	Problem addressed/solved with a solution that has a strong connection to the sun	Team functioned well with all members contributing AND members worked to encourage and teach each other
2	Innovations identified and described but either don't involve the sun or don't help Earth/the environment	NA	Problem addressed/solved but solution has only a slight connection to the sun	Team functioned well with all members contributing
1	Innovations identified but not described	Poorly described problem	Problem addressed/solved but solution does not involve the sun	Team functioned well most of the time, but some members were more engaged than others
0	No innovations described	No problem identified	Presentation or letter not completed	Team required a lot of adult intervention to ensure all members contributed/were included

<u>Renewable Energy</u> *(Note: The following summative challenges can be used as additional activities as part of the NGSS curriculum or if you are using* Sun Catchers *as a supplemental curriculum.)*

1. Students will evaluate the possibility of incorporating solar energy into the school. To do this they will:
    - Identify three areas within the school that could use solar energy. (A)
    - Describe how and why this solar energy could be incorporated into those areas. (B)
    - Give a presentation, design a poster, or write a persuasive letter to another class or group of administrators in the school to encourage use of solar energy. (C)

Rubric:

Score	A	B	C	Teamwork
3	Three areas within the school identified	Complete answer and well written	Complete answer and well communicated	Team functioned well with all members contributing AND members worked to encourage and teach each other
2	Three areas identified, not all in the school	Complete explanation but poorly written	Letter/presentation contains complete information but isn't well organized	Team functioned well with all members contributing
1	Only one or two areas identified	Incomplete explanation	Letter or presentation only describes where the technology can be incorporated and not why or how	Team functioned well most of the time, but some members were more engaged than others
0	No areas identified	No explanation	Presentation or letter not completed	Team required a lot of adult intervention to ensure all members contributed/were included

2. Most people put solar panels on the roof of a house or a building. Some people are even trying to put them on the roads upon which we drive.
    - Other than the roof of a house or building, list three places we can put solar panels and discuss why you suggested those locations. (A)
    - Sometimes sail boats have small solar panels to provide electricity for the lights and equipment on the boat. Name three other forms of transportation could use solar power and why it would be a good idea. (B)
    - Pick your favorite idea for solar-powered transportation and draw a picture of what it might look like. Explain why you decided to put the solar panels where you put them. (C)

Rubric:

Score	A	B	C	Teamwork
3	Complete discussion of all three locations	Complete discussion of all three types of transportation	Picture with complete information and well written	Team functioned well with all members contributing AND members worked to encourage and teach each other
2	Three locations chosen but no justification/less than three locations with justification	Three types chosen but no justification (or less than three types with justification)	Labeled picture but no discussion on why the solar panels are where they are	Team functioned well with all members contributing
1	One or two locations discussed	One or two other types of transportation discussed	Incomplete picture	Team functioned well most of the time, but some members were more engaged than others
0	No discussion of locations	No discussion of modes of transportation	No picture	Team required a lot of adult intervention to ensure all members contributed/were included

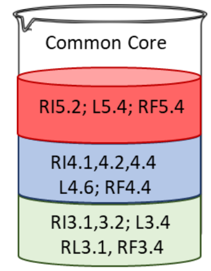
3. Scientists and engineers are working to develop many different types of renewable energy.
    - Students should describe three different types of renewable energy and identify what climate or geographical requirement is necessary for each type (e.g., for solar you need to be in a place with a lot of sun). (A)
    - For each type of renewable energy have them suggest a place in the world that could use that type of energy. Have them explain their choice of location. (B)
    - Have the students prepare a poster or a presentation presenting their findings and poll class to see which one would best fit their community and/or school. (C)

Rubric:

Score	A	B	C	Teamwork
3	Complete discussion of three types of renewable energy	Complete discussion of all three locations	Clearly communicated poster or presentation and well-executed poll	Team functioned well with all members contributing AND members worked to encourage and teach each other
2	Discussion of three types of renewable energy, no comment on geographical requirements	Three locations chosen but no justification or fewer than three locations with justification	Well-done poster or presentation but no class or school poll	Team functioned well with all members contributing
1	Discussion of one or two types of renewable energy	One or two locations discussed	Incomplete poster or presentation and/or incomplete or poorly done poll	Team functioned well most of the time, but some members were more engaged than others
0	No discussion of renewable energy	No discussion of locations	No poster, presentation, or poll	Team required a lot of adult intervention to ensure all members contributed/were included

Ongoing Cross-Curricular Activities

The cross-curricular activities provided in the next few pages are just some suggestions on how you can continue the discussion on the sun and the universe.



Reading Comprehension Formative Assessment Suggestions

The topic introduction, personal biographies, and company information can all be used as informational text reading. Text and questions can be found in the *My STEM Stories*™ notebooks.

1. Have students read the introduction and then answer the following question: What kind of energy would you use and why if you lived in the following places?
   - Near a large waterfall (Niagara Falls, Niagara-on-the-Lake)
   - Near a volcano (Reykjavik, Iceland)
   - In a city with very little rain (Aswan, Egypt)

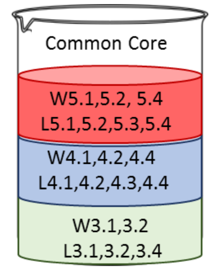
Note: To make the question a bit more challenging use the city provided with each location instead of the climate description and have students research the climate for that city.

2. Using the company and biographical information answer the following questions:
   - Erica states that one of the reasons GRID Alternatives has been successful is because of their vision and collaborative leadership style. What do you think she means by that? What are some examples of collaborations that she describes?
   - The team at GRID Alternatives is always keeping their eyes open for new things they can do to help people. What are two things they are doing now that you don't think they were doing when they started, and what makes you think they weren't doing them when they started the company?

Written Reflections or Discussions

Written reflections and discussions are a great way for students to revisit some of bigger thinking questions in the unit while also working on their writing skills. These open-ended questions encourage students to draw from what they have learnt and apply it to the larger community. This is also a good opportunity to revisit questions that students have raised throughout the unit.

1. How can we use the sun's energy to solve new challenges and problems?
2. Why is it important to use renewable energy?
3. Can you discuss something you think would benefit from solar power?



Creative Writing

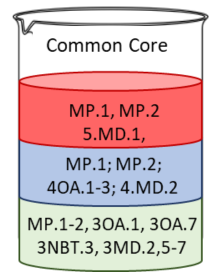
- Set aside 15 minutes each week to work in the *Book of Ideas*.
- Have the students write a story using all the vocabulary words.
- Watch one of the videos about We Care Solar and have the students write Laura Stachel a letter about other places they could use the Solar Suitcase.

Additional Writing Prompts

1. Write three facts you learned today.
2. Write two questions you have for Erica and Tim.
3. What surprised you the most about what you learned today?
4. How does this technology connect with things you or your family do?
5. Where else could this technology be used?
6. Describe an idea for a new product that uses this technology.
7. Identify and describe three reasons why/how this technology is good for our environment.
8. What education does an entrepreneur need?
9. What education does an inventor need?
10. What skills did you need to work as a team?

Social Studies

- Have the students complete one of the suggested timeline activities (see the Appendix for suggestions).
- Research some of the places We Care Solar has Solar Suitcase installations (https://wecaresolar.org/impact/where-we-work/). Have the students think about, discuss, explore, and share ideas on other innovations that may help those communities.



Math Word Problems

- A solar cell changes sunlight into electricity. If a single solar cell makes 0.5 W/h of electricity, how many solar cells would you need to be able to bring 20 W/h of electricity to your house?
- A solar panel is made up of solar cells. If there are four solar cells in a panel, how many panels do you need for that 20 W/h system? (Hint: Use your answer from above to determine how many solar cells you need in total.)
- If each solar cell is 1 unit x 1 unit, how would you set up the array and why? Draw out the array on the graph paper provided. *(Note: Graph paper is provided in the Appendix. Options include one row of 10 panels, two rows of 5 panels, etc.).*
- Imagine you have solar panels on your roof that make 1.5 W/h of electricity. If your house needs 7.5 W of electricity, how many hours of sunlight do you need to provide all the electricity your house needs for the day?

Pacing Guide Resources

Before you begin, we suggest you read through the Unit Overview (p. 3), the Technology Description (p.16) and the Featured Entrepreneur story (p. 20). These three sections are a quick way to get a comprehensive look at the unit before you dive into lesson planning details.

This section contains sample pacing guides for you to use as a resource when planning out how to teach this unit in your class, including lesson sequencing, cross-curricular integration, external resources, and quick assessments to monitor ongoing student understanding. The last page in this section is intentionally left blank for you to develop the outline of your own lesson plans. **More sheets are provided at the end of the Appendix to support the creation of your detailed lesson plans**. Feel free to make modifications to this curriculum in response to your students' interests and needs. If you need additional support or guidance in making modifications, while making sure you are still addressing all the concepts covered in the standards, please feel free to reach out to the CreositySpace curriculum development team by emailing Kath at Kath@CreositySpace.com.

Guiding notes for teachers as you are developing your lesson plans and pacing guides

- Review Learning Progression (p.12), Weekly Goals (p.15), and Essential Questions (p. 41).
- Use provided lesson planning sheets to outline lesson flow and highlight connections to learning objectives you have in other subjects.
- Determine specific introduction strategy for your class (week 1).
- Review how-to videos and safety section for hands-on investigations. Determine any **additional safety precautions** you should highlight to keep ALL students safe during the investigations.
- Review the suggested videos and discussion prompts online.
- Discuss potential collaboration for Color Creations and WATTs Cooking with the Art teacher (if applicable). Determine box acquisition strategy for the Investigation: WATTs Cooking? (see investigation details for suggestions).
- Discuss Solar Solutions summative challenge (begins week 3) with library or resource center staff to determine additional resources available at your school (if applicable).
- Review Ongoing Cross-Curricular Activities (Lesson section) and Additional Resources for implementation throughout the unit and year in general.
- Each week has several suggested Exit Tickets that can be used in various ways (e.g., journal entries, writing prompts, recap videos, small group discussions, etc.) as an ongoing formative assessment of student understanding.
- Review **Teacher Support Documents** in the Appendix for various tips on things such as STEM integration, getting back on-track after an extended student-directed discussion, lesson scaffolding, etc.
- **A composition journal that students can use as a STEM notebook (to support brainstorming, inquiry, research, writing, etc.) is strongly suggested.**

Primary Curriculum

This week-by-week guide is intended for teachers using *Sun Catchers* as a primary NGSS/NYSSLS curriculum. Depending on the extent to which you integrate the concepts from this unit into your ELA, math, social studies, and art classes, this unit could take between **9 to 12 weeks** to complete.

In order to fully support the NGSS and NGSS-related standards students will need more exposure to science concepts than typically allocated in an elementary school day. In order to address this challenge, **nearly 50% of CreositySpace lessons are suitable for instruction during ELA, social studies, math, or art classes**. While these lessons can certainly be delivered during science instructional time, they are intentionally designed to reinforce key ELA, math, social students and art learning objectives **in addition to teaching the intended science concepts**.

The following lesson list and pacing guide describe a suggested unit sequencing with activities intended for a science class presented in **black text** and lessons suitable for an ELA or other instruction block presented in **purple text**. In general, activities can easily be shifted in order or, in some cases, substituted by other content provided in the Introduction and Lesson Planning Tools sections so that you are able to design a unit flow tailored to the interests and needs of your students.

Common Core and NGSS/NYSSLS "beakers" describing the standards associated with each activity can be found preceding the detailed description of the specific activity in the Introduction and Lesson Planning Tools sections as well as in the summary table on page 3.

If you would like some additional support setting up a lesson schedule that fits your needs don't hesitate to reach out to us at Kath@CreositySpace.com.

Please put **Request for lesson support** in the subject line.

Lesson List

Lesson	Lesson Description[1]	Instructional blocks[2]	Non-Science Standards[3]
Introduction *3-5-ETS1-1*			
1	Introductory portion of the **Some Like It Hot!** investigation	Science	W5.2
2	Discuss introductory phenomena, solar energy, initial vocabulary.	Science	SL5.1, L5.4
3	Group discussion, reading, and writing to assess student interests, and prior knowledge on solar and renewable energy.	ELA, Science	W5.2, SL5.1, L5.4
Hands-On Investigation: Solar Sleuthing *(5-PS1-1, 5-PS3-1, 5-ESS1-1, 5-ESS3-1)*			
4	Complete first pass solar interactions model.	Science	W5.2
5, 7	Complete **Heat. Light. Motion!** and **Color Creations** investigations	Science, Art	SL5.1, 5.4
9, 10	Complete **Follow the Energy** investigation	Science	SL5.1, 5.4
12, 13	Complete research and comparisons for **Star Light, Star Bright**	ELA, Science	RI5.2, 5.3, 5.5; W5.2, 5.7
14, 15	Build and evaluate **Solar Circuits**	Science	SL5.1
17	Update solar interaction models	Science	W5.2
Design Challenge: WATTs Cooking? *(5-ESS1-2, 3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3)*			
6	Complete WATTs Cooking introduction including the Active vs. Passive activity.	Science	SL5.1
8	Have students perform some research into how a solar oven works.	ELA, Science	RI5.2, W5.7
11	Collect light intensity data. *(This will take multiple days but does not need to take a full lesson slot each time.)*	Math, Science	5.G1-2
16	Organize light intensity data. Determine oven design criteria.	Science	SL5.1
17, 19	Design and begin construction of the solar oven.	Art, ELA, Science	SL5.1

20	Complete solar oven construction	Art, Science	SL5.1
23	Test out solar ovens	Science, Math, ELA	SL5.1
24	Organize data and analyze results	Science, Math, ELA	5.MD.2, SL5.4
Optional extension: Have students make improvements to their ovens and re-test.			
Summative Challenge: Solar Solutions *(3-LS2-1, 3-LS4-4, 3-ESS2-2, 3-ESS2-3)*			
18	Introduce summative challenge via a discussion or research on a variety of solar energy entrepreneurs.	Science	SL5.1
20	Have students begin research on solar innovators, innovations, and entrepreneurs.	ELA, Science	RI5.2, W5.7
21	As a mid-way check in have students complete the timeline activity.	Social Studies, Science, ELA	W5.7-9
22	Organize initial research and determine summative challenge topic.	ELA, Science	W5.7-9
25,26	Design and describing summative challenge innovations	Science	W5.2, 5.10
27+	Compile summative challenge research and inventions into final form.	ELA, Science	W5.2, 5.10

[1]In general, lesson objectives can be achieved in a 30–40-minute instructional block. However, lessons can easily be extended across multiple instructional blocks if more time is allocated for student-directed inquiry, discussion, and research. Tips on how to facilitate longer discussions are provided within the Lesson Planning Tools section.

[2]While all lessons are suitable for delivery in a science instructional block, lessons that are also suitable for delivery in an ELA-, math-, social studies-, or art-focused instructional block are identified here.

[3]The most relevant common core ELA and math standards have been identified. In many cases state-specific social studies or art standards may also be applicable.

Week	Goals
1	• Determine student interest and prior knowledge about the role the sun plays in our life. • Generate excitement for the *Sun Catchers* unit with the **Some Like It Hot!** introductory activity. Introduce overarching phenomenon. • Get students thinking about how we derive energy from the sun with their initial **Solar Energy Interactions** model and begin the **Solar Sleuthing** investigations. **(5-PS1-1, 5-PS3-1)**
2–3	• Students continue exploring the different ways we interact with the sun through the **Solar Sleuthing** investigations. Students start compiling evidence for their model that matter is made up of particles too small to be seen and of all the ways we get energy from the sun. **(5-PS1-1)** • Students complete background research and preparation for the **WATTs Cooking?** design project. **(3-5-ETS1-1)**
4–5	• Students continue developing their understanding on the structure of matter and various properties and applications of the sun as they complete their **Solar Sleuthing** investigations and revise their solar interactions model. **(5-PS1-1, 5-PS3-1, 5-ESS1-1)** • Students will begin to gather data around patterns of sunlight intensity (heat and luminosity) and shadows for the **WATTs Cooking?** design project. **(3-5-ETS1-1, 5-ESS1-2)**
6	• Students determine critical design parameters and approach for the students' solar oven. **(3-5-ETS1-1)** • Students solidify their understanding of the sun's role in the cosmos as they begin the **Solar Solutions** summative challenge. **(5-ESS1-1, 5-ESS1-2)** • Students obtain and begin organizing evidence on how advancements in our understanding of the sun and solar energy have helped specific communities and the planet in general through the timeline activity. **(5-ESS3-1)**
7–9+	• Students apply knowledge gained throughout the unit to complete the solar oven construction, testing, and, if desired, process or device improvements. **(3-5-ETS1-2, 3-5-ETS1-3)** • Students complete the **Solar Solutions** summative challenge, both describing how STEM innovations have benefited the community and applying the knowledge gained during this unit to solve an innovation challenge. **(5-ESS3-1)**

<table>
<tr><th>Week</th><th>Class Activities</th></tr>
<tr><td>1</td><td>
Week 1 Goals

Determine student interest and prior knowledge about the role the sun plays in our life.
Generate excitement for the Sun Catchers unit with the Some Like It Hot! introductory activity. Introduce overarching phenomenon.
Get students thinking about how we derive energy from the sun and begin the Solar Sleuthing investigations. (5-PS1-1, 5-PS3-1)

Lessons

Complete the introductory activity.
Discuss introductory phenomena: How can you use solar energy, or the sun in general, to solve a challenge in your life? What are all the ways we get power(energy) and information from the sun?
Distribute My STEM Stories™ notebooks. Show and discuss videos and stories about renewable and solar energy.

Short video on alternative energy (2:48 min, short ad to start) http://video.nationalgeographic.com/video/alternative-energy
Short videos on solar energy; focus on solar cells. (Both about 2 min, no ads; the second one builds on the first one.) https://www.youtube.com/watch?v=x4CTceusK9I (The last 40 sec is a plug for BEP, so you might want to stop it before that.) http://energy.gov/eere/videos/energy-101-solar-pv
Introduce Erica, Tim, and GRID Alternatives.

Introduce vocabulary terms: solar radiation, solar thermal, and solar electric.
Assess student interest in and prior knowledge about solar and renewable energy through a KWHLAQ chart or What do you know? What do you want to know? activity.

Exit Tickets
Name and describe three ways we can get energy directly from Earth.
Why do you think it important to use renewable sources of energy?
</td></tr>
</table>

2 & 3	Weeks 2 & 3 Goals
	• Students continue exploring the different ways we interact with the sun through the **Solar Sleuthing** investigations. Students start compiling evidence for their model that matter is made up of particles too small to be seen and of all the ways we get energy from the sun. **(5-PS1-1)**
	• Students complete background research and preparation for the **WATTs Cooking** design project. **(3-5-ETS1-1)**
	
	Lessons
	• Distribute *My STEM Explorer Notes*™ notebooks.
	  o Complete first pass solar interactions model.
	• Continue **Investigation 1: Solar Sleuthing**
	  o Complete **Investigation Light. Heat. Motion!**
	  o Complete **Investigation Color Creations**
	  o Complete **Investigation Follow the Energy**.
	• Begin **Investigation 2: WATTs Cooking?**
	  o Introduce vocabulary terms: passive solar, active solar, and watt. Complete project introduction, including the Active vs. Passive activity.
	  o Have students perform some research into how a solar oven works.
	• Review vocabulary words.
	• Introduce Erica, Tim, and GRID Alternatives.
	• **Writing prompts:** Where could you use renewable energy? Is one form more suited to a given location (East Coast, West Coast, desert, etc.)?
	• **Reading Comprehension:** Complete introduction reading and questions.
	
	Exit Tickets
	Name and describe two ways we can get energy from the sun.
	In your own words describe the difference between active and passive solar energy.

4 & 5	Week 4 and 5 Goals • Students continue developing their understanding on the structure of matter and various properties and applications of the sun as they complete their **Solar Sleuthing** investigations and revise their solar interactions model. **(5-PS1-1, 5-PS3-1, 5-ESS1-1)** • Students will begin to gather data around patterns of sunlight intensity (heat and luminosity) and shadows for the **WATTs Cooking?** design project. **(3-5-ETS1-1, 5-ESS1-2)**

	Lessons
	• Continue **Investigation 1: Solar Sleuthing**.
	  ○ Complete **Investigations Star Light, Star Bright** and **Solar Circuits**.
	  ○ Using the method of their choice (PIC, song, story, interpretive dance, etc.) have students create a model that draws upon their learnings from the **Solar Sleuthing** investigations to provide evidence that matter is made up of particles too small to be seen.
	• Continue **Investigation 2: WATTs Cooking?**
	  ○ Complete data collection on the best times of day (year) and location around the school to use the solar oven.
	
	Exit Tickets
	Why do you think there are more solar cells in Florida and Arizona than in New York or Washington State?
	Which months of the year might it be better for solar energy in Washington and why?

6	**Week 6 Goals**
	• Students determine critical design parameters and approach for the students' solar oven. **(3-5-ETS1-1)**
	• Students solidify their understanding of the sun's role in the cosmos as they begin the Solar Solutions summative challenge. **(5-ESS1-1, 5-ESS1-2)**
	• Students obtain and begin organizing evidence on how advancements in our understanding of the sun and solar energy have helped specific communities and the planet in general through the timeline activity. **(5-ESS3-1)**
	
	Lessons
	• Continue **Investigation 2: WATTs Cooking**.
	  ○ Design and begin construction of the solar oven.
	• **Summative Challenge: Solar Solutions**
	  ○ Introduce summative challenge via a discussion or research on a variety of solar energy entrepreneurs.
	  ○ Have students create a timeline about how our understanding of the Earth, sun, and stars has resulted in discoveries that have impacted all of society. Some examples include Galileo's sun-centric model of the solar system, using stars to navigate ocean crossing, etc. (See Additional Information section for research resources.)
	• **Reading Comprehension:** Complete entrepreneur reading and questions.
	
	Exit Tickets
	Describe two things you found interesting about stars and/or outer space and why those were interesting to you.

7–9 +	**Weeks 7–9 Goals** • Students apply knowledge gained throughout the unit to complete the solar oven construction, testing, and, if desired, process or device improvements. (3-5-ETS1-2, 3-5-ETS1-3) • Students complete the Solar Savers summative challenge, both describing how STEM innovations have benefited the community and applying the knowledge gained during this unit to solve an innovation challenge. (5-ESS3-1) **Lessons** • Continue **Investigation 2: WATTs Cooking** o Week 7: Complete construction of solar oven. o Week 8+: Testing and any modifications (optional) of solar oven. • **Summative Challenge: Solar Solutions** o Week 7: Students should determine the problem they are going to address. o Week 8+: Students should be designing and describing their solutions. • **Writing prompt:** Other than the roof of your house or school, name a place you'd like to put a solar cell and describe why you would put it there. **Exit Tickets** Why is it important to use renewable sources of energy? *(Teacher note: It might be interesting to compare answers with those from week 1.)* Describe three ways the sun helps your community?

Supplemental Program

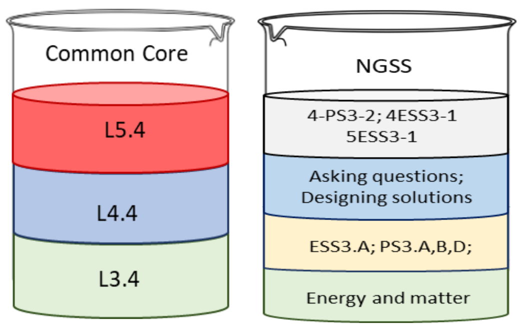
This five-day guide is intended as an example for folks using *Sun Catchers* as a ***supplemental curriculum*** with a focus on **renewable energy**. All activities described can be a part of your science class, however several lessons are also suitable for instruction during ELA and, to a lesser extent, social studies, art or math classes. Lessons that are suitable for an ELA-, social studies-, art-, or math-focused instruction block are presented in purple text.

Since all school schedules are different, activities can easily be shifted a day earlier or a day later. However, we do suggest that all intended activities outlined in days 1–3 be completed prior to the investigations outlined in day 4. ***Note:*** *All links were confirmed as working at the time this Educator Guide was created. If you find a link that doesn't work, please let us know.*

Should you rather focus on the **cosmos** portion of this unit, please let us know and we'd be happy to supply additional lesson planning support with that as the focus.

<table>
<tr><th>Day</th><th>Class Activities</th></tr>
<tr><td>1</td><td>

Standards



Preparation Activities

- Review Ongoing Cross-Curricular Activities for implementation throughout the unit and year in general.

Intended Activities

Science

- Introduce the topic area and vocabulary (see the Appendix for lesson ideas).
    - Discuss introductory **phenomenon:** *How can you use solar energy, or the sun in general, to solve a challenge in your life? What are all the ways we get power(energy) and information from the sun?*
    - Distribute *My STEM Stories*™ student notebooks.

Optional Activities

Science

- Show short video on alternative energy (2:48 min, short ad to start) http://video.nationalgeographic.com/video/alternative-energy

Exit Ticket

Describe three ways we can get energy directly from Earth.

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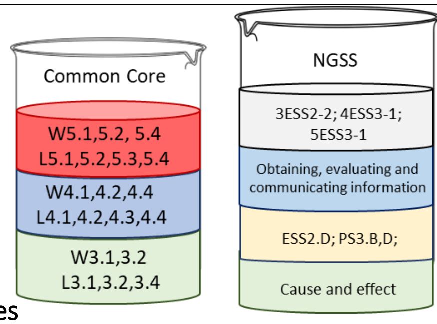
Standards



Preparation Activities

- Review activity section and online videos.

Intended Activities

- Review the vocabulary with the students.
- **Writing Prompt:** Where could you use renewable energy? Is one form more suited to a given location (East Coast, West Coast, desert, etc.)?

Optional Activities

- Do a Technology Historical Timeline activity.

Exit Ticket

Why do you think it is important to use renewable sources of energy?

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<tr>
<td>3</td>
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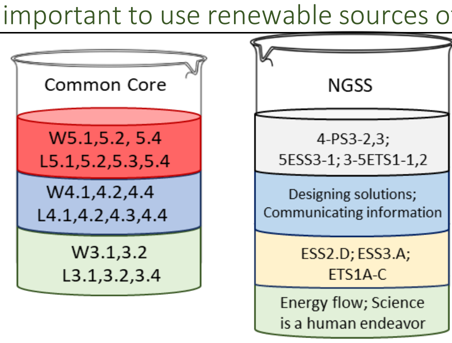
Standards



Intended Activities

- Show the video from We Care Solar about the Solar Suitcase. http://www.cnn.com/videos/bestoftv/2013/12/18/cnnheroes-show-stachel.cnn (5:50 min)
- Show solar energy video; focus on solar cells. (Both about 2 min, no ads; the second one builds on the first one.)
https://www.youtube.com/watch?v=x4CTceusK9I
http://energy.gov/eere/videos/energy-101-solar-pv
- Introduce the *Book of Ideas* (if ordered).
https://www.youtube.com/watch?v=AkELh9qAwUY (2:04 min)

Optional Activities

- **Writing prompt:** Other than the roof of your house or school, name a place you'd like to put a solar cell and describe why you would put it there.

Exit Ticket

Why do you think there are more solar cells in Florida and Arizona than in New York or Washington State?

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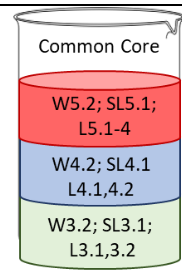
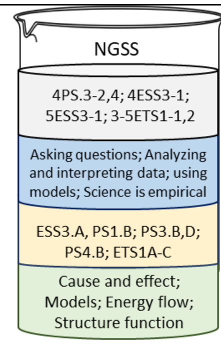
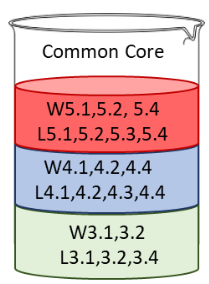
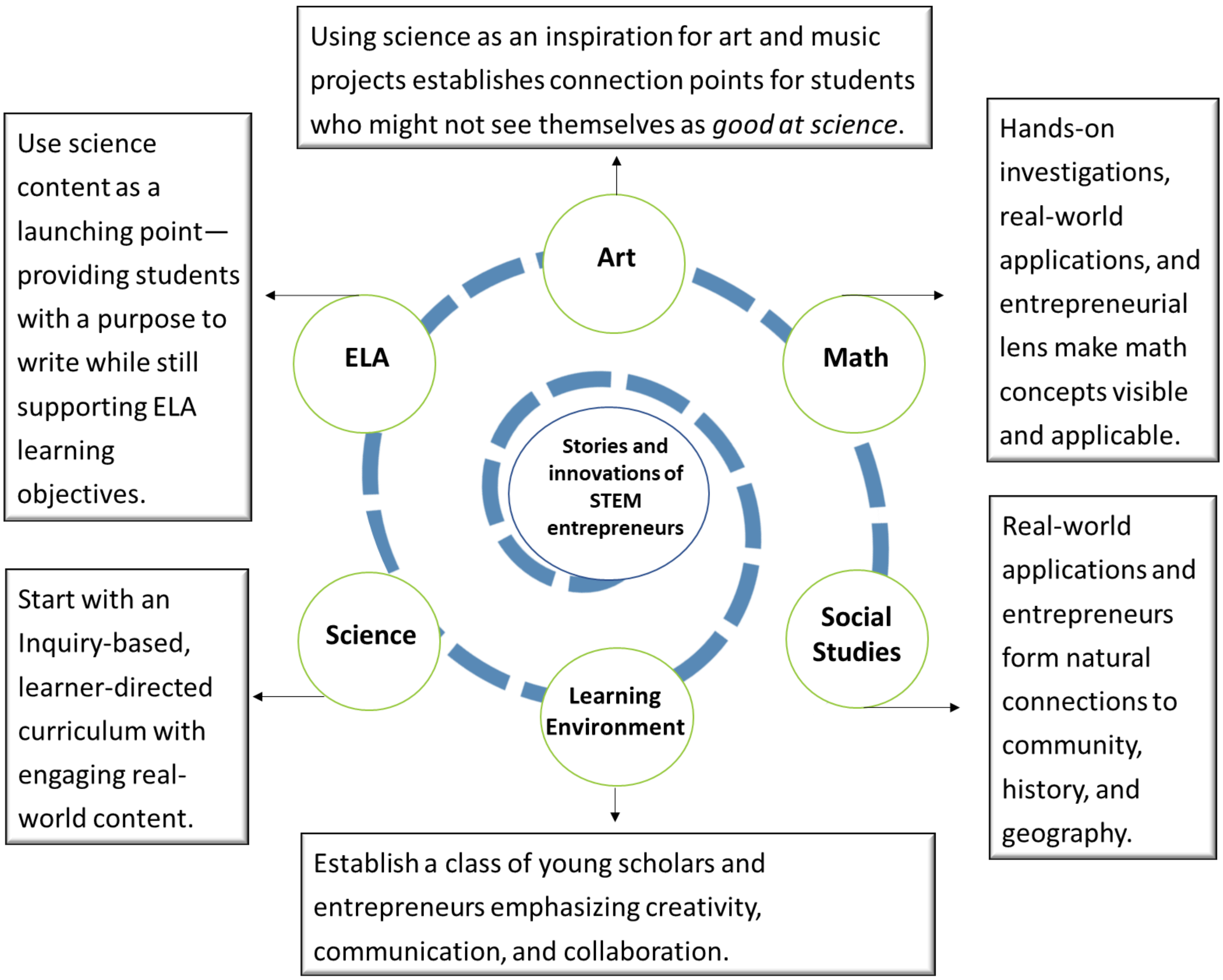
4	**Standards**   **Intended Activities** **If you have purchased the activity kit:** Complete the hands-on experiments in **Solar Sleuthing**. *(Note: Completing all three activities will take about 60–90 minutes.)* 1. Light, Heat, and Motion 2. Color Creations 3. Solar Cell Circuits **If you have not purchased the activity kit:** The investigation WATTs Cooking (solar oven design and construction) can be completed with common items that can be found in the classroom or around the house. If you need additional materials for insulation or boxes for the ovens themselves, grocery stores are often happy to donate extra boxes and butcher paper/newsprint. **Optional Activities** • **Writing prompt:** Write two questions you have from the activity. **Exit Ticket** Describe two interesting properties or facts you know about light. Why do you think they are interesting?
5	**Standards**  **Intended Activities** • **Writing prompt:** Who would you be most excited to tell about this technology and why? **Optional Activities** • Begin a summative challenge described on page 53. **Exit Ticket** Describe three ways the sun helps your community.

Cross-Curricular Integration

Cross-curricular integration is a great way to save time and increase engagement. In the next few pages we describe some examples of how this can be achieved. **The key to success: Students must see how what they are learning connects to their interests.**

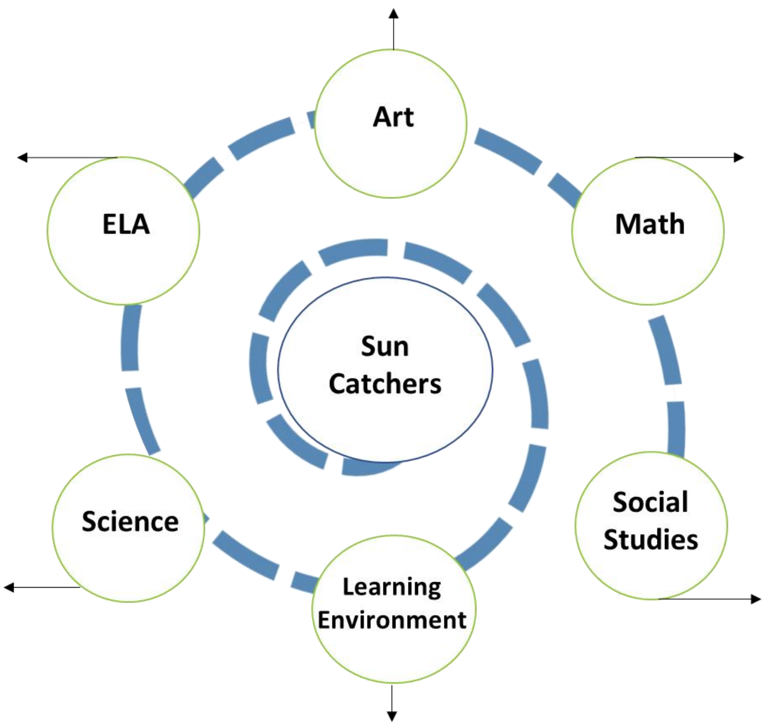


Note: An example of using this spiral as a planning tool is provided on the next page.

Color Creations and WATTs Cooking? have students combining experimental activities with artistic expression.

In *Star Light, Star Bright* students must research and report on different celestial bodies. This includes describing them via comparisons with our sun and describing what type of seasonal changes might be observed from Earth.

To prepare for the *WATTs Cooking?* design challenge, students must collect, graph, and analyze heat and light intensity data.



Think about all the different ways you interact with the sun every day. Plants are growing. The living room gets extra hot every afternoon. The grass in the park feels so much cooler than the basketball court. Can you describe what is happening in each case? Can you explain, or build a model that explains, what is happening at a level smaller than you can see?

Scientists, engineering, and entrepreneurs design inventions and businesses to help their communities solve problems. Grid Alternatives and We Care Solar have community centered missions at the core of their businesses. The Solar Solutions summative challenge allows students to explore these, and other, community connections at a deeper level.

How can we use the sun's energy to power our homes and lives? How can we use the sun's energy to solve new challenges and problems? What do we know about the sun that can help us use it to solve problems?

The unit webpage contains other examples of how classroom teachers have integrated this unit across all of their content areas.

Note: A blank spiral template that you can use to plan out a cross-curricular integration strategy for your classroom is provided in the Appendix.

The blank spirals are also a great tool to give your students an opportunity to show you what they know from the unit.

Blank Pacing Guide

Use this page to summarize your plans for using *Sun Catchers*. Pages for weekly lesson planning are provided in the Appendix.

Introduction:
Lesson Flow:
Summative Assessment:

Education Standards

Don't see the standards for your school district? Contact us at kath@creosityspace.com and we will determine the appropriate standards alignment. Electronic copies of the standards are on the module website.

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Next Generation Science Standards/NY State Science Learning Standards Grade 5

Fully covered through **Primary NGSS/NYSSLS Curriculum** implementation

Performance Expectations

5-PS1-1 Develop a model to describe that matter is made of particles too small to be seen.
5-PS3-1 Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.
5-ESS1-1 Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.
5-ESS1-2 Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.
5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect Earth's resources and environment.
3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Science and Engineering Practices

Asking questions / defining problems; Planning and carrying out investigations; Analyzing and interpreting data
Investigations require all of the above.

Developing and using models; Constructing explanations/designing solutions
Activities in the Solar Sleuthing investigation have students developing a variety of models.

Obtaining, evaluating, and communicating information
Solar Solutions summative challenge has students obtaining, evaluating and communicating a variety of information.

Engaging in argument from evidence
Star Light, Star Bright investigation and required timeline activity have students creating arguments from evidence

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Connections to Nature of Science

Scientific investigations use a variety of methods; Scientific knowledge is based on empirical evidence
Entrepreneur story/presentation and hands on activities illustrate how scientific investigations are conducted and how that information is put to use.

Science models, laws, mechanisms, and theories explain natural phenomena
The activities give student firsthand experience at model solar energy systems and understanding how to get energy from the sun.

Disciplinary Core Ideas

ESS1.A The universe and its stars
ESS1.B Earth and the solar system
Investigations (Star Light, Star Bright; WATTs Cooking, and timeline activity) have students investigating the structure of outer space.

ESS2.A Earth materials and systems
ESS2.D Weather and climate
ESS3.A Natural resources
ESS3.C Human impacts on Earth systems
ESS3.D Global climate change
Focus on solar energy reinforce the interconnectedness between humans and all aspects of their environment.

PS1.A Structure of matter
Solar Sleuthing investigations have students exploring and modeling the structure of matter.

PS3.D Energy in chemical processes and everyday life
LS1.C Organization for matter and energy flow in organisms
Discussion of the transformation of energy from the sun to support plant, animal, and human life.

ETS1.A: Defining and Delimiting Engineering Problems
ETS1.B: Developing Possible Solutions
ETS1.C: Optimizing the Design Solution
WATTs cooking investigation and **Solar Solutions** challenge have students defining problems and designing & optimizing solutions

Crosscutting Concepts

Cause and effect
Investigations explore a variety of cause and effect relationships

Systems and system models
Activities in the Solar Sleuthing investigation have students developing a variety of models.

Patterns
Determination of appropriate cooking strategy in WATTs cooking have students investigating patterns in light, heat and shadows.

Scale, proportion and quantity
Discussion on relative size of the universe as the structure of matter have students thinking about scale and proportion.

Energy and matter: Flows, cycles, and conservation
The discussion on different types of solar energy and how the energy of the sun can be converted into many forms supports the discussion of energy flow and conversion.

Structure and function
WATTs cooking investigation and Solar Solutions challenge have students examining structure and function relationship.

Connections to Nature of Science

Science is a way of knowing; Science addresses questions about the natural and material world
Investigations link science to our understanding of the world around us.

Science is a human endeavor
Entrepreneur story and historical timeline highlight the human aspect of science and engineering.

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology; Influence of Engineering, Technology and Science on Society and the Natural World
Introduction text, historical timeline and entrepreneur story highlight above interactions and interdependencies.

Connections to Common Core State Standards
See following Common Core Standards section for the ELA and Math standards addressed by these activities.

Overarching Enduring Understanding **What are all the different ways we rely on the power of the sun and what is the evidence of its importance in our lives?**	
FLOW OF INSTRUCTION	
5-PS1-1 Develop a model to describe that matter is made of particles too small to be seen. **5-PS3-1** Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun. **5-ESS1-1** Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth. **5-ESS3-1** Obtain and combine information about ways individual communities use science ideas to protect Earth's resources and environment.	**5-ESS1-2** Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. **3-5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. **3-5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. **3-5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
Investigation: Some Like It Hot! (hands-on investigation, occurs during week 1) In this investigation students get their first look at the connection between light and heat. From this they will start building a model to explain their observations based on the fact that matter is made up of particles too small to be seen. They will expand and revise this model throughout the Solar Sleuthing activities. (5-PS1-1) **Investigations: Solar Sleuthing (hands-on investigations, occur during weeks 1, 2, 3, and 4)** In this series of smaller investigations students investigate various attributes of the sun. • In **Light. Heat. Motion!** students continue exploring the connection between light, energy, and particles. (5-PS1-1) • In **Color Creations** students investigate different properties of light, light-blocking materials, and the idea of light-sensitive molecules. (5-PS1-1) • In the short research activity **Follow the Energy** students develop, use, and explain models to describe different ways we use energy from the sun. (5-PS1-1, 5-PS3-1) • In the short research activity **Star Light, Star Bright** students research and report out on evidence that supports an argument focused on the differences in apparent brightness of the sun compared with other stars (5-ESS1-1) as well as the seasonal changes of some stars in the sky. (5-ESS1-2) • In **Solar Circuits** students get some hands-on experience with solar cells. At the end of the series of Solar Sleuthing activities, students must use the knowledge they have gained to develop a model to describe that matter is made up of particles too small to be seen. (5-PS1-1) **Investigation: Solar Solutions (summative challenge, occurs during weeks 5, 6, 7, and 8)** After having discussed and investigated all the different ways the sun plays a role in our lives, students will apply that knowledge toward the development of a *solar solution*. Working in teams of four or five, students must describe three innovations or discoveries that were made possible by our understanding of the sun that have helped to protect the Earth's resources and the environment. (5-ESS3-1) Then students must describe a problem or challenge that could be solved (or improved) with the help of the sun and design a device or test or similar based on that problem. (5-ESS3-1).	**Investigation: WATTs Cooking? (hands-on investigation, occurs during weeks 2 through 6)** Working in groups, students begin this project by researching solar ovens and reporting out on how they work (5-PS-1-1) and their assessment of critical design criteria (3-5-ETS1-1). Groups must then determine their plan for oven construction, build their ovens (3-5-ETS1-2), and determine the plan for testing (3-5-ETS-1-3). Part of their plan must include gathering data (both from reference resources and firsthand) on the sunlight available at different places around the school and throughout the day/year. This includes collecting and tabulating data about patterns in sunlight and shadows (5-ESS1-2). From this data students should finalize and execute their testing plan, reflect on their design, and plan improvements in design or process (3-5-ETS1-3) [Note: Depending on where you are located, it may be fun to perform the testing throughout the year.]

NGSS Evidence Statements

5-PS1-1 Matter and Its Interactions		
Students who demonstrate understanding can: **5-PS1-1.** Develop a model to describe that matter is made of particles too small to be seen. [Clarification Statement: Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] [Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.]		
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Use models to describe phenomena.	**PS1.A: Structure and Properties of Matter** • Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects.	**Scale, Proportion, and Quantity** • Natural objects exist from the very small to the immensely large.

Observable features of the student performance by the end of the grade:
Components of the model
1) Students develop a model to describe* a phenomenon that includes the idea that matter is made of particles too small to be seen. In the model, students identify the relevant components for the phenomenon, including: a. Bulk matter (macroscopic observable matter; e.g., as sugar, air, water). b. Particles of matter that are too small to be seen.
Relationships
1) In the model, students identify and describe* relevant relationships between components, including the relationships between: a. Bulk matter and tiny particles that cannot be seen (e.g., tiny particles of matter that cannot be seen make up bulk matter). b. The behavior of a collection of many tiny particles of matter and observable phenomena involving bulk matter (e.g., an expanding balloon, evaporating liquids, substances that dissolve in a solvent, effects of wind).
Connections
1) Students use the model to describe* how matter composed of tiny particles too small to be seen can account for observable phenomena (e.g., air inflating a basketball, ice melting into water).

**Unless otherwise specified, "descriptions" referenced in evidence statements could include but are not limited to written, oral, pictorial, and kinesthetic descriptions.*

5-PS3-1 Energy

Students who demonstrate understanding can:

5-PS3-1. Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun. [Clarification Statement: Examples of models could include diagrams, and flow charts.]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Use models to describe phenomena.	**PS3.D: Energy in Chemical Processes and Everyday Life** • The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). **LS1.C: Organization for Matter and Energy Flow in Organisms** • Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. (secondary)	**Energy and Matter** • Energy can be transferred in various ways and between objects.

Observable features of the student performance by the end of the grade:
Components of the model
1) Students use models to describe* a phenomenon that includes the idea that energy in animals' food was once energy from the sun. Students identify and describe* the components of the model that are relevant for describing* the phenomenon, including: i. Energy. ii. The sun. iii. Animals, including their bodily functions (e.g., body repair, growth, motion, body warmth maintenance). iv. Plants.
Relationships
1) Students identify and describe* the relevant relationships between components, including: i. The relationship between plants and the energy they get from sunlight to produce food. ii. The relationship between food and the energy and materials that animals require for bodily functions (e.g., body repair, growth, motion, body warmth maintenance). iii. The relationship between animals and the food they eat, which is either other animals or plants (or both), to obtain energy for bodily functions and materials for growth and repair.
Connections
1) Students use the models to describe* causal accounts of the relationships between energy from the sun and animals' needs for energy, including that: i. Since all food can eventually be traced back to plants, all of the energy that animals use for body repair, growth, motion, and body warmth maintenance is energy that once came from the sun. ii. Energy from the sun is transferred to animals through a chain of events that begins with plants producing food then being eaten by animals.

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5-ESS1-1 Earth's Place in the Universe

Students who demonstrate understanding can:

5-ESS1-1. Support an argument that the apparent brightness of the sun and stars is due to their relative distances from the Earth. [Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, stage).]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • Support an argument with evidence, data, or a model.	**ESS1.A: The Universe and its Stars** • The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth.	**Scale, Proportion, and Quantity** • Natural objects exist from the very small to the immensely large.

Observable features of the student performance by the end of the grade:
Supported claims
1) Students identify a given claim to be supported about a given phenomenon. The claim includes the idea that the apparent brightness of the sun and stars is due to their relative distances from Earth.
Identifying scientific evidence
1) Students describe* the evidence, data, and/or models that support the claim, including: i. The sun and other stars are natural bodies in the sky that give off their own light. ii. The apparent brightness of a variety of stars, including the sun. iii. A luminous object close to a person appears much brighter and larger than a similar object that is very far away from a person (e.g., nearby streetlights appear bigger and brighter than distant streetlights). iv. The relative distance of the sun and stars from Earth (e.g., although the sun and other stars are all far from the Earth, the stars are very much farther away; the sun is much closer to Earth than other stars).
Evaluating and critiquing evidence
1) Students evaluate the evidence to determine whether it is relevant to supporting the claim, and sufficient to describe* the relationship between apparent size and apparent brightness of the sun and other stars and their relative distances from Earth. 2) Students determine whether additional evidence is needed to support the claim.
Reasoning and synthesis
1) Students use reasoning to connect the relevant and appropriate evidence to the claim with argumentation. Students describe* a chain of reasoning that includes: i. Because stars are defined as natural bodies that give off their own light, the sun is a star. ii. The sun is many times larger than Earth but appears small because it is very far away. iii. Even though the sun is very far from Earth, it is much closer than other stars. iv. Because the sun is closer to Earth than any other star, it appears much larger and brighter than any other star in the sky. v. Because objects appear smaller and dimmer the farther they are from the viewer, other stars, although immensely large compared to the Earth, seem much smaller and dimmer because they are so far away. vi. Although stars are immensely large compared to Earth, they appear small and dim because they are so far away. vii. Similar stars vary in apparent brightness, indicating that they vary in distance from Earth.

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5-ESS1-2 Earth's Place in the Universe

Students who demonstrate understanding can:

5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [Assessment Boundary: Assessment does not include causes of seasons.]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. • Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.	**ESS1.B: Earth and the Solar System** • The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.	**Patterns** • Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.

Observable features of the student performance by the end of the grade:
Organizing data
1) Using graphical displays (e.g., bar graphs, pictographs), students organize data pertaining to daily and seasonal changes caused by the Earth's rotation and orbit around the sun. Students organize data that include: i. The length and direction of shadows observed several times during one day. ii. The duration of daylight throughout the year, as determined by sunrise and sunset times. iii. Presence or absence of selected stars and/or groups of stars that are visible in the night sky at different times of the year.
Identifying relationships
1) Students use the organized data to find and describe* relationships within the datasets, including: i. The apparent motion of the sun from east to west results in patterns of changes in length and direction of shadows throughout a day as Earth rotates on its axis. ii. The length of the day gradually changes throughout the year as Earth orbits the sun, with longer days in the summer and shorter days in the winter. iii. Some stars and/or groups of stars (i.e., constellations) can be seen in the sky all year, while others appear only at certain times of the year. 2) Students use the organized data to find and describe* relationships among the datasets, including: i. Similarities and differences in the timing of observable changes in shadows, daylight, and the appearance of stars show that events occur at different rates (e.g., Earth rotates on its axis once a day, while its orbit around the sun takes a full year).

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5-ESS3-1 Earth and Human Activity

Students who demonstrate understanding can:

5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluating the merit and accuracy of ideas and methods. • Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.	**ESS3.C: Human Impacts on Earth Systems** • Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.	**Systems and System Models** • A system can be described in terms of its components and their interactions. **Connections to Nature of Science** **Science Addresses Questions About the Natural and Material World.** • Science findings are limited to questions that can be answered with empirical evidence.

Observable features of the student performance by the end of the grade:
Obtaining information
1) Students obtain information from books and other reliable media about: i. How a given human activity (e.g., in agriculture, industry, everyday life) affects the Earth's resources and environments. ii. How a given community uses scientific ideas to protect a given natural resource and the environment in which the resource is found.
Evaluating information
1) Students combine information from two or more sources to provide and describe* evidence about: i. The positive and negative effects on the environment as a result of human activities. ii. How individual communities can use scientific ideas and a scientific understanding of interactions between components of environmental systems to protect a natural resource and the environment in which the resource is found.

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3-5-ETS1-1 Engineering Design

Students who demonstrate understanding can:

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. • Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.	**EST1.A: Defining and Delimiting Engineering Problems** • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.	**Influence of Science, Engineering, and Technology on Society and the Natural World** • People's needs and wants change over time, as do their demands for new and improved technologies.

Observable features of the student performance by the end of the grade:
Identifying the problem to be solved
2) Students use given scientific information and information about a situation or phenomenon to define a simple design problem that includes responding to a need or want. 3) The problem students define is one that can be solved with the development of a new or improved object, tool, process, or system. 4) Students describe* that people's needs and wants change over time.
Defining the boundaries of the system
2) Students define the limits within which the problem will be addressed, which includes addressing something people want and need at the current time.
Defining the criteria and constraints
1) Based on the situation people want to change, students specify criteria (required features) of a successful solution.

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3-5-ETS1-2 Engineering Design

Students who demonstrate understanding can:

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem,	**ETS1.B: Developing Possible Solutions** • Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. • At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.	**Influence of Science, Engineering, and Technology on Society and the Natural World** • Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

Observable features of the student performance by the end of the grade:
Using scientific knowledge to generate design solutions
1) Students use grade-appropriate information from research about a given problem, including the causes and effects of the problem and relevant scientific information. 2) Students generate at least two possible solutions to the problem based on scientific information and understanding of the problem. 3) Students specify how each design solution solves the problem. 4) Students share ideas and findings with others about design solutions to generate a variety of possible solutions. 5) Students describe* the necessary steps for designing a solution to a problem, including conducting research and communicating with others throughout the design process to improve the design [note: emphasis is on what is necessary for designing solutions, not on a step-wise process].
Describing* criteria and constraints, including quantification when appropriate
I. Students describe*: a. The given criteria (required features) and constraints (limits) for the solutions, including increasing benefits, decreasing risks/costs, and meeting societal demands as appropriate. b. How the criteria and constraints will be used to generate and test the design solutions.
Evaluating potential solutions
1) Students test each solution under a range of likely conditions and gather data to determine how well the solutions meet the criteria and constraints of the problem. 2) Students use the collected data to compare solutions based on how well each solution meets the criteria and constraints of the problem.

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3-5-ETS1-3 Engineering Design		
Students who demonstrate understanding can: **3-5-ETS1-3.** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.		
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.	**ETS1.B: Developing Possible Solutions** • Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. **ETS1.C: Optimizing the Design Solution** • Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.	None specified

Observable features of the student performance by the end of the grade:
Using scientific knowledge to generate design solutions
6) Students use grade-appropriate information from research about a given problem, including the causes and effects of the problem and relevant scientific information. 7) Students generate at least two possible solutions to the problem based on scientific information and understanding of the problem. 8) Students specify how each design solution solves the problem. 9) Students share ideas and findings with others about design solutions to generate a variety of possible solutions. 10) Students describe* the necessary steps for designing a solution to a problem, including conducting research and communicating with others throughout the design process to improve the design [note: emphasis is on what is necessary for designing solutions, not on a step-wise process].
Describing* criteria and constraints, including quantification when appropriate
II. Students describe*: a. The given criteria (required features) and constraints (limits) for the solutions, including increasing benefits, decreasing risks/costs, and meeting societal demands as appropriate. b. How the criteria and constraints will be used to generate and test the design solutions.
Evaluating potential solutions
3) Students test each solution under a range of likely conditions and gather data to determine how well the solutions meet the criteria and constraints of the problem. 4) Students use the collected data to compare solutions based on how well each solution meets the criteria and constraints of the problem.

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Next Generation Science Standards/NY State Science Learning Standards 3–5

Supported through **Supplemental Program** implementation

Performance Expectations

3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.

4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect Earth's resources and environment.

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Big Idea and Topic Bundle: How can we use the sun's energy to solve power our homes and lives? How can we use the sun's energy to solve new challenges and problems?

Science and Engineering Practices

Asking questions / defining problems; Planning and carrying out investigations; Analyzing and interpreting data
Investigations require all of the above.

Developing and using models; Constructing explanations/designing solutions
Activities in the Solar Sleuthing investigation have students developing a variety of models.

Obtaining, evaluating, and communicating information
Solar Solutions summative challenge has students obtaining, evaluating and communicating a variety of information.

Engaging in argument from evidence
Star Light, Star Bright investigation and required timeline activity have students creating arguments from evidence

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Connections to Nature of Science

Scientific investigations use a variety of methods; Scientific knowledge is based on empirical evidence
Entrepreneur story/presentation and hands on activities illustrate how scientific investigations are conducted and how that information is put to use.

Science models, laws, mechanisms, and theories explain natural phenomena
The activities give student firsthand experience at model solar energy systems and understanding how to get energy from the sun.

Disciplinary Core Ideas

ESS1.A The universe and its stars
ESS1.B Earth and the solar system
Investigations (Star Light, Star Bright; WATTs Cooking, and timeline activity) have students investigating the structure of outer space.

ESS2.A Earth materials and systems
ESS2.D Weather and climate
ESS3.A Natural resources
ESS3.C Human impacts on Earth systems
ESS3.D Global climate change
Focus on solar energy reinforce the interconnectedness between humans and all aspects of their environment.

PS1.A Structure of matter
Solar Sleuthing investigations have students exploring and modeling the structure of matter.

PS3.D Energy in chemical processes and everyday life
LS1.C Organization for matter and energy flow in organisms
Discussion of the transformation of energy from the sun to support plant, animal, and human life.

ETS1.A: Defining and Delimiting Engineering Problems
ETS1.B: Developing Possible Solutions
ETS1.C: Optimizing the Design Solution
WATTs cooking investigation and **Solar Solutions** challenge have students defining problems and designing & optimizing solutions

Crosscutting Concepts

Cause and effect
Investigations explore a variety of cause and effect relationships

Systems and system models
Activities in the Solar Sleuthing investigation have students developing a variety of models.

Patterns
Determination of appropriate cooking strategy in WATTs cooking have students investigating patterns in light, heat and shadows.

Scale, proportion and quantity
Discussion on relative size of the universe as the structure of matter have students thinking about scale and proportion.

Energy and matter: Flows, cycles, and conservation
The discussion on different types of solar energy and how the energy of the sun can be converted into many forms supports the discussion of energy flow and conversion.

Structure and function
WATTs cooking investigation and Solar Solutions challenge have students examining structure and function relationship.

Connections to Nature of Science

Science is a way of knowing; Science addresses questions about the natural and material world
Investigations link science to our understanding of the world around us.

Science is a human endeavor
Entrepreneur story and historical timeline highlight the human aspect of science and engineering.

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology; Influence of Engineering, Technology and Science on Society and the Natural World
Introduction text, historical timeline and entrepreneur story highlight above interactions and interdependencies.

Common Core ELA Standards

Grade 3

Reading Informational Text:

CCSS.ELA-LITERACY.RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.
CCSS.ELA-LITERACY.RI.3.2 Determine the main idea of a text; recount the key details and explain how they support the main idea.
CCSS.ELA-LITERACY.RI.3.4 Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a *grade 3 topic or subject area*.

Writing:

CCSS.ELA-Literacy.W.3.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
CCSS.ELA-Literacy.W.3.2.a Introduce a topic and group related information together; include illustrations when useful to aiding comprehension.
CCSS.ELA-Literacy.W.3.2.b Develop the topic with facts, definitions, and details.
CCSS.ELA-Literacy.W.3.2.c Use linking words and phrases (e.g., *also*, *another*, *and*, *more*, *but*) to connect ideas within categories of information.
CCSS.ELA-Literacy.W.3.2.d Provide a concluding statement or section.
CCSS.ELA-Literacy.W.3.1 Write opinion pieces on topics or texts, supporting a point of view with reasons.
CCSS.ELA-Literacy.W.3.1.a Introduce the topic or text they are writing about, state an opinion, and create an organizational structure that lists reasons.
CCSS.ELA-Literacy.W.3.1.b Provide reasons that support the opinion.
CCSS.ELA-Literacy.W.3.1.c Use linking words and phrases (e.g., *because*, *therefore*, *since*, *for example*) to connect opinion and reasons.
CCSS.ELA-Literacy.W.3.1.d Provide a concluding statement or section.
CCSS.ELA-Literacy.W.3.4 With guidance and support from adults, produce writing in which the development and organization are appropriate to task and purpose. (Grade-specific expectations for writing types are defined in standards 1-3 above.)
CCSS.ELA-Literacy.W.3.5 With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, and editing.
CCSS.ELA-Literacy.W.3.6 With guidance and support from adults, use technology to produce and publish writing (using keyboarding skills) as well as to interact and collaborate with others.
CCSS.ELA-Literacy.W.3.7 Conduct short research projects that build knowledge about a topic.
CCSS.ELA-Literacy.W.3.8 Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.

Speaking & Listening:

CCSS.ELA-LITERACY.SL.3.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 3 topics and texts*, building on others' ideas and expressing their own clearly.
CCSS.ELA-LITERACY.SL.3.1.A Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.
CCSS.ELA-LITERACY.SL.3.1.B Follow agreed-upon rules for discussions (e.g., gaining the floor in respectful ways, listening to others with care, speaking one at a time about the topics and texts under discussion).
CCSS.ELA-Literacy.SL.3.1.c Ask questions to check understanding of information presented, stay on topic, and link their comments to the remarks of others.
CCSS.ELA-Literacy.SL.3.1.d Explain their own ideas and understanding in light of the discussion.
CCSS.ELA-Literacy.SL.3.3 Ask and answer questions about information from a speaker, offering appropriate elaboration and detail.
CCSS.ELA-Literacy.SL.3.4 Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.
CCSS.ELA-Literacy.SL.3.6 Speak in complete sentences when appropriate to task and situation in order to provide requested detail or clarification.

Language:

CCSS.ELA-LITERACY.L.3.1 Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
CCSS.ELA-LITERACY.L.3.1.A Explain the function of nouns, pronouns, verbs, adjectives, and adverbs in general and their functions in particular sentences.
CCSS.ELA-LITERACY.L.3.2 Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
CCSS.ELA-LITERACY.L.3.4 Determine or clarify the meaning of unknown and multiple-meaning word and phrases based on grade 3 reading and content, choosing flexibly from a range of strategies.

Grade 4

Reading Informational Text:

CCSS.ELA-LITERACY.RI.4.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.
CCSS.ELA-LITERACY.RI.4.2 Determine the main idea of a text and explain how it is supported by key details; summarize the text.
CCSS.ELA-LITERACY.RI.4.4 Determine the meaning of general academic and domain-specific words or phrases in a text relevant to a *grade 4 topic or subject area*.
CCSS.ELA-LITERACY.RI.4.5 Describe the overall structure (e.g., chronology, comparison, cause/effect, problem/solution) of events, ideas, concepts, or information in a text or part of a text.
CCSS.ELA-LITERACY.RI.4.7 Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.

Writing:

CCSS.ELA-LITERACY.W.4.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information.
CCSS.ELA-LITERACY.W.4.1.A Introduce a topic or text clearly, state an opinion, and create an organizational structure in which related ideas are grouped to support the writer's purpose.
CCSS.ELA-LITERACY.W.4.1.B Provide reasons that are supported by facts and details.
CCSS.ELA-LITERACY.W.4.1.C Link opinion and reasons using words and phrases
CCSS.ELA-LITERACY.W.4.1.D Provide a concluding statement or section related to the opinion presented.
CCSS.ELA-LITERACY.W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
CCSS.ELA-LITERACY.W.4.2.A Introduce a topic clearly and group related information in paragraphs and sections; include formatting (e.g., headings), illustrations, and multimedia when useful to aiding comprehension.
CCSS.ELA-LITERACY.W.4.2.B Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic.
CCSS.ELA-LITERACY.W.4.2.C Link ideas within categories of information using words and phrases.
CCSS.ELA-LITERACY.W.4.2.D Use precise language and domain-specific vocabulary to inform about or explain the topic.
CCSS.ELA-LITERACY.W.4.2.E Provide a concluding statement or section related to the information or explanation presented.
CCSS.ELA-LITERACY.W.4.4 Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.
CCSS.ELA-LITERACY.W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

Speaking & Listening:

CCSS.ELA-LITERACY.SL.4.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 4 topics and texts*, building on others' ideas and expressing their own clearly.
CCSS.ELA-LITERACY.SL.4.1.A Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.
CCSS.ELA-LITERACY.SL.4.1.B Follow agreed-upon rules for discussions and carry out assigned roles.
CCSS.ELA-LITERACY.SL.4.1.C Pose and respond to specific questions to clarify or follow up on information, and make comments that contribute to the discussion and link to the remarks of others.
CCSS.ELA-LITERACY.SL.4.1.D Review the key ideas expressed and explain their own ideas and understanding in light of the discussion.
CCSS.ELA-LITERACY.SL.4.3 Identify the reasons and evidence a speaker provides to support particular points.

Language:

CCSS.ELA-LITERACY.L.4.1 Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
CCSS.ELA-LITERACY.L.4.1.A Use relative pronouns (*who, whose, whom, which, that*) and relative adverbs (*where, when, why*).
CCSS.ELA-LITERACY.L.4.2 Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
CCSS.ELA-LITERACY.L.4.3 Use knowledge of language and its conventions when writing, speaking, reading, or listening.
CCSS.ELA-LITERACY.L.4.3.A Choose words and phrases to convey ideas precisely.
CCSS.ELA-LITERACY.L.4.4 Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 4 reading and content, choosing flexibly from a range of strategies.

Grade 5

Reading Informational Text:

CCSS.ELA-LITERACY.RI.5.2 Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text.
CCSS.ELA-LITERACY.RI.5.3 Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text.
CCSS.ELA-LITERACY.RI.5.4 Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a *grade 5 topic or subject area*.

Writing:

CCSS.ELA-LITERACY.W.5.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information.
CCSS.ELA-LITERACY.W.5.1.A Introduce a topic or text clearly, state an opinion, and create an organizational structure in which ideas are logically grouped to support the writer's purpose.
CCSS.ELA-LITERACY.W.5.1.B Provide logically ordered reasons that are supported by facts and details.
CCSS.ELA-LITERACY.W.5.1.C Link opinion and reasons using words, phrases, and clauses
CCSS.ELA-LITERACY.W.5.1.D Provide a concluding statement or section related to the opinion presented.
CCSS.ELA-LITERACY.W.5.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
CCSS.ELA-LITERACY.W.5.2.A Introduce a topic clearly, provide a general observation and focus, and group related information logically; include formatting (e.g., headings), illustrations, and multimedia when useful to aiding comprehension.
CCSS.ELA-LITERACY.W.5.2.B Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic.
CCSS.ELA-LITERACY.W.5.2.C Link ideas within and across categories of information using words, phrases, and clauses (e.g., *in contrast*, *especially*).
CCSS.ELA-LITERACY.W.5.2.D Use precise language and domain-specific vocabulary to inform about or explain the topic.
CCSS.ELA-LITERACY.W.5.2.E Provide a concluding statement or section related to the information or explanation presented.
CCSS.ELA-LITERACY.W.5.4 Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.
CCSS.ELA-LITERACY.W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

Speaking & Listening:

CCSS.ELA-LITERACY.SL.5.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 5 topics and texts*, building on others' ideas and expressing their own clearly.
CCSS.ELA-LITERACY.SL.5.1.A Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.
CCSS.ELA-LITERACY.SL.5.1.B Follow agreed-upon rules for discussions and carry out assigned roles.
CCSS.ELA-LITERACY.SL.5.1.C Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others.
CCSS.ELA-LITERACY.SL.5.1.D Review the key ideas expressed and draw conclusions in light of information and knowledge gained from the discussions.
CCSS.ELA-LITERACY.SL.5.3 Summarize the points a speaker makes and explain how each claim is supported by reasons and evidence.

Language:

CCSS.ELA-LITERACY.L.5.1 Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
CCSS.ELA-LITERACY.L.5.1.A Explain the function of conjunctions, prepositions, and interjections in general and their function in particular sentences.
CCSS.ELA-LITERACY.L.5.2 Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
CCSS.ELA-LITERACY.L.5.3 Use knowledge of language and its conventions when writing, speaking, reading, or listening.
CCSS.ELA-LITERACY.L.5.4 Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 5 reading and content, choosing flexibly from a range of strategies.

Common Core Math Standards

Grade 3

MP.1 Make sense of problems and persevere in solving them.

MP.2 Reason abstractly and quantitatively.

3.OA.1-3 Represent and solve problems involving multiplication and division.

3.OA.7 Multiply and divide within 100.

3.NBT.3 Use place value understanding and properties of operations to perform multi-digit arithmetic.

3.MD.5-7 Geometric measurement: understand concepts of area and relate area to multiplication and to addition.

Grade 4

MP.1 Make sense of problems and persevere in solving them.

MP.2 Reason abstractly and quantitatively.

4.OA.1-3 Use the four operations with whole numbers to solve problems.

4.MD.2 Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.

Grade 5

MP.1 Make sense of problems and persevere in solving them.

MP.2 Reason abstractly and quantitatively.

5.MD.1 Convert like measurement units within a given measurement system

Additional Resources

***Note:** All links were confirmed as working at the time this Educator Guide was created. If you find a link that doesn't work, let us know so we may find a suitable—and working—link.*

Renewable Energy/Energy: General

Videos

http://www.neok12.com/Energy-Sources.htm Energy sources videos for kids but geared a bit higher. However, can be used to challenge students who need challenges. Includes interactive games and worksheets to supplement presentation.

Articles/Websites

https://waste-management-world.com/a/bacteria-that-turn-waste-to-energy-in-microbial-fuel-cells-studied, https://www.newscientist.com/article/mg23130840-100-bacteria-made-to-turn-sewage-into-clean-water-and-electricity/ A few short articles on how waste is turned into electricity using microbial fuel cells.
http://www.kidwind.org/ A great website with various challenges, activities, and kits for wind-related projects.
http://www.alliantenergykids.com/energyandtheenvironment/renewableenergy/022397 A website with kid-friendly explanations about wind energy.
http://www.eia.gov/kids/energy.cfm?page=wind_home-basics A good explanation of various types of windmills and wind turbines.

Solar Energy: Specific

Videos

http://video.nationalgeographic.com/video/solar-power Excellent solar energy video (2:36 min with a 17-sec ad at the beginning).
http://www.neok12.com/Solar-Energy.htm Multiple videos (short) on solar energy for kids. Most geared toward grades 4–12; however, most are appropriate for grade 3.
http://video.pbs.org/video/2289310391/ PBS video (3:00 min) on solar energy (photovoltaic cells, concentrators, why we can't use only this form of energy).
http://science360.gov/obj/video/83d67b75-f6f5-43e6-bbef-8c8b9d9584c1/solar-panels-work Video (3:56 min) from the Boston Museum of Science.

Solar Ovens

https://www.saveonenergy.com/learning-center/post/solar-ovens/ Blog post on how solar ovens work.
https://www.homesciencetools.com/article/how-to-build-a-solar-oven-project/ Website on how to build a solar oven.
https://www.loc.gov/rr/scitech/SciRefGuides/solarovens.html Various online resources about solar ovens.

Additional Books

Counting on Katherine: How Katherine Johnson Saved Apollo 13 by Helaine Becker
Sun by Steve Tomecek
National Geographic: *Space Encyclopedia: A Tour of Our Solar System* by David A. Aguilar
Rigby InfoQuest: *Our Place in Space*
Delta Science Readers™: *Solar System*

Applications/Company Information

Articles Related to GRID Alternatives:

- Blog: Environmental and Social Justice Summit

Blog: What Solar Savings Can Buy
Article: "GRID Alternatives Awarded $4.4 Million to Develop First Low-Income Community Solar Pilot Projects in California"
Article: "GRID Alternatives Gets Renewed Funding for SolarCorps Fellowship Program"

We Care Solar Videos:

https://www.youtube.com/watch?v=3h_Quso1QyM (7:06 min) Laura talks about what compelled her to create the Solar Suitcase. Note: This video contains the mature topic of maternal death during childbirth. While this is a valuable and worthwhile topic to discuss, it may not be something your students are equipped to discuss. Please use your judgment before showing this video to your class.

http://www.cnn.com/videos/bestoftv/2013/12/18/cnnheroes-show-stachel.cnn (5:50 min) Presentation of the CNN Hero award. The first four minutes describe We Care Solar. The final ~ two minutes are Laura's acceptance speech.

https://www.youtube.com/watch?v=6p29fXco6oY (7:58 min) Laura talks about what compelled her to create the Solar Suitcase. Note: This video contains the mature topic of maternal death during childbirth. While this is a valuable and worthwhile topic to discuss, it may not be something your students are equipped to discuss. Please use your judgment before showing this video to your class.

Additional links to companies using solar energy

SolarMill: https://www.solarmill.com/
New Sun Road: http://newsunroad.com/#home
PV Pure: http://www.pvpure.com/

Appendix

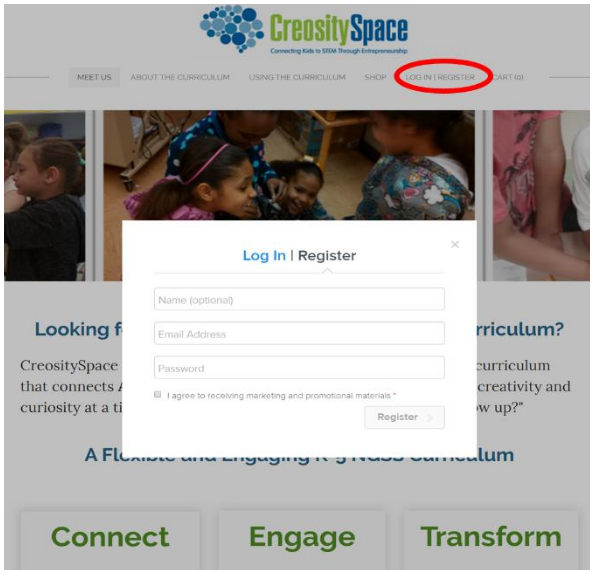
Contents:

Electronic copies of all notebooks, cards, and worksheets can be found on the unit website.

Accessing Online Content

To access your digital content, you must register with our website (www.creosityspace.com). To register with the website just select the Log In/Register tab on the homepage. A registration window will pop up, and you can register from there (see below). You may have already received a link to sign up; if so, you can skip this step.

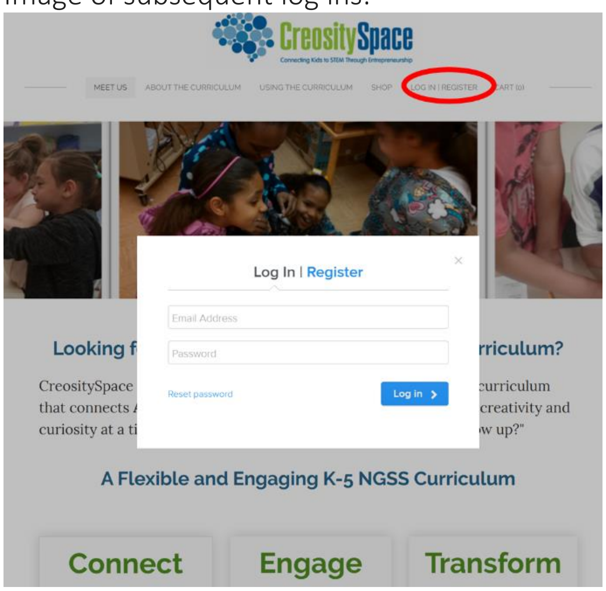
Image of initial registration:



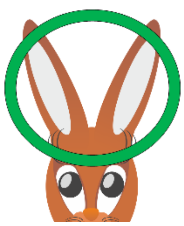
Note: In compliance with the European Union's (EU) General Data Protection Regulation (GDPR), registration with CreositySpace requires agreement to receive the occasional support and promotional materials. ***CreositySpace does not share member personal information or data****. CreositySpace uses member email information to provide content, updates, and support. If you have any questions or concerns, please contact us directly.*

For future sign-ins you will do the same thing (select the Log In/Register tab), but you will have to click Log In so you don't accidentally register again (see below).

Image of subsequent log ins:



Please contact us if you have any challenges signing up or accessing the page once you have signed up by emailing Kath@CreositySpace.com.

Science Safety and Behavior Contract	
I know the class emergency plan • If anything happens, the first thing you need to do is tell the teacher. • If something dangerous happens, we will walk outside into the hall to make sure everyone is safe.	**I will follow directions** • Make sure that you know what to do before you do it. Ask any questions BEFORE you begin. 
I will wear goggles if I am told to 	**I will tell the teacher if I have an accident or injury** • Even if it seems small, please let the teacher know if an accident or injury happens.
I will listen carefully  I understand I will be removed from the science activity area by the teacher if **I am preventing others from learning.**	**I will not touch any materials unless I have been given permission** 
I will wash my hands after science activities 	**I will not eat, taste, drink, or inhale anything we use in science** 

I have read the attached safety rules and have been present when they were discussed in class.

Student's Name ____ Date ___________________________

I have read and discussed the laboratory safety rules with my child.

Parent signature ____ Date ___________________________

This student has allergies/sensitivities to:

____

Topic Introduction Tools

Phenomenon, Big Ideas, and Topic Bundle

How can you use solar energy, or the sun in general, to solve a challenge in your life?

- How can we use the sun's energy to solve new challenges and problems?
- Given Earth's limited resources, how can we use technology to accomplish more with renewable sources of energy?

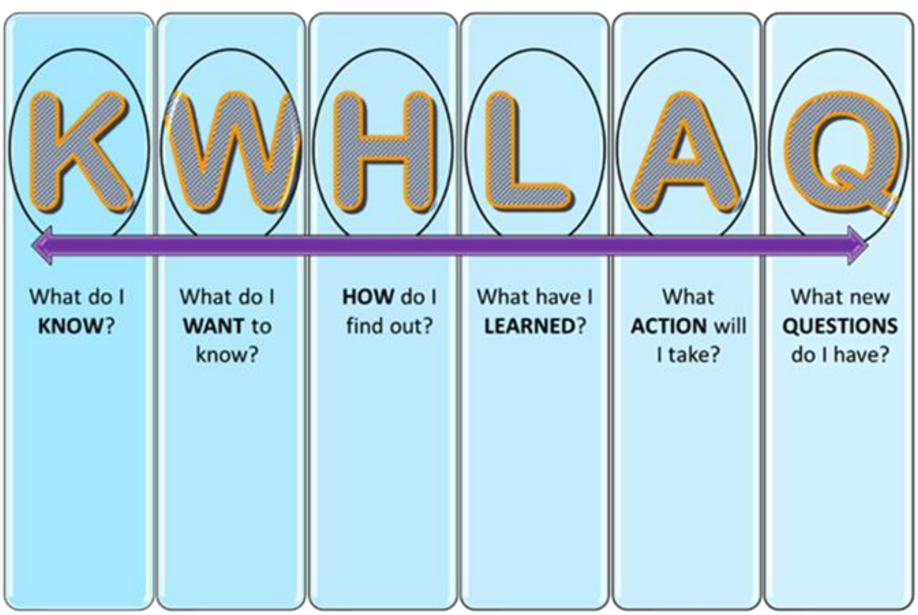
In this unit students learn about all the ways the sun provides us with energy and information. They then use that knowledge to determine solutions to a variety of challenges

KWHLAQ Tools

KWHLAQ charts (know, want, how, learned, action, questions) are a great way to get students thinking about a topic area. Depending on your students you may choose to complete the chart as a class with you leading the discussion or have the students work together in small groups.

A couple possible starting prompts are:

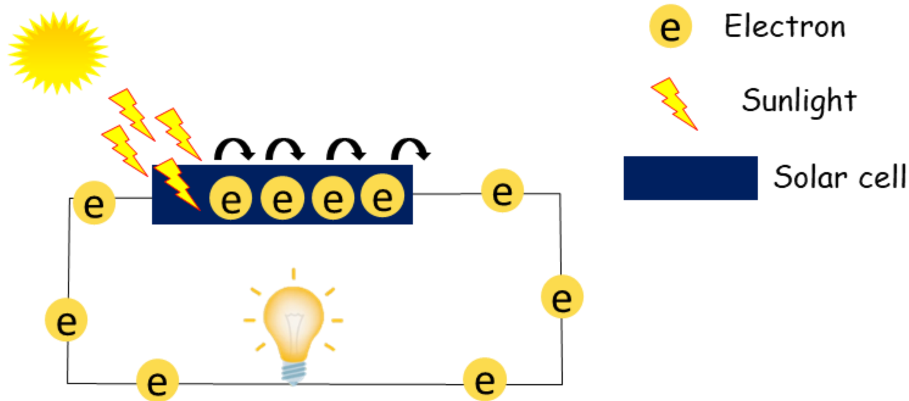
- How does the sun help us every day?
- What are different sources of energy?
- What do I wonder about renewable energy?



A couple possible themes for PICs are:

- Develop a model to explain different ways the sun's energy is used by plants, animals, and people.
- Develop a model to show how the sun's energy is turned into electricity.

(Note: A PIC is a great way to create a model of a concept that students can use as a reference throughout the unit.)

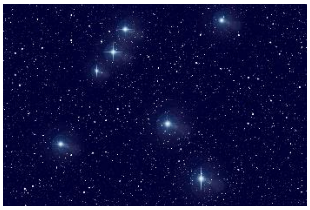


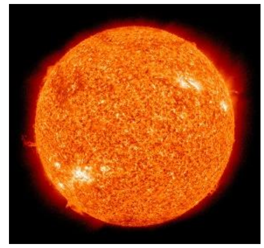
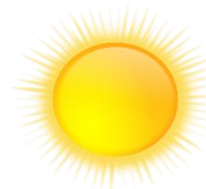
Introductory Videos

- http://video.nationalgeographic.com/video/alternative-energy (2:48 min) A short introduction to renewable energy (focus on solar energy, biofuels, and wind) by National Geographic.
- http://energy.gov/eere/videos/energy-101-solar-pv (2:00 min) A general introduction to solar electric energy.
- https://www.youtube.com/watch?v=x4CTceusK9I (2:04 min) The first 1:25 min of this is a good general introduction to solar energy with a focus on solar electric energy. The last 40 sec is a plug for BEP, so you might want to stop it before that.

What Do You See? What Do You Know? What Do You Want to Know?

Here are some sample pictures you would use for a What do you see? What do you know? What do you want to know? exercise with the *Sun Catchers* unit.









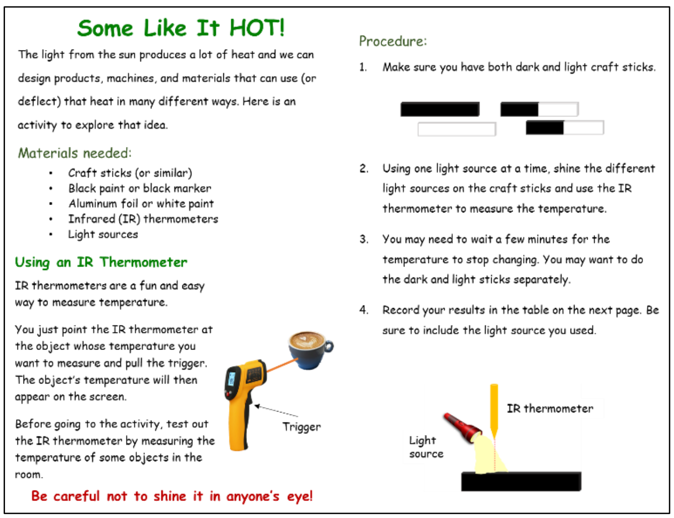


Introductory Investigation

Teacher Guidance

Prior knowledge expectations

It is assumed that students will have some general understanding of the ability of the sun and other light sources to heat up surfaces from K-PS3-1,2 and also some general understand of meauring and quantifying temperature from 2-PS1-4 and 3-ESS2-1. If not, this investigation can proceed as describe but may take additional time or require additional group discussion and reflection.



Some Like It HOT!

The light from the sun produces a lot of heat and we can design products, machines, and materials that can use (or deflect) that heat in many different ways. Here is an activity to explore that idea.

Materials needed:
- Craft sticks (or similar)
- Black paint or black marker
- Aluminum foil or white paint
- Infrared (IR) thermometers
- Light sources

Using an IR Thermometer

IR thermometers are a fun and easy way to measure temperature.

You just point the IR thermometer at the object whose temperature you want to measure and pull the trigger. The object's temperature will then appear on the screen.

Trigger

Before going to the activity, test out the IR thermometer by measuring the temperature of some objects in the room.

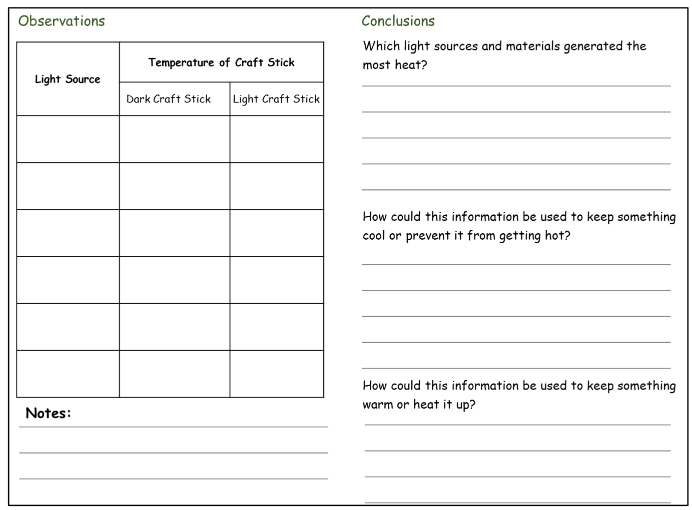
Be careful not to shine it in anyone's eye!

Procedure:

1. Make sure you have both dark and light craft sticks.
2. Using one light source at a time, shine the different light sources on the craft sticks and use the IR thermometer to measure the temperature.
3. You may need to wait a few minutes for the temperature to stop changing. You may want to do the dark and light sticks separately.
4. Record your results in the table on the next page. Be sure to include the light source you used.

IR thermometer

Light source



Observations

Light Source	Temperature of Craft Stick	
	Dark Craft Stick	Light Craft Stick

Notes:

Conclusions

Which light sources and materials generated the most heat?

How could this information be used to keep something cool or prevent it from getting hot?

How could this information be used to keep something warm or heat it up?

Expected range of student responses

Data collection – Student data collection should show that the darker objects become warmer than the lighter objects. If this is not the case it could be that students aren't using the IR thermometer correctly, they aren't waiting long enough for the darker material to heat up or they are using too hot or too cool of a light source – which could make the difference between dark and light harder to measure.

Conclusions – Student responses may vary but some guidance is provided below:

- Light sources that are LED based or lower wattage typically generate less heat. Lighter colors should be cooler than darker colors when exposed to the same conditions.
- Based on this information we should wear light clothes or use LED lights or low light levels if we want things to stay cool.
- Based on this information we should wear dark clothes or use incandescent light bulbs or high light levels if we want to heat things up.

Some Like It HOT!

The light from the sun produces a lot of heat and we can design products, machines, and materials that can use (or deflect) that heat in many different ways. Here is an activity to explore that idea.

Materials needed:

- Craft sticks (or similar)
- Black paint or black marker
- Aluminum foil or white paint
- Infrared (IR) thermometers
- Light sources

Using an IR Thermometer

IR thermometers are a fun and easy way to measure temperature.

You just point the IR thermometer at the object whose temperature you want to measure and pull the trigger. The object's temperature will then appear on the screen.

Before going to the activity, test out the IR thermometer by measuring the temperature of some objects in the room.

Be careful not to shine it in anyone's eye!

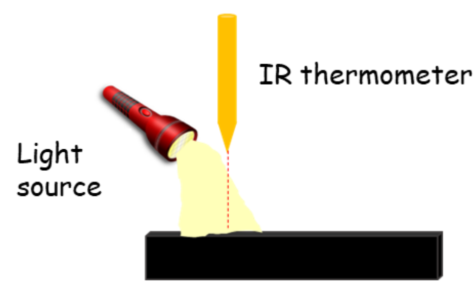
Procedure:

1. Make sure you have both dark and light craft sticks.

2. Using one light source at a time, shine the different light sources on the craft sticks and use the IR thermometer to measure the temperature.

3. You may need to wait a few minutes for the temperature to stop changing. You may want to do the dark and light sticks separately.

4. Record your results in the table on the next page. Be sure to include the light source you used.



Observations

Light Source	Temperature of Craft Stick	
	Dark Craft Stick	Light Craft Stick

Notes:

Conclusions

Which light sources and materials generated the most heat?

How could this information be used to keep something cool or prevent it from getting hot?

How could this information be used to keep something warm or heat it up?

Technology Historical Timeline

The Technology Historical Timeline is a great tool to use to give your students historical context for what they are learning and to show them how any single scientific discovery or understanding is built from all the discoveries and understandings that came before. In many cases, scientific discoveries only thrived if there was a community need they helped to solve.

The following worksheets contain a couple versions of the timeline you can use with your class:

- The completed timeline is one we think links critical events in the history of solar energy. As an activity you could have your students pick their top three events on the timeline and then justify why they thought they were the most important.

- You could have your students pick one event on the timeline (e.g., setting up your house to make best use of the sun for heating) and create another timeline that includes that invention. Some examples could be:

  - How our understanding of the Earth, sun, and stars has resulted in discoveries that have impacted all of society ***(Note: This is a required activity for folks using this unit as a primary NGSS/NYSSLS curriculum.)***
  - How people have constructed houses throughout the ages
  - Our understanding of the sun and its role in the universe

- You could take the blank timeline and have the students pick a different technology from which to create their own timeline.

- You could take the dateless descriptions and have the students try to put them in chronological order. Ask them to justify their order.

- Most online technology historical timelines have a paragraph associated with each event. As a class you could pick a different technology historical timeline (these can be found online by googling “X historical timeline”) and have the students use the blank timeline to summarize and write down critical events.

6000 BCE

Magnifying glass is used to concentrate the sun's rays and burn small things.

~20 CE

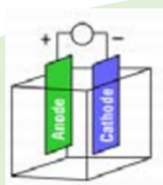
The Chinese document use of "burning mirrors" to light torches for religious purposes.

1200 CE

Ancestral Puebloans, who lived in the region where Arizona, New Mexico, Colorado, and Utah intersect, construct south-facing cliff dwellings that capture the heat of the winter sun.

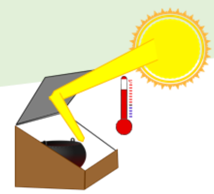
1839 CE

French scientist Edmond Becquerel discovers that, with the help of certain materials, the sun's light can be turned into electricity.



1760 CE

Swiss scientist Horace de Saussure is credited with building the world's first solar oven.



~1950 CE

Scientist Maria Telkes and architect Eleanor Raymond work together to build the first house heated entirely by solar energy.

The Dover Sun House

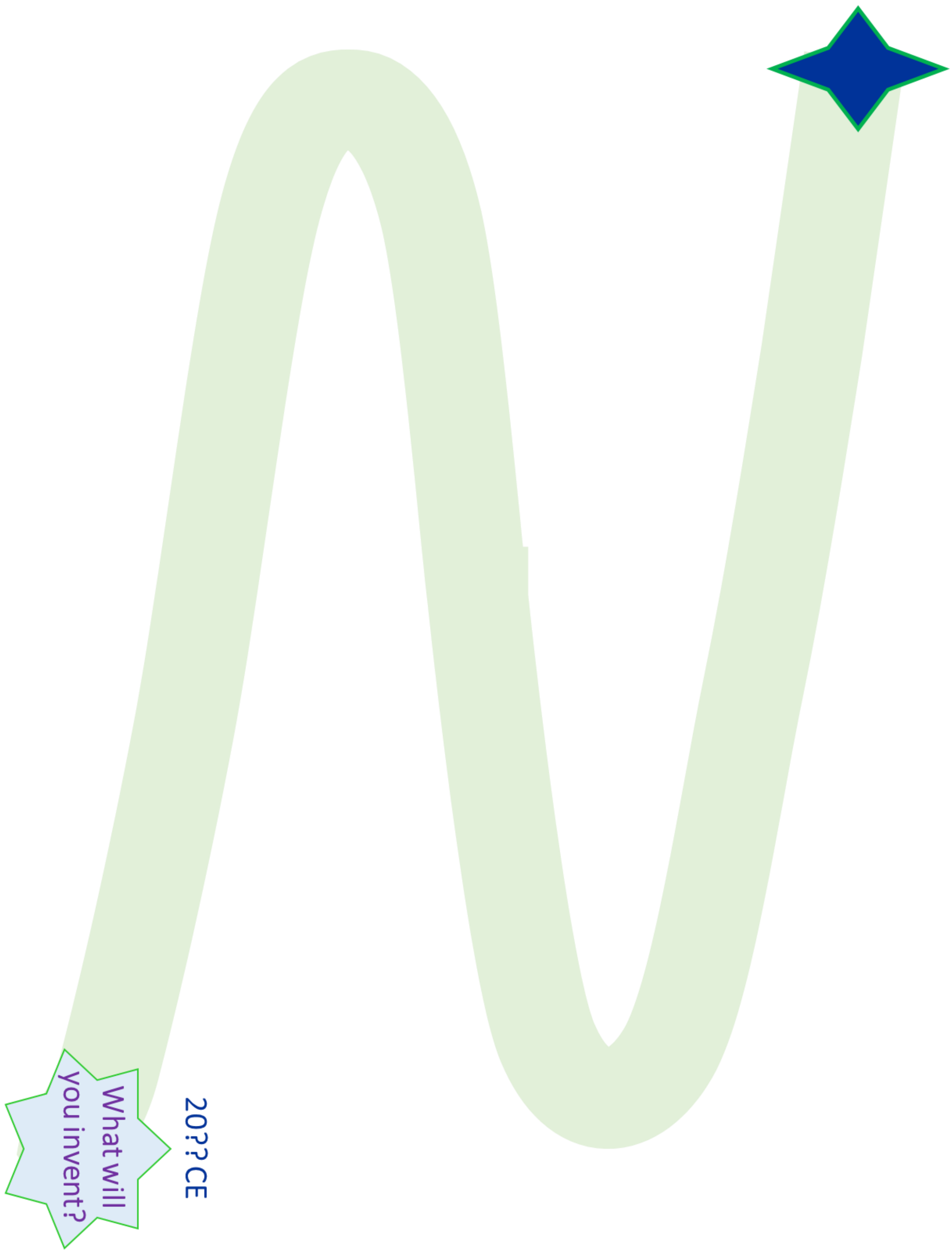
1982 CE

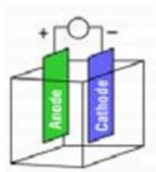
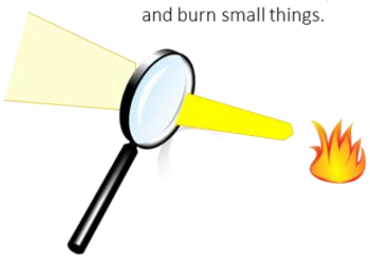
Australian Hans Tholstrup drives the first solar-powered car almost 2,800 miles between Sydney and Perth, Australia. That is the same distance as between New York City and Los Angeles!

The Quiet Achiever

20?? CE

What will you invent?


What will you invent?
20?? CE

French scientist Edmond Becquerel discovers that, with the help of certain materials, the sun's light can be turned into electricity.  	Ancestral Puebloans, who lived in the region where Arizona, New Mexico, Colorado, and Utah intersect, construct south-facing cliff dwellings that capture the heat of the winter sun. 	Scientist Maria Telkes and architect Eleanor Raymond work together to build the first house heated entirely by solar energy. 
Swiss scientist Horace de Saussure is credited with building the world's first solar oven. 		Australian Hans Tholstrup drives the first solar-powered car almost 2,800 miles between Sydney and Perth, Australia. That is the same distance as between New York City and Los Angeles!  **The Quiet Achiever**
Magnifying glass is used to concentrate the sun's rays and burn small things. 		The Chinese document use of "burning mirrors" to light torches for religious purposes. 

Put the historical events in the order you think they belong and justify your order.

Exit Ticket Support

Exit tickets are a great method for quick formative assessments. In some cases, they can also be used a quick pre-assessment or a conversation starter.

As a formative assessment strategy, students should hand you their completed exit tickets as they are transitioning to another activity (e.g., lunch, recess, gym, etc.). Exit tickets can be completed on index cards, half-sheets of paper, etc. and should only take about five minutes for students to complete. Exit tickets help you assess if students have understood the main concepts from the preceding lessons. If not, you may choose to have a additional discussion or to repeat portions of the lesson so that students have additional time to explore and practice key concepts.

The list below contains the *Exit Tickets* for this unit and some guidance on the type and range of student answers you should expect.

1. **Name and describe three ways we can get energy directly from Earth.**

There are a variety of acceptable responses, but it is assumed students will choose answers from the introduction. Typical responses include:

Solar power – Energy from the sun can heat things up directly or can be turned into electrical via solar panels.

Wind power – The wind pushes a blade or fan and the energy of motion is turned into electrical energy.

Geothermal – Heat from inside Earth is used to provide heat energy to different systems.

Tidal – The energy from the motion of the tides is captured and converted into electrical energy.

2. **Why do you think it important to use renewable sources of energy?**

Student responses may vary but are expected to touch on either protecting the environment or providing equal access to resources. It is possible students will take the position that they **DO NOT** think it is important to use renewable sources of energy. Since this question asks their opinion, that is an acceptable response but they should present evidence that they have considered the environmental and equity implications of their position.

3. **Name and describe two ways we can get energy from the sun.**

The expectation is that students will describe passive solar (a.k.a. direct heating) and active solar (e.g., using solar panels) methods.

4. **In your own words describe the difference between active and passive solar energy.**

Student responses may vary but the key differences can be described as follows: **passive solar** energy uses the **heat** of the sun **directly,** while an **active solar** system uses the sun's radiation (the sun's rays) to generate **electricity** via solar panels or uses some mechanical energy to transfer the heat of the sun to a different location.

5. **Why do you think there are more solar cells in Florida and Arizona than in New York or Washington State?**

Answer: There is, on average, more sunlight in Florida and Arizona than in New York or Washington State.

6. **Which months of the year might it be better for solar energy in Washington and why?**

Answer: The summer months—May, June, July and August—would be better for solar energy in Washington because there is more sunlight (days are longer and there is less rain).

7. **Describe two things you found interesting about stars and/or outer space and why those were interesting to you.**

Student responses may vary.

8. **Why is it important to use renewable sources of energy? *(Teacher note: It might be interesting to compare answers with those from week 1.)***

See entry above for expected range of responses.

9. **Describe three ways the sun helps your community?**

Student responses may vary. Some expected responses include:

- Solar electric energy
- Green houses
- Provides energy to plants
- Provides light during the day
- Warms up Earth

Follow the Energy Worksheets

A blank sheet is provided at the end if you would like to use your own final condition.

Prior knowledge expectations

It is assumed that students will have some general understanding of how the energy of the sun is transformed into different energy sources we use every day from K-PS3-1, 2-LS2-1, 4PS3-2 and 4ESS3-1.

If students are struggling to make connections one or more of the Follow the Energy scenarios can be completed as a class or in small groups. Either way, students should all record their final justification.

Sun

Hot Water for
Outdoor Shower

Determine and explain the transformations of the sun's energy needed to provide energy to the final product or organism.

____

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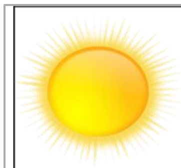
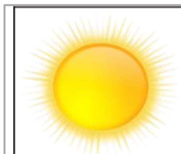
Solution:
Sun→ Dark bag of water→ Hot water for outdoor shower



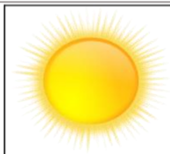
Determine and explain the transformations of the sun's energy needed to provide energy to the final product or organism.

Solution: There are many options. A few are outlined below.
Sun→ Grass → Rabbit → Wolf; Sun→ Tree → Nuts → Squirrel → Wolf



Determine and explain the transformations of the sun's energy needed to provide energy to the final product or organism.

Solution: There are many options. A few are outlined below.
Sun→ Kelp → Fish → Shark; Sun→ Kelp → Fish → Seal → Shark;

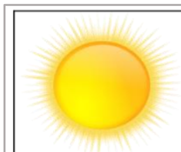


Sun

Electric Car

Determine and explain the transformations of the sun's energy needed to provide energy to the final product or organism.

Solution: There are many options. A few are outlined below.
Sun→ Solar Panel → Charging Station → Electric Car; Sun→ Solar Powered Charging Station→ Car;

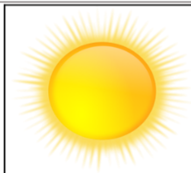


Sun

Gas-Powered Car

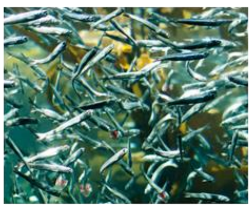
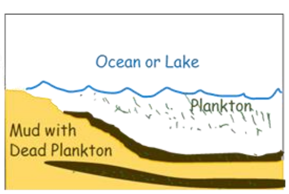
Determine and explain the transformations of the sun's energy needed to provide energy to the final product or organism.

Solution:
Sun→ Kelp/Seaweed → Buried Mud Layers → Fossil Fuel → Gas Powered Car



Sun

Determine and explain the transformations of the sun's energy needed to provide energy to the final product or organism.

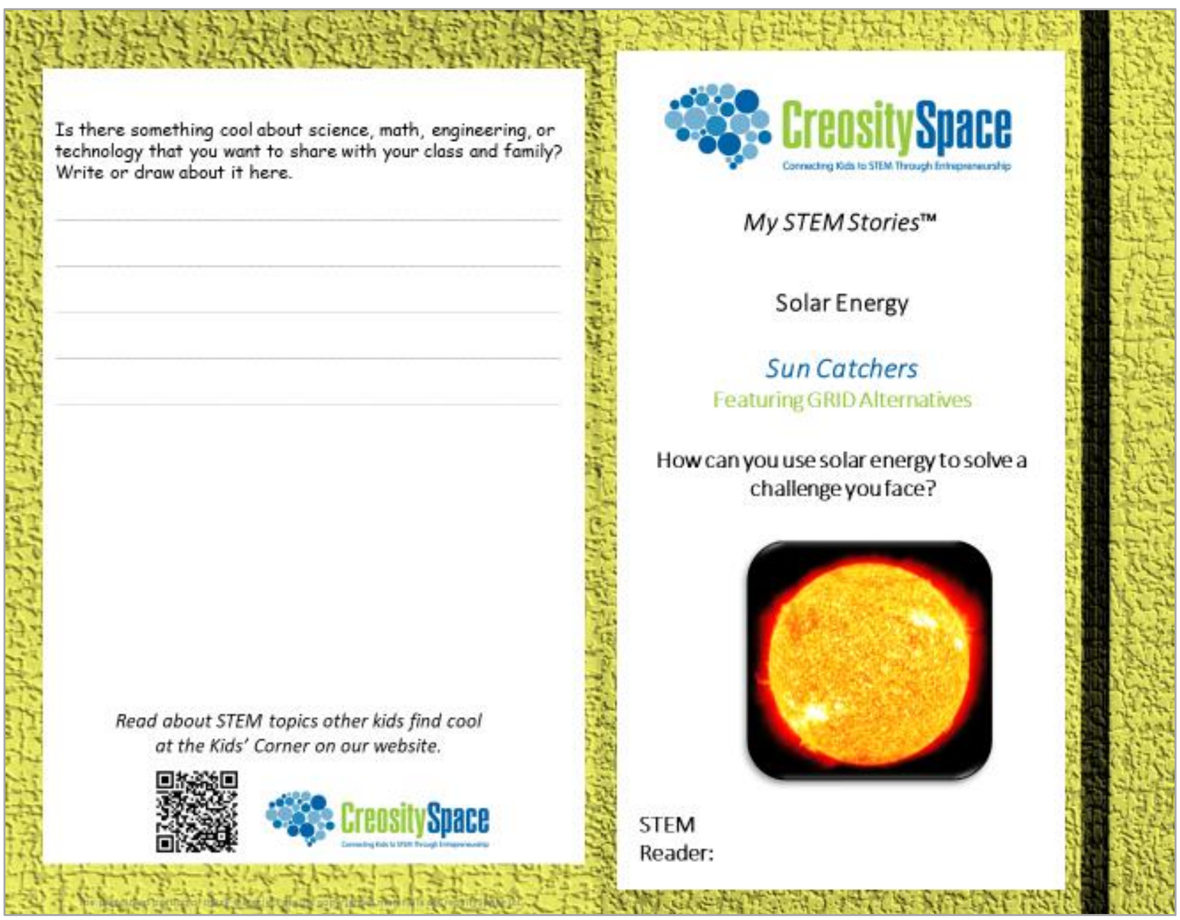
 Charging Station	 Fish	 Rabbit	 Fern
 Raccoon	 Fossil Fuel/Oil	 Shrimp	 Nuts
 Sardines	 Kelp/Seaweed	 Squirrel	 Solar Panel
 Algae	 Grass	 Tree	 Deer
 Seal	 Berries	 Solar Power Station	 Moss
 Dandelions	 Buried Mud Layers	 Seeds	 Dark Bag of Water

My STEM Stories™ Notebook

The next few pages contain copies of the *My STEM Stories*™ notebook. **Where appropriate guidance on the range of acceptable work is given below the relevant notebook pages.**

Please refer to the online content webpage for:

- Versions of this notebook that can be printed single sided. *Note: The single sided version is formatted so that each page is presented as an 8.5 x 11 spread—similar to the layout in the following pages.*
- Version of this notebook that can be printed double sided.
- Digital files with text descriptions of the pictures.
- Digital files that can be easily incorporated into online learning platforms such as Google Classroom, Canvas or other LMS..



Vocabulary

Term	Definition	A Picture or Simplified Definition
Solar Radiation	Solar radiation is energy given off by the sun.	
Passive Solar Energy	Passive solar energy involves using the sun's energy without any changes to it or the use of mechanical devices.	
Active Solar Energy	Active solar energy involves using the sun's energy by changing it with a second process or machine.	
Solar Thermal Energy	Solar thermal energy involves specifically using the sun's heat to warm things up.	
Solar Electric Energy	Solar electric energy (also known as solar photovoltaic) is turning sunlight into electrical energy.	
Circuit	A circuit is a path or route for electrons/electricity that will start and return to the same place.	
Watt	A watt is a unit of power—the amount of energy that is transferred in a second.	

2 3

Renewable Energy

Increasing pressure to seek alternative energy sources has generated new business opportunities and scientific study. Scientists, engineers, and entrepreneurs alike are interested in how to sustainably harvest our renewable resources—sun, wind, geothermal, tides, rivers, etc.

Solar power involves harnessing energy from the sun's light. This can be done in two ways: either as passive solar thermal or as active solar power. Passive solar thermal uses the heat from the sun's light to increase the temperature of a place or object. Active solar power uses the sun's light or heat in one place to deliver electricity or heat to another place.

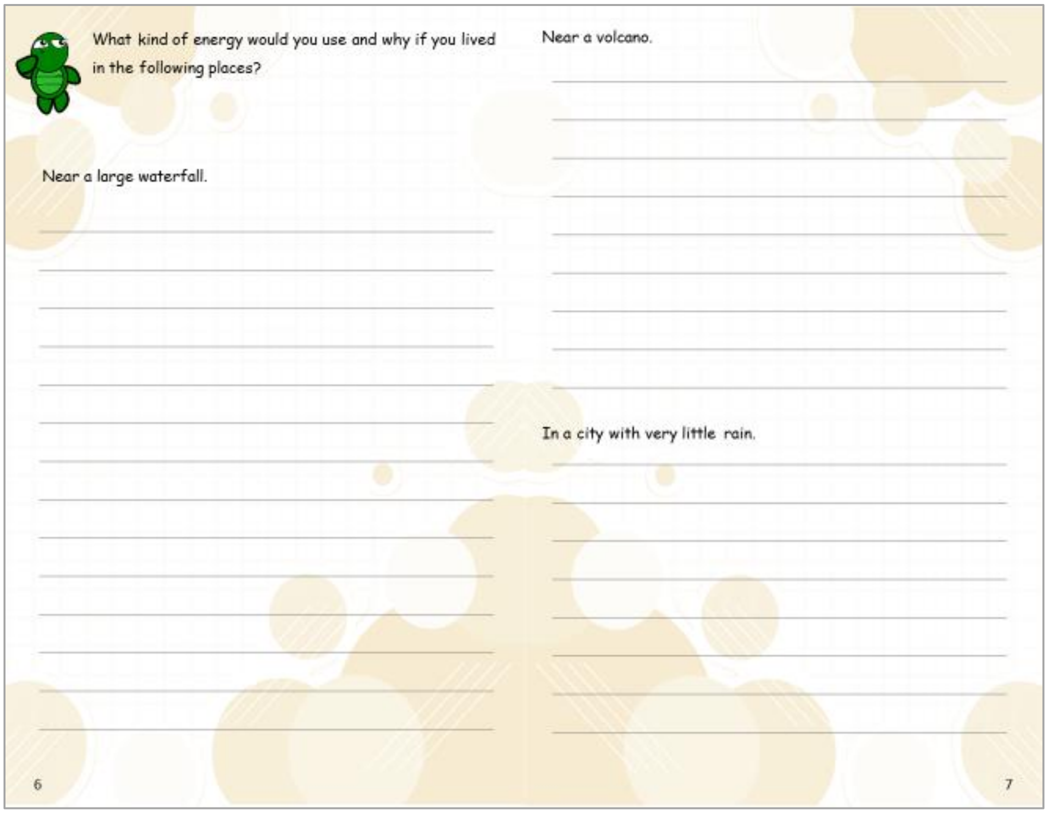
Hydropower is energy generated from the energy of falling water or running water. For example, a large dam that is placed in a river forces the water to flow over or through the dam. The falling water has a lot of energy and when it passes through the dam's turbines it generates electricity.

Wind power uses the energy in the movement of the wind. Wind turbines convert the kinetic energy (the energy of motion) of the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water), or it can be converted into electricity to power things like homes, businesses, and schools.

Geothermal energy is heat from Earth. It comes from many places: volcanos, hot water springs, and more. In the United States a lot of the geothermal energy comes from the top 10 feet of ground, that stays between 50°F and 60°F year-round. Heat exchangers use the heat difference between the ground and a home to heat the home in the winter and cool it in the summer.

As we develop new source of energy, there is a need for improved materials and better processes for energy capture and storage. These needs are a source of endless opportunity for new discoveries and inventions.

4 5


What kind of energy would you use and why if you lived in the following places?

Near a large waterfall.

Near a volcano.

In a city with very little rain.

6

7

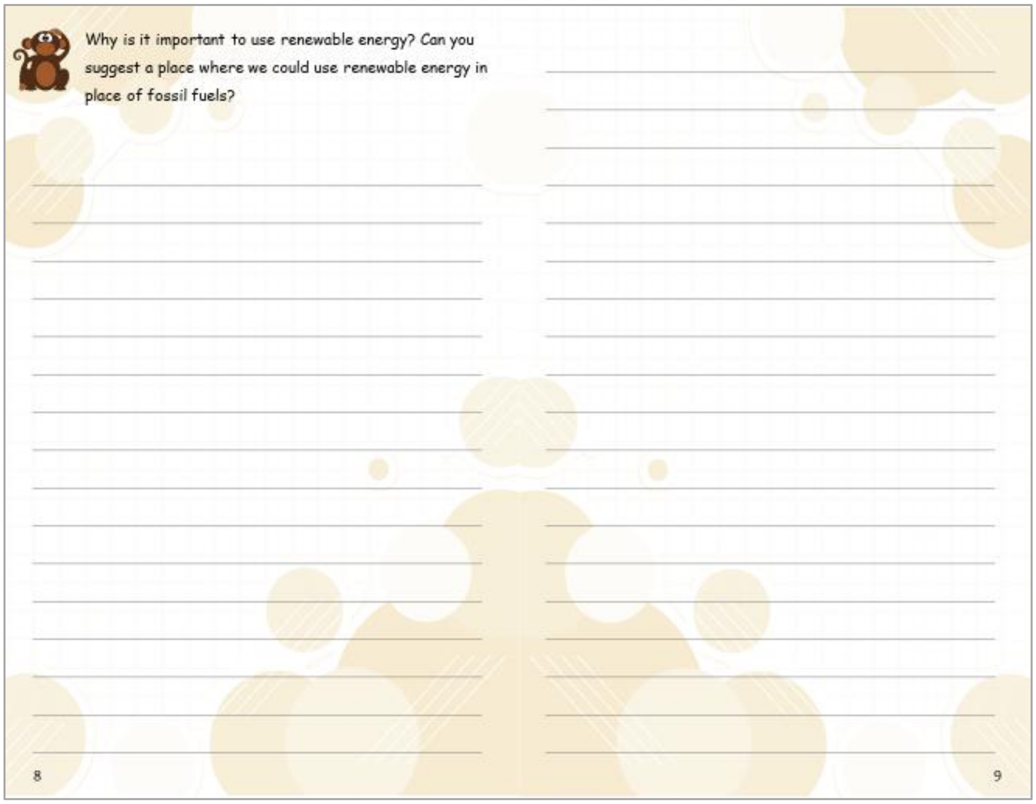
Range of expected student responses

Students are expected to apply information from the introduction to answer these questions. As well, the questions serve to get them thinking about connections between natural resources and weather and “more suitable” forms of energy.

Near a large waterfall – hydropower (moving water is readily available)

Near a volcano – geothermal (the volcano general indicates underground heat sources and steam sources).

In a city with very little rain – solar power (the fact that there isn’t much rain would suggest that there could be a lot of sun).


Why is it important to use renewable energy? Can you suggest a place where we could use renewable energy in place of fossil fuels?

8

9

The range of work for the above writing prompt is quite broad. The primary intent is that students display **relevant critical thinking** and use **relevant arguments and evidence** to make their case. For this writing piece, relevant = pertaining to renewable energy and connecting renewable energy to a reduction in stress placed on or pollution of the environment.

Ideally students will demonstrate knowledge that using energy sources that put less stress on the environment is valuable—and that one way to achieve this is through the use of renewable energy sources. However, they may not yet have this understanding, or your students may not believe that renewable sources of energy are actually better for the environment. In this case we encourage you to have your students to explain their thinking. If the explanation seems reasonable than that is also an acceptable response for this question.

Research Your Own Timeline

Pick one event on the provided timeline and create another timeline that includes that invention and describes how our understanding of the Earth, sun, and stars has resulted in discoveries that have impacted all of society.

10

11

12

13

Range of expected student responses

Student responses are expected to vary significantly for this investigation. It is suggested that students identify and justify three to five events, in addition to the one they took from the provided timeline, to create their own timelines.

Students should use the provided trade books to find events for their timeline.

Some examples of timeline themes include:

- Space travel
- Navigation
- Farming and agriculture
- Energy

Meet Erica Mackie: Co-Founder and CEO of GRID Alternatives

Erica Mackie, PE, is the co-founder and CEO of GRID Alternatives. We asked her to talk a bit about herself and about the solar electricity company she started with Tim Sears.

How would you describe yourself and your career path?

"I think of myself as a social worker turned engineer then turned back to something in between. My path to clean energy included work with survivors of domestic violence, at-risk youth, women's studies, outdoor education, math, and physics. I am an entrepreneur because in the end, in order to have the job and impact I dreamed of having, I needed to create it."

How did you get the idea for GRID Alternatives?

"In 2001, I was working as a professional engineer implementing large-scale renewable energy and energy efficiency projects for the private sector. It was at this job that Tim Sears and I met and thought of the idea for GRID Alternatives. It took us a few years to actually quit our jobs and decide to start our own nonprofit business, but that time we took to create a joint vision and establish a collaborative leadership style has been critical to our success today."

How would you describe GRID Alternatives?

GRID Alternatives is a national leader in making clean, affordable solar power and solar jobs accessible to all communities. By putting people first, GRID Alternatives develops and implements solar projects that serve qualifying households and affordable housing providers and offers solar education and hands-on job training to help people jumpstart their solar careers.

16 17

Meet Erica Mackie: Co-Founder and CEO of GRID Alternatives

How has GRID Alternatives grown over the years?

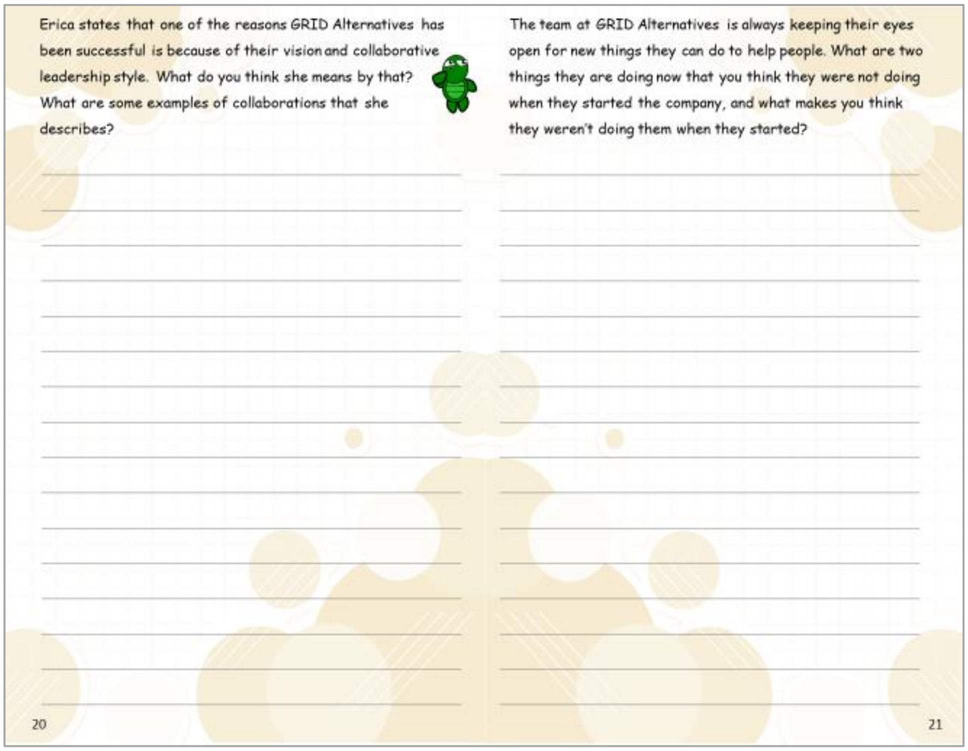
"GRID Alternatives has grown a lot over the years. We started out with the idea of installing solar for low-income homeowners with volunteers, like Habitat for Humanity except with solar. As we grew, we kept finding more community needs and opportunities to do more. Today we have a staff of 350 around the United States, and we're installing 1,500 solar electric systems a year, mostly for homeowners but also for renters, affordable housing buildings, and even some community organizations that have goals that are similar to ours.

We also do work in Nicaragua, Nepal, and Mexico for communities that either have no access to electricity or for which access is expensive and unreliable. We also train people. We found that many people were volunteering with us because they wanted work experience for jobs in solar, so we started to build out a real workforce development program. We've trained over 35,000 people, both volunteers and solar career aspirants, in solar installation."

What do you think it take to be a successful entrepreneur?

"Being a successful entrepreneur, whether in the nonprofit sector or in business, is about more than just that initial vision. It's also about being able to adapt and grow as the environment changes and opportunities arise. With a new technology like solar, there's so much opportunity and so much need, and we'll keep working and innovating until we're not needed anymore."

18 19



Erica states that one of the reasons GRID Alternatives has been successful is because of their vision and collaborative leadership style. What do you think she means by that? What are some examples of collaborations that she describes?

The team at GRID Alternatives is always keeping their eyes open for new things they can do to help people. What are two things they are doing now that you think they were not doing when they started the company, and what makes you think they weren't doing them when they started?

20 21

Expected Response:

Question 1:

Examples of collaboration include:

- Working with community organizations
- Working with renters and affordable housing buildings in addition to owners
- Training people for jobs in solar (and not just with GRID Alternatives)

Question 2:

Some things they are doing now that were not doing when they started are:

- Training people for jobs in solar
    - o Justification: The text states that it is something they started doing **after** they realized people were working with them to gain job experience.

- Working with a variety of people including renters, owners, and community organization.
    - o Justification: The text states that they started out only with low-income homeowners.

- Hiring employees to help with installations.
    - o Justification: The text states that they started out with volunteers and now employ over 350 people across the United State.

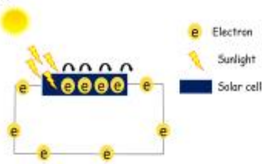
Meet Laura Stachel: Co-Founder of We Care Solar

ABOUT LAURA

Laura studied medicine and lives in California. In 2008 she went to Northern Nigeria to try to figure out ways to make having a baby safer for moms and babies. When she was there, she saw that most hospitals didn't have a reliable and constant source of electricity! While this made things hard during the day, it made having a baby at night very dangerous. Sometimes babies were born in total darkness. Other times mothers and babies had to wait hours for important surgery.

FOUNDATIONAL SCIENCE

Solar electric (also known as solar photovoltaic) is the action of turning sunlight into electrical energy. This is done with solar cells that are made of materials called SEMICONDUCTORS that have special properties. Semiconductors are a mix between a conductor (like metal) and an insulator (like rubber). When sunlight hits a semiconductor, some of the electrons get pushed out (like too many people sitting on a bench) and they flow through the wires making electricity.



22

Photo of Laura Stachel from We Care Solar Used with permission

GAME-CHANGING IDEA

When she got home from Nigeria, Laura joined forces with Hal Aronson, and together they started We Care Solar to help provide hospitals with reliable electricity. Hal created a suitcase-sized solar electric system, which included solar panels, batteries, LED lights, and headlamps, for Laura to show to the Nigerian hospital workers. When Laura returned to Nigeria with the "solar suitcase," her Nigerian colleagues were very excited that everything they needed to bring light and electricity to their clinics was contained in an easy-to-use suitcase. They began using the kit to charge headlamps and walkie-talkies immediately! To date We Care Solar and their partners have distributed almost 3,000 Solar Suitcases around the world.

23

Can you think of something that would benefit from solar power?

Draw or write about it here.

24

25

Useful Phrases for Having Constructive Discussions

Asking Clarifying Questions

Can you be more specific?
Can you explain your answer further?
Can you give an example?
Can you please explain your thinking?
Can you repeat what you said?
Could you rephrase that?
Could you say that one more time?
What is your evidence?
Can you give me another example, so I can understand?
Can you tell me more?
Why do you think that is important?
Why do you think that happened?
What if the opposite were true?

26

Adding to an Idea

I agree with _____ because _____.
I agree with _____.
I agree with _____ and I also think _____.
I agree with _____ and would like to add _____.
I agree, and I have an addition: _____.
I believe this is true because _____.
I know that too because _____.
I have something to add: _____.
I think you are right, and I also think _____.
I would like to add to that idea.
This reminds me of _____ because _____.
Yes, that makes sense, and I would also like to add _____.

Respectfully Disagreeing with an Idea

Could you explain, because I have a different idea.
I disagree with that idea because _____.
I disagree with your reasoning because _____.
I disagree with _____ because _____.
I have completely different opinion on that.
I respect your opinion and _____.
I respect your point, and in my opinion _____.
I respectfully disagree because _____.
I see your reasoning and disagree with some of the idea because _____.
That's a good point, and _____.

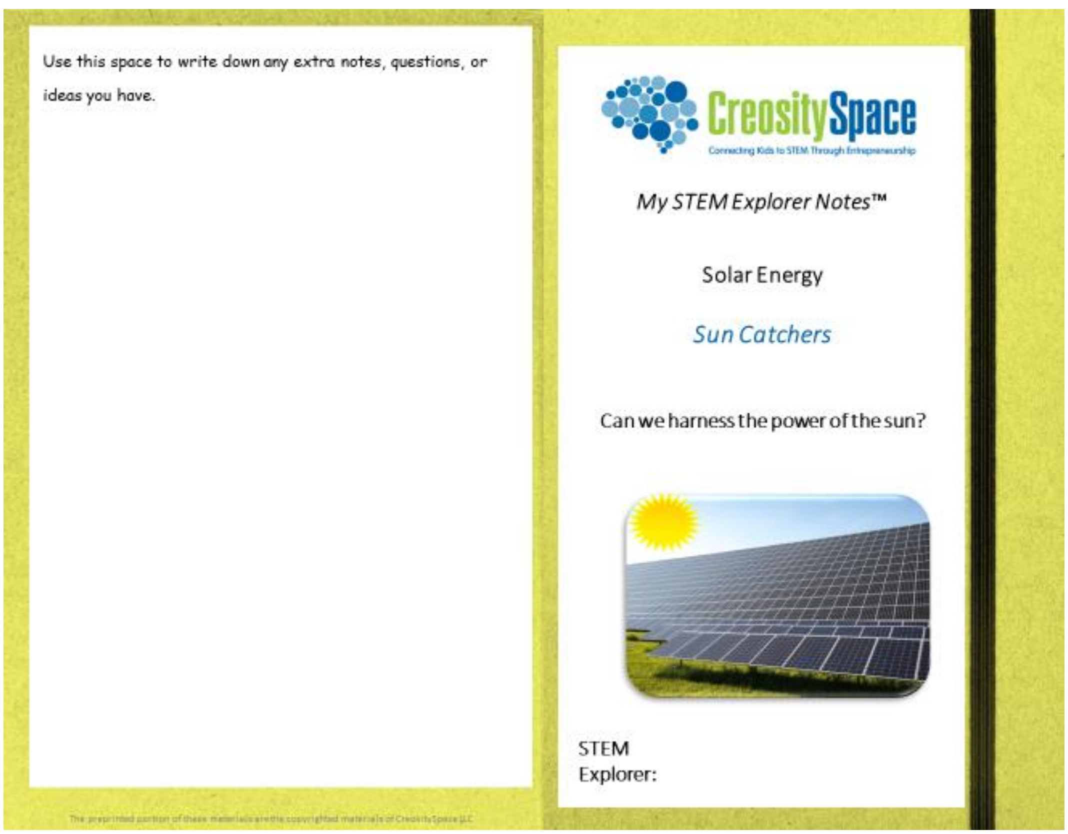
27

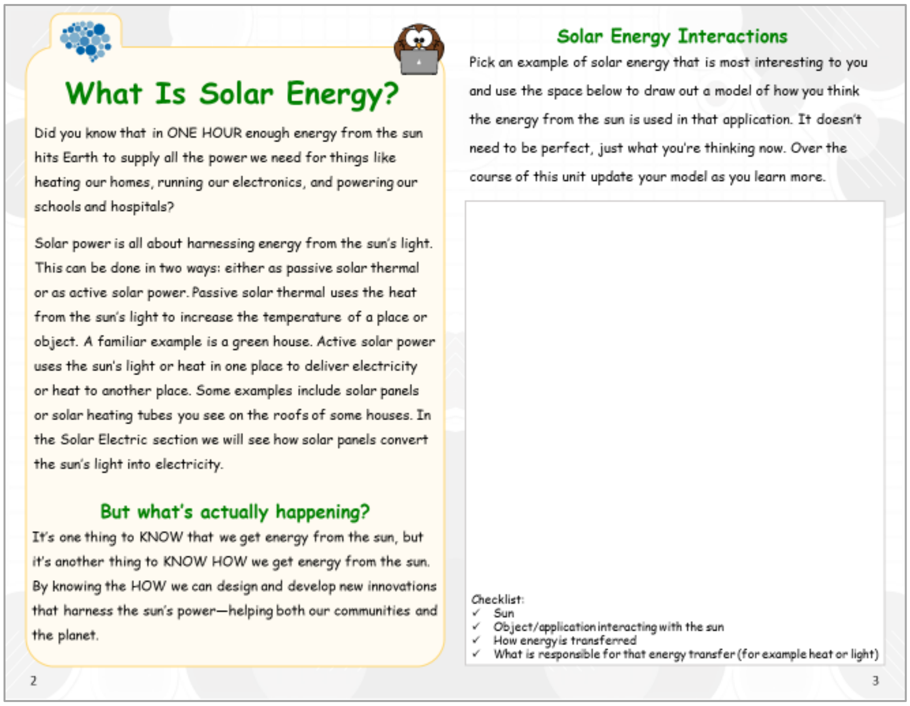
My STEM Explorer Notes™ Notebook

The next few pages contain copies of the *My STEM Explorer Notes*™ notebook. **Where appropriate guidance on the range of acceptable work is given below the relevant notebook pages.**

Please refer to the online content webpage for:

- Versions of this notebook that can be printed single sided. *Note: The single sided version is formatted so that each page is presented as an 8.5 x 11 spread—similar to the layout in the following pages.*
- Version of this notebook that can be printed double sided.
- Digital files with text descriptions of the pictures.
- Digital files that can be easily incorporated into online learning platforms such as Google Classroom, Canvas or other LMS..





What Is Solar Energy?

Did you know that in ONE HOUR enough energy from the sun hits Earth to supply all the power we need for things like heating our homes, running our electronics, and powering our schools and hospitals?

Solar power is all about harnessing energy from the sun's light. This can be done in two ways: either as passive solar thermal or as active solar power. Passive solar thermal uses the heat from the sun's light to increase the temperature of a place or object. A familiar example is a green house. Active solar power uses the sun's light or heat in one place to deliver electricity or heat to another place. Some examples include solar panels or solar heating tubes you see on the roofs of some houses. In the Solar Electric section we will see how solar panels convert the sun's light into electricity.

But what's actually happening?

It's one thing to KNOW that we get energy from the sun, but it's another thing to KNOW HOW we get energy from the sun. By knowing the HOW we can design and develop new innovations that harness the sun's power—helping both our communities and the planet.

2

Solar Energy Interactions

Pick an example of solar energy that is most interesting to you and use the space below to draw out a model of how you think the energy from the sun is used in that application. It doesn't need to be perfect, just what you're thinking now. Over the course of this unit update your model as you learn more.

Checklist:
- ✓ Sun
- ✓ Object/application interacting with the sun
- ✓ How energy is transferred
- ✓ What is responsible for that energy transfer (for example heat or light)

3

Prior knowledge expectations – Solar Interactions Model

Students are expected to have general knowledge about the properties of matter and interactions—scale, proportionality, and quantity—through 2-PS1-1,2,3. For example students should understand the difference between conductors and insulators—what that means in terms of material properties and how that is possible. Students should also have a general understanding of the relationship between the solid, liquid, and gas forms of common substances. If students are struggling with this understanding then a series of pictorial charts or anchor charts comparing ice, liquid water, and water vapor would be a useful refresher.

Expected range of student responses

Note: You may want to complete a few of the Solar Sleuthing investigations before you have students start their models.

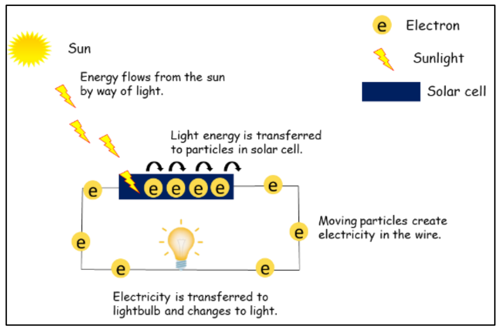
Students may choose from a variety of phenomena to use as the basis of their solar interactions model. Some examples include:

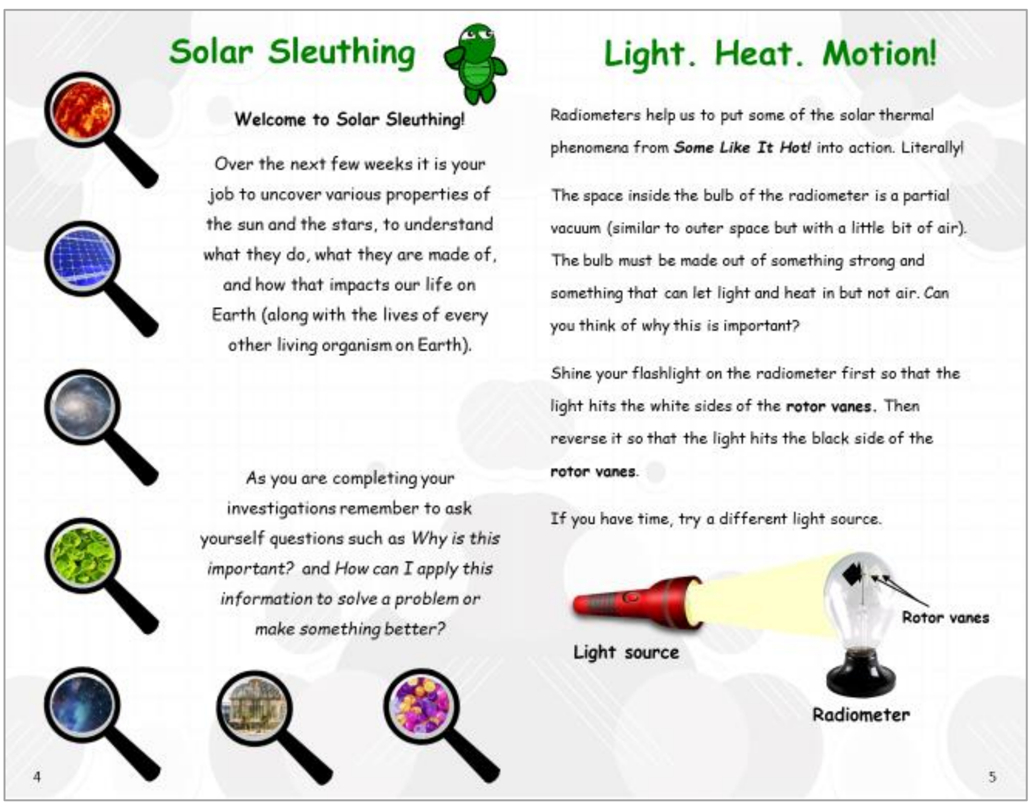
- The radiometer and why it turns.
- A green house (or some other passive heating device) and how it captures energy from the sun.
- How solar panels convert sunlight into electricity.

- How a solar oven works.
- Why the UV sensitive beads are changing color.
- How plants convert sunlight into energy.

An example response is provided below. Student responses may vary but models should include:

- Energy flow
- Energy conversion
- Particles responsible for the energy/evidence of energy





Solar Sleuthing

Welcome to Solar Sleuthing!

Over the next few weeks it is your job to uncover various properties of the sun and the stars, to understand what they do, what they are made of, and how that impacts our life on Earth (along with the lives of every other living organism on Earth).

As you are completing your investigations remember to ask yourself questions such as *Why is this important?* and *How can I apply this information to solve a problem or make something better?*

4

Light. Heat. Motion!

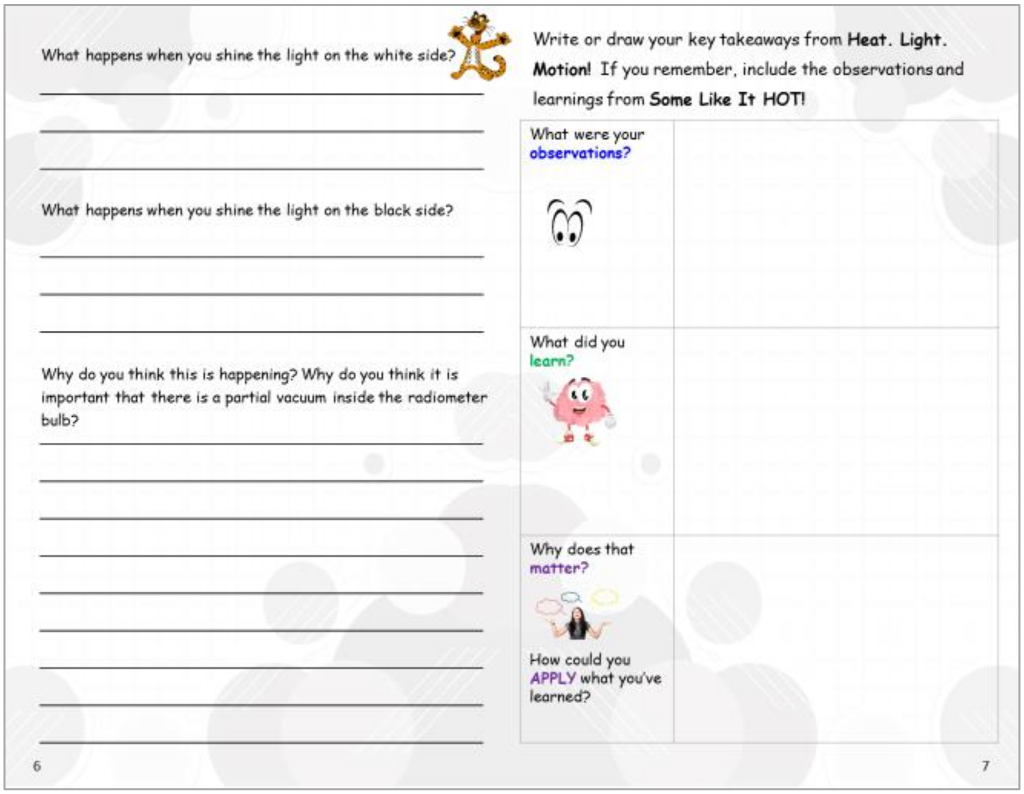
Radiometers help us to put some of the solar thermal phenomena from ***Some Like It Hot!*** into action. Literally!

The space inside the bulb of the radiometer is a partial vacuum (similar to outer space but with a little bit of air). The bulb must be made out of something strong and something that can let light and heat in but not air. Can you think of why this is important?

Shine your flashlight on the radiometer first so that the light hits the white sides of the **rotor vanes**. Then reverse it so that the light hits the black side of the **rotor vanes**.

If you have time, try a different light source.

5



What happens when you shine the light on the white side?

What happens when you shine the light on the black side?

Why do you think this is happening? Why do you think it is important that there is a partial vacuum inside the radiometer bulb?

6

Write or draw your key takeaways from **Heat. Light. Motion!** If you remember, include the observations and learnings from **Some Like It HOT!**

What were your observations?	
What did you learn?	
Why does that matter? How could you APPLY what you've learned?	

7

Ranged of expected student responses

Questions (page 6)

Nothing happened when students shone the light on the white side.

The rotator vanes started to move when students shone light on the black side.

The black surface is absorbing energy from the light source and turning it into heat. That heat is transferred to the gas particles in the radiometer which causes them to move. The motion of the gas particles causes the rotator vanes to start spinning.

Summary table (page 7)

We're looking for the following:

Observations – What they did and observed in during the investigation.

Learnings – What cause and effect relationships and indicators of the properties of matter can they identify from their observations.

Applications – There is flexibility here as we're looking for students to express why this learning is relevant to them.

Solar Chemical

Light is made of very small pieces of energy called **photons**. The energy of the light determines its color. The color of the light determines if we can see it.

Light people can see is called **visible light**. The highest energy color of visible light is violet (or purple) and the lowest energy color of visible light is red. There is also light that is higher energy than violet, called **ultraviolet (UV)**, and lower energy than red, called **infrared (IR)**.

Even though people can't see **ultraviolet** light, there are a lot of chemicals that can absorb the **ultraviolet** energy and will glow a different color.

Discussion prompt: If people can't see **ultraviolet** light, why do you think you can see the light from your UV flashlight?

Color Creations

Objective

Using the UV flashlights, blocking materials, and UV beads, determine what happens to the beads when they are exposed to UV light and which materials can stop that from happening.

Materials needed:

- UV flashlight
- beads, string, key ring, other art supplies (optional)
- Blocking materials (foil, waxed paper, white cloth, dark cloth) What others can you think of?

Before you do anything make a guess as to what will happen during the experiments. This guess is called your **hypothesis**.

What will happen to the beads when we shine UV light on them?	
Which materials will stop that change from happening (by blocking the UV light)?	
Which materials will allow that change to happen (by letting the UV light pass through)?	

Procedure:

1. Take the beads (7-10 of each kind), string, key ring, and any other art supplies you want and make something with them. Some examples are a bracelet, necklace, key chain charm, or anything else you can think of that will let you investigate what happens when you shine light on the beads. For these experiments you will need to be able to separate the beads into two groups, so make sure you are able to do that. Record what the beads look like at the beginning.
2. Cover one group of beads with one of the blocking materials.
3. Shine the UV flashlight over the beads for about one minute.
4. Remove the blocking material and record your observations of both groups.
5. Wait until all beads return to how they looked originally.
6. Repeat until you have tested all the blocking materials.
7. Summarize your observations and draw some conclusions about the properties of the blocking materials.

Experimental Observations

Initial observations

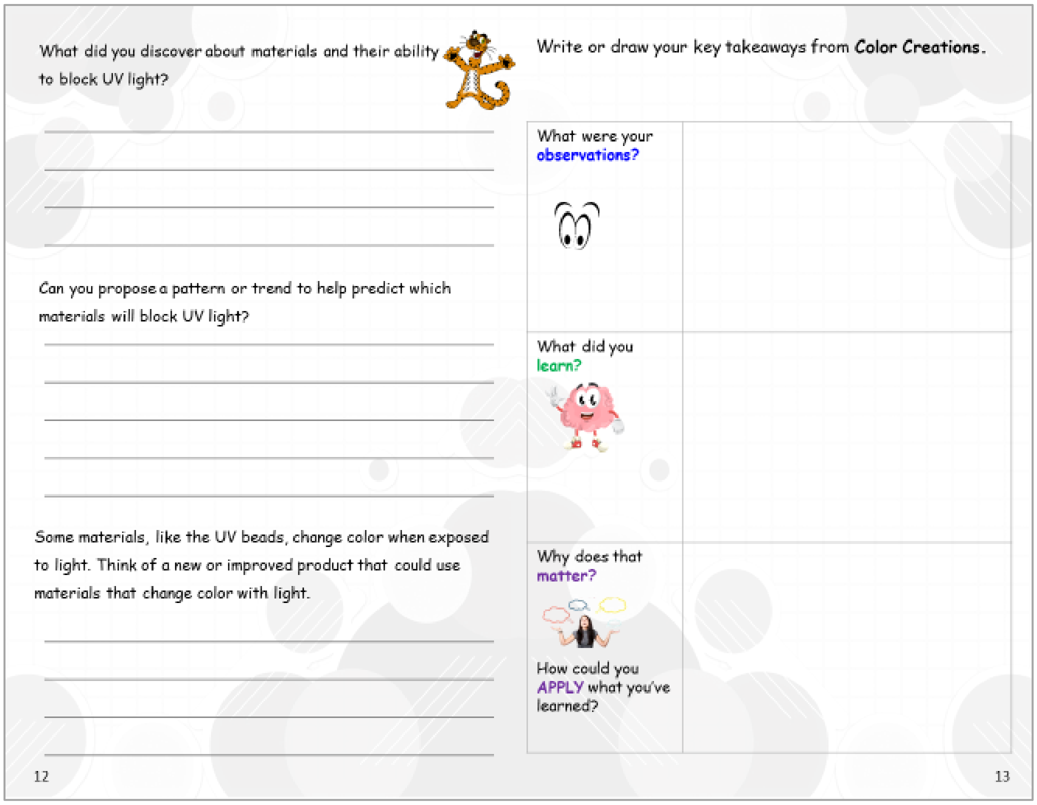
What do the beads look like before any experiments?

____

____

____

Blocking Material	Covered Beads	Uncovered Beads


What did you discover about materials and their ability to block UV light?

Can you propose a pattern or trend to help predict which materials will block UV light?

Some materials, like the UV beads, change color when exposed to light. Think of a new or improved product that could use materials that change color with light.

12

Write or draw your key takeaways from **Color Creations**.

What were your observations?	
What did you learn?	
Why does that matter? How could you APPLY what you've learned?	

13

Ranged of expected student responses

Questions (page 12)

The materials varied in their ability to block UV light. Some worked well, others did not.

Darker materials were better at blocking UV light as were materials that you can't see through.

Student responses will vary.

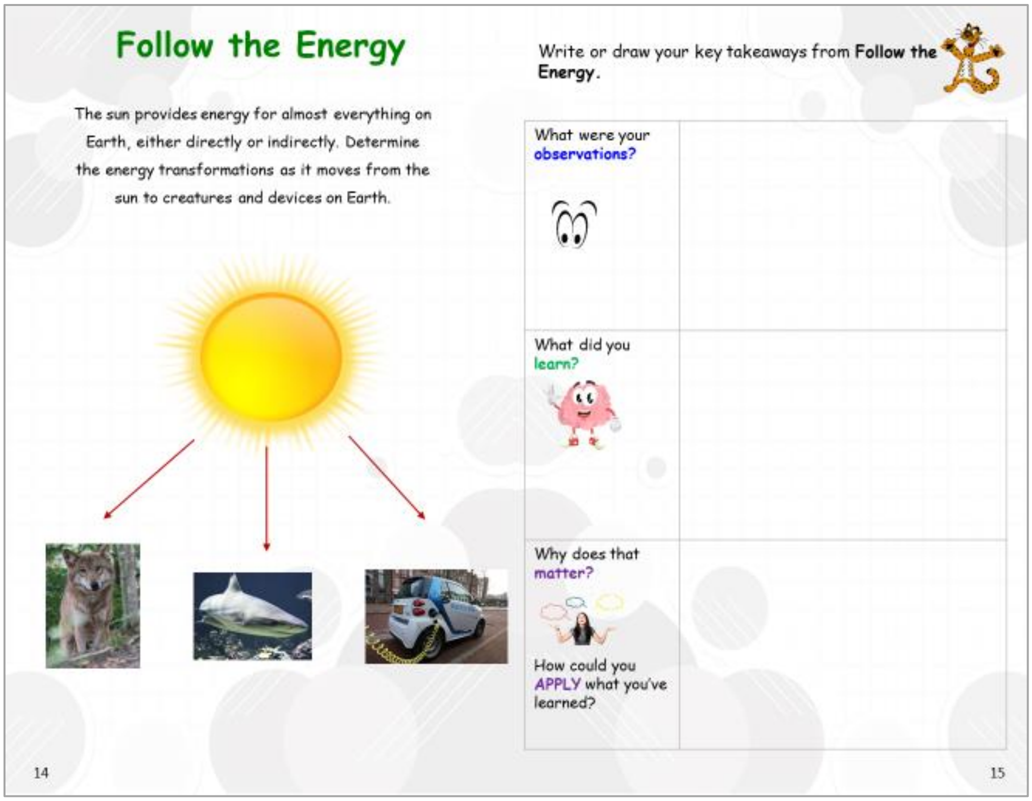
Summary table (page 7)

We're looking for the following:

Observations – What they did and observed in during the investigation.

Learnings – What do they think it causing the color change they are observing? What does this tell them about what may be happening at a scale too small for them to see?

Applications – There is flexibility here as we're looking for students to express why this learning is relevant to them.



Expected prior knowledge and range of student response

Please see previous section for details around expected prior knowledge and range of students responses for the Follow the Energy main investigation.

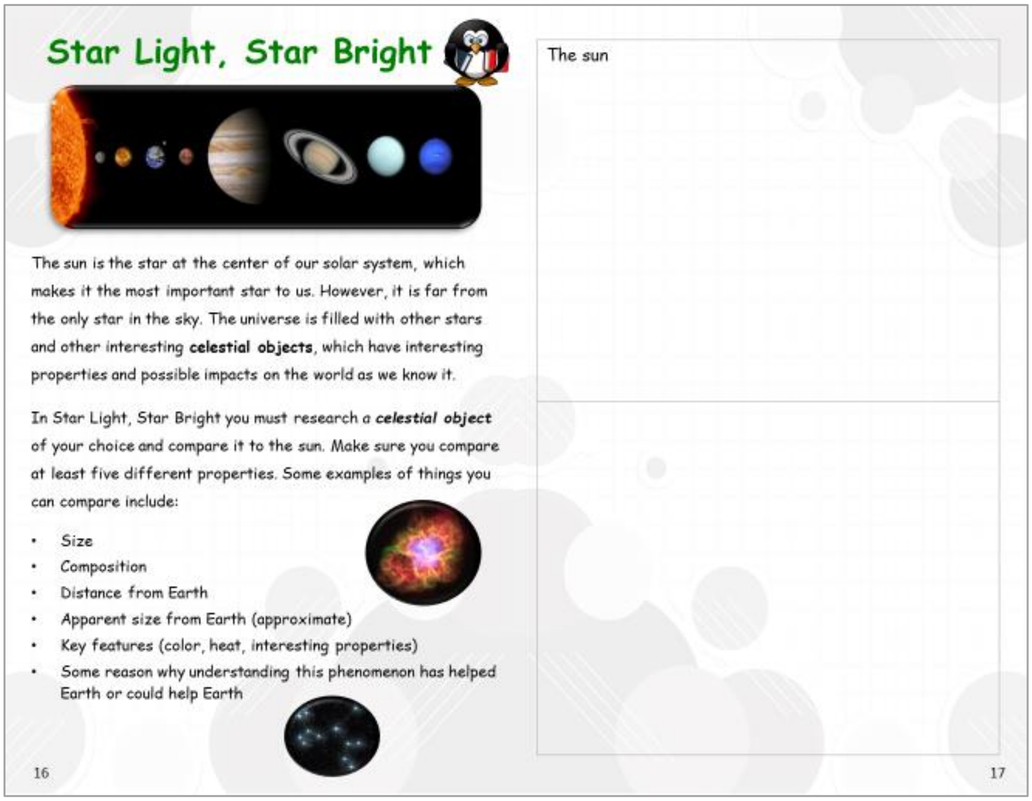
Summary table (page 15)

We're looking for the following:

Observations – What they did and observed in during the investigation.

Learnings – What they learned—especially with respect to the flow of energy between different organisms and objects and in different forms.

Applications – There is flexibility here as we're looking for students to express why this learning is relevant to them.


Star Light, Star Bright

The sun is the star at the center of our solar system, which makes it the most important star to us. However, it is far from the only star in the sky. The universe is filled with other stars and other interesting **celestial objects**, which have interesting properties and possible impacts on the world as we know it.

In Star Light, Star Bright you must research a ***celestial object*** of your choice and compare it to the sun. Make sure you compare at least five different properties. Some examples of things you can compare include:

- Size
- Composition
- Distance from Earth
- Apparent size from Earth (approximate)
- Key features (color, heat, interesting properties)
- Some reason why understanding this phenomenon has helped Earth or could help Earth

16

The sun

17

Prior knowledge expectations

Students are expected to have a general understanding about the orientation of the celestial bodies in our solar system (sun, planets, Earth's moon, etc) from 1-ESS1-1 and about seasonal patterns as they pertain to changes in positioning of the sun and stars as well as the resulting environmental conditions (e.g., average temperature, hours of daylight, etc.) from 1-ESS1-1,2; and 3-ESS2-1. If students have gaps in their foundational knowledge about the solar system, the provided trade books (especially Natational Geographic's *Everything Space*) have some easy to read overviews and fun "quizes".

Range of expected responses

Students should provide references for their research. You may also want to have them edit and formally write out their comparison for an ELA assignment.

The sun (Sol)

From DK Universe (pp. 20-21):

- Size: 870,000 miles across (100 times bigger than Earth)
- Distance: 93 million miles from Earth (8 minutes travelling at the speed of light)
- Composition: Hot gas, 27 million°F at core; 9,900°F at surface
- Provides heat and light to Earth

- Apparent size when viewed from Earth: Looks big—bigger than the planets we can see from Earth (which it is).
- We can see it all year round (except at the poles) but it shifts slightly in the sky based on the season.

Comparisons

There are a range of possible comparisons students might choose to make. For general comparisons and information about other celestial objects the following sections of the provided reference books are a good place to start:

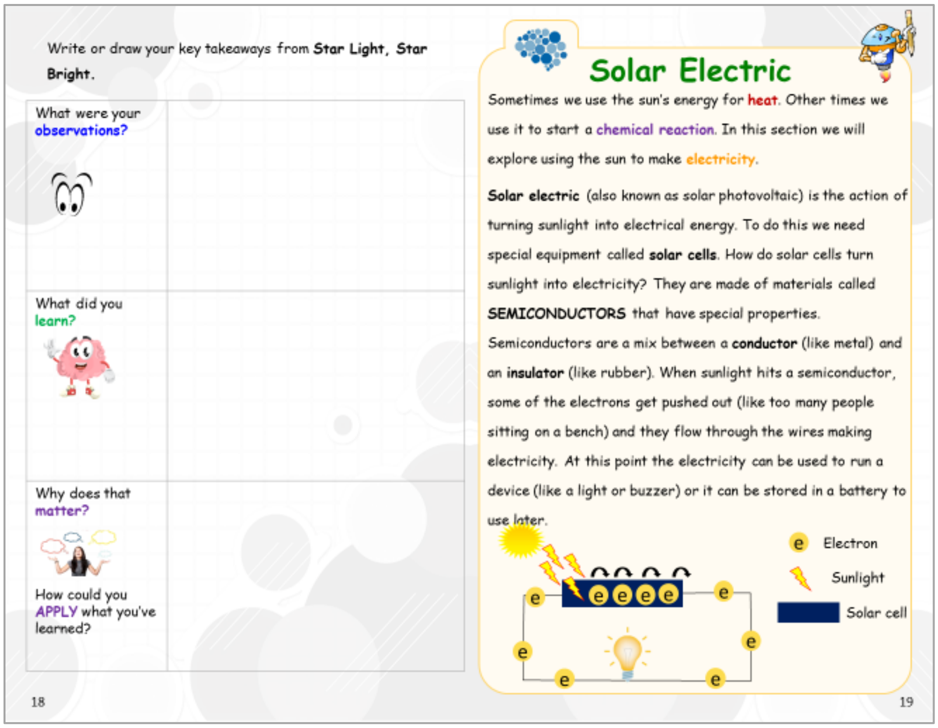
Everything Space: page 22 – 24
DK Universe: pages 18-21, 42-45, 56-57,64-65
DK SPACE a visual encyclopedia: pages 212-213, 222-229, 232-234.

A specific example of a comparison is provided below, but it's very likely you're students will use additional online resources to deepen their comparisons.

M31 – Andromeda galaxy

From information found in DK Universe (pp. 57, 64):

- Size: Bigger than the Milky Way
- Distance: 2.5 million light years from Earth
- Composition: more than 400 billion stars
- Apparent size from Earth: Looks like a fuzzy, averaged size star—because it is so far away and we are looking at the edge of it, but is really over 400 billion stars.
- Can be found in the sky near the Cassiopeia and Pegasus constellations.



Summary table (page 18)

We're looking for the following:

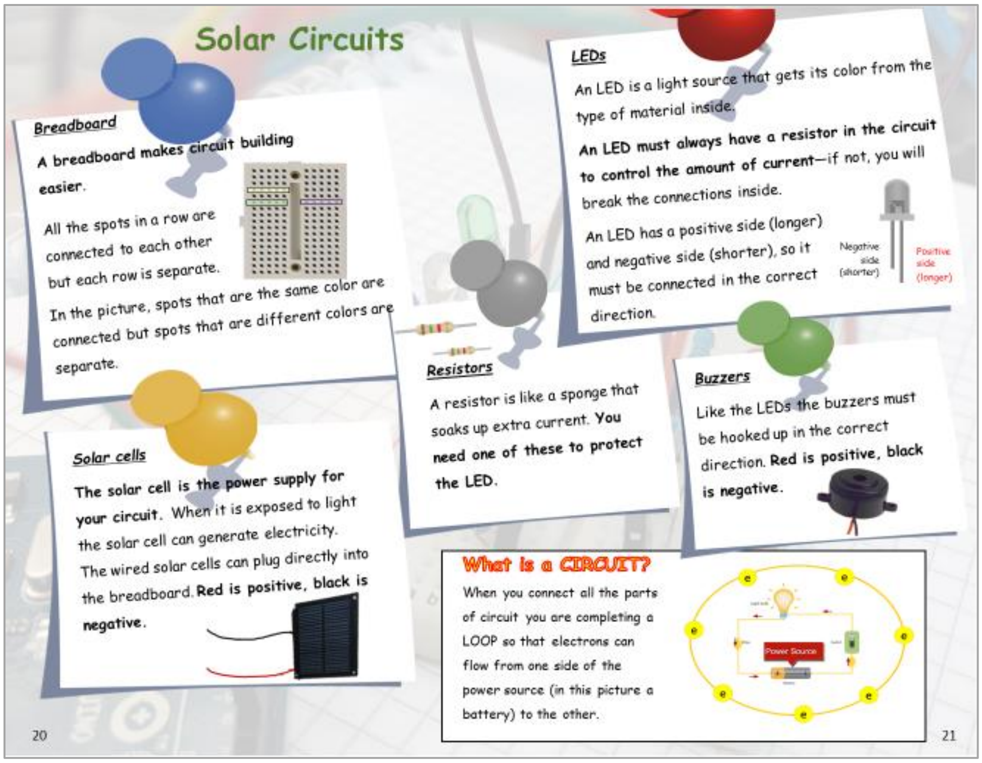
Observations – What are some interesting facts they uncovered during the investigation?

Learnings – What they learned—especially with respect to relative properties of objects in the sky.

Applications – There is flexibility here as we're looking for students to express why this learning is relevant to them.

Note: There are a couple of important concepts that students should walk away with:

- That all the other stars in the universe SEEM smaller and not as bright as our sun because they are far away. In reality, some are bigger and brighter while others are smaller and dimmer.
- That some stars are visible all year round and others are only visible during certain seasons.


Solar Circuits

Breadboard

A breadboard makes circuit building easier.

All the spots in a row are connected to each other but each row is separate.

In the picture, spots that are the same color are connected but spots that are different colors are separate.

Solar cells

The solar cell is the power supply for your circuit. When it is exposed to light the solar cell can generate electricity.

The wired solar cells can plug directly into the breadboard. **Red is positive, black is negative.**

Resistors

A resistor is like a sponge that soaks up extra current. **You need one of these to protect the LED.**

LEDs

An LED is a light source that gets its color from the type of material inside.

An LED must always have a resistor in the circuit to control the amount of current—if not, you will break the connections inside.

An LED has a positive side (longer) and negative side (shorter), so it must be connected in the correct direction.

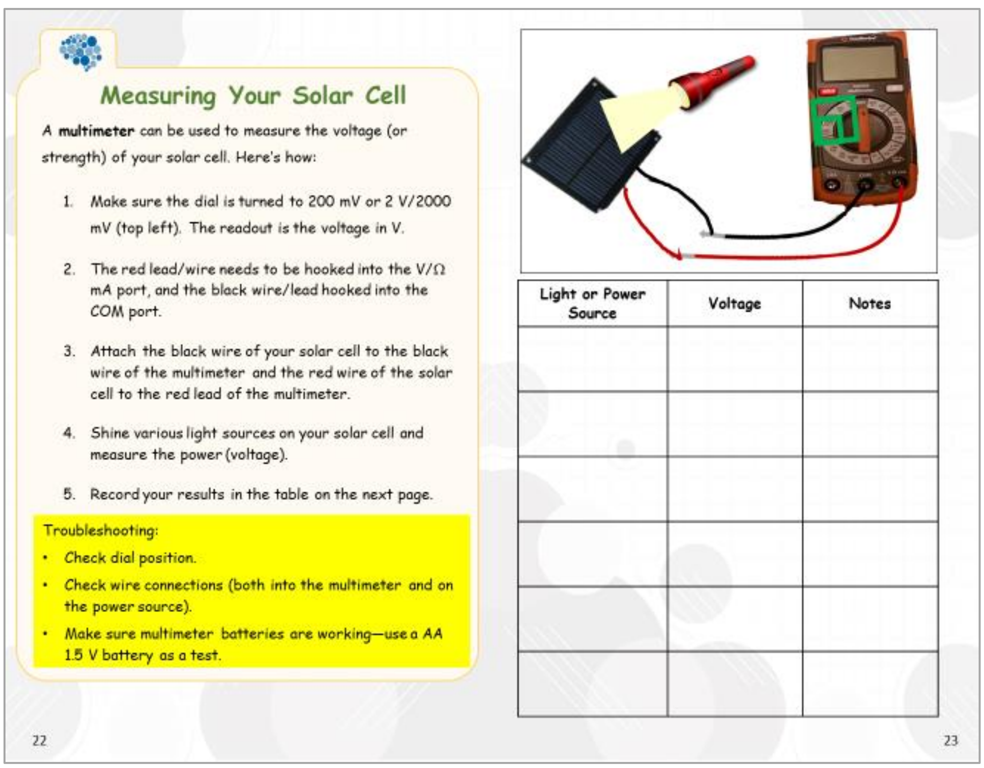
Buzzers

Like the LEDs the buzzers must be hooked up in the correct direction. **Red is positive, black is negative.**

What is a CIRCUIT?

When you connect all the parts of circuit you are completing a LOOP so that electrons can flow from one side of the power source (in this picture a battery) to the other.

20 21


Measuring Your Solar Cell

A **multimeter** can be used to measure the voltage (or strength) of your solar cell. Here's how:

1. Make sure the dial is turned to 200 mV or 2 V/2000 mV (top left). The readout is the voltage in V.
2. The red lead/wire needs to be hooked into the V/Ω mA port, and the black wire/lead hooked into the COM port.
3. Attach the black wire of your solar cell to the black wire of the multimeter and the red wire of the solar cell to the red lead of the multimeter.
4. Shine various light sources on your solar cell and measure the power (voltage).
5. Record your results in the table on the next page.

Troubleshooting:
- Check dial position.
- Check wire connections (both into the multimeter and on the power source).
- Make sure multimeter batteries are working—use a AA 1.5 V battery as a test.

Light or Power Source	Voltage	Notes

22 23

Expected range of responses

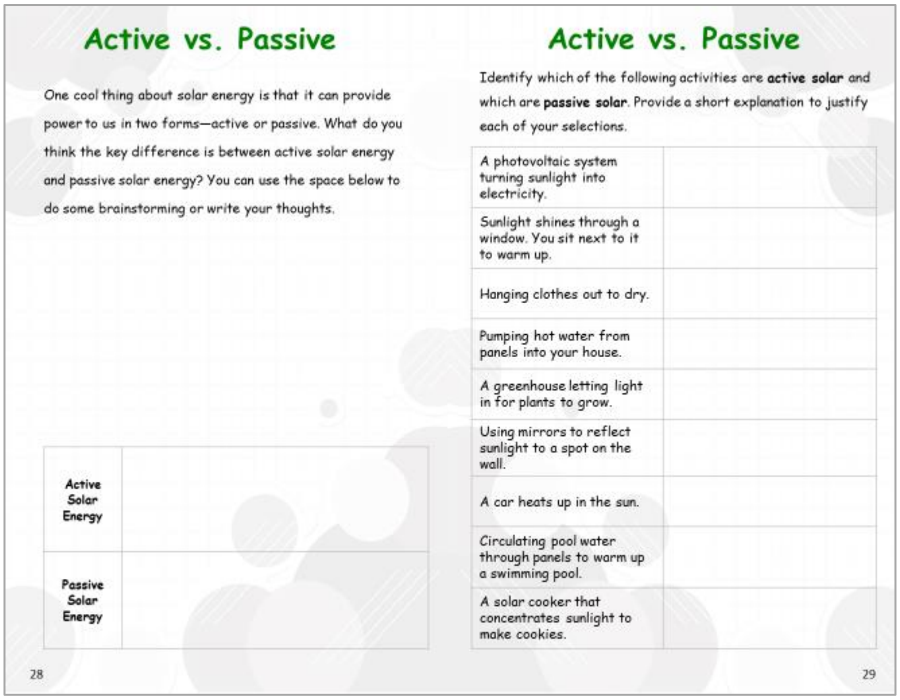
Students should observe voltages between 1–6 V depending on light source.

Summary table (page 27)

Observations – What did they observe during the investigation (e.g., different brightness of light or volume of buzzer based on light source).

Learnings – What they learned—especially with respect to what is happening to the light energy.

Applications – There is flexibility here as we're looking for students to express why this learning is relevant to them.



Active vs. Passive

One cool thing about solar energy is that it can provide power to us in two forms—active or passive. What do you think the key difference is between active solar energy and passive solar energy? You can use the space below to do some brainstorming or write your thoughts.

Active Solar Energy	
Passive Solar Energy	

28

Active vs. Passive

Identify which of the following activities are **active solar** and which are **passive solar**. Provide a short explanation to justify each of your selections.

A photovoltaic system turning sunlight into electricity.	
Sunlight shines through a window. You sit next to it to warm up.	
Hanging clothes out to dry.	
Pumping hot water from panels into your house.	
A greenhouse letting light in for plants to grow.	
Using mirrors to reflect sunlight to a spot on the wall.	
A car heats up in the sun.	
Circulating pool water through panels to warm up a swimming pool.	
A solar cooker that concentrates sunlight to make cookies.	

29

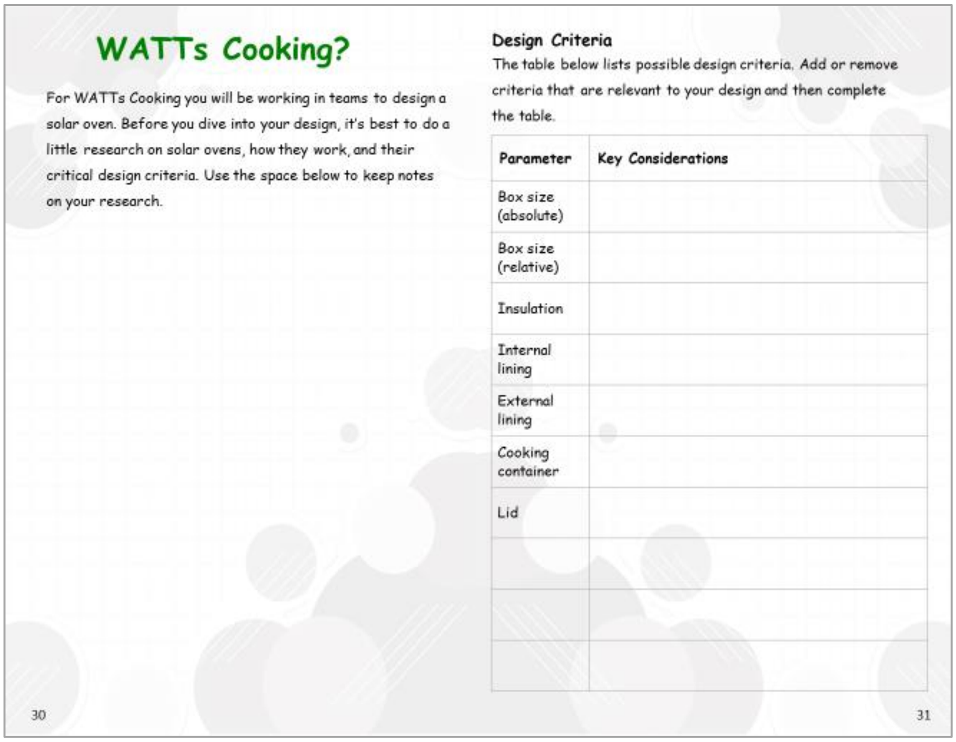
Expected range of student responses

Passive Solar Energy - uses the **heat** of the sun **directly**

Active Solar Energy - uses the sun's radiation (the sun's rays) to generate **electricity** via solar panels or uses some mechanical energy to transfer the heat of the sun to a different location

Active vs. Passive Answers

A photovoltaic system turning sunlight into electricity.	Active – sunlight is turned into electricity
Sunlight shines through a window. You sit next to it to warm up.	Passive – sunlight heats you up directly
Hanging clothes out to dry.	Passive – sunlight heats clothes up directly
Pumping hot water from panels into your house.	Active – hot water must be pumped
A greenhouse letting light in for plants to grow.	Passive – sunlight heats greenhouse up directly
Using mirrors to reflect sunlight to a spot on the wall.	Student choice: Active if you consider *reflection* a type of work. Passive if you do not.
A car heats up in the sun.	Passive – sunlight heats car up directly
Circulating pool water through panels to warm up a swimming pool.	Active – hot water must be pumped
A solar cooker that concentrates sunlight to make cookies.	Student choice: Active if you consider *reflection* a type of work. Passive if you do not.



WATTs Cooking?

For WATTs Cooking you will be working in teams to design a solar oven. Before you dive into your design, it's best to do a little research on solar ovens, how they work, and their critical design criteria. Use the space below to keep notes on your research.

Design Criteria

The table below lists possible design criteria. Add or remove criteria that are relevant to your design and then complete the table.

Parameter	Key Considerations
Box size (absolute)	
Box size (relative)	
Insulation	
Internal lining	
External lining	
Cooking container	
Lid	

30 31

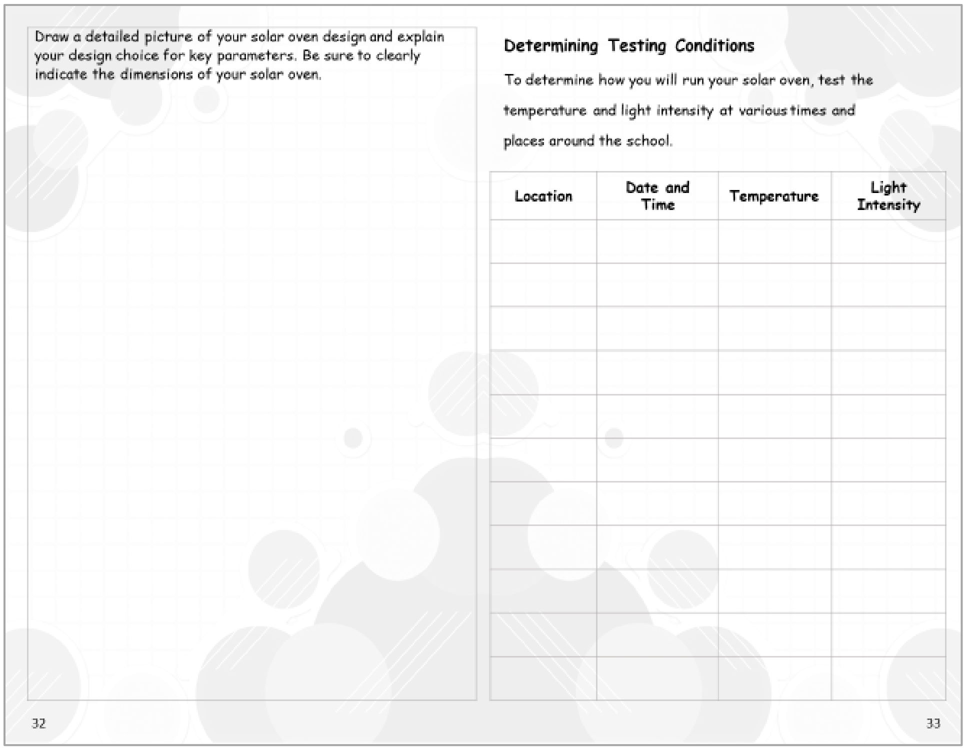
Prior knowledge expectations and expected range of responses

It is expected that your students will have had experience with the engineering design process and engineering challenges—specifically the content associated with 3-5-ETS1-1,2,3—in previous grades and will be comfortable thinking about design criteria without specific direction from the teacher. However, if your students still struggle with this goal setting and design criteria discussions can be completed via a class discussion. Just make sure that each student completes their own table in their *My STEM Explorer Notes*™ notebooks.

On page 30 of their *My STEM Explorer Notes*™ notebooks students should write down some of the key properties of solar ovens. These notes can include information such as:

- Solar ovens are often made of two nested cardboard boxes with some type of insulation between them.
- Solar ovens are often have a reflective coating on the inside.
- Solar ovens often have an absorbent coating on the outside.

Page 54 of this Educator Guide outline some common design criteria for the different components of the solar oven.



Draw a detailed picture of your solar oven design and explain your design choice for key parameters. Be sure to clearly indicate the dimensions of your solar oven.

Determining Testing Conditions

To determine how you will run your solar oven, test the temperature and light intensity at various times and places around the school.

Location	Date and Time	Temperature	Light Intensity

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33

Prior knowledge expectations and expected range of responses

It is expected that students will have experience developing detailed diagrams or sketches for engineering design projects. Students should be sure to clearly indicate relevant dimensions and explain the different components of their design.

To determine the solar oven testing conditions student will need to use the IR thermometer and light meter. They should have had some experience with these two pieces of equipment during the previous investigations (Some Like It Hot! and Solar Circuits) but may need a referesher.

We suggest each team pick a different location to monitor and around the school and that they evaluate the same place at different times during the day. In addition to recording light and temperature data they should describe the general weather and what they see in their location—such as any shadows or large-scale observable differences. This will help to provide them with context when they are analyzing their data and to help reinforce the learning object associated with 5-ESS1-2.

Use your data to determine your testing conditions.
Describe your testing conditions below.

Solar Oven Testing

Weather conditions	
Cooking container	
Cooking material	

Observations

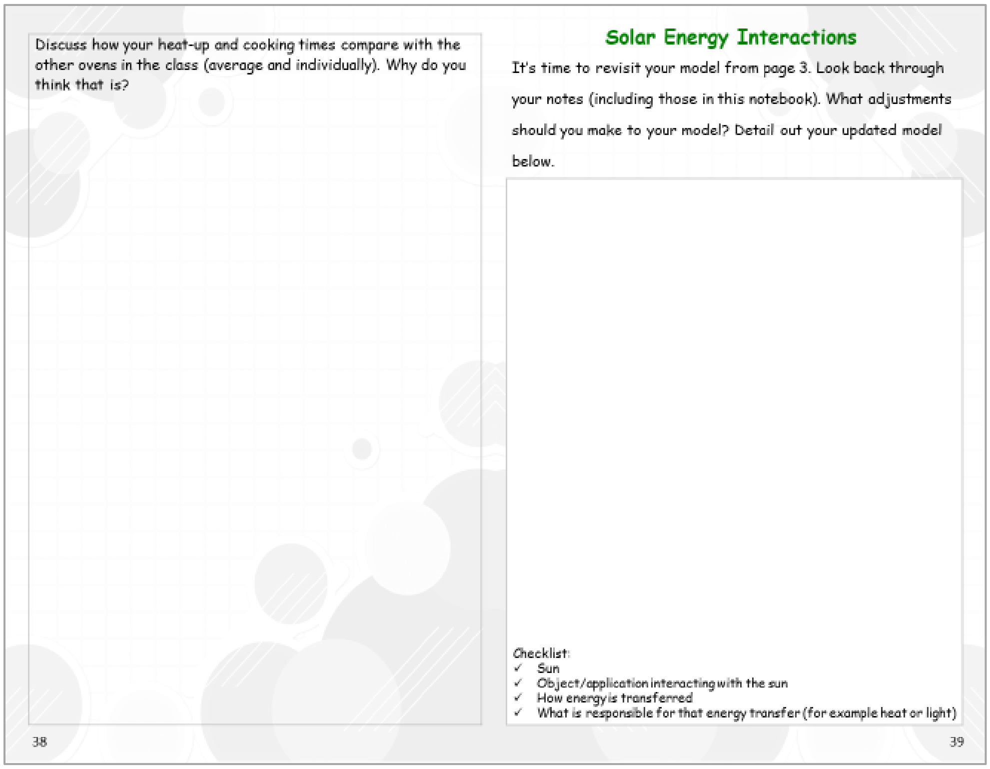
Time to heat up	
Time to cook	

Describe your visual observations.

Describe your thoughts on your observations.

Class Data

Tabulate class oven heat-up times	Tabulate class oven cook times	Plot out class heat-up times	Plot out class cook times
		0	0


Discuss how your heat-up and cooking times compare with the other ovens in the class (average and individually). Why do you think that is?

38

Solar Energy Interactions

It's time to revisit your model from page 3. Look back through your notes (including those in this notebook). What adjustments should you make to your model? Detail out your updated model below.

Checklist:
- ✓ Sun
- ✓ Object/application interacting with the sun
- ✓ How energy is transferred
- ✓ What is responsible for that energy transfer (for example heat or light)

39

Expected range of responses

It is hard to predict heat up and cooking times as they can vary significantly with the weather, solar oven configuration, and material being cooked. Having said that, students should use the IR thermometers to measure the temperature both inside and outside of their solar ovens and use that data to help compare and explain cooking differences.

Some factors students should be expected to identify as influencing heat up and cooking time are:

- Size of oven
- Light intensity/weather
- Color of oven (inside and outside)
- Temperature outside oven
- Temperature inside oven
- What and how much they are cooking (i.e., Are they heating up something large or something small?)

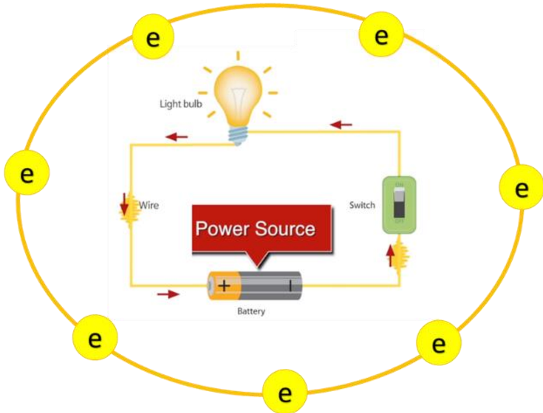
Updated Solar Interactions Model

At this point students should update their solar interactions model. Please see previous discussion for range of expected results for the solar interactions model.

Building Circuits with a Breadboard Primer

The following few pages provide a quick primer for buidling a circuit using a breadboard. These pages can be downloaded as a handout for your students from the content webpage.

Circuit Building Tutorial



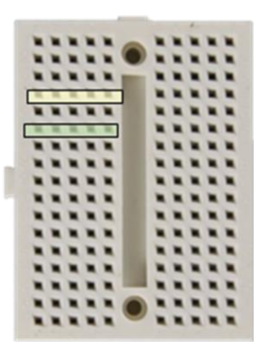
A Circuit Is a LOOP for the Electrons

Building a Circuit

Breadboard:

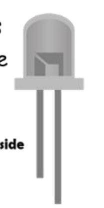
A breadboard makes circuit building easier. All the spots in a row are connected to each other but each row is separated from another row.

For example, the green slots are connected to each other and the yellow slots are connected to each other, but the green slots are not connected to the yellow slots.



LEDs:

An LED is a light source that gets its color from the type of material inside (called a semiconductor).



An LED must always have a resistor in the circuit to control the amount of current—if not, you will break the connection to the semiconductor material.

An LED has a positive side (longer) and negative side (shorter), so it must be connected in the correct direction.

Resistors:

A resistor is like a sponge that soaks up extra current. You need one of these to protect the LED.

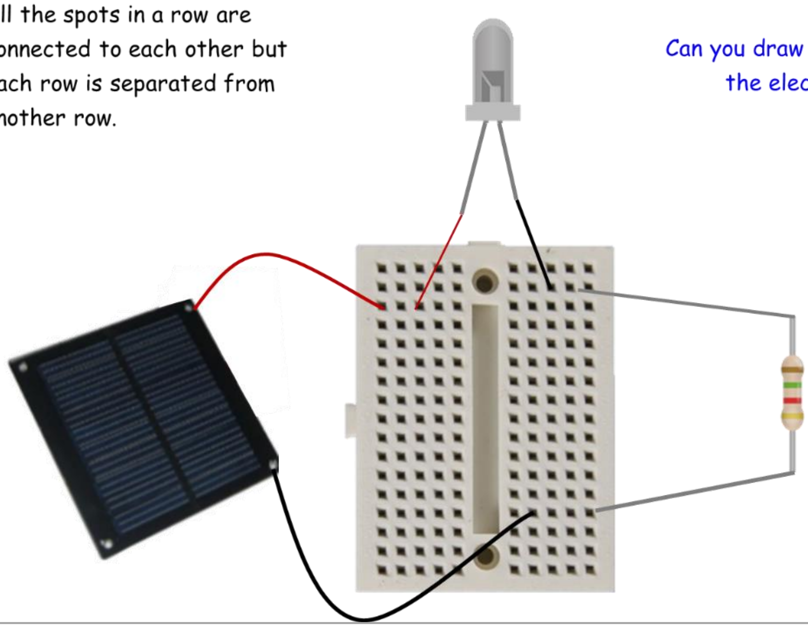
They work the same way in either direction (just like the jumper wires).

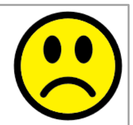
A Sample Circuit

A Circuit Is a LOOP for the Electrons

All the spots in a row are connected to each other but each row is separated from another row.

Can you draw the loop for the electrons?





Having Some TROUBLE?

Is your circuit a loop?

Follow the path of the electrons.

Is everything firmly in the breadboard?

Test for loose connections.

What happens if you switch the location of the wires for the solar cells?

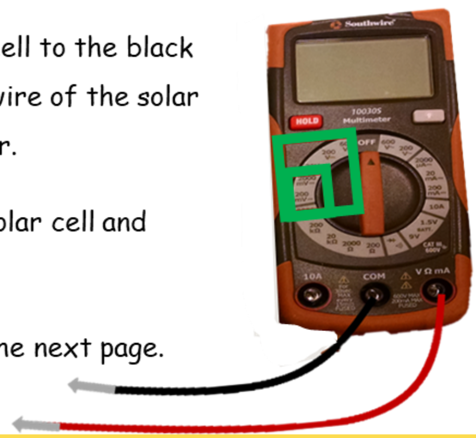
The LED only lets electrons flow one way.

Using a Multimeter

A **multimeter** can be used to measure the voltage (or strength) of your solar cell. Here's how:

1. Make sure the dial is turned to 200 mV or 2 V/2000 mV (top left). The readout is the voltage in V.

2. The red lead/wire needs to be hooked into the V/Ω mA port, and the black wire/lead hooked into the COM port.



3. Attach the black wire of your solar cell to the black wire of the multimeter and the red wire of the solar cell to the red lead of the multimeter.

4. Shine various light sources on your solar cell and measure the power (voltage).

5. Record your results in the table on the next page.

Troubleshooting:

- Check dial position.
- Check wire connections (both into the multimeter and on the power source).
- Make sure multimeter batteries are working—use a AA 1.5 V battery as a test.

No-Fuss Solar Oven Procedure

While we think this activity provides more value to the students when they can explore the various oven design parameters, we understand it may be nice to have an idea of a "standard" procedure so that you can help answer questions and provide opinions and guidance. The following procedure can be used as a reference but there are many configurations that will work.

Materials:

1. Cardboard box 1: 12 in. x 12 in. x 6 in. deep
2. Cardboard box 2: 14 in. x 14 in. x 10 in. deep
3. Insulating material: Old newspaper
4. A lid: a third piece of cardboard, a few inches larger all the way around than the top of the smaller box
5. A cooking tray: a fourth piece of cardboard that fits in the smaller box
6. Internal lining: aluminum foil
7. External lining: black paint (with paintbrush)
8. Glue or strong tape
9. Something to prop the lid open: a wire coat hanger
10. Cooking container: transparent oven cooking bags

Building your solar oven:

1. Paint the outside of the larger box and the lid black.
2. Line the inside of both boxes and the lid with aluminum foil (use tape or glue). Attach the lid to the larger box.
3. Put a layer of crumpled up newspaper in the bottom of the large box. Place the smaller box inside and surround with more crumpled up newspaper. This will act as insulation.
4. Cover the smaller piece of cardboard with foil and paint it black. When it is dry place it inside the smaller box.
5. Optional: Use the cooking bag to create a "curtain" that hangs down from the lid and traps light and heat inside your oven.

Cooking with your solar oven:

Place it on a flat, dry surface away from any shadows (or future shadows—your cooker will have to stay shadow-free for many hours). To cook a meal for noon, have your cooker facing southeast and begin cooking between 9 and 10 a.m. To cook a meal for the evening, have your cooker facing southwest and begin cooking between 1 and 2 p.m. For all-day cooking, have your cooker face directly south. To increase the temperature in your pot, place the pot in another cooking bag. There are many different things you can cook but potatoes and hot dogs are commonly used.

Teacher Support Documents

The following resources have been recommended to us by a number of teachers who are a part of our CreositySpace community. While many of them are freely available via a quick internet search, we have included them here for your use. Where possible, we have given credit to the resource's creator.

1. Useful phrases for having constructive discussions
2. Goals for Productive Discussions and Nine Talk Moves (excerpt from TERC's Talk Science Primer, S. Michaels and C. O'Connor)
3. Cooperative learning strategies (A. Venegas)
4. ELPS scaffolds (N. Balayan, 2019)
5. Multidimensional strategies that support English language development
6. Claim-Evidence-Reasoning (C-E-R) student graphic organizer (A. Venegas)
7. Supporting students so that they will be more successful at constructing evidence-based explanations (A. Venegas)
8. Modeling support
9. Graph paper
10. Cross-curricular integration w/template (Teaching From the Inside Out) (T. Paradis)
11. Tips for getting student-directed conversations back on topic

Useful Phrases for Having Constructive Discussions

Asking Clarifying Questions

Can you be more specific?

Can you explain your answer further?

Can you give an example?

Can you please explain your thinking?

Can you repeat what you said?

Could you rephrase that?

Could you say that one more time?

Did I hear you correctly what you said … ?

Did I hear you say … ?

Did I understand you when you said … ?

Is this what you said: __________?

What do you mean by __________?

What's another way you might … ?

What is your evidence?

What resources were used for this project?

Adding to an Idea

I agree with __________because __________.

I agree with __________.

I agree with __________, and I also think __________.

I agree with __________, and would like to add __________.

I agree, but I have an addition: __________.

I believe this is true because __________.

I know that too because __________.

I have something to add; __________.

I think you are right, and I also think __________.

I would like to add to that idea.

This reminds me of __________ because __________.

Yes, that makes sense, and I would also like to add __________.

Respectfully Disagreeing with an Idea

Could you explain, because I have a different idea.

I disagree with that idea because __________.

I disagree with your reasoning because __________.

I disagree with __________ because __________.

I have completely different opinion on that.

I respect your opinion and __________.

I respect your point, and in my opinion __________.

I respectfully disagree because __________.

I see your reasoning and disagree with some of the idea because __________.

That's a good point, and __________.

Goals for Productive Discussions and Nine Talk Moves

Goal: Individual students share, expand and clarify their own thinking

1. Time to Think:
    - Partner Talk
    - Writing as Think Time
    - Wait Time
2. Say More:
    - "Can you say more about that?" "What do you mean by that?" "Can you give an example?"
3. So, Are You Saying…?:
    - "So, let me see if I've got what you're saying. Are you saying…?" (always leaving space for the original student to agree or disagree and say more)

Goal: Students listen carefully to one another

4. Who Can Rephrase or Repeat?
    - "Who can repeat what Javon just said or put it into their own words?" (After a partner talk) "What did your partner say?"

Goal: Students deepen their reasoning

5. Asking for Evidence or Reasoning:
    - "Why do you think that?" "What's your evidence?" "How did you arrive at that conclusion?" "Is there anything in the text that made you think that?"
6. Challenge or Counterexample:
    - "Does it always work that way?" "How does that idea square with Sonia's example?" "What if it had been a copper cube instead?"

Goal: Students think with others

7. Agree/Disagree and Why?:
    - "Do you agree/disagree? (And why?)" "Are you saying the same thing as Jelya or something different, and if it's different, how is it different?" "What do people think about what Vannia said?" "Does anyone want to respond to that idea?"
8. Add On:
    - "Who can add onto the idea that Jamal is building?"
    - "Can anyone take that suggestion and push it a little further?"
9. Explaining What Someone Else Means:
    - "Who can explain what Aisha means when she says that?" "Who thinks they could explain in their words why Simon came up with that answer?" "Why do you think he said that?"

Cooperative Learning Strategies

There are some popular strategies that can be used with all students to learn content (such as science, math, social studies, language arts, and foreign languages). However, they are particularly beneficial to ELLs for learning English and content at the same time. Most of these strategies are especially effective in teams of four.

1. Round Robin
   Present a category (such as names of mammals) for discussion. Have students take turns going around the group and naming items that fit the category.

2. Roundtable
   Present a category (such as words that begin with b). Have students take turns writing one word at a time.

3. Write-Around
   For creative writing or summarization, give a sentence starter (for example, if you give an elephant a cookie, he’s going to ask for...). Ask all students in each team to finish that sentence. Then, they pass their paper to the right, read the one they received, and add a sentence to that one. After a few rounds, four great stories or summaries emerge. Give children time to add a conclusion and/or edit their favorite one to share with the class.

4. Numbered Heads Together
   Ask students to number off in their teams from one to four. Announce a question and a time limit. Students put their heads together to come up with an answer. Call a number and ask all students with that number to stand and answer the question. Recognize correct responses and elaborate through rich discussions.

5. Team Jigsaw
   Assign each student in a team one fourth of a page to read from any text (for example, a social studies text), or one fourth of a topic to investigate or memorize. Each student completes his or her assignment and then teaches the others or helps to put together a team product by contributing a piece of the puzzle.

6. Tea Party
   Students form two concentric circles or two lines facing each other. You ask a question and students discuss the answer with the student facing them. After one minute, the outside circle or one line moves to the right so that students have new partners. Then pose a second question for them to discuss. Continue with five or more questions.

After each cooperative learning activity, you will want to debrief with the children by asking questions such as: What did you learn from this activity? How did you feel working with your teammates? If we do this again, how will you improve working together?

ELPS Scaffolds

Level 1	Level 2	Level 3	Level 4	Level 5
WHOLE CLASS:	WHOLE CLASS:	WHOLE CLASS:	WHOLE CLASS:	WHOLE CLASS:
Minilesson: - Visuals (video) - Stop and ask questions - Wait time - Private reasoning - Clarify vocab - Graphic organizer - Collecting feedback - TPR/realia - Modeling (verbally, in writing, ELMO) - Multiple representations - Analyzing sample work	Minilesson: - Visuals (video) - Stop and ask questions - Wait time - Private reasoning - Clarify vocab - Graphic organizer - Collecting feedback - TPR/realia - Modeling (verbally, in writing, ELMO) - Multiple representations - Analyzing sample work	Minilesson: - Visuals (video) - Stop and ask questions - Wait time - Private reasoning - Clarify vocab - Graphic organizer - Collecting feedback - TPR/realia - Modeling (verbally, in writing, ELMO) - Multiple representations - Analyzing sample work	Minilesson: - Visuals (video) - Stop and ask questions - Wait time - Private reasoning - Clarify vocab - Graphic organizer - Collecting feedback - TPR/realia - Modeling (verbally, in writing, ELMO) - Multiple representations - Analyzing sample work	Minilesson: - Visuals (video) - Stop and ask questions - Wait time - Private reasoning - Clarify vocab - Graphic organizer - Collecting feedback - TPR/realia - Modeling (verbally, in writing, ELMO) - Multiple representations - Analyzing sample work
DIFFERENTIATION:	DIFFERENTIATION:	DIFFERENTIATION:	DIFFERENTIATION:	DIFFERENTIATION:
Group/pair work: - Intentional grouping - Graphic organizer - Structured talk - Sentence frames - Translations - Pictures - Word bank - Multiple pathways Individual work: - Translations - Sentence frames - Graphic organizer - Vocabulary - Different ways to show what they know - Extended time - Making connections between representations	Group/pair work: - Intentional grouping - Graphic organizer - Structured talk - Sentence frames - Translations - Pictures - Multiple pathways Individual work: - Translations - Sentence frames - Vocabulary - Graphic organizer - Different ways to show what they know - Making connections between representations	Group/pair work: - Intentional grouping - Graphic organizer - Structured talk - Sentence frames - Multiple pathways Individual work: - Graphic organizer - Vocabulary - Making connections between representations	Group/pair work: - Intentional grouping - Graphic organizer - Structured talk - Multiple pathways Individual work: - Graphic organizer - Making connections between representations	Group/pair work: - Intentional grouping - Graphic organizer - Structured talk - Multiple pathways Individual work: - Graphic organizer - Making connections between representations

Multidimensional Strategies That Support English Language Development

When planning for instruction, use a variety of strategies, techniques, and materials for making grade-level core curriculum accessible for English language learners while at the same time promoting their English language development. The chart below provides examples of sensory, graphic, and interactive supports for English language development within each lesson. Use at least one strategy from each column daily (for example, when showing videos, use the graphic organizer to take notes in addition to providing students with an opportunity to turn and talk with partners).

Sensory Support	Graphic Support	Interactive Support
Real-life objects	Charts	In pairs or partners
Scientific instruments	Graphs	Small groups
Measurement tools	Tables	Whole group
Physical models	Number lines	Using cooperative group structures
Natural materials	Timelines	Using the internet or software programs
Actual substances	Advanced organizers	In student's native language
Organisms or object of investigation	Drawing	With mentors
Posters/illustrations of processes or cycles	Models	Other
Illustrations and diagrams	Graphic organizers (Venn diagram, T-chart, cycles, cause and effect, semantic web)	
Pictures, icons, and symbols	Other	
Videos and films		
Interactive investigations		
Photographs		

Support is an instructional strategy or tool used to assist students in accessing content necessary for classroom understanding or communication. Support may include teaching techniques, such as modeling, feedback, or questioning. Other types of support involve students using visuals or graphics, interacting with others, or using their senses to help construct meaning of oral or written language. We believe that support is important for all learners to gain access to meaning through multiple modalities, but it is absolutely essential for ELL.

Claim-Evidence-Reasoning (C-E-R) Student Graphic Organizer

Question: ____

C (Claim) Write a statement that responds to the question.	

E (Evidence) Provide scientific data to support your claim. Your evidence should be appropriate (relevant) and sufficient (enough to convince someone that your claim is correct). This can be bullet points instead of sentences.	

R (Reasoning) Use scientific principles and knowledge that you have about the topic to explain **why** your evidence (data) supports your claim. In other words, explain how your data proves your point. (Use paragraph format.)	

Need help with your reasoning?

Follow this path….

Step 1

- Restate your claim.

Step 2

- Provide some scientific principles/knowledge that you already have about the topic.

Step 3

- Provide data from the investigation/research that connects to the scientific principles/knowledge you mentioned in step 2. Show that your data/ information/evidence can be used to prove or support (justify) your claim.

Step 4

- Wrap up your reasoning with a conclusion sentence that begins with a word such as “Therefore,” “Hence,” “Thus,” or “So,” and then restate your claim.

Supporting Students So That They Will Be More Successful at Constructing Evidence-Based Explanations

Setting students up for success

To help students successfully construct evidence-based explanations, it is imperative that you provide support in time for formulating ideas before you ask students to formally talk or write about their final explanations in front of "high-stakes" audiences such as you and the whole class. The following steps have helped me ensure that students have the ideas, skills, language, and confidence necessary for success in my science classes. Everything I've included here came from 10 years of collaboration with numerous specialist at schools where I've worked. When you have a student with special needs or ELL students, I recommend talking about specific strategies that you can try in your classroom. No strategy will work like magic, but overtime you will find ways to support learning for every student.

Step 1: Structured rehearsal time to prethink and prewrite
[This usually last for two to three days about a week before I expect students to have a polished version of their explanations to share publicly.]

STRUCTURED PRETHINKING AND PREWRITING

Students need lots of structure, scaffolding, and time to think about their ideas and to write or draw their ideas in small pieces.

- Prompt students to write or draw their explanation in narrative form like a storyboard. Students should be telling or showing their ideas about the beginning, middle, and end of the phenomenon. For example:

Beginning:	Middle:	End:

WRITING SCAFFOLDS

Use writing scaffolds to support students' writing in the bottom row of their storyboard. I provide a mixture of generic writing scaffolds that students can use in any explanation for any science idea and specific writing scaffolds are only useful in the context of one particular assignment . For example:

1) Sentence starters—help students by giving them a running start for some sentences.
    a. Examples: "The rollerblader starts his gliding motion by…." "One reason this happens is because…." "This made me think that…."

2) Sentence idea banks —help students by prompting specific science ideas for a particular explanation.
    a. Examples: "In your explanation, be sure to use these ideas: push, drag, normal force, friction force,…."
3) Sentence transition phrases—help students by providing connecting words/phrases characteristic of academic writing.
    a. Examples: "In addition,…." "Therefore,…." "But another possibility is…." "Because.…"
4) Science concept cards—help students utilize science terminology while writing.
    a. Examples: Students build a collection of cards with terms, drawings, and student-generated definitions. Students are free to use these cards whenever they are working on tasks in class or on homework assignments. A Word Wall can serve a similar function.

STRATEGIC PARTNERSHIPS

This prethinking or prewriting task can be done individually or in pairs where the partners have been strategically selected to support the specific needs of certain students. The goal when planning strategic thinking or writing partnerships is to distribute the cognitive load across two people without totally removing the cognitive load from either student. It takes time to build a culture where two students have learned how to be good partners. As students develope throughout the year, this scaffolding can be reduced and eventually removed.

- Consider pairing two same language ELL students where one student has developed slightly more advanced English language skills so that students could switch back and forth between languages. Consider allowing ELL students to communicate in a language other than English and work on translating into English later. However, I would not want students to be excluded from using English or excluded from hearing academic English (students need to use and hear academic English in order to learn academic English). Use these pairings sparingly—introduce this practice as students progress throughout the year.
- Consider pairing certain special needs students with patient and helpful students who can serve as sounding boards, writing tutors, or reminders to stay focused. However, remember that there is a lot to consider here:
    - Students won't learn to develop literacy skills (like writing) if they are never allowed to write so I wouldn't have a student serve as the scribe for another student with learning disabilities unless an IEP specifically directed me to do so.
    - I would have Student Services scribe for a student with a physical disability (like when I had a student with cerebral palsy who is unable to write or draw for himself).

Step 2: Rehearsing evidence without adding more writing
[This usually takes one more day.]

Once you have a student-generated artifact representing students' explanatory models, you can ask them "How do you know this part works this way?" and see if students can connect the "parts" of their story to some specific experiences. Students can add these connections to experience and evidence by placing a sticky note with a short phrase on their story board. When working with students who have typically struggled in school, it is important to pay attention to your tone of voice and social cues when asking questions like "How do you know?" Students can interpret this as a challenge or a put down, which can cause them to shut down or become defensive. Instead, explained to students that you want them to figure out how they learned about parts of their explanation and then pose your question.

Step 3: More rehearsal and time to rethink and rewrite
[This usually takes one more day.]

After each student has worked out their ideas, then students should be ready to communicate with a partner or very small group. However, it's probably not safe to try to have vulnerable students try to communicate in front of a whole group yet, so don't skip this step. Pair-sharing or very small group sharing time allows students to do two things: (1) rehearse their own ideas and language with a small audience and (2) grab ideas and language from their peers as well. You should build in some time for students to add to their storyboards, to delete or change their ideas after hearing from their peers.

Step 4: The big performance—talking in front of the whole class and the teacher

Now students might be ready to engage in the official dialogue as outlined in this steps of discourse tool 3. If you have done the prep work described here, students will have already formulated and rehearsed their ideas, gathered their thoughts, and tried out some language. When they are now asked to say things out loud (to you or to the whole group) it's not about trying to think on their feet or speak off the top of their head, it's about telling a story that has been rehearsed a little bit over the previous days of class time. Timeframes for all of these steps will condense of it as students become more proficient and comfortable over the year.

Step 5: The final product—contstructing a polished version of an evidence-based explanation

After all of this, you could ask students to polish up their work from the previous week and write or draw a final draft of their evidence-based explanation.

I often work with colleagues from literacy and language classes to develop science writing, paragraph writing, and essay writing support that is consistent across students' subject areas. Many schools use a writing model to assist students when writing paragraphs and essays.

Modeling Support

General

- Guidance on models, their function and grade appropriate expectations, can be found in Appendix F of the *NRC K-12 Framework*.
- Models should be used as <u>TOOLS</u> to help address the **HOW** and/or **WHY** of various phenomena, concepts, and questions.
    - Models shouldn't be confused with ***<u>representations</u>*** which only identify parts of a concept or phenomenon without addressing the **HOW** or **WHY**.
    - While not complete models, representations can still be useful in supporting learning and understanding.
- Models have limitations. A good model helps to explain and clarify key points or phenomena that are central to the specific learning objective. It gives students a *framework or scaffold* they can use to think about the phenomenon under investigation.

Tips on modeling

- Since models only focus on a portion of a system or phenomenon, it is helpful to provide a checklist for students that clearly states the elements their model should contain. Assigning a specific color to each element can also be a helpful strategy to enable quick and ongoing assessments.
- Models should work towards answering **HOW** and/or **WHY**. They are tools for students to use to work through their understanding and to make their learning (and misconceptions) visible. As a result, **models should be revised and improved over time**.
- When possible, the model should be a tool students use with a subsequent investigation, or to explain a previous observation, versus a standalone activity.

A modeling template is provided on the next page. An electronic copy is available on the unit website.

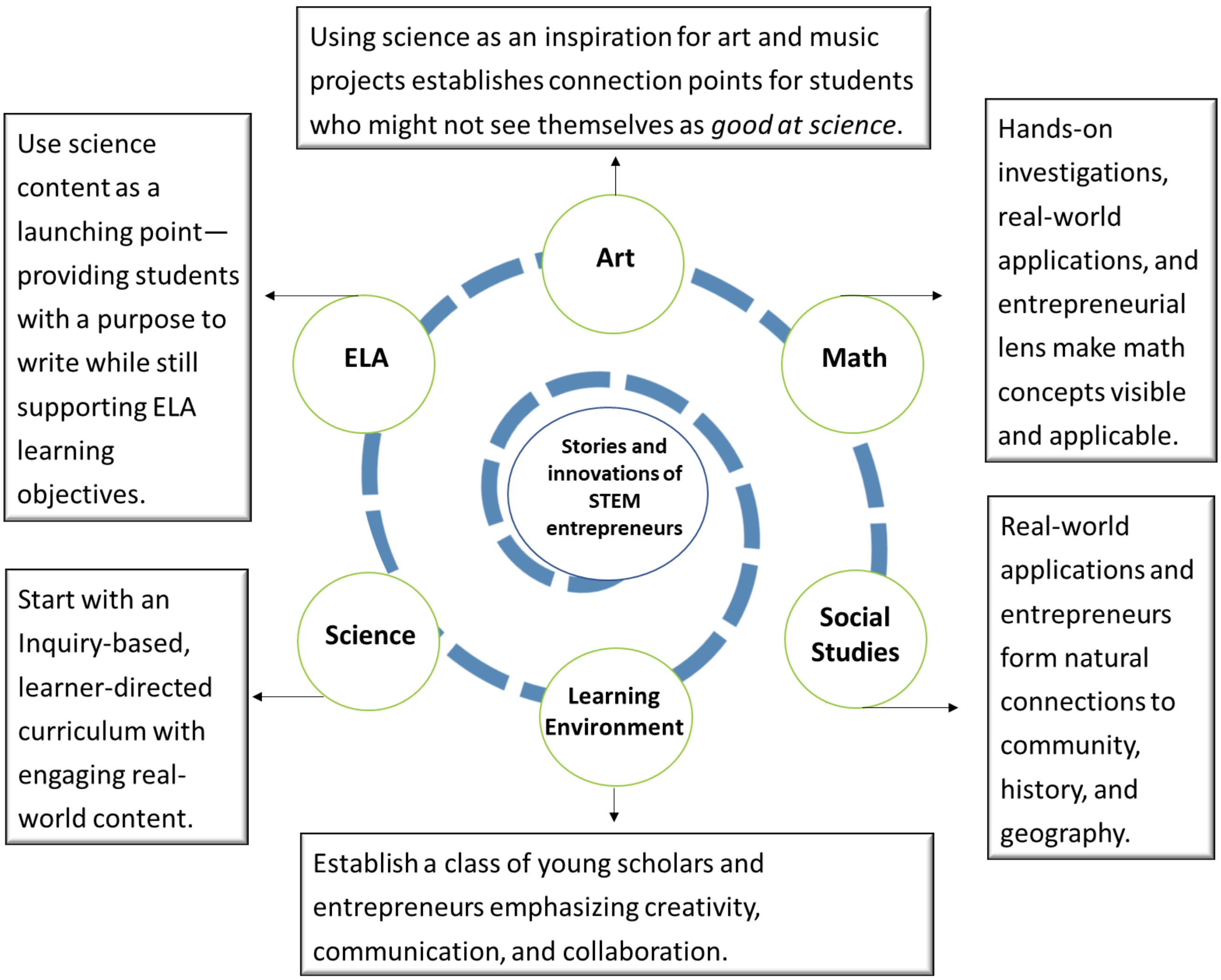
Goal for today: With your partner create an initial model. The model is just to get your first ideas out on paper. We are not aiming for "correct answers." We'll make our models better and more accurate as we learn more. There are MANY different ways to show your theories.

Directions:

1. Talk together and agree on something to include before anyone starts drawing.
2. In each phase—before, during, after—draw and label with words what you **can see** and what you think might be happening that is **unobservable**.

Before	During	After
		Puzzle Box: What questions are puzzling you about this? What would you like to know to improve your model for next time?

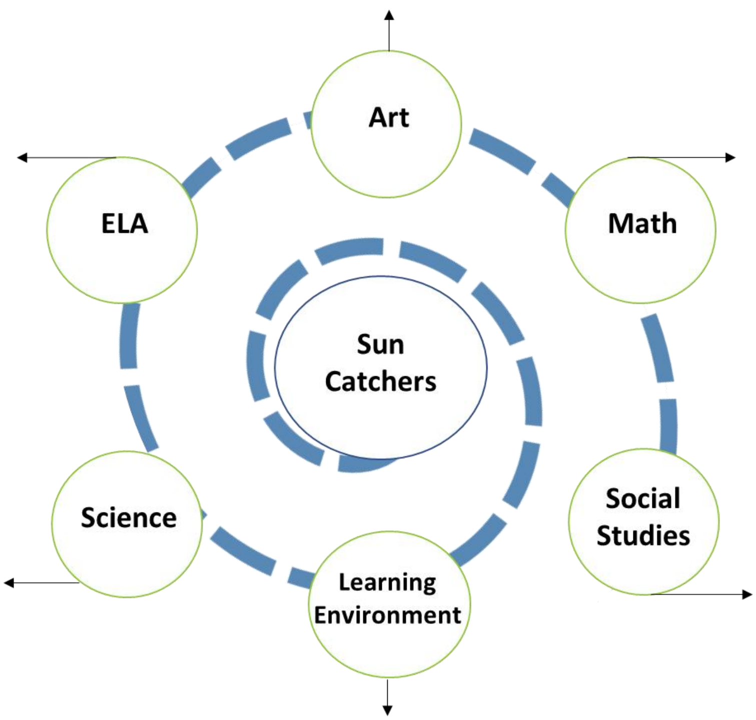
Cross-curriulular Integration Template (Teaching from the Inside Out)



Color Creations and WATTs Cooking? have students combining experimental activities with artistic expression.

In *Star Light, Star Bright* students must research and report on different celestial bodies. This includes describing them via comparisons with our sun and describing what type of seasonal changes might be observed from Earth.

To prepare for the *WATTs Cooking?* design challenge, students must collect, graph, and analyze heat and light intensity data.

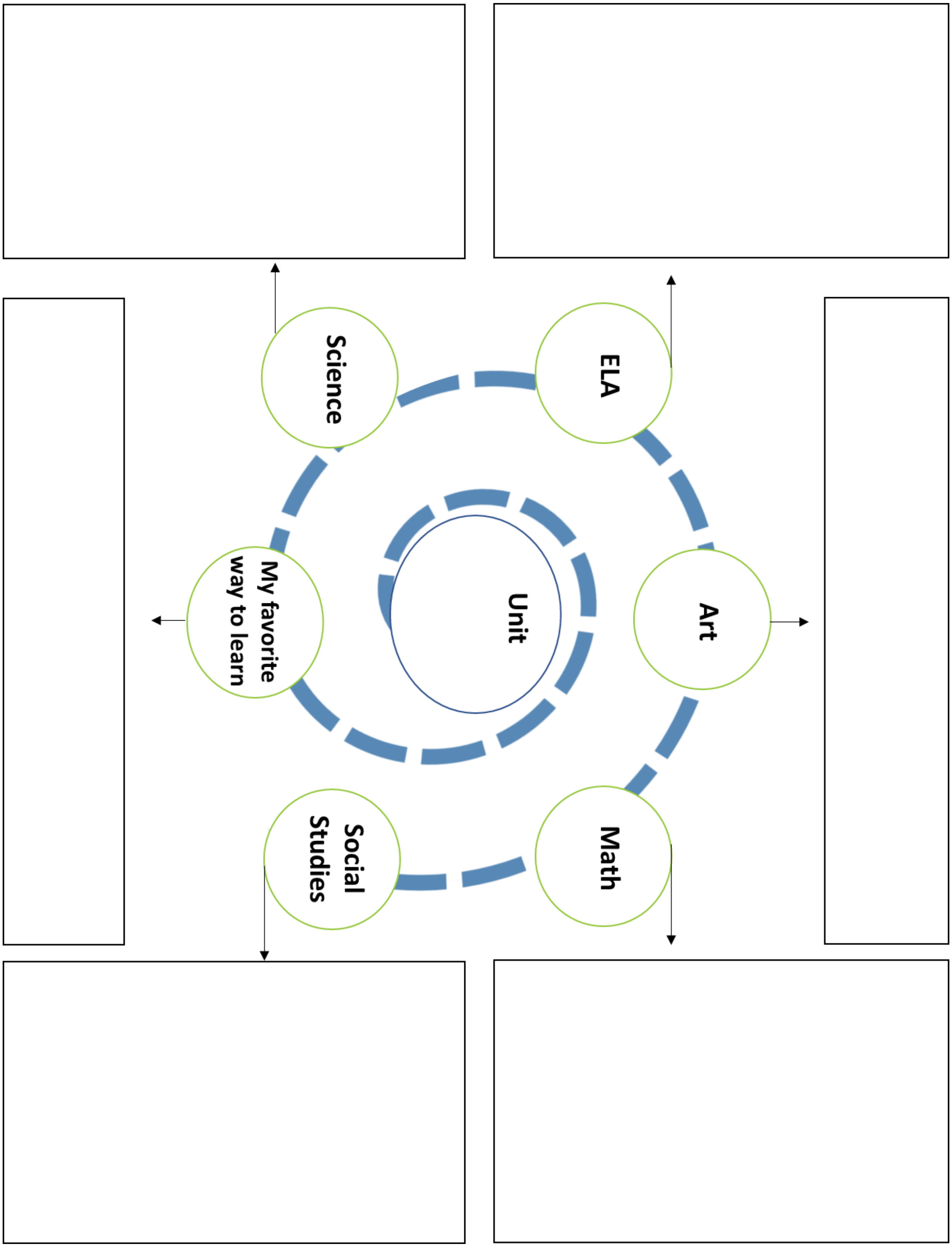


Think about all the different ways you interact with the sun every day. Plants are growing. The living room gets extra hot every afternoon. The grass in the park feels so much cooler than the basketball court. Can you describe what is happening in each case? Can you explain, or build a model that explains, what is happening at a level smaller than you can see?

Scientists, engineering, and entrepreneurs design inventions and businesses to help their communities solve problems. Grid Alternatives and We Care Solar have community centered missions at the core of their businesses. The Solar Solutions summative challenge allows students to explore these, and other, community connections at a deeper level.

How can we use the sun's energy to power our homes and lives? How can we use the sun's energy to solve new challenges and problems? What do we know about the sun that can help us use it to solve problems?


Science
ELA
Learning Environment
Sun Catchers
Art
Social Studies
Math


Science
ELA
My favorite way to learn
Unit
Art
Social Studies
Math

Tips for getting student-directed conversations back on topic

While healthy student-directed discussion is engaging, fun, and informative for students and teachers alike, they can sometimes lead us down a rabbit hole, prompting teachers to ask: "How do I get us back on task?" There is no right or wrong way to do this, but below we list some ideas that you may find helpful.

1. Use the unit phenomenon or theme.

In each unit the investigations, lessons, and discussion prompts all connect to the overarching phenomenon or theme. By asking them directly how the discussion connects back to either of these gives them, or you, a chance to get the conversation back on track. While the specific way you do this will depend on your unique discussion, some ideas are listed below:

- What does this discussion tell us ways in which we can use energy from the sun?
- How does this illustrate different ways we are interacting with the sun?

2. Use one of the essential questions.

The essential questions and enduring understandings associated with each unit are another option for getting conversations back on track. They are generally a little more focused on the specific investigation you are discussing than the overarching phenomenon or theme, so may provide slightly more guidance for your students as they work the discussion back to the task at hand. Some ideas are listed below.

- How does this discussion help us to understand more about how we interact with the sun or how we fit into the universe?
- How can we use this discussion to help us think about using renewable resources?

3. Use one of the standards or objectives connected with the specific investigation are working on.

Finally, a specific standard or stated objective associated with the investigation—these can be found in the Lesson Planning Tools section and are further detailed in the Education Standards section—are a very direct method to focus your students onto the key take-aways from the discussion.

- How does this information help us understand what is happening at a level too small for us to see?
- What are some patterns that might help us use or apply what we've been talking about?

Lesson Planning

The following pages are provided for you to use for lesson planning.

Preparation:

Day/Week	Class Activities

Unit Documents

Fifth Grade Science Sun Catchers—Suggested Number of Days: 50–60			
NGSS/NYSSLS Standards		ELPS Standards or Mathematical Practice	Other Content Standards Connections
Focus Standards	**5-PS1-1**. Develop a model to describe that matter is made of particles too small to be seen. **5-PS3-1.** Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun. **5-ESS1-1.** Support an argument that differences in the apparent brightness of the Sun compared to other stars is due to their relative distances from Earth. **5-ESS1-2**. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. **5-ESS3-1.** Obtain and combine information about ways individual communities use science ideas to protect Earth's resources and environment. **3-5-ETS1-1.** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. **3-5-ETS1-2**. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. **3-5-ETS1-3**. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	**ELPS** **ELP Standard 1:** …construct meaning from oral presentations and literary and informational text through grade-appropriate listening, reading, and viewing… **ELP Standard 2:** …participate in grade-appropriate oral and written exchanges of information, ideas, and analyses, responding to peer, audience, or reader comments and questions… **ELP Standard 3:** …speak and write about grade-appropriate complex literary and informational texts and topics… **ELP Standard 4:** …construct grade-appropriate oral and written claims and support them with reasoning and evidence… **ELP Standard 5:** …conduct research and evaluate and communicate findings to answer questions or solve problems… **ELP Standard 6:** …analyze and critique the arguments of others orally and in writing… **ELP Standard 7:** …adapt language choices to purpose, task, and audience when speaking and writing **. . .** **Standard 8:** …determine the meaning of words and phrases in oral presentations and literary and informational text… **ELP Standard 9:** …create clear and coherent grade-appropriate speech and text…	**ELA Standards** RI.5.2 Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text. RI.5.3 Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text. 5.4 Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a *grade 5 topic or subject area*. W.5.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information. W.5.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly. W.5.4 Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience. W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. SL.5.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 5 topics and texts*, building on others' ideas and expressing their own clearly. SL.5.3 Summarize the points a speaker makes and explain how each claim is supported by reasons and evidence. *Language*: L.5.1 Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. L.5.2 Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. L.5.3 Use knowledge of language and its conventions when writing, speaking, reading, or listening. L.5.4 Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 5 reading and content, choosing flexibly from a range of strategies.
Other Content Standards	**Art Standards (in progress)**	**Math Standards** **MP.1** Make sense of problems and persevere in solving them. **MP.2** Reason abstractly and quantitatively. **5.MD.1** Convert like measurement units within a given measurement system	

<table>
<tr><th colspan="2">Overarching Enduring Understanding—
What are all the different ways we rely on the power of the sun and what is the evidence of its importance in our lives?</th></tr>
<tr><th colspan="2">CONCEPTUAL FLOW OF INSTRUCTION</th></tr>
<tr><td>5-PS1-1
Develop a model to describe that matter is made of particles too small to be seen.
5-PS3-1
Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.
5-ESS1-1
Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.
5-ESS3-1
Obtain and combine information about ways individual communities use science ideas to protect Earth's resources and environment.</td>
<td>5-ESS1-2
Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.
3-5-ETS1-1
Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2
Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS1-3
Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.</td></tr>
<tr><td>Investigation: Some Like It Hot! (hands-on investigation, occurs during week 1)
In this investigation students get their first look at the connection between light and heat. From this they will start building a model to explain their observations based on the fact that matter is made up of particles too small to be seen. They will expand and revise this model throughout the Solar Sleuthing activities. (5-PS1-1)

Investigations: Solar Sleuthing (hands-on investigations, occur during weeks 1, 2, 3, and 4)
In this series of smaller investigations students investigate various attributes of the sun.
In Light. Heat. Motion! students continue exploring the connection between light, energy, and particles. (5-PS1-1)
In Color Creations students investigate different properties of light, light-blocking materials, and the idea of light-sensitive molecules. (5-PS1-1)
In the short research activity Follow the Energy students develop, use, and explain models to describe different ways we use energy from the sun. (5-PS1-1, 5-PS3-1)
In the short research activity Star Light, Star Bright students research and report out on evidence that supports an argument focused on the differences in apparent brightness of the sun compared with other stars (5-ESS1-1) as well as the seasonal changes of some stars in the sky. (5-ESS1-2)
In Solar Circuits students get some hands-on experience with solar cells.
At the end of the series of Solar Sleuthing activities, students must use the knowledge they have gained to develop a model to describe that matter is made up of particles too small to be seen. (5-PS1-1)
Investigation: Solar Solutions (summative challenge, occurs during weeks 5, 6, 7, and 8)
After having discussed and investigated all the different ways the sun plays a role in our lives, students will apply that knowledge toward the development of a solar solution. Working in teams of four or five, students must describe three innovations or discoveries that were made possible by our understanding of the sun that have helped to protect the Earth's resources and the environment. (5-ESS3-1) Then students must describe a problem or challenge that could be solved (or improved) with the help of the sun and design a device or test or similar based on that problem. (5-ESS3-1).</td>
<td>Investigation: WATTs Cooking? (hands-on investigation, occurs during weeks 2 through 6)
Working in groups, students begin this project by researching solar ovens and reporting out on how they work (5-PS-1-1) and their assessment of critical design criteria (3-5-ETS1-1). Groups must then determine their plan for oven construction, build their ovens (3-5-ETS1-2), and determine the plan for testing (3-5-ETS-1-3). Part of their plan must include gathering data (both from reference resources and firsthand) on the sunlight available at different places around the school and throughout the day/year. This includes collecting and tabulating data about patterns in sunlight and shadows (5-ESS1-2). From this data students should finalize and execute their testing plan, reflect on their design, and plan improvements in design or process (3-5-ETS1-3) [Note: Depending on where you are located, it may be fun to perform the testing throughout the year.]</td></tr>
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<tr><th>Essential Questions</th><th>Unit Assessments</th></tr>
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How can you use solar energy, or the sun in general, to solve a challenge in your life?

How do we get energy from the sun? (5-PS1-1, 5-PS3-1)

How do with interact with the sun every day? (5-ESS1-2, 5-ESS3-1)

How can we use the sun's energy to power our homes and lives? (5-PS1-1, 5-ESS3-1)

How does the sun teach us about the universe? (5-ESS1-1)

Solar Sleuthing (5-PS1-1 5-PS3-1 5-ESS1-1)
There are many questions throughout the lessons. Students will be focusing on the following:

What are your observations with the radiometer? Why do you think this is happening? Why is it important there is some air inside the radiometer?
What did you discover about materials and their ability to block UV light? What type of pattern or trend would help you to predict which materials will block UV light?
What is something interesting about stars other than the sun?
What are some similarities and differences between the sun and other stars?
How does energy from the sun get to plants, animals, and humans?

WATTs Cooking? (3-5-ETS1-1 3-5-ETS1-2 3-5-ETS1-3 5-ESS3-1)
There are many questions throughout the lessons. Students will be focusing on the following:

How does a solar oven work?
What are the key design criteria and constraints for building a solar oven?
What factors must you consider when testing a solar oven? What time of day and/or year might be better to test the solar oven?
What could you improve in the design or testing of your solar oven?
What is your favorite type of cookie? Can you cook it in your solar oven?

Solar Solutions (5-ESS3-1)

What are three discoveries that have been made possible by our understanding of the sun?
What is a current problem or challenge that may be helped by using some properties of the sun?
How would you use the sun to help solve or improve the above challenge or problem?

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Formative
Exit Tickets

Name and describe three ways we can get energy directly from Earth.
Why do you think it important to use renewable sources of energy?
Name and describe two ways we can get energy from the sun.
In your own words describe the difference between active and passive solar energy.
Why do you think there are more solar cells in Florida and Arizona than in New York or Washington State? Which months of the year might it be better for solar energy in Washington and why?
Describe two things you found interesting about stars and/or outer space and why those things were interesting to you.
Describe three ways the sun helps your community.

Shorter activities

Follow the Energy (week 2)
Timeline activity on understanding the sun
Star Light, Star Bright mini research project
OLA/summary charts Solar Sleuthing Investigations 1A, 1C, and 1E (weeks 1, 2, and 4)
Solar Sleuthing cumulative model (week 4)

Writing prompts and reading comprehension questions

Introductory phenomenon: Why is it colder in the shade? How can we use the sun to cook a cookie? How do solar panels use the sun to make electricity?
Other than the roof of your house or school, name a place you'd like to put a solar cell and describe why you would put it there.
What kind of energy would you use (and why) if you lived in the following places?

Near a large waterfall (Niagara Falls, Niagara-on-the-Lake)
Near a volcano (Reykjavik, Iceland)
In a city with very little rain (Aswan, Egypt)

Summative
Solar Sleuthing
5-PS1-1 Develop a model to describe that matter is made of particles too small to be seen.
5-PS3-1 Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.

Midway through the series of Solar Sleuthing investigations (after Follow the Energy) students are required to develop a pictorial information chart in which they illustrate a model the transfer of energy from the sun to an example of (a) active solar energy, (b) passive solar energy, and (c) the energy in the food of an animal. (5-PS3-1).

Upon completion of all the Solar Sleuthing investigations, students are required, using the method of their choice (PIC, song, story, interpretive dance, etc.), to create a model that draws upon their learnings from the Solar Sleuthing investigations to provide evidence that matter is made up of particles too small to be seen. (5-PS1-1)
Historical Timeline
5-ESS1-1 Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.

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	5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect Earth's resources and environment. As students are finishing up their Solar Sleuthing investigations and getting ready for the summative challenge, they must create a timeline about how our understanding of the Earth, sun, and stars has resulted in discoveries that have impacted all of society. **WATTs Cooking?** **5-ESS1-2** Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. **3-5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. **3-5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. **3-5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. Students must **build, test, and evaluate** a solar oven. Prior to testing they will **gather and graph** data on sunlight, sun intensity (light and heat), and shadows around the school to determine daily patterns and the best time and location to test their ovens **Solar Solutions Summative Challenge** **5-ESS3-1** Obtain and combine information about ways individual communities use science ideas to protect Earth's resources and environment. To finish off this unit student must both obtain and discuss information about how advancements in understanding the different ways the sun plays a role in our lives as well as determine a sun related solution to a problem or challenge.

Common Misconceptions:

The following lists contains possible student misconceptions around concepts related to or discussed in this unit:

- Stars and constellations appear in the same place in the sky every night.
- The sun rises exactly in the east and sets exactly in the west every day.
- The sun is always directly south at 12:00 noon.
- The tip of a shadow always moves along an east-west line.
- We experience seasons because of the earth's changing distance from the sun (closer in the summer, farther in the winter).
- The earth is the center of the solar system. (The planets, sun, and moon revolve around the Earth.)
- The moon can only be seen during the night.
- The moon does not rotate on its axis as it revolves around the earth.
- The phases of the moon are caused by shadows cast on its surface by other objects in the solar system.
- The phases of the moon are caused by the shadow of the Earth on the moon.
- The phases of the moon are caused by the moon moving into the sun's shadow.
- The shape of the moon always appears the same.
- The earth is the largest object in the solar system.
- The solar system is very crowded.
- The solar system contains only the sun, planets, and moon.
- Meteors are falling stars.
- Comets and meteors are out in space and do not reach the ground.
- The surface of the sun is without visible features.
- All the stars in a constellation are near each other.
- All the stars are the same distance from the Earth.
- The galaxy is very crowded.
- Stars are evenly distributed throughout the universe.
- All stars are the same size.
- The brightness of a star depends only on its distance from the Earth.
- Stars are evenly distributed throughout the galaxy.

- The constellations form patterns clearly resembling people, animals, or objects.
- There is no relationship between matter and energy.
- If energy is conserved, why are we running out of it?
- Children who have used measuring devices at home already know how to measure.
- Some objects cannot be measured because of their size or inaccessibility.
- The five senses are infallible.
- An object must be "touched" to measure it.
- Objects float in water because they are lighter than water.
- A white light source, such as an incandescent or fluorescent bulb, produces light made up of only one color.
- Sunlight is different from other sources of light because it contains no color.
- Heat is a substance.
- Heat is not energy.
- Temperature is a property of a particular material or object. (Metal is naturally cooler than plastic.)
- The temperature of an object depends on its size.
- Heat and cold are different, rather than being opposite ends of a continuum.
- Boiling is the maximum temperature a substance can reach.
- Ice cannot change temperature.
- Light is associated only with either a source or its effects. Light is not considered to exist independently in space, and hence, light is not conceived of as "travelling."
- An object is "seen" because light shines on it. Light is a necessary condition for seeing an object and the eye.
- Lines drawn outward from a light bulb represent the "glow" surrounding the bulb.
- A shadow is something that exists on its own. Light pushes the shadow away from the object to the wall or the ground and is thought of as a "dark" reflection of the object.
- Light is not necessarily conserved. It may disappear or be intensified.
- Light from a bulb only extends outward a certain distance, and then stops. How far it extends depends on the brightness of the bulb.
- The effects of light are instantaneous. Light does not travel with a finite speed.

The following links provide some reference on common misconceptions around science and scientific facts in general:
http://static.nsta.org/connections/elementaryschool/201209AppropriateTopics-ElementaryStudentScienceMisconceptions.pdf
https://secure.lcisd.org/GlobalImages/Children%20Misconseptions%20%20PDF.pdf
http://amasci.com/miscon/opphys.html
http://newyorkscienceteacher.com/sci/pages/miscon/index.php

Core Resources	Intervention Resources	Enrichment Resources
CreositySpace Educator Guides *Sun Catchers* **Student Notebooks** *My STEM Explorer Notes™* *My STEM Stories™* **CreositySpace Online Resources** *Sun Catchers* Digital Forum **CreositySpace Videos** *Solar Sleuthing How-to Video* **Sun Catchers Activity Kit** Radiometers, light meter, multimeter, breadboards, wires, solar panels, LEDs, resistors, buzzers, UV-sensitive beads, UV-flashlights, various crafting supplies Books: DK Eyewitness Books: Universe DK Books: Space: A Visual Encyclopedia National Geographic: Everything Space	Suggestions and rubrics for a variety of methods for students to demonstrate knowledge. Student organizers and documents provided in the Appendix: • Useful phrases for having constructive discussions • Cooperative learning strategies • ELPS scaffolds • Multidimensional stratgies that support English language development • Claim-Evidence-Reasoning (C-E-R) student graphic organizer • Supporting students so that they will be more successful at constructing evidence-based explanations	Additional summative challenges Additional writing prompts and investigations

Supplemental Resources
Light sources, cardboard boxes, insulation materials (e.g., newspaper), black paint, white paint, glue or strong tape, something to cook in the solar oven

Additional Online Resource to Support the Teaching of this Unit See Additional Resources section above	
Routines and Rituals	**Supports for Academic Discourse:** Brainstorming Justification (evidence) criteria in opinion writing pieces Feedback guidelines/useful phrases for having constructive discussions **Supports for Metacognition:** Summary tables Student graphic organizers Summative challenges—exhibition checklists **Supports for Questioning:** KWHLAQ charts Pictures (What do you see? What do you know? What do you want to know?) Innovation and brainstorming prompts. Additional background information for teachers
Technology Skills and Tools	Online research Presentation development (optional)