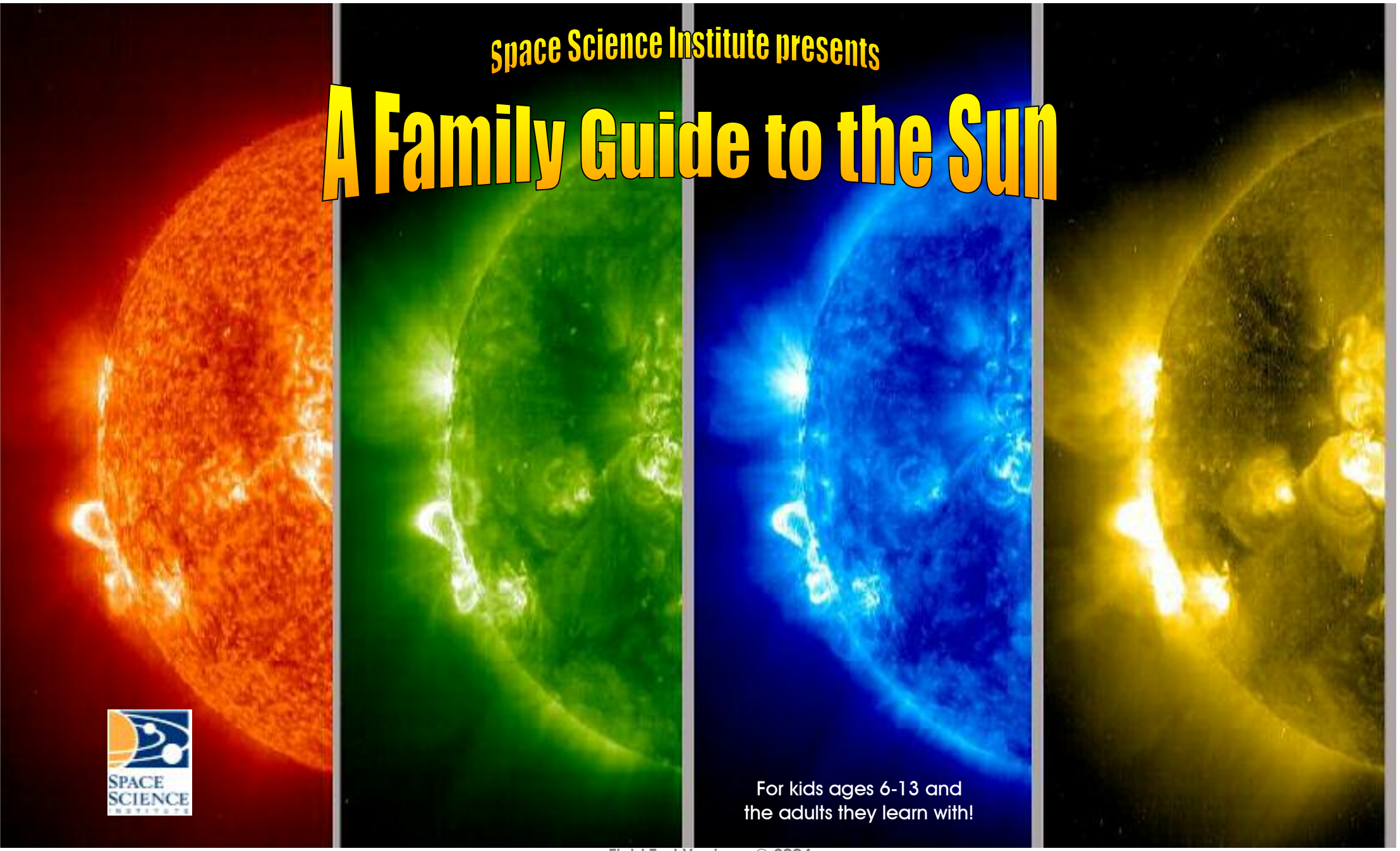

Space Science Institute presents

A Family Guide to the Sun

SPACE SCIENCE INSTITUTE

For kids ages 6-13 and
the adults they learn with!

FROM THE DEVELOPMENT TEAM

Dear Learning Enthusiast,

Welcome to the Family Guide to the Sun!

We invite you to use the diverse activities and resources here to have fun learning about the Sun – the star at the center of our Solar System*!

The Guide includes an innovative collection of puzzles, pictures, poetry, and projects, all designed to stimulate enjoyable co-learning experiences between kids aged 6-13 and the caring adults in their lives.

Much learning in life takes place in informal environments outside the classroom. We envision this Guide being of value wherever kids and adults find themselves together and excited about learning.

Before getting started, we strongly urge adults to read the "Tips to Guide Your Child's Enjoyment of Learning" (p. 4). It is very important to realize that being a good learning companion to kids is NOT the same as being the expert who tells all the answers.

Whatever your age or background, we firmly believe that just one significant experience of the joy of discovering something for yourself can vastly enhance your confidence and interest in learning for the rest of your life.

The Guide assumes little or no prior knowledge about the Sun or astronomy in general.

The Guide's content develops and re-enforces four overall themes:

- The Sun as a star
- The Sun's connection to life on Earth
- The Sun's "motion" in Earth's sky
- The Sun's 11-year cycle of activity

We encourage you to begin with the Fill-in-the-Blanks Game on p. 16-17 to warm up your minds and hearts to the Sun and its place in the Universe.

Be sure to check out the FAQ at the back of the Guide, which provides general background on the Sun, with questions posed as kids tend to ask them. We crafted the "Gee Whiz" Facts to elicit the irresistible urge to tell someone else about them. Look for terms from the Glossary (on p. 42) throughout the Guide – they are marked with an asterisk*.

We want this Family Guide to be the best it can be. We sincerely hope you will explore its riches and tell us about your experience.

The Development Team

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TABLE OF CONTENTS

TIPS TO GUIDE YOUR CHILD'S ENJOYMENT OF LEARNING

Be a guide on the side!

This Family Guide is intended to assist you in sharing **the joy of exploration and discovery** with the children in your life. It is a wonderful gift to enjoy our minds at play!

1. Children are naturally curious and enthusiastic to learn about the world around them. Listen to their ideas and opinions – they will fascinate you! Encourage your child's inclination to observe, wonder, and investigate.

2. The resources and activities in the *Family Guide to the Sun* can assist you in making enjoyable connections between the Sun and real places and experiences in your home, neighborhood, and recreational settings.

3. You can be a good teacher, even if learning about the Sun is new to you. Good teachers introduce ways to find the answers, rather than presenting themselves as a source of all information.

4. Help your child learn how to ask questions by asking questions yourself. You are a powerful role model. Even if you don't know the answer, you can explore *with* your child to find answers together.

5. If you *do* know the answer, it is often valuable to ask leading questions that guide a child to discover something new for themselves.

6. The *Toy Dog Dialogue* on the facing page offers one example of how a caring adult can lead children to discover a new and enriching perspective.

7. Encourage your children to use different dimensions of their intelligence to record their impressions and observations. Telling stories, drawing pictures, creating poems or songs, making a photo album or collage, recording a video, and writing in a journal are all ways to remember and share information. Also, watch for *Star Challenges* throughout the Guide.

IT MOVES BECAUSE THE SUN SHINES

Adapted from physicist Richard Feynman's 1966 speech to the National Science Teachers Association, titled "What is Science?"

The Toy Dog Dialogue

Child: Why does the toy dog move?

Adult: It moves because the sun is shining.

Child: No it doesn't. What does that have to do with the Sun shining? The toy dog moves because I wind up the spring.

Adult: Yes, but why are you able to move to wind up the spring?

Child: Because I eat.

Adult: Okay…what do you eat?

Child: I eat food.

Adult: Where does that food come from?

Child: Plants and trees…

Adult: And how do plants and trees grow?

Child: Aha! They grow because the Sun is shining….

Adult: Right! So both you and the toy dog move because the Sun is shining.

You can use this idea to enjoy connecting sunshine to many other moving things on Earth.

For example, cars and trucks move using gasoline, which comes from the accumulated energy of the Sun captured by plants and preserved in the ground as oil.

The air moves, making the wind, because the Sun heats some places on Earth more intensely than others. Water moves, making streams and waterfalls, because the Sun melts the snow and ice at higher elevations.

STAR CHALLENGE

Look around you at things that move and grow. See how many of them you can trace back to being because "the Sun shines"!

NAMES FOR THE SUN IN DIFFERENT LANGUAGES AROUND THE WORLD

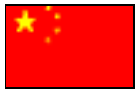
The same Sun that travels across your sky each day shines down on people all across the planet! Here are a few of the names the Sun is known by in other languages…

My language is : _____

My language is : _____

My language is : _____

Arabic*
Shams



Chinese
Taiyang

Danish
Sol

Dutch
Zon

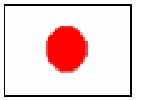
French
Soleil

German
Sonne

Greek
Helios

Hawaiian
La

Italian
Sole



Japanese
Taiyo

Lakota
Anpetu wi

Navajo
Sha

Russian
Solnce

Spanish
Sol

Swahili**
Jua

Turkish
Güneş

My language is : _____

My language is : _____

My language is : _____

STAR CHALLENGE

You can learn more names for the Sun at:
http://www.mreclipse.com/Special/SElanguage.html

* We have chosen to display the flag of Saudi Arabia because of its cultural significance to the Arabic speaking world.
** This is the flag of Tanzania, where Swahili is an official language.

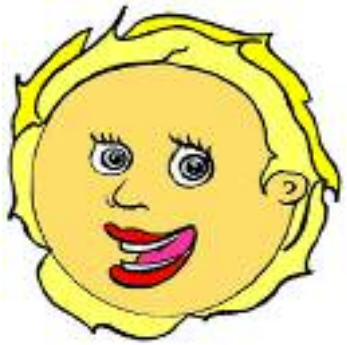
INTRODUCING SOLAR MAXIMUM* AND MINIMUM*

People all around the world have a name for the Sun.
But naming something is not the same as knowing …

Hi! I'm Max. Some people say I'm a cool guy with a very "magnetic" personality. Maybe I should have a nickname like "Cool Max" or "Magnetic Max"!

Max is a wild and rambunctious guy! He is named in honor of solar maximum – the most active part of the Sun's 11-year sunspot cycle. During solar maximum, the Sun's surface and atmosphere are very magnetically active. There are many sunspots (see Max's freckles) and a higher chance of violent solar storms that can enhance auroras, damage satellites, endanger astronauts and cause power blackouts.

The Sun near solar maximum.



Hello! My name is Minnie. Most people agree that I'm really bright, even though I'm usually quiet as a mouse.

Minnie is a calm and peaceful gal. She is named in honor of solar minimum*, the quiet part of the Sun's 11-year sunspot cycle. During solar minimum, there are fewer solar storms and fewer sunspots (see Minnie's fair complexion).

The Sun near solar minimum.

INTRODUCTION TO THE SUN

The Sun is a seething ball of energy with several distinct layers...

1. Core: The core produces colossal amounts of energy, including all of the Sun's light and heat. Here the temperature and pressure are so great that hydrogen atoms are squeezed together to form helium. This reaction is called nuclear fusion.

2. Radiation zone: In the radiative zone, energy from the core slowly travels outward. This region is so dense that the Sun's energy takes about 150,000 years to work its way through.

3. Convection zone: In the convection zone, rising and falling currents carry heat from the radiative zone to the surface. This nonstop churning is similar to what happens when you boil water on a stove.

4. Photosphere: The photosphere is what our eyes perceive as the visible surface of the Sun. Here, energy escapes from the interior and streams into the Sun's atmosphere and beyond. The photosphere is home to dark sunspots*.

5. Sunspots: Dark blemishes on the Sun's surface. Sunspots are cooler than the area around them.

6. Chromosphere: The chromosphere is a turbulent layer of the Sun's atmosphere just above the photosphere. It is home to magnificent arcs of gas called prominences* and tremendous explosions of energy called solar flares. It gives off most of the ultraviolet (UV) light of the Sun.

7. Flare: Intense explosions on the Sun that spew enormous amounts of energy into space.

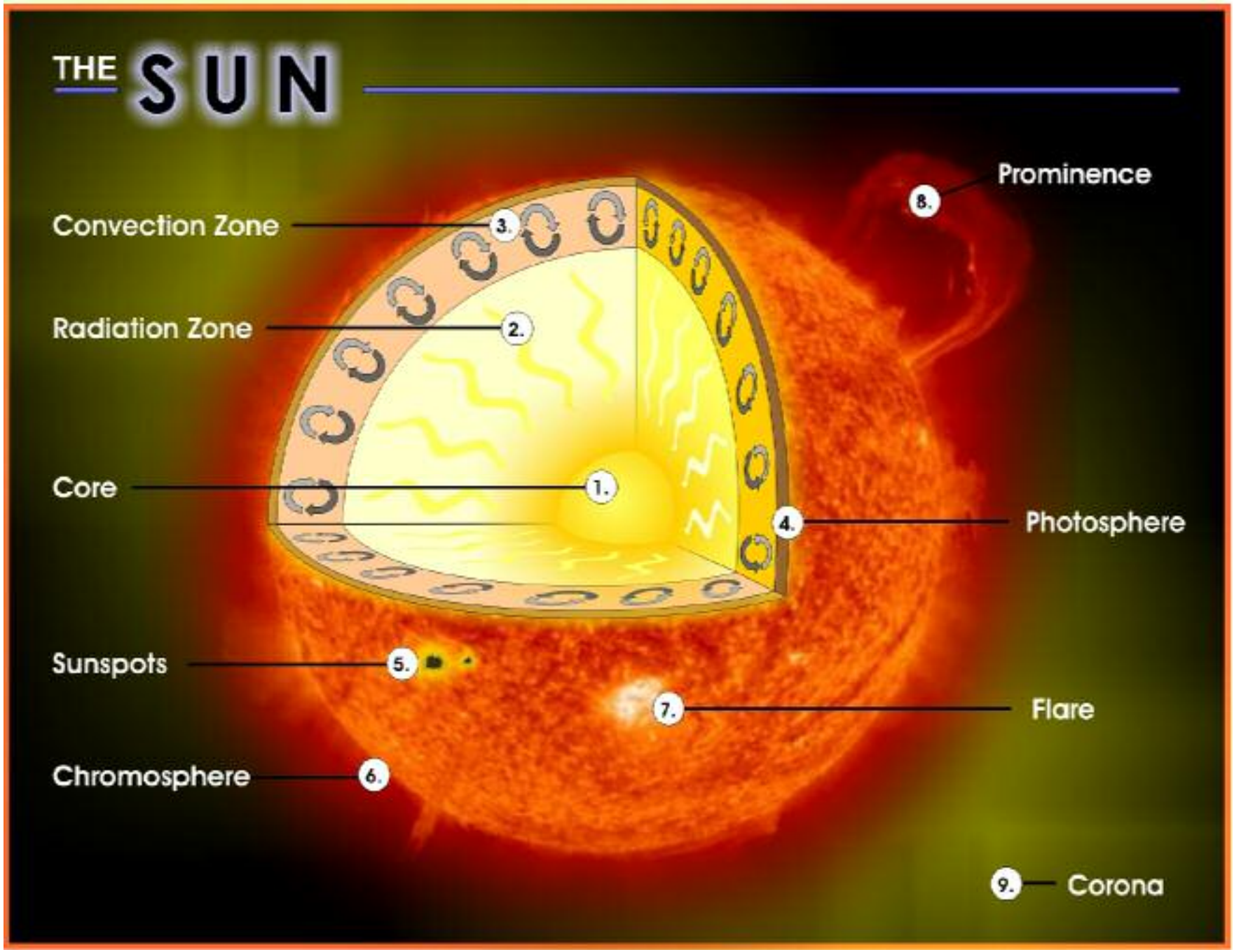
8. Prominence: Great looping arcs of hot gas that erupt from the Sun.

9. Corona: The corona is the Sun's extended outer atmosphere. It is the luminous white halo visible in a photo of a total solar eclipse*. Mysteriously, the corona is much hotter than the surface of the Sun, so hot that it also produces a type of light called X-rays.

See REAL images of the layers of the Sun's atmosphere on p. 14!

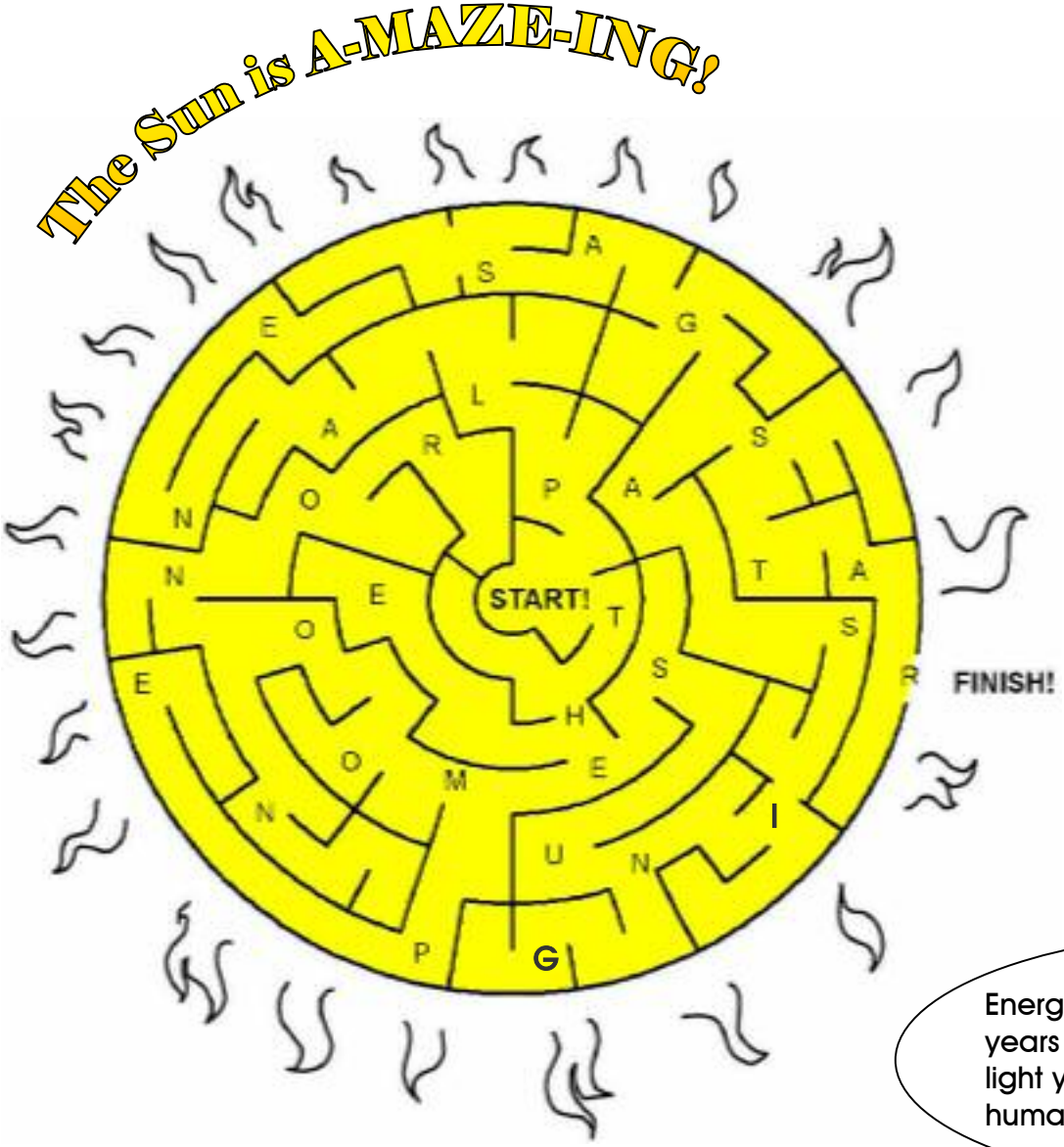
STAR CHALLENGE

Draw your own AMAZING picture of the Sun. It could be displayed online! Visit http://solar-center.stanford.edu/art.html to find out how to submit your artwork to the Stanford Solar Center web site!


THE SUN
Prominence
8.
Convection Zone
3.
Radiation Zone
2.
Core
1.
4.
Photosphere
Sunspots
5.
7.
Flare
Chromosphere
6.
9.
Corona

CAN YOU ESCAPE FROM THE SUN?

You are a photon of light… Make your way out of the Sun's core* and into space!
Pick up letters along the way to spell out a special message about the Sun. (Take a look at Gee Whiz fact #15 on p. 39.)



MESSAGE

___ ___ ___

___ ___ ___

___ ___ ___

___ ___ ___ ___ !

Energy from the Sun's core takes 150,000 years to reach the photosphere*. So the light you see today was produced when humans were still in the stone age!

CHECK OUT FREQUENTLY ASKED QUESTIONS ABOUT THE SUN!

How BIG is the Sun?

What is the Sun made of?

STAR CHALLENGE

Want to know the answers to these and more questions about the Sun? Check out the FAQ, starting on page 34!

How far away is the Sun?

Will the Sun ever become a BLACK HOLE?

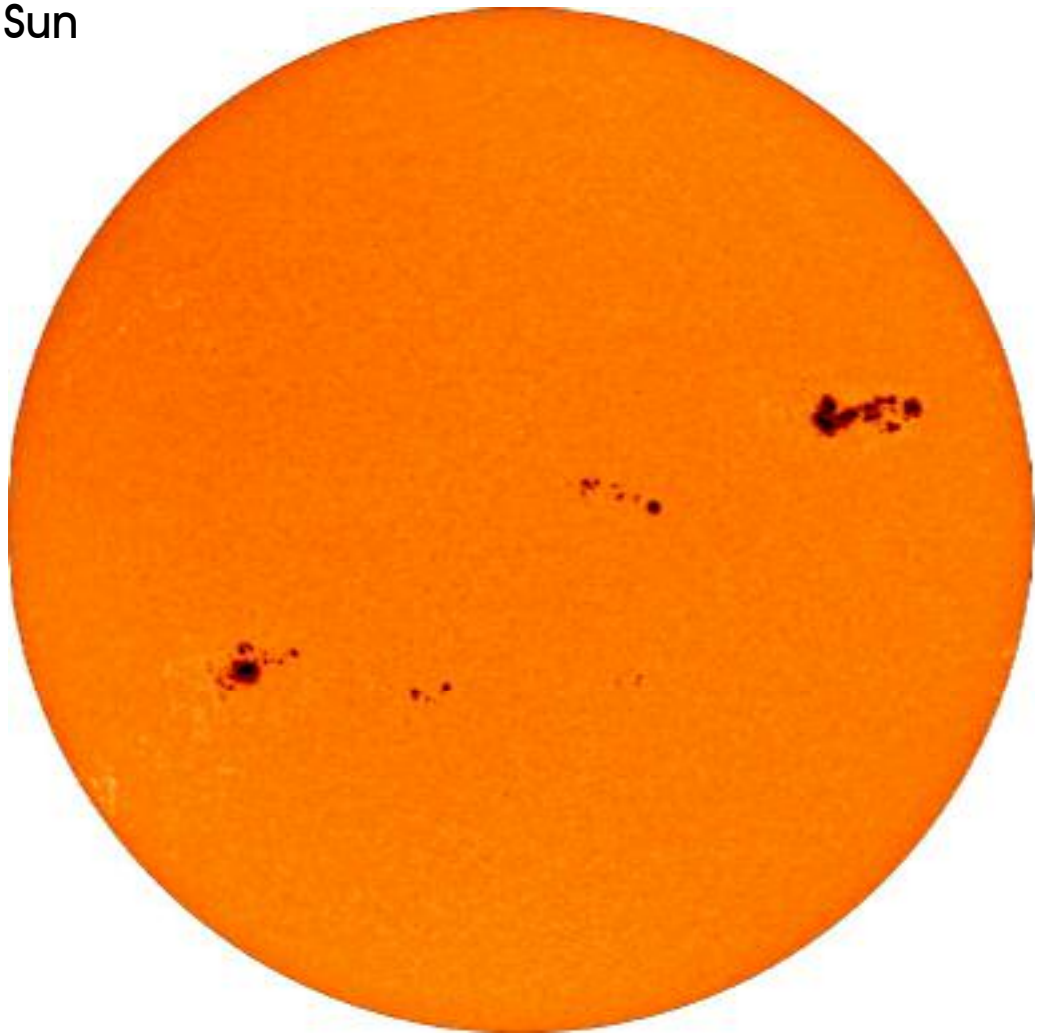
How OLD is the Sun?

Is the Sun on Fire?

SCALE MODEL OF THE SUN, EARTH AND MOON

HEY! CUT IT OUT!

Sun



Here are images that show the relative size of Earth compared to the Sun. Earth is tiny isn't it? This page is too small to show the proper scale distance from Earth to the Sun - that part is up to you!

First, cut out the images. Then measure about 50 feet (15 meters) from the Sun to the Earth. Now you have your own scale model!

Moon Earth

Is the Sun nearer or farther away than you thought? Remember, each foot in your model represents about 2 million miles (3.2 million kilometers) in space!

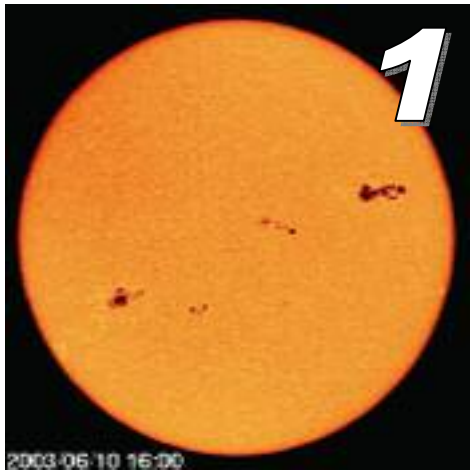
DRAW YOUR OWN PICTURE OF THE SUN!

Try to draw: **SUNSPOTS** **PROMINENCE** **FLARE** **CORONA**

See pages 8 and 9 to learn more about these features!

LAYERS OF THE SUN

Can you match the labels in the center with the correct pictures?
Hint: use the temperatures and the clues from the electromagnetic spectrum on the next page…



The "surface" of the Sun – the photosphere
TEMP° 10,000F, 6000Kelvin

X-RAY

Image # _____

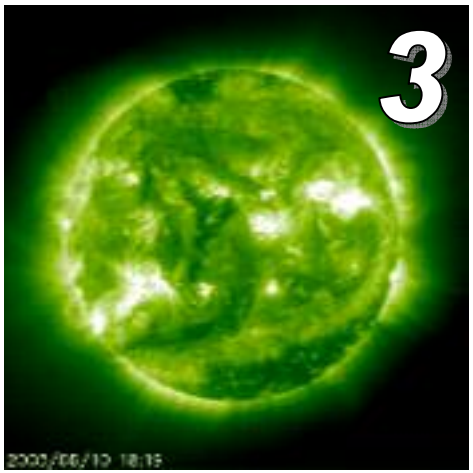
ULTRA-VIOLET

Image # _____

The chromosphere – Just above the photosphere
TEMP° 7500F, 4000Kelvin

VISIBLE LIGHT

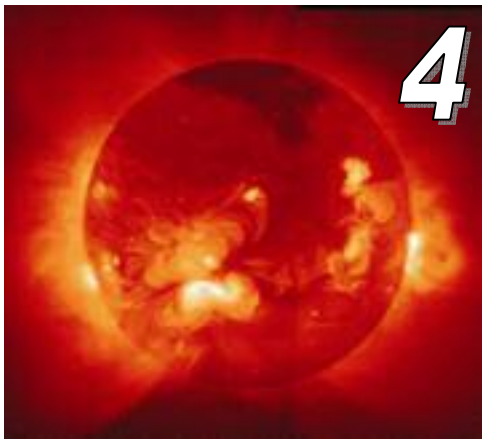
Image # _____



The upper chromosphere
TEMP° 17,500F, 9700Kelvin

EXTREME ULTRAVIOLET

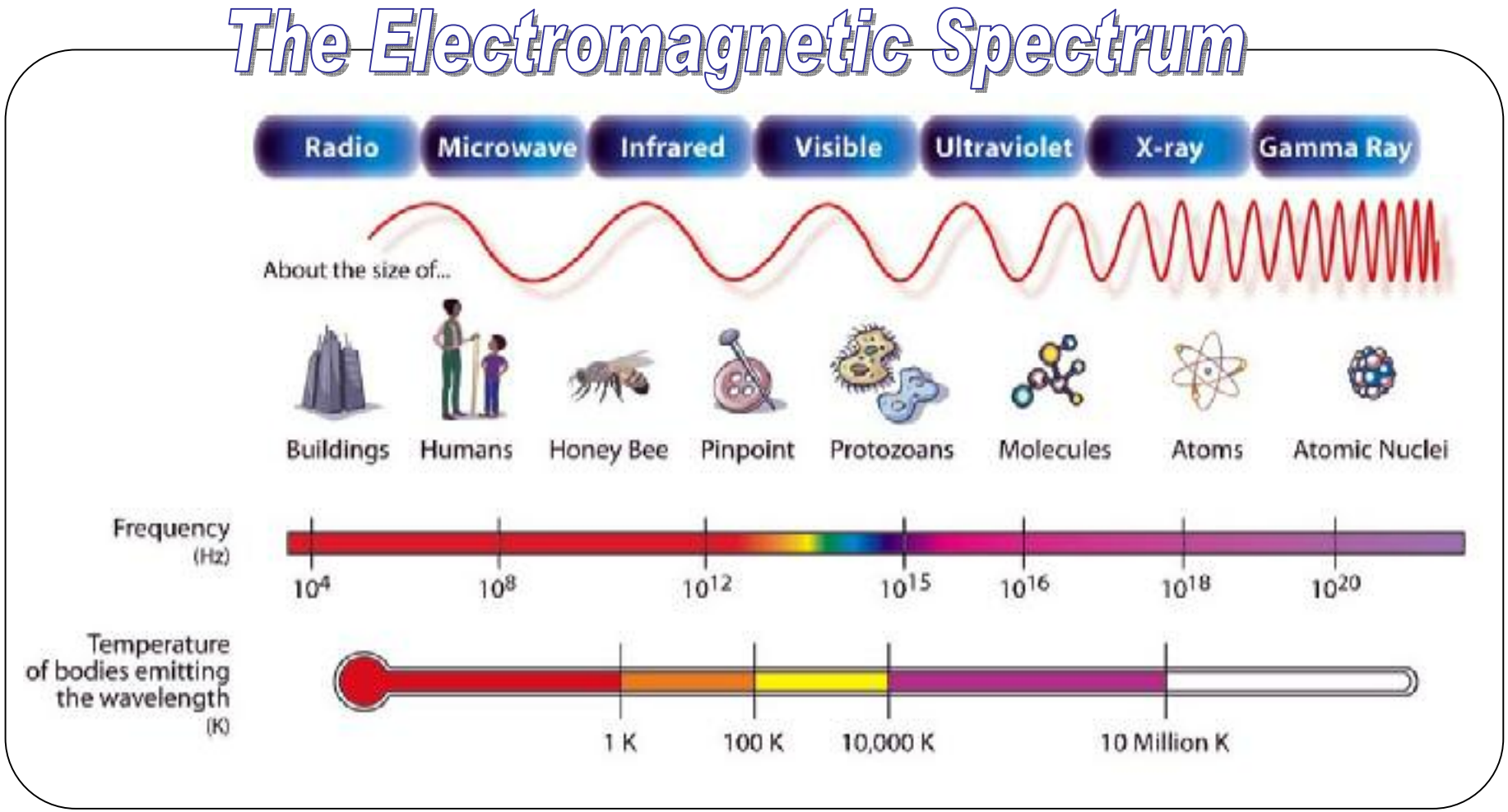
Image # _____



The corona – the outermost layer
TEMP°1-2 million (F and Kelvin)

LAYERS OF THE SUN

There's more to light than meets the eye! Different kinds of light have different names, different wavelengths, different frequencies, and different temperatures. Use this diagram to help you match the pictures and labels of the Sun.



ANSWERS:

X-Ray – 4 Ultraviolet – 2 Visible Light – 1 Extreme Ultraviolet - 3

SUN-EARTH CONNECTIONS

Which of these have you seen with your own eyes?

Sunset

Earth blocks light from the Sun.

Rainbow

Sun shines on water droplets in the air.

Total Solar Eclipse

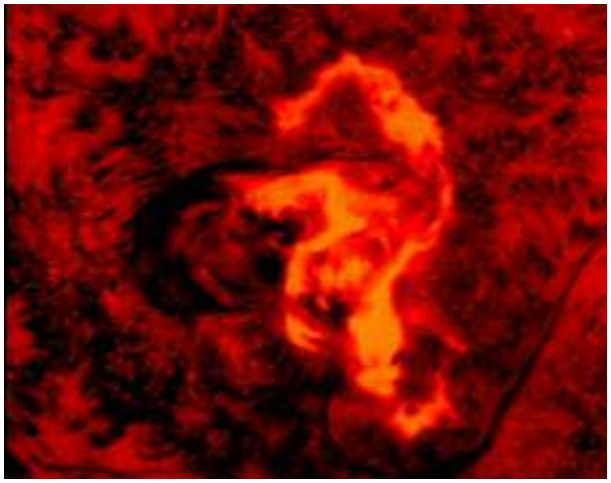
Moon blocks light from the Sun.

Aurora

Eerie glow caused by the solar wind.

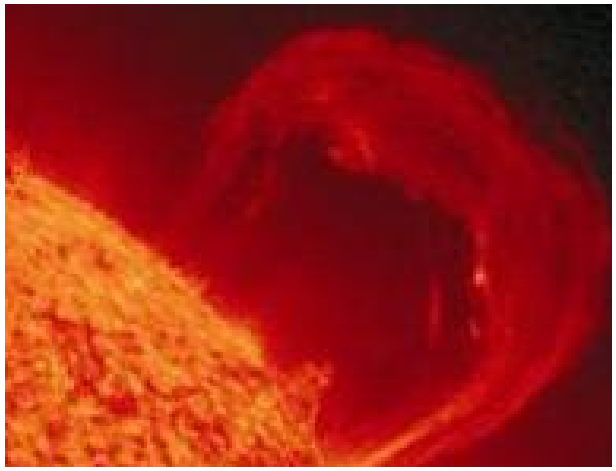
STORMS OF THE SUN

Try to match the three basic types of solar storms with how big the Earth would be in each picture.
These storms can have significant effects on Earth. (See Gee Whiz fact #6, p. 38)



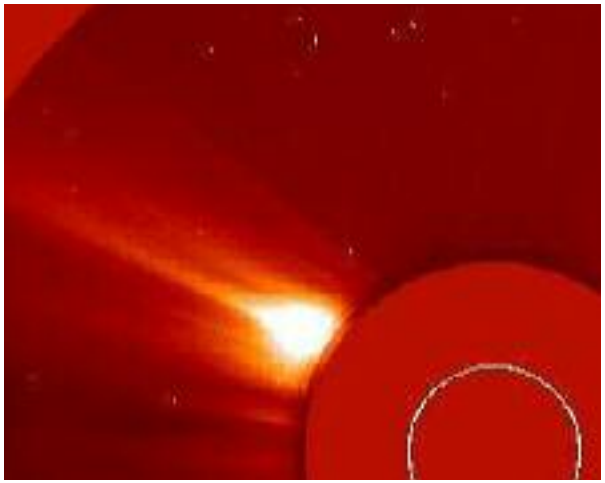
Solar Flare – **explosions on the surface**

1



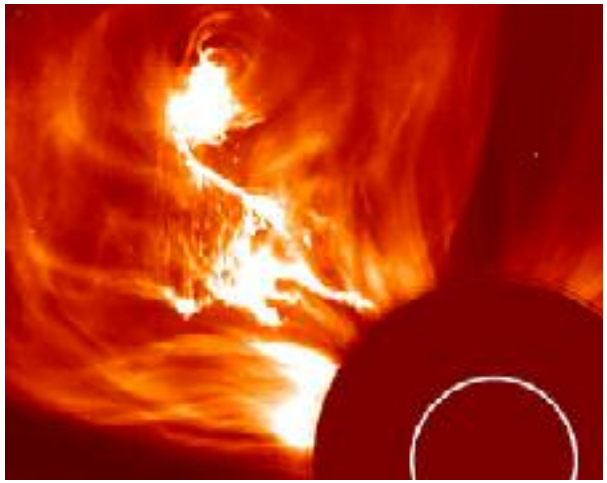
Solar Prominence* – **plasma arches**

2



Quiet Corona

3



Coronal Mass Ejection – **eruptions from the corona***

ANSWERS: Solar Flare – 1 Solar Prominence – 2 Coronal Mass Ejection - 3

OUR STAR THE SUN: FILL-IN-THE-BLANKS GAME – PART 1

PART 1: Fill in the blanks with the terms below! Cross out the words as you use them.

STAR	FAR AWAY	100 BILLION	SOLAR ECLIPSE
PLANETS	CLOSER	93 MILLION	SOLAR SYSTEM
EARTH	RISE	MILLION	MILKY WAY
ROTATING	WEST	WINTER	CORONA

The Sun is a _____ located at the center of our _____. The Sun is so large that about one _____ Earths would fit inside it! The Sun is one of over _____ (100,000,000,000) stars in our galaxy called the _____.

The Sun is _____ miles from Earth. The Sun appears to be much brighter than other stars because it is much _____ to Earth. Many of the stars we see at night are much brighter than our Sun, but these stars are so _____ that we only see twinkling points of light.

The Moon is much smaller than the Sun, but it is also much closer to Earth so the Moon and Sun appear to be about the same size in Earth's sky! This makes it possible to see a beautiful total _____ where the Moon blocks the inner light from the Sun, revealing the luminous, white halo of the Sun's _____.

Nine _____ orbit around the Sun, including the one we live on called _____. If I am _____ years old [enter your own age], then I have made _____ trips around the Sun during my life [enter your own answer, not provided in list].

In summer months, the Sun is _____ (highest/lowest) in the sky and there are _____ (more/less) daylight hours. In _____ months, the Sun is lowest in the sky and there are less daylight hours.

Each day, the Sun appears to _____ in the east and set in the _____ because Earth is _____ toward the east.

OUR STAR THE SUN: FILL-IN-THE-BLANKS GAME – PART 2

PART 2: Fill in the blanks with the terms below! Cross out the words as you use them.

1 BILLIONTH	VEGETABLES	AURORAS
PHOTOSYNTHESIS*	FLOWING	PLANTS
SUNSPOTS	SOLAR MAXIMUM*	BLOWING
ANIMALS	ASTRONAUTS	SOLAR WIND*

The Sun puts out huge amounts of energy, but Earth intercepts only _____ of this energy. The Sun's light keeps the _____ and trees growing. The Sun's heat melts the ice and snow and keeps the waters _____. The Sun warms the surface of Earth unevenly and keeps the winds _____.

Plants and trees get their life energy directly from the Sun through a process called _____. Pigs, cows, chickens, and other _____ get their energy from the Sun indirectly by eating things that come from plants and trees (like seeds, nuts, grains, fruits and _____).

The Sun gives off more than the light and heat needed for life. The _____ is a million mile-per-hour flow of charged particles that continuously streams from the Sun.

These particles interact with Earth's magnetic field and upper atmosphere, causing the _____ (Northern and Southern Lights).

Disturbances in the solar wind* caused by storms from the Sun can enhance the auroras, damage satellites, and endanger _____ in space. In 1989, millions of people in the Canadian province of Quebec lost electricity due to the effects of a violent solar storm (a solar flare).

The 11-year solar cycle* alternates between times of low and high solar activity. Near solar minimum*, the Sun is less active, with very few magnetic dark patches called _____ and fewer solar storms. Five to six years later, near _____, the Sun is very magnetically active with lots more sunspots and solar storms.

SUNSHINE FOR LIFE

by Cheri Morrow*

Our Sun is a cool star that lights up our days
And shines ever brightly with life-giving rays.
Our natural cycles – the air, water, leaves –
Are run by the sunlight our planet _____.

As Earth orbits* 'round to its summertime place,
So long is the daytime! So high the Sun's face!
Enjoying a picnic, we might have a hunch
That sunshine helped fashion the foods in our _____!

The Autumn brings changes – now day equals night –
It's time now to pick what the Sun has made ripe!
The apples and pumpkins we'll make into pies
Have soaked up some sunlight that beamed from our _____!

The Sun seems so low on those short winter days –
They say from the Sun, we are *tilted* away!
The air is much colder – it might even snow!
If so we'd be lucky, and sledding we'll _____.

The Spring lures the flowers with life-giving Sun,
And *more* daylight hours means *more* time for _____!
We watch for the sunrise at this time of year,
And try to predict where the Sun will appear.

We also love sunsets and skies red and pink.
With Earth turning eastward, the Sun seems to _____!
And when colors fade, so we see all the stars,
We hope we might find one as awesome as ours.

Use these words!

skies fun lunch
sink go receives

STAR CHALLENGE

Write your own poem or song about the Sun or draw a picture about how the Sun supports life on Earth.

COLOR US!

A SECRET MESSAGE ABOUT THE SUN!

Use the key on the next page to fill in the blanks beneath each picture.

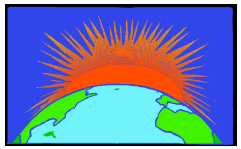


THE SUN'S _____ KEEPS THE _____ AND _____ *GROWING*.




THE SUN'S HEAT _____ THE _____ AND _____ TO KEEP THE _____ *FLOWING*.


THE SUN WARMS THE SURFACE OF _____ UNEVENLY, AND THIS KEEPS THE _____ *BLOWING*.

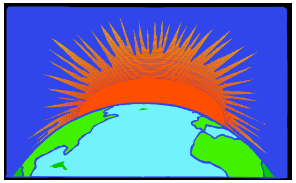


THE SUN'S ACTIVITY KEEPS THE AURORAS _____.

USE THIS KEY TO DECODE THE SECRET MESSAGE

EARTH =

GLOWING =

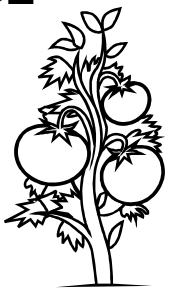


ICE =

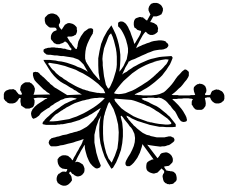
LIGHT =

MELTS =

PLANTS =



SNOW =



TREES =

WATERS =

WINDS =

DISCOVER WHY THE SUN APPEARS TO RISE & SET

Adapted from *Kinesthetic Astronomy: The Sky Time* Lesson by Morrow and Zawaski

[This activity can be done alone or in a larger group arranged around the balloon.]

The Sun only *appears* to rise in the east in the morning, travel across the sky, and set in the west in the evening. Follow these simple steps to learn what's REALLY happening.

1. Find a helium balloon -- a yellow one is best because you will use it to represent the Sun.

2. Tie the balloon to something so that it floats about 3 feet (I meter) off the floor or ground.

3. Write "E" for east on a small slip of paper and "W" for west on another slip of paper and keep them handy.

4. Stand about 8-10 feet (3 meters) away from the balloon with the front of your body facing directly toward it.

5. Pretend that your upper body represents the whole planet Earth.

6. Put a hand on your "North Pole". Where is it? Where would your Equator be?

7. Say that North America is out on the front of your chest. Which of your hands is toward the east and which is toward the west?

8. Where would South America be? What countries would be on your back? Where would Australia be?

9. So as you face the "Sun" with North America on your chest. What time of day would it be along a line down the middle of the front of you?

10. Now turn around with your back to the "Sun". What time of day would it be now? What would you see in the sky at this time of day?

11. So while *you* are seeing stars at midnight in North America, people on the other side of planet Earth in China and Asia are seeing the Sun at noon.

12. Now turn back around to face directly toward the Sun. This is your noon position.

13. Hold your arms outstretched and make a 90-degree turn toward your left (toward the east).

14. Look down your right arm to see the Sun alongside the "W" in your right hand. What time of day would this be when the Sun is about to disappear in the west?

15. Keep turning to the left until you are again at midnight position. From midnight position make another 90-degree turn to your left (toward the east).

16. Look down your left arm as the Sun re-appears in front of the "E" in your left hand. What time of day would this be? [midway between midnight & noon]

17. Does it make sense to you that the Sun could rise and set because of Earth's rotation?

18. How long does it take for Earth to make one complete rotation?

Write the correct times of day for the boy rotating below

(Choose from Sunrise, Sunset, Noon or Midnight)

1. _____ 2. _____ 3. _____ 4. _____

WHY IS IT COLDER IN WINTER?

Adapted from *Kinesthetic Astronomy: The Sky Time Lesson* by Morrow and Zawaski

Check it out!

Earth takes one year to orbit the Sun.

Earth's orbit is nearly circular

So, Earth is about the same distance from the Sun no matter the season (summer, fall, winter, spring)

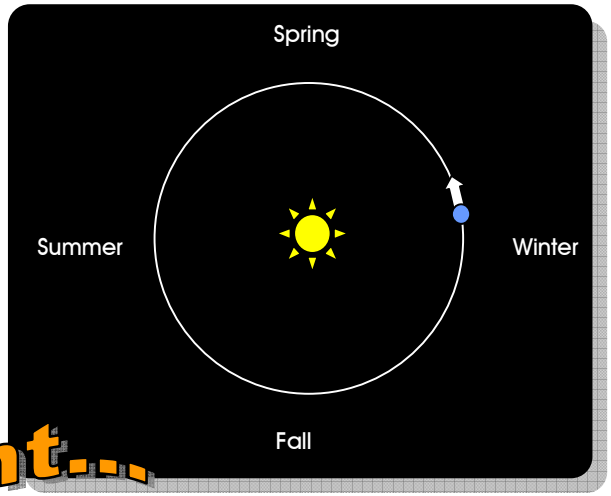
SO WHY IS IT COLDER IN WINTER?

Try this!

1. Pretend you body is Earth in orbit around the Sun. Let a helium balloon be the Sun.

2. The top of your head is Earth's north pole. Pick a point on the ceiling to be the North Star (Polaris). Tilt your head toward Polaris, like the kids in the drawing below.

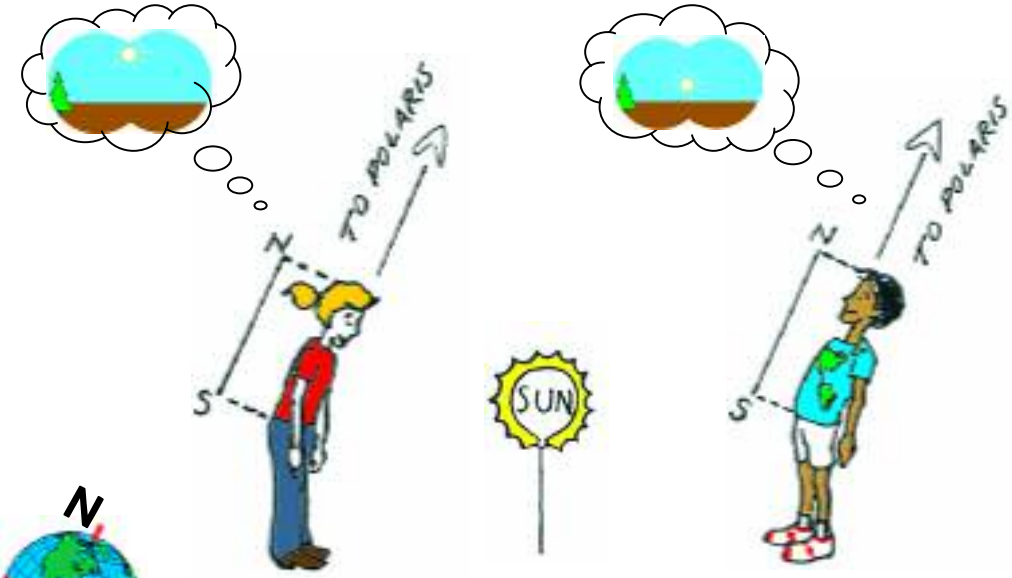
3. Try to "orbit" the Sun while keeping your head tilted toward Polaris.



hint...

When your northern hemisphere is tilted away from the Sun, will the Sun appear higher or lower in the sky?

The hemisphere which is tilted away from the Sun is in winter. The Sun appears lower in the sky, giving fewer daylight hours, less time to heat the planet's surface – thus making colder temperatures.



What season is the girl's Northern Hemisphere in?

_____

What season is the boy's Northern Hemisphere in?

_____

ANSWERS: For their Northern Hemispheres, the girl is in summer; the boy is winter. What about their Southern Hemispheres?

OBSERVING WHERE THE SUN SETS

Adapted by permission from PASS (Planetarium Activities for Student Success), Vol. 11 Astronomy of the Americas.

This activity can be done from a place in your neighborhood. When you complete it, you will have created a horizon Sun calendar much like ones that have been used in many Native American tribes.

Materials:

- Pencil and Paper
- Magnetic Compass
- Optional: Camera

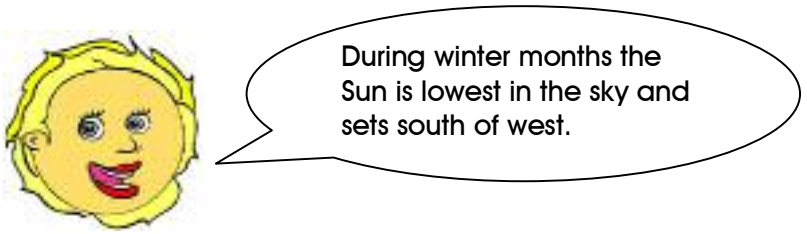
What to Do:

1. Select a position where you can observe the setting Sun. Note where on the horizon the Sun sets on a given night. Make a drawing or take a picture of the horizon in that general area.

2. Using a magnetic compass, mark the compass directions northwest, west, and southwest on your picture or drawing.

3. Once or twice a week for the next month, mark the location where the Sun sets for each clear day, and record the date and time of the sunset. Be sure to always make your observations from the same spot.

4. Discuss results with friends or family members. Does the Sun set farther to the south, farther to the north, or in the same place on later days as compared with the first day?



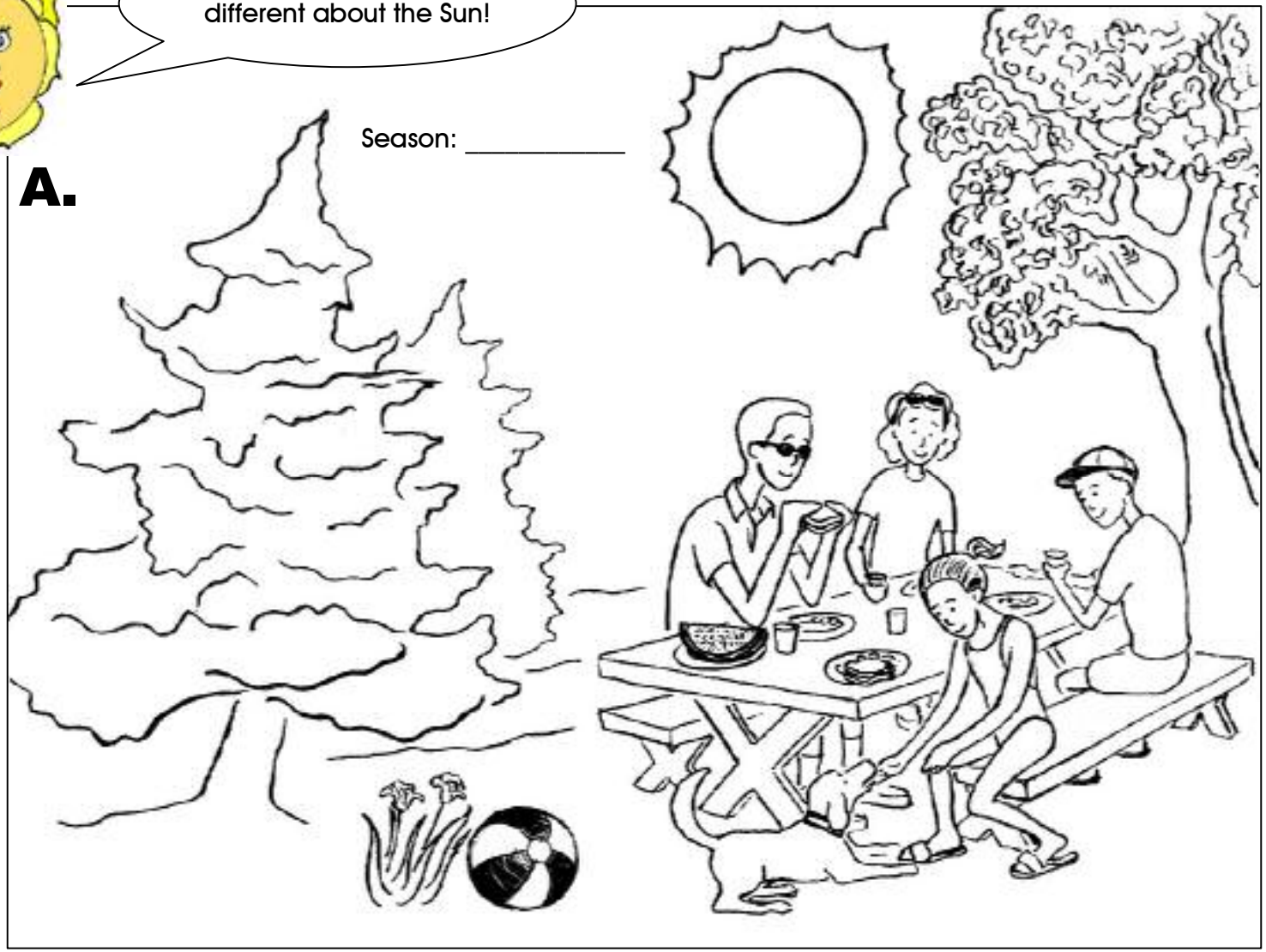
SOLAR PICNIC – WHAT ARE THE SEASONS IN THE TWO DRAWINGS?

This family is enjoying a picnic at the same time in the afternoon, but on two different days of the year.
Can you find 10 things that are different between the two images? Can you guess the seasons?

Be sure to note what's different about the Sun!

A.

Season: _____



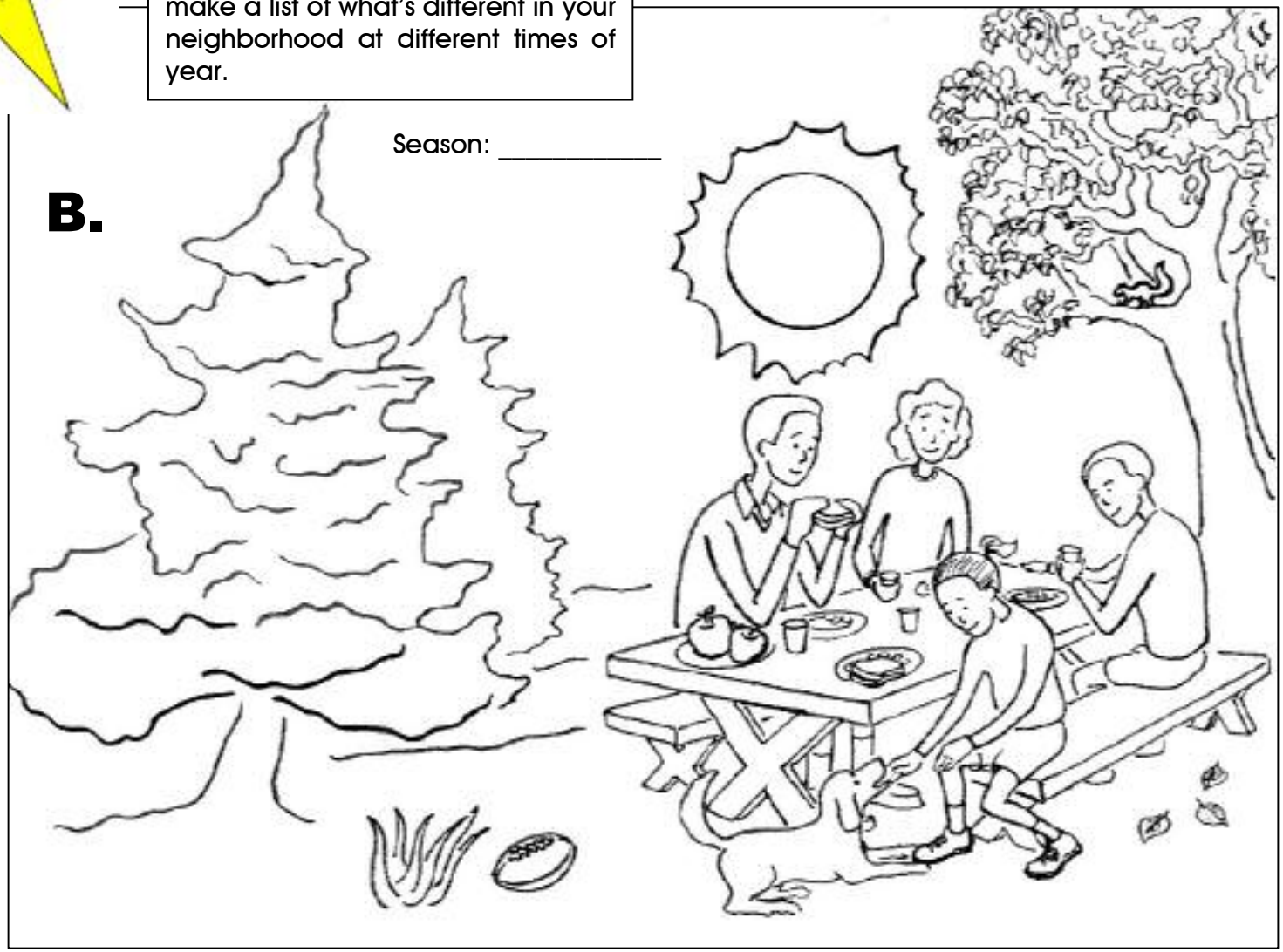
SOLAR PICNIC – WHAT ARE THE SEASONS IN THE TWO DRAWINGS?

STAR CHALLENGE

Make a list of things that are different in the two drawings, then make a list of what's different in your neighborhood at different times of year.

Season: _____

B.



SHADOWS AND SUN IN THE CITY

by Preston Dyches

In the city we have a lot of TALL buildings. We have cars and streetlights and statues. We also have shadows.

One sunny morning on my way to school, I passed this statue in the park near my house. I looked down at the shadow cast by the statue and saw that it was long and pointing west. Later in the day when I went home, the shadow was pointing the other way, to the east. "How did this happen?" I wondered.

The next day, I asked my teacher, Mr. Ryan, about the weird behavior of the statue's shadow. His face brightened and he seemed really glad that I had asked. But then he did something weird. He refused to answer my question! He told me to look at other shadows on the way home including my own, and see if I noticed anything that helped me figure this out for myself. Great. Big help he was.

So I walked home, looking at lots of shadows. I looked at the lamppost's shadow outside the school building. I observed at the shadow of a parked car on the street. I looked at my shadow. When I got to the park near my building, I saw the statue's shadow again, pretty much the same as it had been the day before. I didn't get it. The answer to my question just wasn't coming to me. "Mr. Ryan gave me too much credit for being smart," I thought.

When I got home, I went into my room and tossed my books on the bed. I went over to the window and looked outside. I thought of how pretty the sky looked at that time of day, just before sunset. I couldn't see the Sun from my window, because it faces east and the Sun sets in the west (my Dad told me that). I looked down at the street below, and saw a bus stopping in the shadow of my building...

Suddenly I understood! The Sun is in a different place in the sky at different times of day. The Sun was behind my building at sunset and the building cast a shadow on the street below. The shadow pointed to the east, away from the Sun. I raced downstairs and over to the park to confirm what I had guessed.

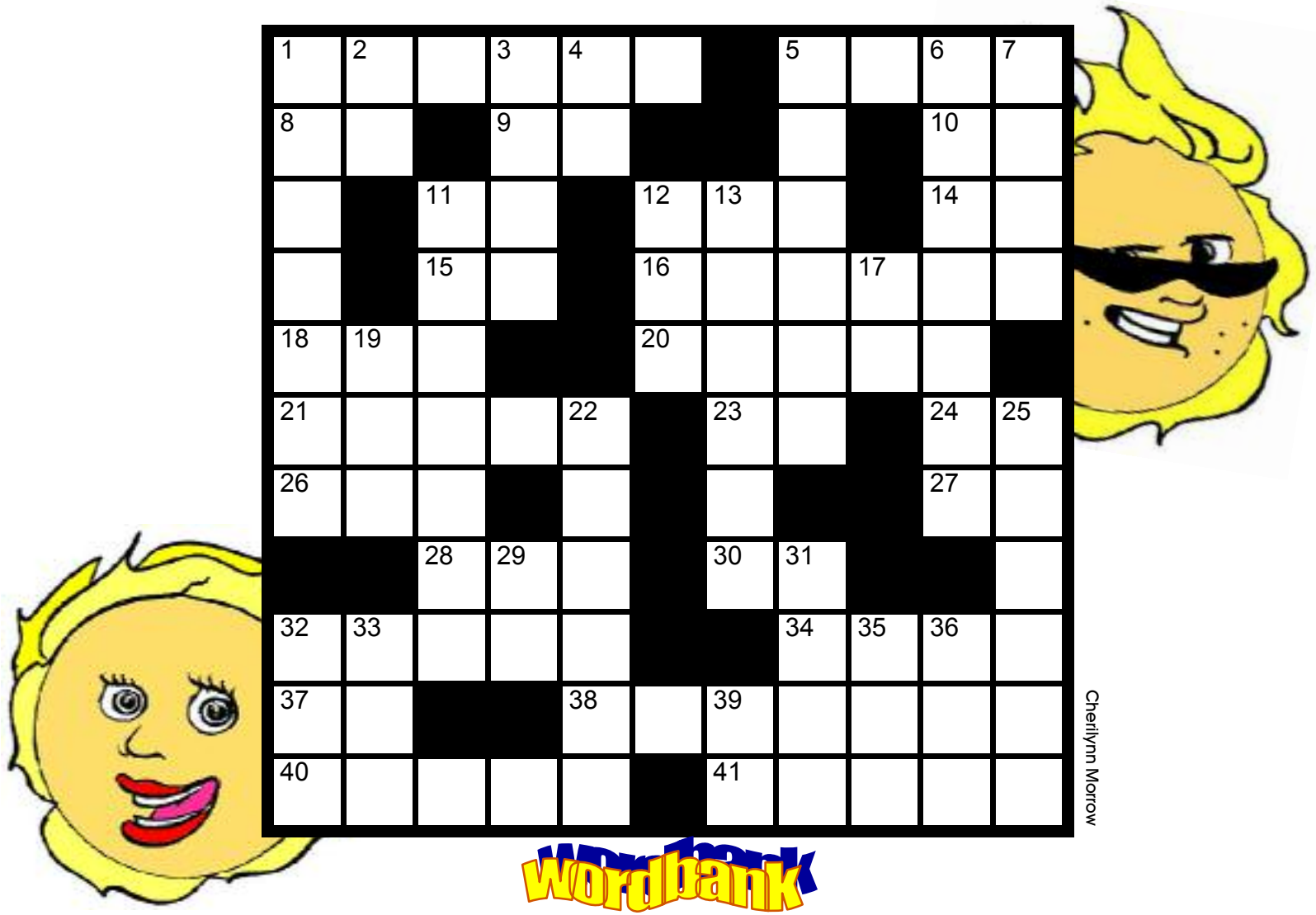
There, I found the statue's shadow, and my own, and everything else's were pointing to the east, just like the big shadow cast by my apartment building. It all depends on where the Sun is in the sky!

The next day I told Mr. Ryan what I had discovered about shadows and the Sun. He said he was impressed, but then he asked me if I noticed shadows changing in length during the day. I said, "I guess," but he wouldn't accept that. He told me to take another look and give him my answer the next day.

Well, I finally figured it out, but it took a little help from my teacher. I'd tell you the answer, but it might be more fun if you see for yourself. Try it!

After you read this story, check out your own shadow at different times of day. Does it point in different directions?

CROSSWORD PUZZLE ABOUT THE SUN AND SUN-EARTH CONNECTIONS



Cherilynn Morrow

Wordbank

SUNSPOT ECLIPSE CME EQUATOR AURORA
AUTUMN WINTER SUMMERS SPRING
SUNSET STAR SUN

ACROSS

1. Season for robins, daffodils, and tulips

5. Earth's rotation makes the Sun appear to rise in the east and set in the _ _ _ _.

8. United States (abbr) [HINT: "abbr" means "abbreviation". For example, the abbreviation for "National Aeronautics and Space Administration" would be "NASA", and the abbreviation for "feet" would be "ft"]

9. The Wizard of _ _.

10. University of Hawaii (abbr). This university operates telescopes that observe the Sun.

11. Extra-Terrestrial (abbr)

12. Person who roots for a sports team

14. Third note on a major musical scale [HINT: Remember the song in The Sound of Music?]

15. State on the western coast of the US that has the Golden Gate bridge, redwood trees, and Hollywood (abbr)

16. Season of falling leaves

18. A pen _ _ _ is a buddy to whom you write letters and who writes letters to you.

20. A very thin folded or rolled pancake, as in a _ _ _ _ _ suzette -- a famous French dessert.

21. Funny papers = C _ _ _ _ _.

23. State on the west coast of the US with California to the south of it and Washington to the north of it (abbr) [HINT: Look at a map or atlas if you need it to help you]

24. Room (abbr)

26. Money you leave on your table at a restaurant if the service has been good

27. Fifth note on a major musical scale

28. The _ _ _ is our star. Earth intercepts only 1 billionth of the energy it puts out, but this is enough to support plant and animal life.

30. Quiet _ _ a mouse.

32. Board game with a king, queen, 2 bishops, 2 knights, 2 rooks, and 8 pawns

34. Large, low-pitched brass instrument, often seen in marching bands

37. Greek letter for M [HINT: If you do not know this one, try the cross words first (32 and 33 DOWN) to see if they help you]

38. The North Pole is at 90 degrees north latitude where it is very cold. The _ _ _ _ _ _ _ is at 0 degrees latitude where it is very warm.

40. Country with large, stone pyramids. People there used to worship a sun god named Ra.

41. Trick or _ _ _ _ _!

DOWN

1. Dark patch on the Sun. There are more of them during times of maximum solar activity (Solar Maximum*). Solar Maxima occur about every 11 years. The last one was in 2001.

2. Letters to use when you want to add a note at the bottom of a letter to a friend

3. Small amount (same as Greek letter for I) [HINT: If you do not know this one, try the cross words first (1, 9, 11, and 15 ACROSS) to see if they help you discover the answer.]

4. Country in the southern hemisphere that is famous for flightless birds called Kiwis (abbr)

5. Season for sledding and ice skating

6. Times of year for vacations

7. Pizza can have thick or _ _ _ _ crust.

11. When the Moon blocks light from the Sun, we call this a solar _ _ _ _ _ _ _.

12. Friday Afternoon Club (abbr)

13. _ _ _ _ _ _ borealis. Another name for the Northern Lights caused by the Sun's activity.

17. The Sun appears to come _ _ at sunrise, and go down at sunset.

19. In French, "une amie" is a female friend. So a male friend would be "un _ _ _".

22. Opposite of "sunrise"

25. Famous 18th century musical composer who wrote "The Magic Flute" and "The Marriage of Figaro": Wolfgang Amadeus _ _ _ _ _ _.

29. Same as 8 ACROSS.

31. The Sun is a _ _ _ _. It is the only one in our solar system*, but it is one of over 100 billion in the Milky Way galaxy!

32. Coronal Mass Ejection (abbr). This is a storm from the Sun that can cause especially bright auroras* or power outages on Earth.

33. Kiss and a _ _ _ for someone you love

35. Group of Native American people living in parts of Utah, Colorado, and New Mexico

36. _ _ _ constrictor -- a Brazilian snake

39. Universal Time (abbr). This is the time at Earth's prime meridian -- the zero line of longitude that passes through Greenwich, England. If it is midnight in New York then it is five hours later, or 5am, in Greenwich. At this time, astronomers would write 0500 UT no matter where in the world they were observing.

FREQUENTLY ASKED QUESTIONS ABOUT THE SUN

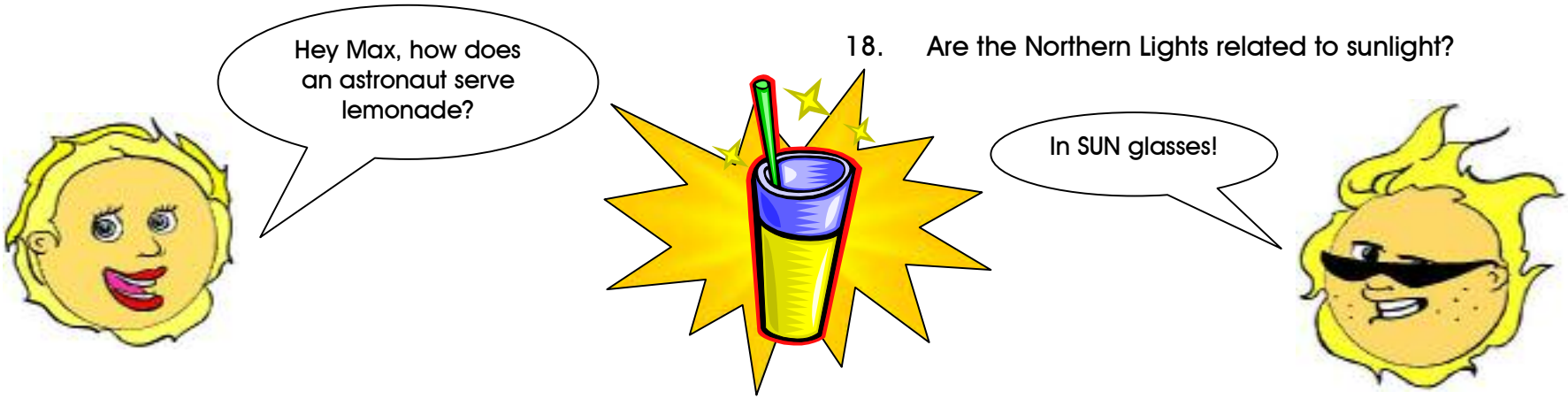
Here are the topics/questions covered in this section:

The Sun and its Fate

1. How far away is the Sun?
2. How big is the Sun?
3. What is the Sun made of?
4. How do we know what the Sun is made of?
5. How hot is the Sun?
6. What makes the Sun shine? / Is the Sun on fire?
7. How old is the Sun?
8. Will the Sun ever become a black hole?
9. How will our Sun end its days?

The Sun in Earth's Sky

10. Does the Sun go around Earth?
11. How long does it take for our planet to go around the Sun?
12. Why do we have fewer daylight hours in winter than in summer?
13. Why do the Sun and Moon seem to be the same size in the sky?
14. What is a solar eclipse*?
15. How can I view a solar eclipse?
16. Why does the Sun look bigger at sunset?
17. Why does the Sun look red/orange at sunrise/sunset?
18. Are the Northern Lights related to sunlight?



The Sun and its Fate

1. How far away is the Sun? The Sun is 93 million miles (150 million kilometers) from Earth. This is pretty close by outer space standards, since the next closest star is 25 TRILLION miles (40 trillion kilometers) away!

2. How big is the Sun? Enormous! It may look small in the sky, but that's because it is so far away. It's about 800,000 miles (more than 1 million kilometers) across – more than 100 Earths could fit across the Sun's face. Some stars are hundreds of times wider than the Sun!

3. What is the Sun made of? The Sun is mostly hydrogen gas, with some helium and traces of other elements found on Earth, such as carbon, oxygen, calcium and iron. Hydrogen is the most abundant element in the Universe. On Earth, hydrogen and helium are lighter than air. Helium gas is what makes party balloons float.

4. How do we know what the Sun is made of? By studying its light. Each of the hot gases in a star produces a unique "fingerprint" of light. By using an instrument called a spectroscope, astronomers can tell which gases are there. Most of what we know about the Sun and other stars comes from studying their light.

5. How hot is the Sun? Deep in the core*, the temperature is an amazing 27 million degrees Fahrenheit (15 million degrees Celsius)! The surface of the Sun is almost 11,000 degrees Fahrenheit (6000 degrees Celsius). The Sun's outer atmosphere (the corona*) is even hotter – about 2 million degrees Fahrenheit (1million degrees Celsius).

6. What makes the Sun shine? Is the Sun on fire? No, the burning that takes place in the Sun is different from fire we are used to experiencing on Earth. The Sun shines because the core produces tremendous amounts of energy by a process called nuclear fusion.

   Every second, 4 million tons of hydrogen in the core are converted into helium and titanic amounts of energy. This energy makes its way to the Sun's surface, where it heats the gas there, causing it to glow.

7. How old is the Sun? Our evidence shows that the Sun has been shining for nearly 5 BILLION years! Sure, that sounds old, but it's less than half the age of the Universe, which is about 14 billion years old! Humans have only been around for the tiniest part of that time.

8. Will the Sun ever become a black hole? No need to worry, our star will never become a black hole. Only stars that are a lot more massive than ours meaning they have a lot more stuff in them can end their days as black holes. Such a massive star eventually explodes, leaving behind a black hole, which has gravity so powerful that not even light can escape.

9. How will our Sun end its days? Our Sun will end its days by expanding to the size of Earth's orbit* and puffing off its outer layers. At that time we would call

it a red giant star. Eventually, all that will remain is a tiny core* (a white dwarf star) about the size of Earth. Earth will be burnt to a crisp, but this won't happen for about 5 BILLION years so don't start packing your bags for Alpha Centauri just yet!

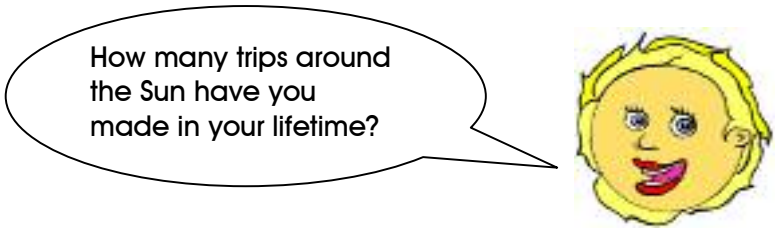
The Sun in Earth's Sky

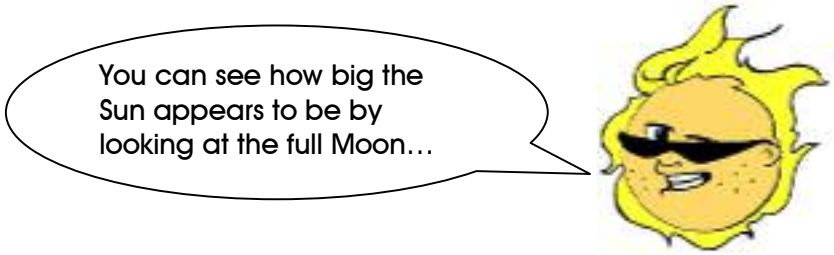
10. **Does the Sun go around Earth?** No, Earth orbits* around the Sun. It may seem the other way around because the Sun *appears* to travel across the sky from east to west each day. But this is just due to Earth's daily rotation toward the east [See the sunrise/sunset kinesthetic activity on p.22].

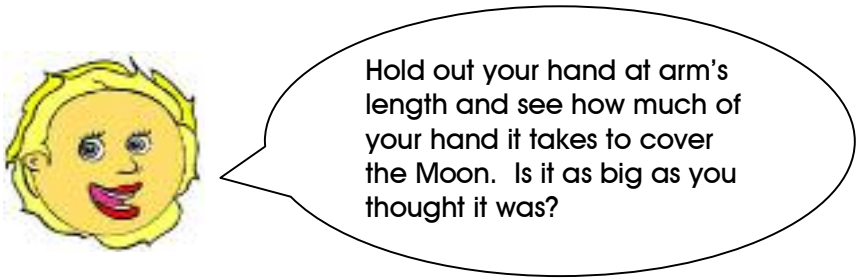
11. **How long does it take for our planet to go around the Sun?** It takes one year for Earth to make one orbit around the Sun. Planets that are closer to the Sun take less time, and those that are farther away take more time to go around. Mars takes about two Earth years to go around the Sun.

12. **Why do we have fewer daylight hours in winter than in summer?** Because Earth's axis (the imaginary line that runs through the north and south poles) is tilted 23.5 degrees from the vertical toward a distant star called Polaris. This tilt causes the Sun to appear lower in the sky in winter months and higher in the sky in the summer months. If the Sun is lower in the sky in winter, then it spends less time above the horizon, resulting in fewer daylight hours and cooler temperatures. [See the Kinesthetic activity on p.24].

13. **Why do the Sun and Moon seem to be the same size in the sky?** The Sun is actually 400 times wider than the Moon, but it just so happens to be 400 times farther away in space, so it appears to be about the same size as the Moon. Because of this coincidence, the Moon sometimes completely blocks the Sun's light – an event called a total solar eclipse*.







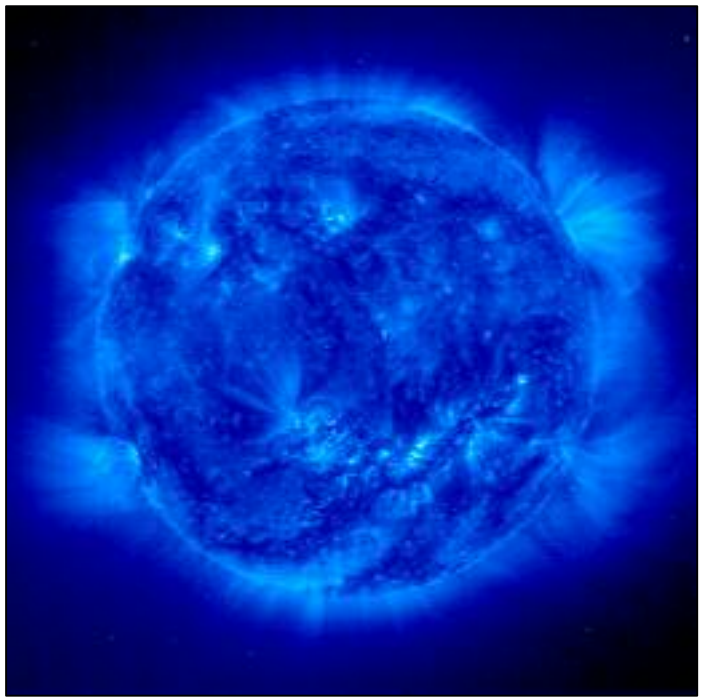
14. **What is a solar eclipse*?** A solar eclipse occurs when the Sun, Moon, and Earth are lined up just right so that the Moon blocks the Sun's light and casts a shadow onto the Earth.

15. **How can I view a solar eclipse?** A solar eclipse occurs somewhere on Earth about every 18 months. Often they are only visible from remote places, so not everyone on Earth is able to view them. Sometimes the only place to see an eclipse is from a boat on the ocean! There are lots of web sites and magazines that contain information about upcoming eclipses and where you must go to view them. Visit www.exploratorium.edu/eclipse to learn more about eclipses and how to view them.

16. **Why does the Sun look bigger at sunset?** Your mind is playing tricks on you! The Sun looks bigger because of an optical illusion. When the Sun is near the horizon, it sometimes *seems* to be much bigger and closer than during the rest of the day. At sunrise or sunset, your brain has other objects to compare the Sun's size to, such as trees and buildings.

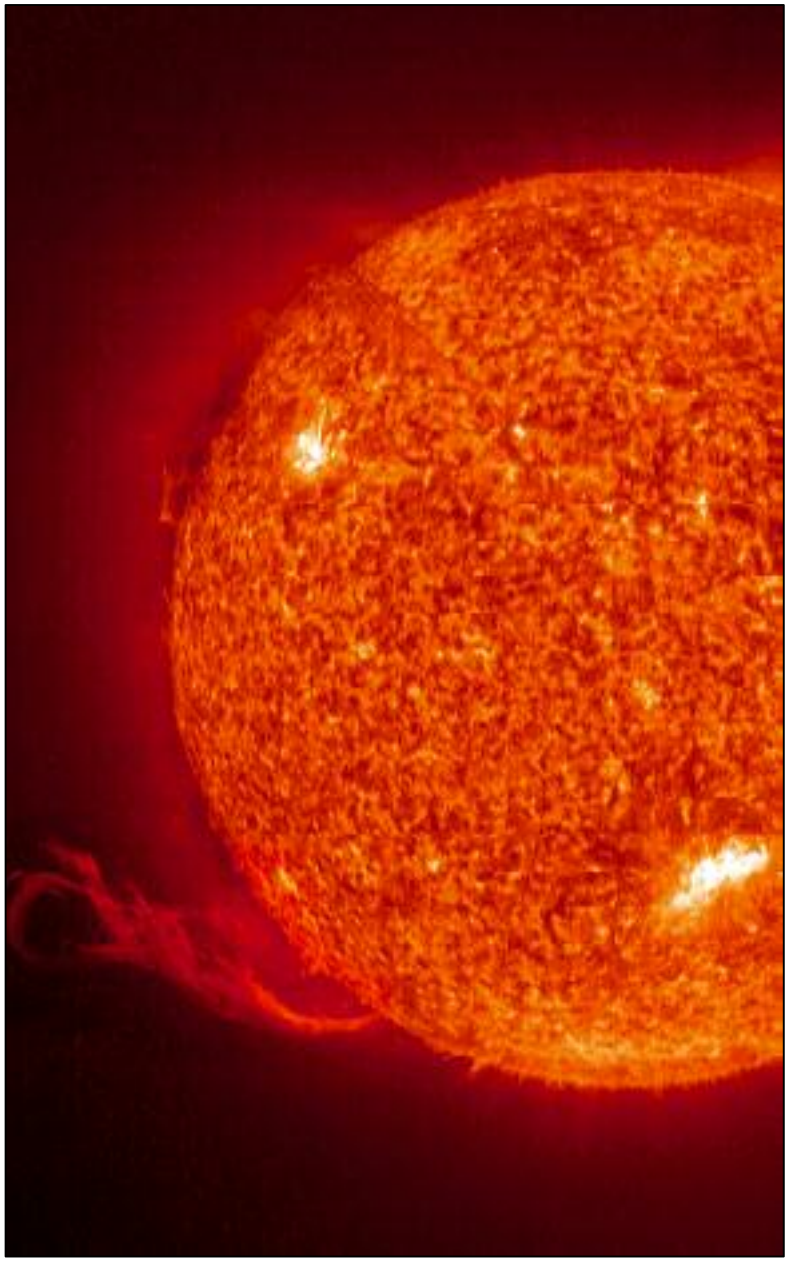
17. **Why does the Sun look red/orange at sunrise/sunset?** The Sun emits light of all colors that combine to make white light. At mid-day our atmosphere scatters the sunlight to make the sky appear blue and the Sun a yellowish white. At sunset, the sunlight is scattered even more because it passes through more atmosphere to get to your eyes. More scattering means a redder color. The Sun's apparent color can also be affected by smoke or dust particles in the air which can enhance the scattering effect.

18. **Are the Northern Lights related to sunlight?** The Northern Lights (or auroras*) are not caused by the Sun's *light* but by tiny charged particles that constantly stream from the Sun. Auroras are caused when this stream of particles (called the solar wind*) interacts with Earth's magnetic field and upper atmosphere (high above where airplanes fly). Auroras are always present in both the north and south polar regions of Earth. Whether we can see them depends on the time of year, cloud cover, and the intensity of solar activity. Storms from the Sun can enhance the brightness and dynamics of auroras.



The Sun as seen in ultraviolet light by the SOHO spacecraft.

GEE WHIZ! FACTS ABOUT THE SUN



1. The Sun is just one of 100 billion stars in our galaxy, the Milky Way.

2. Only about a billionth of the total energy emitted by the Sun reaches Earth.

3. If we could harness all the sunlight that reaches Earth in a single day, it could meet the entire planet's current energy needs for 30 years!

4. The energy in the gas that powers your car came from the Sun. Gasoline comes from oil, which is what we call a fossil fuel. Fossil fuels come from plants and animals that lived millions of years ago, and they got their energy from the Sun.

5. Because of the solar wind*, the Sun loses over 50 billion tons (50 trillion kilograms) of material per day.

6. The Sun's corona* can rip open and spew as much as 20 billion tons of material into space. These explosions are known as coronal mass ejections (CMEs), the hurricanes of space weather. If a CME heads toward Earth, it can endanger spacecraft and astronauts.

7. A solar flare releases enough energy in two hours to meet Earth's present energy needs for 10,000 years!

8. The element helium was first discovered on the Sun!

GEE WHIZ! FACTS ABOUT THE SUN

9. The gas in the Sun rotates (or spins) about 10 days faster at its equator than around the poles.

10. The Sun makes up about 99% of the stuff in the whole Solar System*.

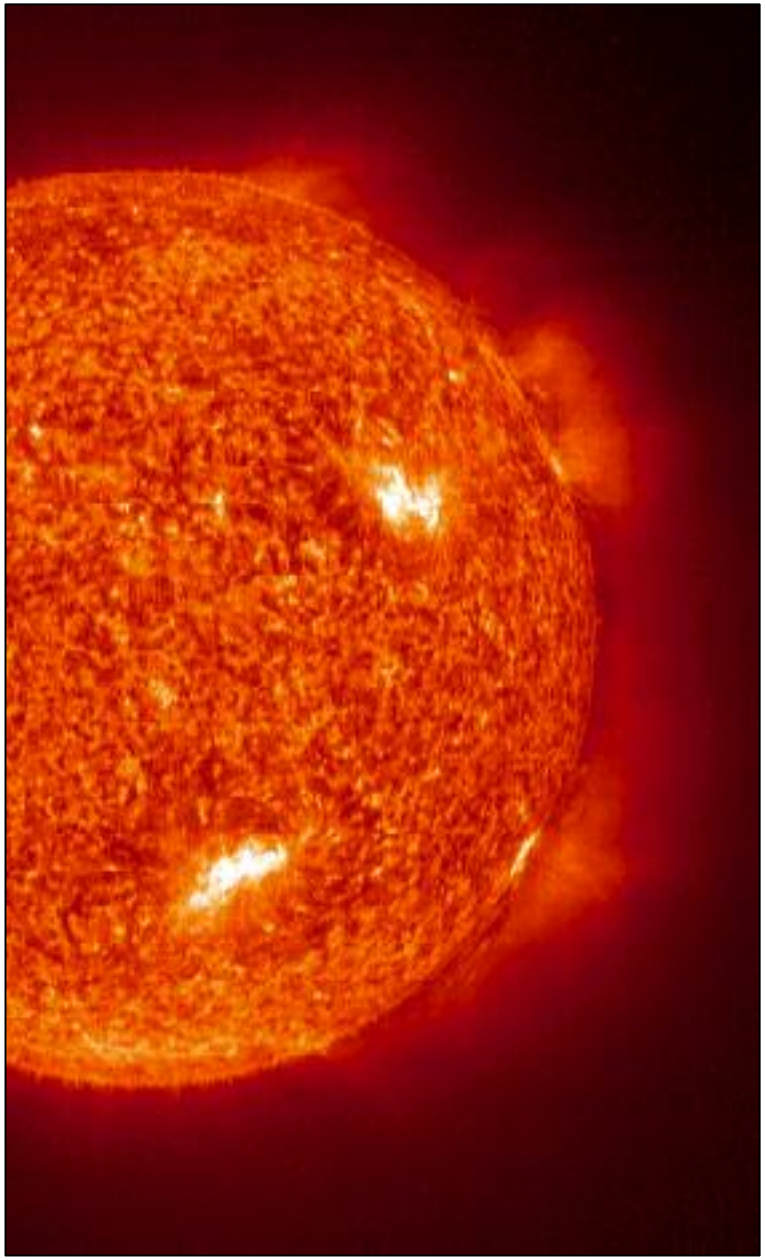
11. Earth has its own protective force field! Earth's magnetic field and atmosphere shelter us from tremendous explosions of energy and dangerous radiation from the Sun.

12. There are places on Earth, near the north and south poles, where when the Sun is in the sky 24 hours a day near the peak of summertime (midnight sun), and below the horizon all day in wintertime.

13. Some sunspots* are as much as 20 times wider than Earth!

14. It takes light from the Sun about 8½ minutes to travel to Earth. This means that from Earth we can only know what happened on the Sun 8½ minutes ago. Light travels through space at a whopping 186,000 miles per second (300,000 kilometers/second)!

15. Energy from the Sun's core* takes about 150,000 years to reach the photosphere* (visible surface). That means the light you see today was produced in the core when humans were still in the stone age!



FUN SUN RESOURCES

After sharing this Guide with your family, you are probably wondering where you can learn more and where you can find activities on your favorite topics.

Explore these four areas, and keep the fun going!

- **Look at Beautiful Images**
- **Share Fun Activities**
- **Explore with Background Resources**
- **Read a Book about the Sun**
- **Get Some Teaching Tools**

Look at Beautiful Images

See Outstanding Sunrises and Sunsets

Some of the most beautiful photographs of sunrises and sunsets can be found here. The site is in French, but the images speak across all languages.
http://www.soleildujour.com

Admire Photographs of Auroras*

See nine pages of incredible aurora borealis images, selected from the works of Jan Curtis. The photographs were taken near the Fairbanks, AK area, and are astoundingly beautiful.
http://www.geo.mtu.edu/weather/aurora/images/aurora/jan.curtis

Browse through a Total Solar Eclipse* Photo Gallery

Eclipse images by "eclipse chaser" Jeffrey R. Charles show not only what is happening in the sky but also interesting people and places encountered on each expedition.
http://www.eclipsechaser.com

Share Fun Activities

Listen to a Song about the Sun

Here you can listen to the Sun Song by AstroCappella a marriage of astronomy and music. Their songs are developed by astronomers and professionally recorded by the a cappella group The Chromatics.
http://www.astrocappella.com/sun.shtml

Make a Solar Oven to Cook Pizza

Using just a few simple supplies and following four easy steps, you can make a solar oven from a pizza box and eat food you cook yourself with the power of the Sun.
http://www.solarnow.org/pizzabx.htm

Make a Pinhole Camera to Observe the Sun

While you should NEVER look at the Sun directly or through a telescope, there are ways you can view the Sun or eclipses safely. You can make a pinhole projector and see an image of the Sun on a sheet of white paper.
http://www.exploratorium.edu/eclipse/how.html

Submit Your Own Sun Artwork

Create your own artistic expression of the Sun a poem, story, music, or perhaps an image and submit it. Your work might be displayed on the World Wide Web!
http://solar-center.stanford.edu/art.html

Build a Simple Sundial to Tell Time

http://liftoff.msfc.nasa.gov/Academy/Earth/Sundial/SundialConstructSimple.html

or

Make a Sun Clock to Tell Time

http://www.exploratorium.edu/science_explorer/sunclock.html

Explore with Background Resources

Read Sun Stories from Another Culture

Each of our world's cultures has a unique view of life and humanity's place in it. These worldviews are reflected in stories people tell about a significant object in everyone's sky the Sun. Visit this site to read some stories that people tell to explain and understand nature.
http://solar-center.stanford.edu/folklore.html

Get Smart about Space Weather

Written by the staff of NOAA's Space Environment Center, this site provides a broad view of the entire Sun-Earth environment, with a particular focus on space weather. SPANISH language version is also available.
http://www.sec.noaa.gov/primer/primer.html

Take a Tour of an Aurora*

This self-guided tour offers comprehensive answers to some common questions about auroras, including: What do auroras look like? What makes them happen? What is the solar connection? Where can you see them? What do auroras look like from space? Why are they different colors?
http://www.exploratorium.edu/learning_studio/auroras/selfguide1.html

Find What You Want to Know about the Sun

A well organized presentation of basic facts about the Sun.
http://seds.lpl.arizona.edu/nineplanets/nineplanets/sol.html

Read about Sun News as It Happens

This is a top choice for up to date information. The site has daily images of the Sun and its active regions, as well as up-to-date alerts of possible auroras and links to classroom activities.
http://www.spaceweather.com

Learn about Your Birthday Sun

You can plot sunspot* numbers around any date… like your birthday! Were you born when the Sun was very active or very quiet?
http://www.spaceweather.com/java/sunspot.html

Tune in to a Sun Weather Station

You tune in to your local news for current conditions and forecasts in your hometown, but how do you know about the weather on the Sun? Go to this website for space weather as well as images of auroras, eclipses, and asteroids.
http://www.sunspotcycle.com

Find Out Sunrise and Sunset Times

Enter any date and location to obtain times for sunrise, sunset, moonrise, and moonset.
http://aa.usno.navy.mil/data/docs/RS_OneDay.html

Read about Observing the Sun
This article by Von Del Chamberlain invites you to observe sunsets, and it explains how to pay attention to the position of the Sun to track the changing of the seasons. The author has researched and written about Native American ethnoastronomy and even co-hosted the first world conference on that topic.
http://www.clarkfoundation.org/astro-utah/vondel/sun calendar.html

Discover Earth and Space Sciences
Windows to the Universe includes images, movies, animations, and data sets that explore the Earth and Space sciences and the historical and cultural ties between science, exploration, and the human experience. The site is written in three reading levels approximating elementary, middle school and high school reading levels. Portions of the web site have been translated into Spanish, and in the future, the whole web site will be available in Spanish.
http://www.windows.ucar.edu/

Read a Book about the Sun

The Sun by Paulette Bourgeois, Ages 7-11
Stunning images and illustrations illuminate activities, experiments, and stories about the Sun. This resource encourages learning about solar power, sunsets, shadows, and other cultures' historical ideas about the Sun.
40 pp., ISBN: 1-55074-158-6 (bound), ISBN: 1-55074-330-9 (paperback)

Sunshine Makes the Seasons
by Franklyn M. Branley, Ages 5-9
Answers to questions about the length of days and the seasons become clear as you demonstrate the tilt of the Earth and its movement around the Sun using a pencil, an orange, and a flashlight.
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GLOSSARY OF SUN RELATED TERMS

Aurora: Glowing, dancing curtains of light in the upper atmosphere of a planet. Auroras are caused by the interaction between the planet's magnetic field and charged particles from the Sun. Aurora Borealis are the Northern Lights and Aurora Australis are the Southern Lights.

Convection zone: See p. 8, Introduction to the Sun.

Core: See p. 8, Introduction to the Sun.

Chromosphere: See p. 8, Introduction to the Sun.

Corona: See p. 8, Introduction to the Sun.

Equinox: The two days of the year (March 21 & September 21) when the number of daylight and nighttime hours is equal.

Orbit: The circular or elliptical path of one object around another. The Sun's powerful gravity holds Earth and the other planets in orbit around it.

Photosphere: See p. 8, Introduction to the Sun.

Photosynthesis: The process by which plants make their own food by using sunlight. Because of photosynthesis, most life on Earth is, in some way, powered by the Sun.

Prominences: See p. 8, Introduction to the Sun.

Radiation zone: See p. 8, Introduction to the Sun.

Solar Cycle: The approximately 11-year period during which the frequency and number of sunspots*, coronal mass ejections, solar flares, and other solar activity rises and falls. Also called the sunspot cycle.

Solar Eclipse: See FAQ #14, p. 37.

Solar Maximum / Solar Minimum: See p. 7.

Solar System: The Sun and the family of objects that orbit it. The solar system includes things like planets, moons, comets and asteroids.

Solar Wind: A million mile-per-hour gale of tiny charged particles continuously streaming out of the Sun. It interacts with the magnetic field and atmosphere of Earth causing auroras (the northern and southern lights).

Solstice: Summer solstice (June 21) is the first day of summer – with the most daylight hours. Winter solstice (December 21) is the first day of winter – with the fewest daylight hours (the Sun is lowest in the sky on this day).

Sunspot: A dark, fringed blemish on the Sun's surface. Sunspots look dark because they are cooler than the plasma surrounding them. Sunspots appear in groups and last from several hours to several months. The number of sunspots increases and decreases over an 11-year cycle. Some individual spots cover areas 20 times the diameter of Earth. Sunspots are areas of intense magnetic fields.

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