Answer Keys for Teachers

KINESTHETIC ASTRONOMY™

Written Assessment Options for the *Sky Time* Lesson

Table of Contents

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Answer Key for Teachers

WHAT DO YOU KNOW? [p 1 of 3]

This questionnaire is not meant to be graded, but rather to inform the teacher about the prior knowledge of his or her students.

1. **Draw arrows to connect each box with the correct place on planet Earth.**

2. **Draw the EQUATOR on the Earth cartoon above.**

3. **Order the objects below from smallest (1) to largest (3).**

__**2**__Earth

__**1**__Moon

__**3**__Sun

4. **Order the objects below from closest (1) to farthest (3) from Earth.**

__**2**__Sun

__**1**__Moon

__**3**__North Star

5. **How many stars are in the Solar System? _____1_____**

6. **How do you think people kept track of time before the invention of clocks, watches, and numbered calendars? What is a day? What is a year?**

Basic examples include: Using sundials to tell the time of day, watching the changing phases of the Moon to count weeks and months, and watching the rising & setting positions of the Sun or the height of the Sun at noon to tell the seasons. More advanced examples: Seasons could also be determined by observing which stars were rising just before sunrise or noting the constellation that was visible during that time of year.

A DAY is the time it takes for Earth to spin once (rotate) once on its axis. A YEAR is the time it takes for Earth to go once (orbit) around the Sun.

7. **If it is noon where you are, what time is it on the opposite side of Earth?**

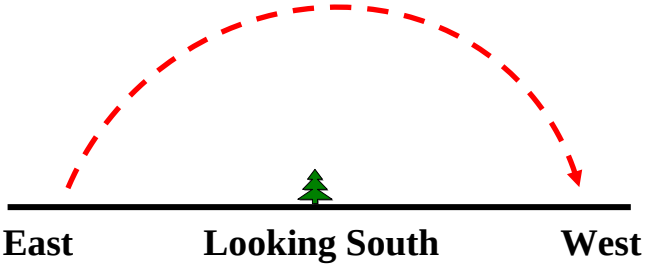
_____Midnight_____

Answer Key for Teachers

WHAT DO YOU KNOW? [p 2 of 3]

8. How does the Sun appear to move in the sky during the day? Draw the path of the Sun on the diagram below.

The Sun appears to rise in the east and set in the west.



9. Why do you think the Sun appears to rise in the East and set in the West?

This occurs because Earth is turning (rotating) toward the east.

10. Do stars and constellations also appear to rise and set?

Circle one: **YES** **NO**

Explain: Because Earth is turning (spinning or rotating).

11. Does Earth move in space? **Circle one:** **YES** **NO**

Explain (draw pictures if it helps to explain):

Basic:
Earth is spinning (rotating) on it's North-South axis once each day.
Earth is going around (orbiting) the Sun once each year.

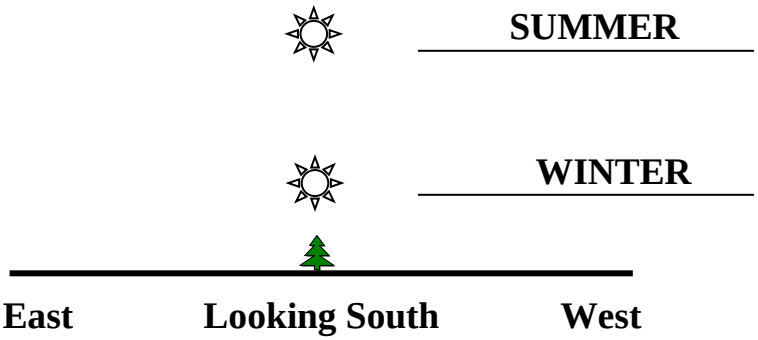
Advanced:
Earth's axis precesses (or wobbles around) one time every 26,000 years.

Answer Key for Teachers

WHAT DO YOU KNOW? [p 3 of 3]

12. How many trips around the Sun have you made in your life? Your age (in years)

13. Write "summer" next to the sun that represents noon time in the summer. Write "winter" next to the sun that represents noon time in the winter.



14. In what season do we experience the most daylight hours? __SUMMER__

15. Why is it hotter in summer and colder in winter? (Use drawings if it helps you to explain)

In summer, the Sun is higher in the sky near noon so Earth receives greater intensity of the Sun's light. The Sun is also above the horizon for more hours so there are more hours to heat Earth's surface and less hours at night for the surface to cool down.

16. Do we see the same stars and constellations at different times of year?

Circle one: YES (NO)

Explain (use drawings if it helps you to explain):

No, because as Earth orbits the Sun during the year, the night side of Earth will be facing out into different directions in the galaxy. Thus we will generally see different stars and constellations at different times of year.

Answer Key for Teachers

PAGE INTENTIONALLY LEFT BLANK TO RETAIN CORRESPONDENCE of PAGE NUMBERS BETWEEN ASSESSMENT OPTIONS (pp ST1 – ST26) and the ASSESSMENT ANSWER KEY (pp STA1 – STA26)

Answer Key for Teachers

EXPLORING THE STRUCTURE OF THE UNIVERSE

Fill in the blanks. ~~Cross out~~ the words below as you use them.

asteroids	galaxy	Meteoroids	orbit	Solar System	Sun
comets	galaxies	Moon	planets	star	Universe
Earth	Jupiter	Moons	planets	Sun	100 billion

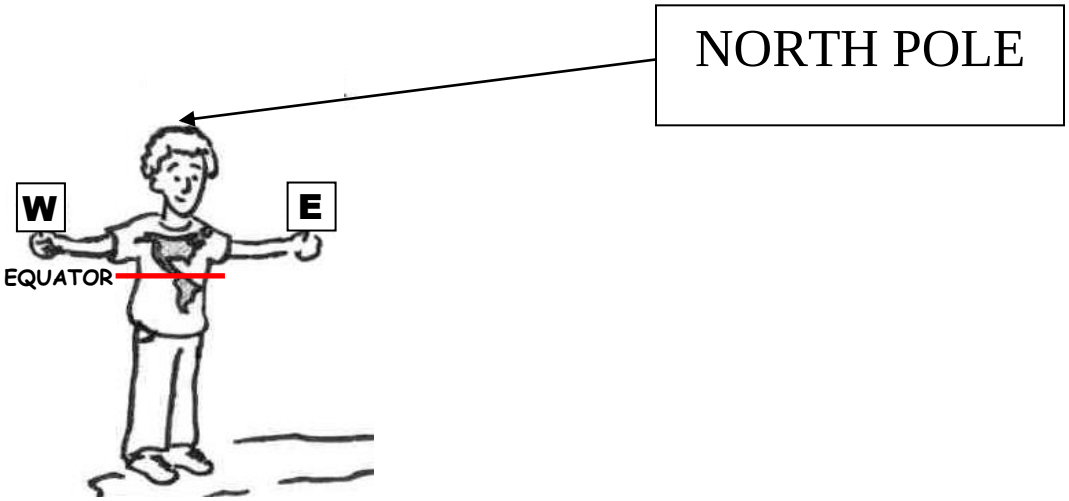
The Sun is a __**star**___ located at the center of our __**Solar_System**____. Our home, called _**Earth**____, is one of 9 __**planets**____ that orbit around the __**Sun**____. Earth has one __**moon**__ that orbits around it each month, showing different phases. Some planets have many __**moons**____ that __**orbit**___ around them. Mercury and Venus have no moons. In addition to the Sun, planets, and moons the Solar System contains smaller objects such as __**asteroids**__, _**comets**_, and _ **meteors**_. Sometimes these smaller objects collide with the larger objects. Most meteors are between the size of a grain of sand and a peanut, but they can make a bright streak across the sky as they travel through Earth's atmosphere. In 1994, astronomers all over the world watched a comet break up and impact the atmosphere of the largest planet in the Solar System called __**Jupiter**___. Our ___**Sun**____ is one of about ___**100 billion**___ stars contained in the ___**galaxy**___ we call the Milky Way. Astronomers are just now discovering Jupiter-sized __**planets**___ that orbit around some of those distant stars. Outer space is even bigger yet because the Milky Way is only one of an estimated 100 Billion (100,000,000,000) __**galaxies**___ in the __**Universe**_____.

Answer Key for Teachers

BODY GEOGRAPHY

DIRECTIONS:

1. Label the North and South Poles by filling in the boxes shown.
2. Fill in the “E” and “W” signs in the student’s hands.
3. Draw the Equator on the boy (whose body represents the whole Earth).



Answer Key for Teachers

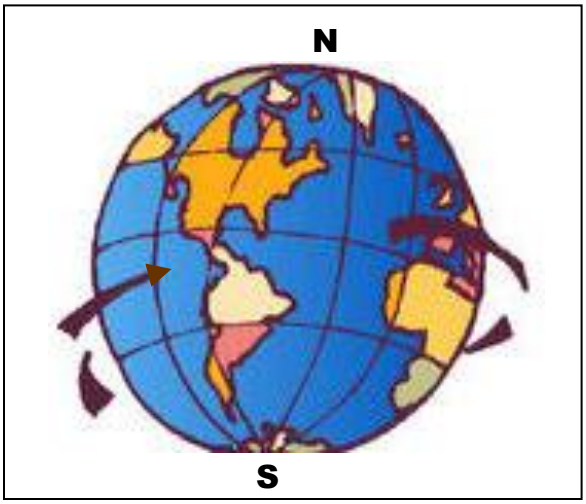
KINESTHETIC TIMES OF DAY

A. Write the correct times of day for someone on the front of the rotating boy.

Choose from: **SUNRISE, SUNSET, NOON or MIDNIGHT**

1. ____NOON_____ 2. ___SUNSET_____ 3. ___MIDNIGHT____ 4. __SUNRISE__

B. Fill in the blanks below

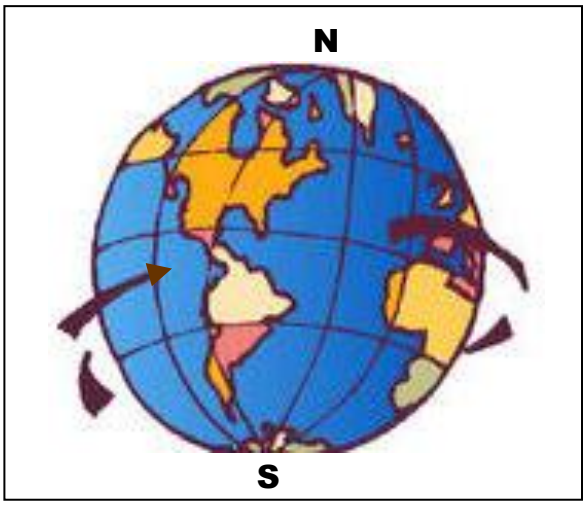


Earth turns about its axis. We call this movement **__A DAY_____**. Earth takes **__24____** hours to rotate around. We call this length of time Earth's rotational period.

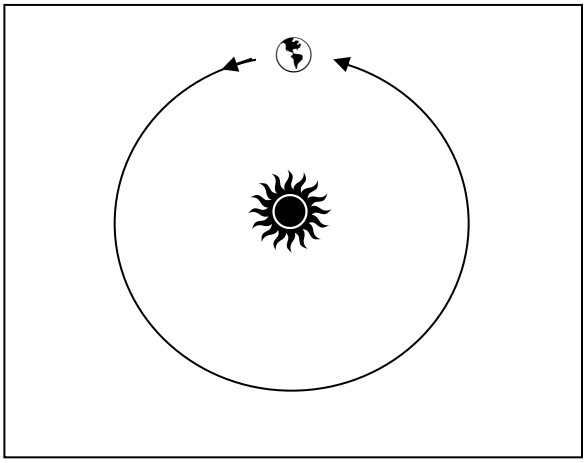
Answer Key for Teachers

ROTATION VS. ORBIT

Fill in the blanks below



Earth turns about its own axis. We call this movement __**ROTATION**_____. Earth takes __**24**____ hours to rotate around. We call this length of time Earth's rotational period.



Earth moves around the Sun. We say that Earth ___**ORBITS**_____ the Sun. Earth takes __**365**_____days to go once around. We call this length of time Earth's orbital period.

Answer Key for Teachers

THE "DATING" GAME

Use the diagram below to fill in the *10 blanks* about the kinesthetic times of day and year.

FOR THE BOY

1. What is the time along a line down the middle of the front of his body?

_____ NOON_____

2. What is the season in North America?

_____ WINTER_____

3. What is the date in North America?

_____21 DECEMBER_____

4. What is the season in South America?

_____ SUMMER_____

5. What is the date in South America?

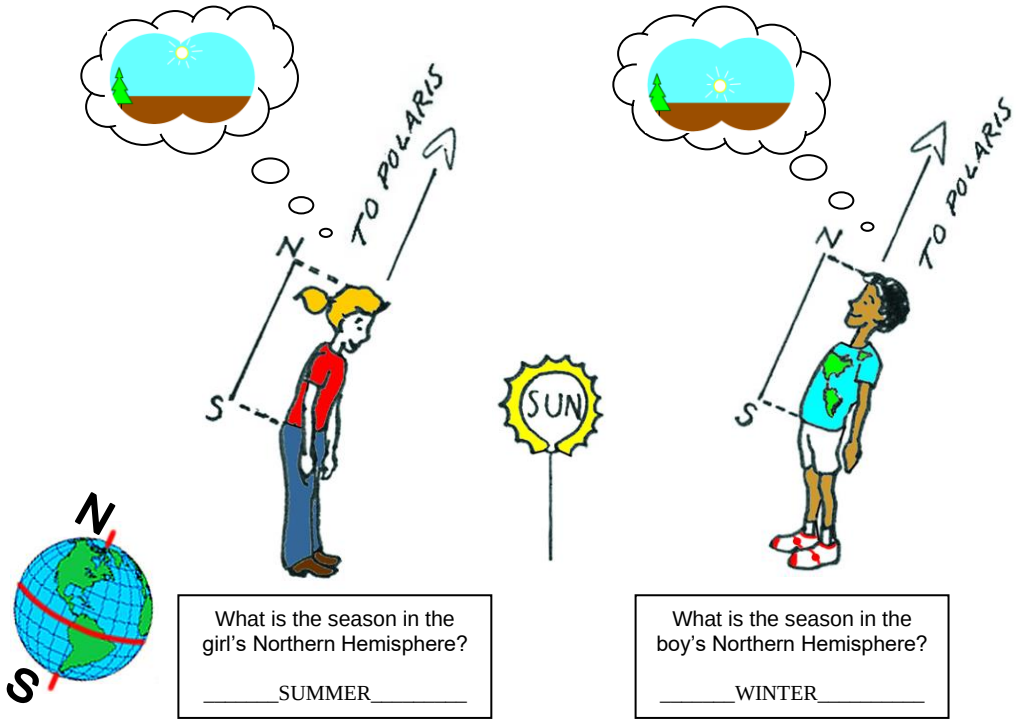
_____21 DECEMBER_____

6. What is the time along a line down the middle of his back?

_____ MIDNIGHT_____

7. What is the season on his upper back (China)?

_____ WINTER_____



What is the season in the girl's Northern Hemisphere?

_____SUMMER_____

What is the season in the boy's Northern Hemisphere?

_____WINTER_____

CHALLENGE: Can you also answer questions 1-7 for the GIRL?
1). NOON, 2). SUMMER, 3). 21 JUNE, 4). WINTER, 5). 21 JUNE, 6). MIDNIGHT, 7). SUMMER.

BONUS: What is the season on the girl's lower back?

_____ WINTER_____

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KINESTHETIC SEASONS

Answer Key for Teachers

Layout adapted from the *Family Guide to the Sun***

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).

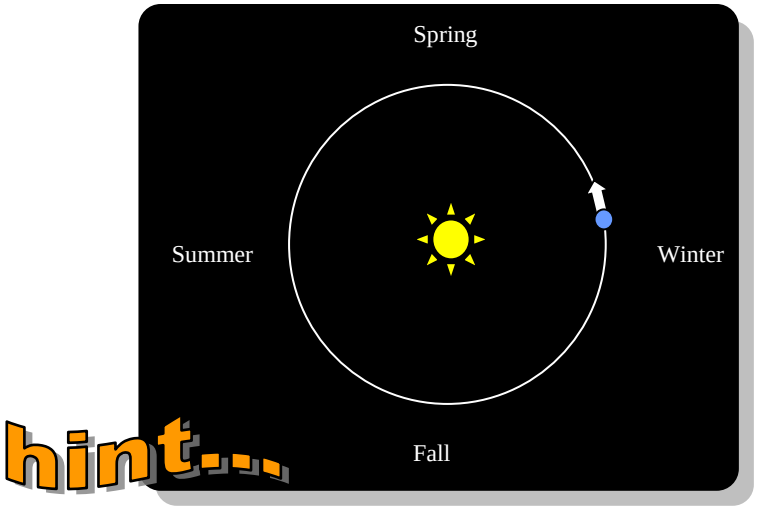
SO WHY IS IT COLDER IN WINTER?

Try this!

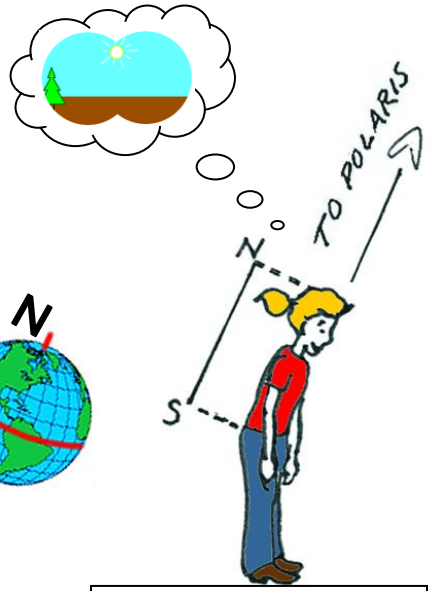
1. Pretend your body is Earth in orbit around the Sun. Let a helium balloon be the Sun.

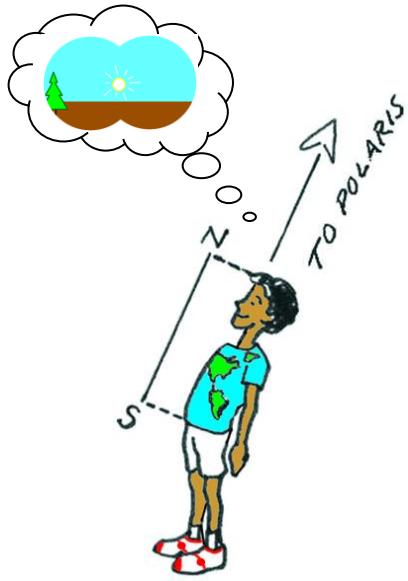
2. The top of your head is Earth's North Pole. Tilt toward Polaris 23.5º like the kids below.

3. Try to rotate around your axis and "orbit" the Sun while keeping your head pointed toward Polaris.



hint...





When your Northern Hemisphere is leaning away from the Sun, will the Sun appear *higher* or *lower* in the sky?

_____LOWER_____

The hemisphere which is leaning away from the Sun is in winter. The Sun appears lower in the sky, giving fewer daylight hours and so less time to heat the planet's surface. This causes colder temperatures.

What is the season at the girl's upper chest (North America)?	What is the season at the boy's upper chest (North America)?
_____SUMMER_____	**_____WINTER_____**
What is the season at the girl's upper back (China)?	What is the season at the boy's belly (South America)?
_____SUMMER_____	**_____SUMMER_____**

******See http://www.spaceweathercenter.org/resources/04/04.html

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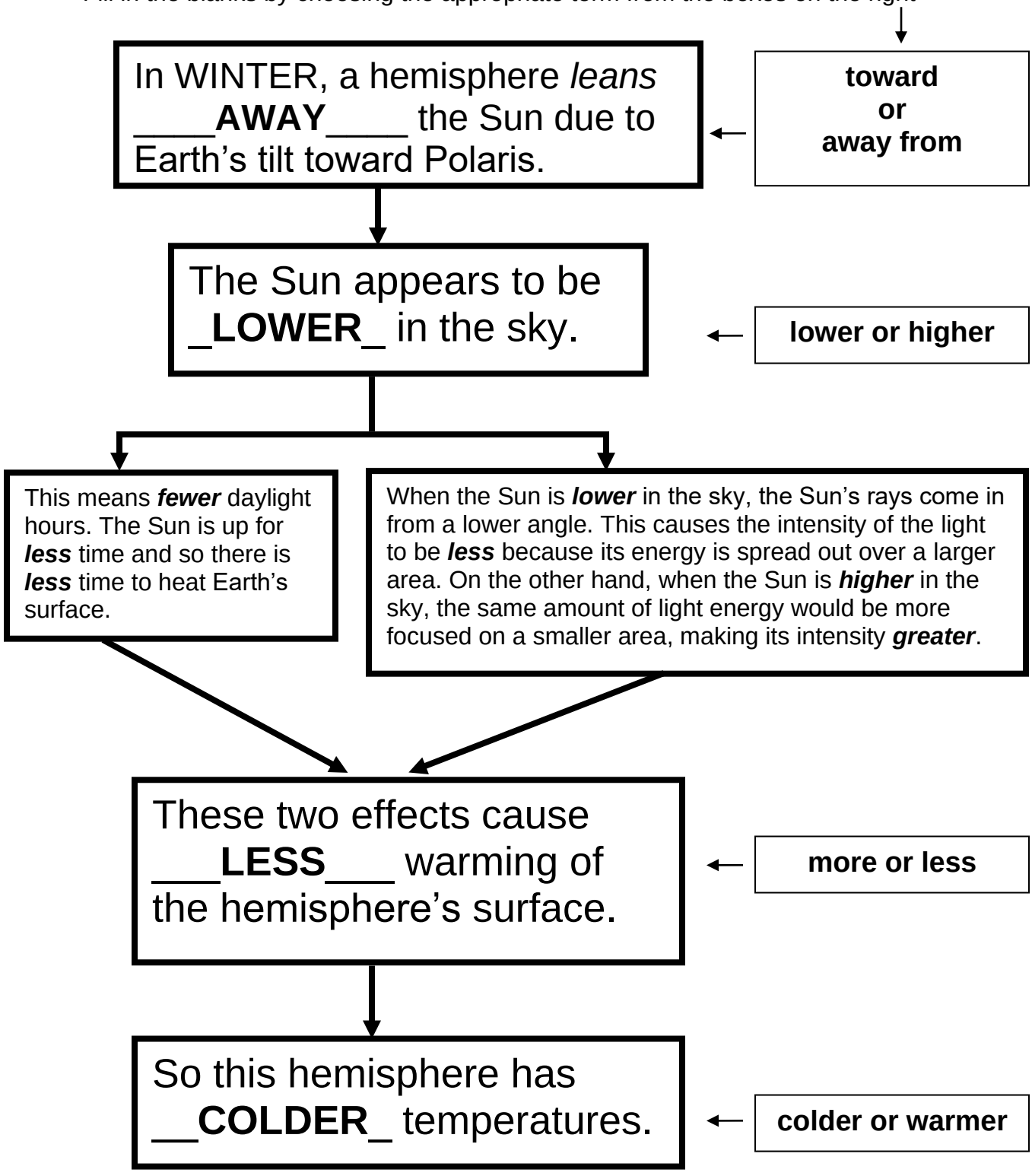
Answer Key for Teachers

REASONS FOR SEASONS CONCEPT MAP ACTIVITY

Seasons Concept Map for **WINTER** **[p 1 of 2]**

Fill in the blanks by choosing the appropriate term from the boxes on the right

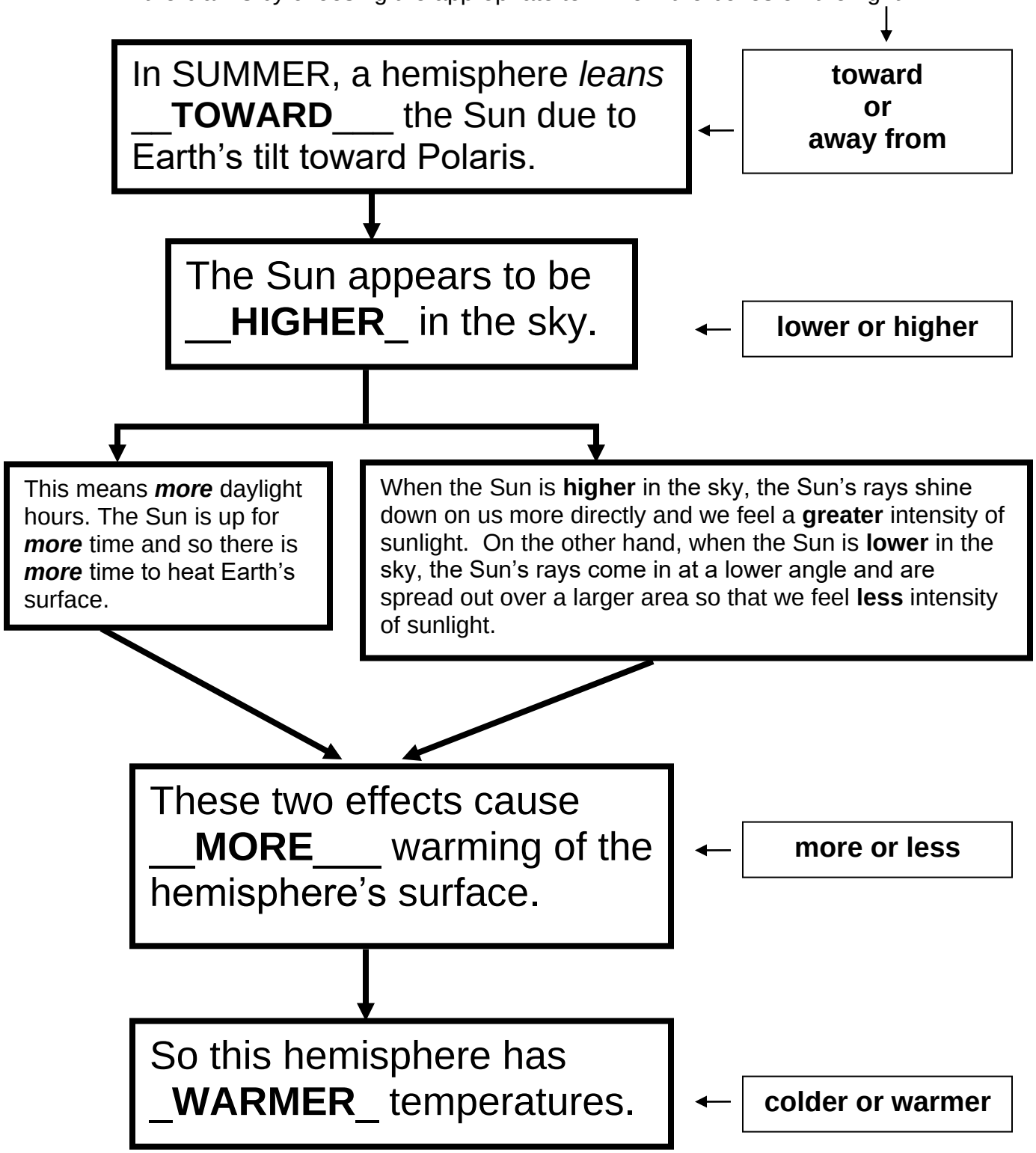


Answer Key for Teachers

REASONS FOR SEASONS CONCEPT MAP ACTIVITY

Seasons Concept Map for **SUMMER** **[p 2 of 2]**

Fill in the blanks by choosing the appropriate term from the boxes on the right



Answer Key for Teachers

REASONS FOR SEASONS [p 1 of 2]

Fill in the blanks. ~~Cross out~~ each term below as you use it!

day	Sun	winter	24	colder	axis
year	Polaris	winter	365	warmer	circle
solstice	orbit	summer	23.5	Southern	elliptical
equinoxes	rotates	summer	Hemisphere	Northern	tilt

Planet Earth __**rotates**___ once around its axis every ___**24**____ hours. We call this period of time a ___**day**____. There are ___**365**___ days in a ____**year**_____. It takes one year for Earth to ___**orbit**____ once around the ___**Sun**____. If I am ___**(ex.)15**____ years old [enter your own age], then I have made __**[age]** ____ trips around the Sun during my life [enter your own answer].

Earth's orbit around the Sun traces out an almost perfect ___**circle**_____. Thus the distance between the Sun and Earth does not change very much over the course of a year. So the reason that temperatures are __**warmer**___ in the summer and ____**colder**____ in the winter is the tilt of Earth's rotation axis. Earth's seasons are NOT caused by being closer or farther from the Sun.

Earth's rotation axis is tilted __**23.5**___ degrees so that the North Pole points toward a distant star called _____**Polaris**_____ (the North Star). As Earth moves around the Sun, Earth's North Pole stays pointed toward this star. Polaris is 500 light-years from our solar system. Earth's axis remains tilted toward Polaris, but how Earth is leaning relative to the Sun changes as Earth moves in its orbit around the Sun.

When Earth is located on one side of the Sun, the tilt causes the Northern Hemisphere to be leaning toward the Sun. When Earth is on the opposite side of the Sun, this same ___**tilt**____ toward Polaris causes the Northern Hemisphere to be leaning away from the Sun. When the Northern Hemisphere is leaning toward the Sun, the season is ____**summer**_____ in the ____**Northern**____ Hemisphere and winter in the Southern Hemisphere. When the Northern Hemisphere is leaning away from the Sun, the season is ____**winter**_____ in the Northern __ **Hemisphere** ___ and summer in the __**Southern**____ Hemisphere.

Answer Key for Teachers

REASONS FOR SEASONS [p 2 of 2]

When we are leaning away from the Sun, as in the season of ____**winter**___, the Sun appears ____ **lower** ___ [higher/lower] in the sky. This means the Sun will spend _____**less** ____ [less/more] time above the horizons (rising later and setting earlier), and thus there will be fewer daylight hours and less time to warm Earth. The day of the year with the ___ **least** ___ [least/most] daylight hours is December 21st, the first day of winter (in the Northern Hemisphere). This day is also called the Winter Solstice.

When we are leaning toward the Sun, as in the season of ____**summer**____, the Sun appears _____**higher** _____ [higher/lower] in the sky. This means the Sun will spend _____**more** ____ [less/more] time above the horizons (rising earlier and setting later), and thus there will be more daylight hours and more time to warm Earth. It is also true, that when the Sun is higher in the sky, the Sun's rays impact Earth at a steeper angle and are _____**more** ___ [less/more] intense than when the Sun is lower in the sky. This also helps to explain why it is warmer in summer and colder in winter. The day of the year with the _____**most** _____ [least/most] daylight hours is June 21st, the first day of summer (in the Northern Hemisphere). This day is also called the summer ____**solstice**____.

When Earth is neither leaning toward nor away from the Sun, we have the Fall and Spring ____**equinox**_____, when daylight and nighttime hours are about equal.

For Earth, the following phrase is a way to remember the reason for colder and warmer seasons: "Length of "days"; Angle of rays; Nothing to do with how far away". But what about the seasons on Mars? Mars' rotation ____**axis**____ is tilted about the same amount as Earth's, but Mars' orbit around the Sun is more ___**elliptical**___ (like an oval). Thus Mars' distance from the Sun varies a lot more than Earth's distance from the Sun. This means that both the tilt of the Mars' rotation axis and its closer and farther distances from the Sun are important to consider in determining the more extreme nature of Martian seasons.

Answer Key for Teachers

YOUR BIRTHDAY STARS [p 1 of 2]

Use the *Zodiac Diagram* to answer these questions.

1. Estimate the date at the girl's position: **~ 2 Feb (Ground Hog Day).**

2. Name a Zodiac constellation that would be visible to her *at midnight*:

_____Cancer_____

3. Write the names of two Zodiac constellations that would be visible in the night sky *at midnight* on the Summer Solstice (21 June).

_____Scorpius_____ _____Sagittarius_____

4. Do we see different stars at different times of year?

Circle one: (YES) NO

Explain: At different times of year the nighttime side of Earth is facing out different directions in space.

5. Write down your birthdate (day, month, year): **Example: 21 Aug 1995**

6. Mark an "X" on the Diagram to show your birthday position in Earth's orbit around the Sun.

7. Write the names of two constellations that would be visible in the night sky *at midnight* on your birthday:

__ Aquarius___ __Capricorn__

8. Can you see the constellation representing your "sign" of the Zodiac in the night sky on your birthday?

Circle one: YES (NO)

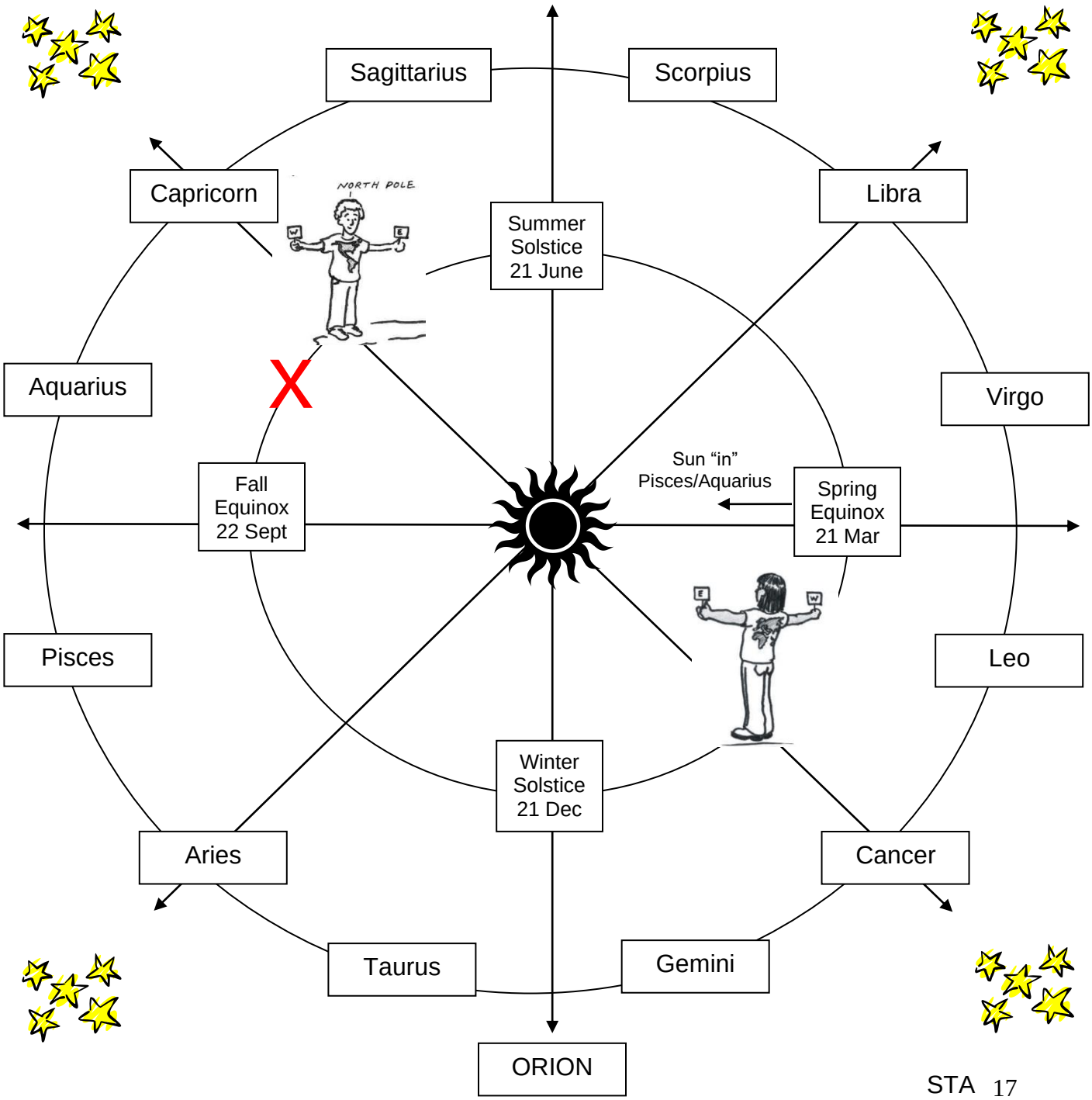
Explain: On my birthday, those stars that make up that constellation are being blocked by the Sun, and when it is nighttime, I am looking out away from those stars.

Answer Key for Teachers

THE ZODIAC DIAGRAM [p 2 of 2]

Use this Zodiac Diagram to answer questions.

REMEMBER: During the lesson, you were standing around the inner circle with your body representing Earth in orbit around the Sun.



Answer Key for Teachers

DIFFERENT STARS FOR DIFFERENT SEASONS
FILL-IN-THE-POEM

by Cherilynn Morrow
cheri@KinestheticAstronomy.com

Use the words at the bottom to fill in the blanks of the poem. As you choose your answers, be sure to consider the astronomy you know as well as the rhyming scheme.

Now we KNOW planet _E A R T H_, she does circle the _S U N_;.

And it takes her a _Y E A R_ 'til one orbit is done.

She _T I L T S_ to a pole star – this causes the _S E A S O N S_,

And moves through our birthdays with gravity's reason.

There's _L E O_ the lion – we see THIS in the Spring,

But night skies in Fall gives us Pegasus' wings.

In summertime nights we see Cygnus the swan;

In _W I N T E R_, Orion flies dusk until _D A W N_.

So why DO we not see the same constellations,

As Earth _O R B I T S_ 'round through her seasonal stations?

See, the _N I G H T_ side of Earth – without Sun's reflections –

Faces out to the _S T A R S_ in different _D I R E C T I O N S_.

STARS	YEAR	SEASONS
ORBITS	DAWN	WINTER
TILTS	NIGHT	EARTH
DIRECTIONS	LEO	SUN

Answer Key for Teachers

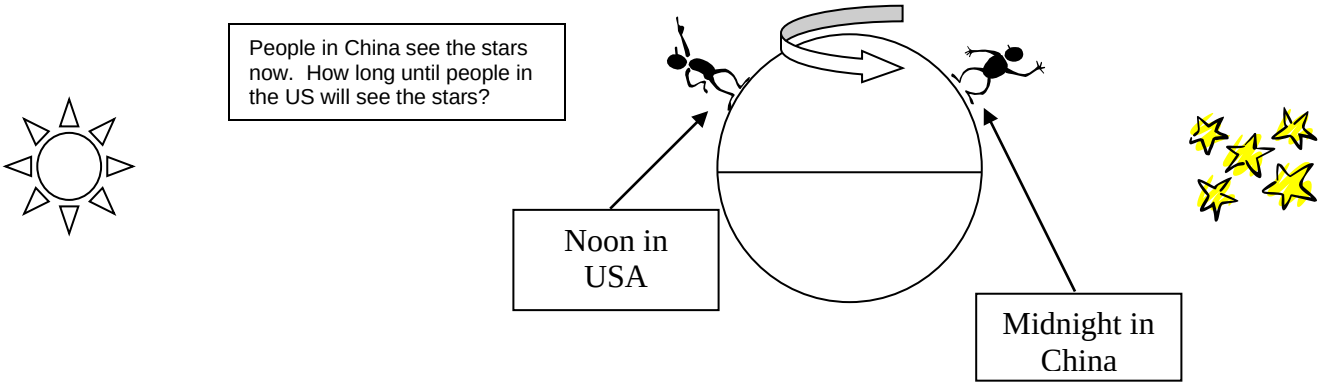
THE NIGHT SKY IN CHINA

Fill in the answers and design a kinesthetic demonstration

1. Do you think people in the US will see pretty much the same stars tonight as people in China saw 12 hours ago? **Circle one:** **YES** **NO**

STOP! RECORD AND KEEP YOUR ANSWER ABOVE. THEN GO ON TO SEE IF YOUR ANSWER CHANGES OR STAYS THE SAME BY THE END. *LET'S GO!*

2. What is Earth's rotational period (in hours)? _____**24**_____
3. What is Earth's orbital period around the Sun (in days)? _____**365**_____
4. How many times does Earth rotate during one orbit of the Sun? ___**365**____
5. How many degrees are in a circular orbit? _____**360º**_____
6. So *about* how many degrees does Earth move in orbit in one day? ___**1º**____
   Explain: With 365 days in a year and 360° in a circle, Earth must complete about 1° of orbit each day to complete one orbit each year.
7. Look at the diagram. How long will it take for Earth to rotate from noon in the USA (midnight in China) to midnight in the USA (noon in China)? __**12**_hrs?
8. So *about* how far will Earth have moved in its orbit during this time? __**1/2 º**_



9. Will people in the US see pretty much the same stars tonight as people in China saw 12 hours ago? **Circle one:** **YES** **NO**
10. Work in pairs to design a ***kinesthetic demonstration*** that proves your answer.

Answer Key for Teachers

WHO CAN SEE ORION WHEN?

Use kinesthetic techniques to confirm Orion's visibility.

Orion is not visible at any time because it **rises at sunrise** and **sets at <u>sunset</u>**.

Heliacal rise of Orion. Orion visible low in the east for a short time just before **<u>sunrise</u>**.

Heliacal set of Orion. Orion visible low in the west for a short time just after sunset

Summer Solstice 21 June

Orion **rises at midnight**. Visible in the eastern sky until it fades away at sunrise. **Sets at noon**.

Fall Equinox 22 Sept

Spring Equinox 21 Mar

Orion **rises at noon**. Only visible in the western sky after sunset. **Sets at <u>midnight</u>**.

Orion rises between sunset and midnight and fades away in the western sky at sunrise.

Winter Solstice 21 Dec

Orion rises between noon and sunset. Only visible after sunset until setting in the west in the early AM.

Orion visible the whole night: **rises at <u>sunset</u>** and **sets at <u>sunrise</u>.**

This diagram is NOT to scale. Place the Orion sign as far away as is practical.

TO ORION

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Answer Key for Teachers

COMPARING THE SEASONS ON EARTH AND MARS

1. **How long is a Martian day? How does this compare to Earth?**
   The Martian day is 24.6 hours long, about the same as Earth. Thus the two planets are rotating at about the same speed.

2. **How long is a Martian year? How does this compare to Earth?**
   About 2 Earth years. Mars takes twice as long to orbit the Sun.

3. **If you lived on Mars would you have made more or less trips around the Sun in your life? How old would you be in Martian years?**
   If you lived on Mars, you would have made only half as many trips around the Sun, so you'd be half as old in Martian years!

4. **How does the tilt of Mars' axis compare to Earth?**
   The tilts are about the same.

5. **Will it be generally colder or warmer on Mars compared to Earth? Why?**
   Colder because Mars is significantly farther from the Sun.

6. **Do you think Mars will have seasons? Why or why not?**
   Yes, because Mars' axis is tilted like Earth's. Thus the same effects of the Sun being higher and lower in the sky at different times of year will be the result – more or less direct sunlight, longer and shorter days. When the northern hemisphere is tilted toward the Sun it will be warmer (in summer), and when it is tilted away it will be colder (in winter). The opposite will be true for the southern hemisphere, just as it is on Earth.

7. **How long are seasons on Earth? How long would a Martian season be?**
   Seasons on Earth last 3 Earth months. A Martian season would be about twice as long because it takes twice as long for Mars to orbit the Sun.

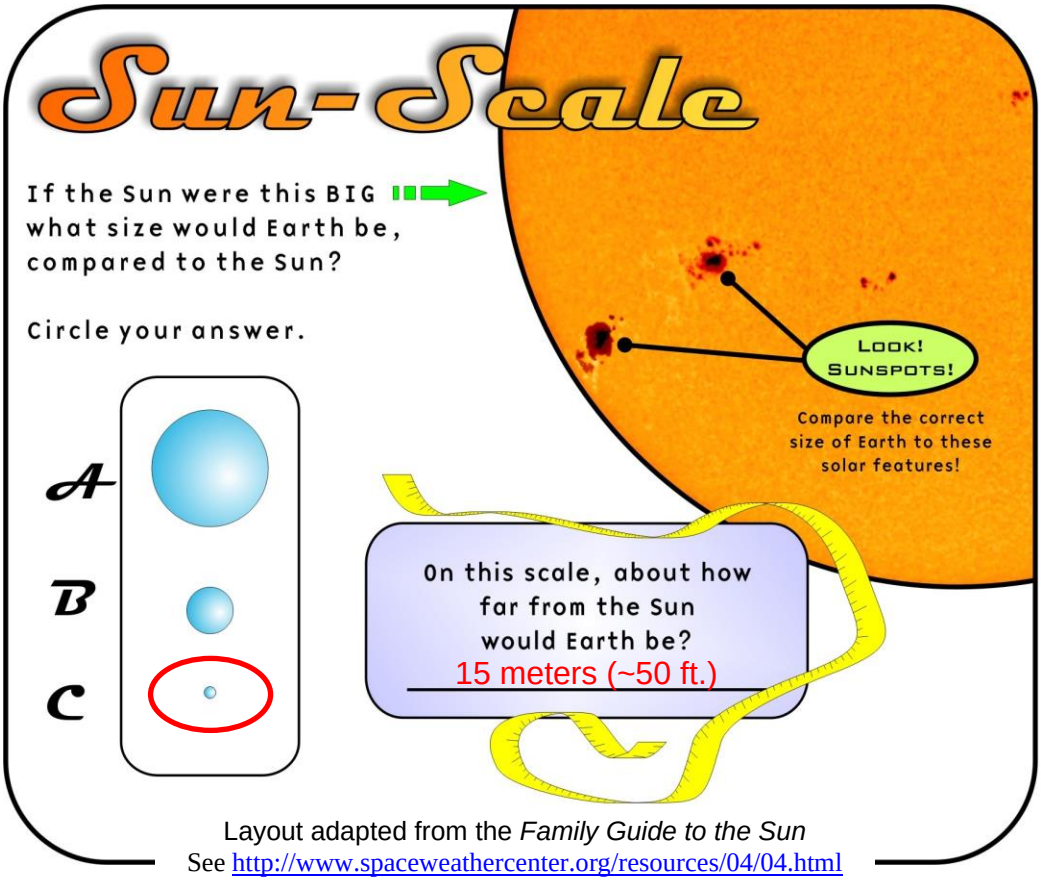
8. **Do you think the more elliptical orbit of Mars makes the Mars-Sun distance a more important factor in the seasonal temperatures of Mars?**
   Compared to Earth, Mars' distance from the Sun is far more important in determining seasonal behavior. Mars is closest to the Sun in northern hemisphere winter (southern hemisphere summer), and farther from the Sun in northern hemisphere summer (southern hemisphere winter). This is true for Earth as well, but Mars' orbit is more elliptical (more like an oval) and thus Mars receives 50% more energy from the Sun when it is closest compared to when it is farthest from the Sun. This makes the seasons significantly more intense in the southern hemisphere (even more cold OR(**colder**) in winter and even more hot (**hotter**) in summer). When Mars is closest to the Sun, atmospheric motions can sometimes trigger great global dust storms that can change the shape of the bright and dark areas on the surface of Mars. These shifting shapes fooled early astronomers into believing that Mars had a seasonal variation of vegetation. Today we know there are no trees on Mars, and we know of no other forms of life.

Answer Key for Teachers

WHAT HAVE YOU LEARNED? [p 1 of 5]

1. How many stars are in the Solar System? _____1_____

2. Provide the TWO answers requested in the box below:



Layout adapted from the *Family Guide to the Sun*
See http://www.spaceweathercenter.org/resources/04/04.html

3. Write the correct times of day for someone on the front of the rotating boy.

1. ____NOON_____ 2. ___SUNSET____ 3. ___MIDNIGHT____ 4. __SUNRISE_

Choose from SUNRISE, SUNSET, NOON or MIDNIGHT.

Answer Key for Teachers

WHAT HAVE YOU LEARNED? [p 2 of 5]

3. **Do stars appear to rise and set? Why or why not?**

   Because Earth is turning (rotating).

4. **Fill in the blanks below and DRAW PICTURES to show what you mean.**

   a) Earth turns about its own axis. It takes ___**24**___ hours to turn once around.

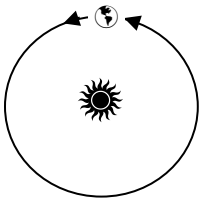
   We call this movement _____**ROTATION**_____.

DRAWING of Earth doing this movement:

   b) Earth moves around the Sun. It takes ___**365**____days to go once around.

   We say that Earth is in _____**0RBIT**_____ around the Sun. How many trips around the Sun have you made in your life? ___**[YOUR AGE]**___

DRAWING of Earth doing this movement:



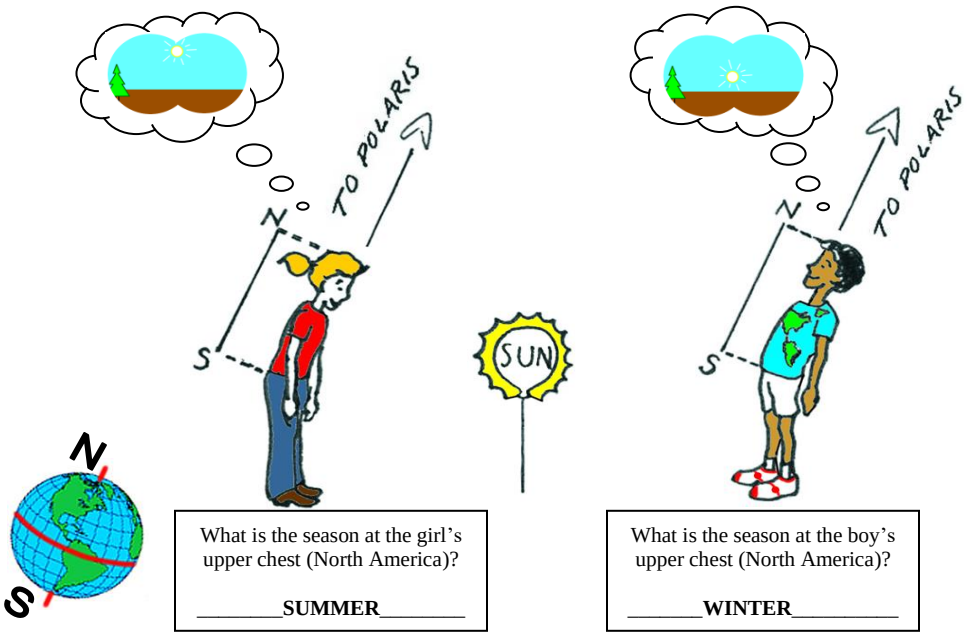
5. **How many times does Earth rotate during one orbit of the Sun? __365___**

6. **About how much (out of 360º) does Earth move in orbit in one day? _1º_**
   Explain your reasoning: With 365 days in a year and 360° in a circle, Earth must complete about 1° of orbit each day to complete one orbit each year.

Answer Key for Teachers

WHAT HAVE YOU LEARNED? [p 3 of 5]

7. Fill in the blanks below the girl and boy:



What is the season at the girl's upper chest (North America)?

_____**SUMMER**_____

What is the season at the boy's upper chest (North America)?

_____**WINTER**_____

What is the season at the girl's upper back (China)?

_____**SUMMER**_____

What is the season at the boy's lower belly (South America)?

_____**SUMMER**_____

8. What time of year do we experience more daylight hours? Why?

Summer. In summer our hemisphere is leaning toward the Sun. This makes more of the Northern Hemisphere illuminated by the Sun causing the Sun to be above the horizon for more hours than in winter.

9. Why is it hotter in summer and colder in winter on Earth?

In summer, the Sun is higher in the sky near noon so Earth receives greater intensity of the Sun's light. The Sun is also above the horizon for more hours so the Sun heats Earth's surface longer, and there are less hours at night for the surface to cool down. In winter, the Sun is lower causing less heating and we have less hours of daylight to warm the surface and more hours at night for the surface to cool down.

Answer Key for Teachers

WHAT HAVE YOU LEARNED? [p 4 of 5]

11. Refer to the Zodiac Diagram on the next page to answer these questions:

a) Estimate the date at the boy's position: __**~ 5 AUG**____.

b) Name a Zodiac constellation that would be visible to him *at midnight*:

_____CAPRICORN_____

c) Estimate the date at the girl's position: **~ 2 FEB (Ground Hog day)**.

d) Name a Zodiac constellation that would be visible to her *at midnight*:

_____CANCER_____

e) Write the names of two constellations that would be visible in the night sky *at midnight* on the Winter Solstice (21 December).

_____TAURUS_____ _____GEMINI_____

f) Do we see the same stars at different times of year? Why or why not?

Yes, because at different times of year the nighttime side of Earth is facing out into different directions into space.

g) Write down the date of your birthday: ___**Example: 31 OCTOBER**___

h) Mark an "X" on the Diagram to show your birthday position in Earth's orbit.

i) Write the names of two constellations that would be visible in the night sky *at midnight* on your birthday.

_____PISCES_____ _____ARIES_____

j) BONUS: Can you see the constellation representing your "sign" of the Zodiac in the night sky on your birthday? Explain your answer on the back.

NO, on my birthday I am looking out away from those stars that make up that constellation when it is nighttime. At noon I am looking toward those stars, but they are being blocked by the Sun.

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Answer Key for Teachers

THE ZODIAC DIAGRAM [p 5 of 5]

DIRECTIONS: Use this Zodiac Diagram to answer questions.

REMEMBER: During the lesson, you were standing around the inner circle with your body representing Earth in orbit around the Sun.