Names: Partner 1 _____ Partner 2 _____

Worksheet: Latitude, Angle of Sun and Solar Energy

Why is it hot in the summer (select the best answer)?

A. Because it's summer.
B. Because the earth is closer to the sun.
C. Because the solar energy is stronger.
D. Because the solar energy is concentrated over a smaller surface area.
E. Because the winter snow melted.

Hold on to your answer. We'll come back to it later?

Let's try an experiment. Each lab team will use a flashlight that has been taped to one end of a meter stick.

Lab protocol:

1. Hold the meter stick perpendicular to the floor with the flashlight pointing down.
2. Turn the flashlight on and focus the beam so that you get a nicely defined small circle of light projecting on the floor.
3. Measure and record the diameter of the circle.
4. Then tilt the meter stick so that it is at a 45° angle to the floor.
5. Measure and record the longest distance across the oval.
6. Estimate and record how much more surface area the 45° angle circle covers versus the 90° angle circle (2x, 3x, 3.5x?).
7. Now compare the brightness of the light where it hits the floor surface by shining the light at 45° and 90°. Record which setting had a brighter area of light?

Whenever you see a, , partners should record data in your data log or lab book

Gathering and analyzing data:

Let's look at some data to try to see patterns that might relate to the question as to why it's hotter in the summer. Open the file *latitudeangle.xls*. There are six columns of data: *City, State, Latitude, Angle of the sun* (at noon on Spring Equinox day), *surface area covered by a square meter of light energy* and *Elevation*.

Whenever you see a, , a partner should do something with the speadsheet file

Science is often driven by data. Huge amounts a data. Data that can look like this - messy and unwieldy. Let's try to organize it to see if any patterns emerge that might help us answer the question why it's hot in the summer.

There are a number of different data points associated with every city. We are interested in factors (there may be more than one) that might influence temperature. How can we organize the spreadsheet so that a pattern or patterns might emerge. Well, since we're interested in temperature, let's organize the data by temperature.

Click on any cell (box) in the spreadsheet and hold the command key (apple key for Macs) and push "A" to select all.
Go to the *Data* menu and pull down to *Sort.*
Pull down the *Sort by* options menu and choose *Avg. Annual Temp.* and then select descending radio button and click *OK*.

It looks like there is somewhat of a relationship between temperature and latitude and angle of the sun. Let's explore more.

- Click on any cell (box) in the spreadsheet and hold the command key (apple key for Macs) and push "A" to select all.
- Go to the Data menu and pull down to *Sort*
- Pull down the *Sort by* options menu and choose *Angle of the sun* and then select ascending radio button and click *OK*.

There does seem to be a direct inverse relationship between *Angle of the sun* and *Latitude.* At noon on Spring Equinox day at 71.3° latitude of Barrow, Alaska, the sun is at an 18.7° angle in relation to the surface of the earth.

1. What is the mathematical relationship between *angle of the sun* and *latitude* (hint: scroll down to Quito, Ecuador at 0° on the equator?

   _____

When you go outside on a sunny day it is usually hotter than on a cloudy day. As you may have guessed, the heat is due to the sunlight… but it is not heat energy that travels here from the sun. Do you know why?_____

Whenever you see a ?, partners should write out answers **together**. If you don't know the answer, ask another group for help before moving on.

What does travel from the sun to Earth is light energy, in the form of photons that hit the planet surface. That light energy is then converted to thermal energy.

2. Beside clouds, what else might influence how much light energy hits a specific area of the planet (hint: think about the little lab we just did)?

   _____

- Look at your spreadsheet. There also seems to be another direct inverse relationship between *Angle of the sun* and something else besides *latitude.*

3. As the angle of the sun increases, what decreases? _____

4. If the same amount of energy (1 square meter) is distributed over either 3 square meters of earth surface or……. 1 square meter, which surface receives a more intense or concentrated amount of energy, say in just one of its square centimeters? _____

For the most part, the closer to the equator as city is the higher the angle of the sun AND the less surface area a square meter of sunlight is distributed over AND the higher average annual temperature. There are some exceptions. You may have noticed the average annual temperature of Quito, Ecuador is only 15° Celsius and yet, it's on the Equator! There might be some other factor or factors at work.

5. Can you see any data in our spreadsheet about Quito, Ecuador that might be different than most other cities? _____

6. In California it rains over most of the state during the winter months, but on the very same day, high in the Sierra mountains, it will be snowing. Can anyone guess why it's colder in the mountains?

   _____

   If we suspect the higher altitude might be why Quito has a colder climate than expected, how might we check to see if altitude has an effect on average annual temperature?

   _____

Now let's get back to the original question…… **Why is it hot in the summer?**

7. Does a city's latitude change as summer solstice approaches?_____
8. What does change? _____

Why is it hot in the summer (select the best answer)?

A. Because it's summer.
B. Because the earth is closer to the sun.
C. Because the solar energy is stronger.
D. Because the solar energy is concentrated over a smaller surface area.
E. Because the winter snow melted.

Due to the tilt of the Earth, which always points the same way, as the earth revolves around the sun, the angle of the sun changes no matter where one is located. As summer solstice approaches, the sun beam at 90° angle (at noon) is positioned a little more north each day, until the solstice when it is at latitude 23.5° N. From then on, until to winter solstice, the 90° angle moves further southward with each day

9. If the angle of the sun is at 50° in Columbus, Ohio on March equinox (when it is 90° at the equator), what will the angle be in Columbus on summer solstice when 90° is at 23.5° N? _____
10. How did you figure that out? _____
11. What will the approximate surface area be for 1 square meter of light (hint: you have a large dataset to pick the answer from)?_____
12. If the surface area for 1 square meter of light is smaller, will the energy be more concentrated?_____
13. If the surface area is smaller and the energy more concentrated, how will that affect temperature?

    _____
14. What will the sun's angle be in Columbus on winter solstice (it's 90° at 23.5° S)? _____
15. What will the approximate surface area be for 1 square meter of light?_____
16. If the surface area for 1 square meter of light is larger, will the energy be more concentrated?_____
17. If the surface area is larger and the energy less concentrated, how will that affect temperature?

    _____

Applying what we have learned:

Science is about learning about the world. One of the ways scientists study the world is to collect data. The data can then be organized and sometimes it falls into patterns. Scientists often use patterns to make predictions.

18. Rochester, NY is at 43.12° latitude and Fort Worth, TX is at 32.83 (they're both at about the same elevation). Predict which of these two cities might have the higher average temperature?

    _____

19. If we suspect that latitude/angle of the sun/surface area (they are all directly related) might effect average annual temperature, why is it better to look just at cities of the similar elevation?

_____

20. Denver, CO is at the same latitude as Atlantic City, NJ. However, Denver is at 5,280 ft. elevation and Atlantic City is at 66 ft.. Predict which of these two cities might have the higher average temperature? _____