Name: _____ Date: _____ Period: _____

Earth's Energy Budget Activity

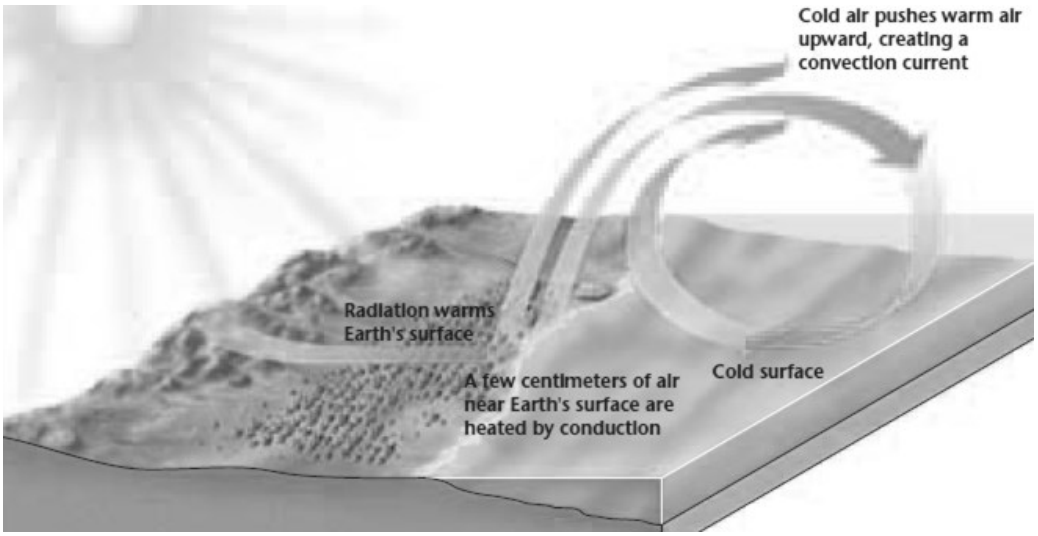
****Please Turn In This Assignment****

Background Notes:

Complete the background notes on the Sun's energy by using your textbook on pages 275 – 277.

Radiation

- Radiation is the transfer of energy through space by _____ _____, _____ radiation, and other forms of electromagnetic waves.
- While Earth is _____ solar radiation, it is also continuously sending energy back into space.
- Different areas absorb energy and heat up at different rates. For example, water heats up and cools down more _____ than land. And, as a general rule, _____ objects absorb energy faster than _____ ones.
- The energy radiated by Earth's _____ does not pass back through the atmosphere. Rather, it is absorbed by the atmosphere and warms air through the processes of _____ and _____, which along with radiation, make up the three methods of energy transfer



Conduction

- Conduction, which is the transfer of energy that occurs when molecules _____
- Energy is transferred from the particles of air near Earth's _____ to the particles of air in the _____ layer of the atmosphere
- For conduction to occur, substances must be in _____ with one another. That's why conduction affects only a very thin atmospheric layer near Earth's surface.

Convection

- Convection, the transfer of energy by the flow of a _____ substance
- Pockets of air near Earth's surface are heated, become _____ dense than the surrounding air, and rise
- As the warm air rises, it expands and starts to cool. When it cools below the temperature of the surrounding air, it _____ in density and sinks. As it sinks, it _____ again and the process starts anew.
- Convection _____, as these movements of air are called, are among the main mechanisms responsible for the vertical motions of air, which in turn cause the different types of weather

Goal:
You will learn about the movement of solar radiation using stacks of paper to illustrate Earth's Energy Budget on a diagram.

Directions:
Read and follow the steps concerning your diagram while completing thought questions throughout your process.

Set-Up:
- With your partner, count out **100 slips of paper** from your bag to represent energy units. These slips represent all of the solar energy reaching the top of the atmosphere from the sun, or 100%.
- Start at the upper left of the energy balance diagram. With your marker, fill in the box next to the sun with the number 100.

Part 1: Incoming Solar Radiation

Solar energy is constantly moving through space and bathing our planet and its atmosphere. The energy that arrives at the top of the atmosphere is either reflected or absorbed.

About 30% of the solar energy that arrives at the top of the atmosphere is reflected back to space by clouds, atmospheric particles, or bright ground surfaces like sea ice and snow. This energy plays no role in Earth's climate system. Thus, about 70% of the total incoming solar energy is absorbed by the Earth's atmosphere and surface.

Distribute the Sun's Radiation:
- Stack the slips on the diagram according to what happens to each unit of energy as it travels through the atmosphere on its way to Earth's surface:
    1. 23% of incoming solar energy is reflected by clouds in the atmosphere
    2. 7% is reflected by the surface of the Earth
    3. 19% is absorbed by the atmosphere (ozone, aerosols, dust)
    4. 4% is absorbed by clouds
    5. 47% absorbed by the Earth's surfaces (primarily the ocean)

Record the values for the five markers you have just placed in Part 1 for incoming solar radiation.

✍ **Thought Question**

Record the following totals:
Total reflected by clouds, atmosphere & surface: _____
Total absorbed by atmosphere and clouds: _____
Total absorbed by land surface: _____

Part 2: Surface Energy Budget

In Part 1 you saw that about 30% of incoming sunlight is reflected back to space by particles in the atmosphere or bright ground surfaces, which leaves about 70% to be absorbed by the atmosphere (23%) and Earth's surface (47%) including the ocean.

For the energy budget at Earth's surface to balance, processes on the surface must transfer and transform the 47% of incoming solar energy that the ocean and land surfaces absorbed back into the atmosphere and eventually space. Energy leaves the surface through three key processes: evaporation, convection, and emission of thermal infrared (IR) energy.

Distribute the Radiation Absorbed by Earth's Surface:

- Take the stack of 47 slips absorbed by Earth's land and oceans and move them to four *new* location on the energy balance diagram:
  1. 24 slips to latent heat – the energy used in evaporation, transpiration, and condensation
  2. 5 slips to sensible heat – energy that becomes convection where air in direct contact with the sun-warmed ground becomes warm and rises
  3. 12 slips emitted from Earth **directly** back to space
  4. 6 slips for net radiation amount absorbed by atmosphere
     - Note: This is the long-wave energy that is emitted by Earth to the atmosphere (116), minus the energy that is directly transferred to space (12) combined with that which re-radiated back to Earth by the atmosphere (98**).** **116-(12+98) = 6**

Record the values for the four markers you have just placed in Part 2 for absorbed radiation.

✍ **Thought Question**

Latent heat is sometimes referred to as "hidden" heat. Why do you think this is an appropriate term for heat that is used in the water cycle?

_____
_____
_____

Part 3: The Atmosphere's Energy Budget

Just as the incoming and outgoing energy at the Earth's surface must balance, the flow of energy into the atmosphere must be balanced by an equal flow of energy out of the atmosphere and back to space.

Satellite measurements, taken at the top of the atmosphere, indicate that the atmosphere radiates thermal infrared energy equivalent to 58% of the incoming solar energy. If the atmosphere is radiating this much, it must be absorbing this much. Where does the energy come from?

Distribute the Radiation in Earth's Atmosphere:

- Collect the 19 and 4 slips which were absorbed by the atmosphere and clouds in Part 1
- Collect the 24 and 5 slips that were transferred to the atmosphere by way of latent and sensible heat in Part 2
- Collect the 6 slips that remained in the atmosphere
- Count the total slips you have. Move the following percentage of slips to the *new* locations (round to the nearest whole number):
  1. 84.5% of your slips are emitted by the atmosphere
  2. 15.5% of your slips are emitted by clouds

Record the values for the two markers you have just placed in Part 3 for emitted radiation.

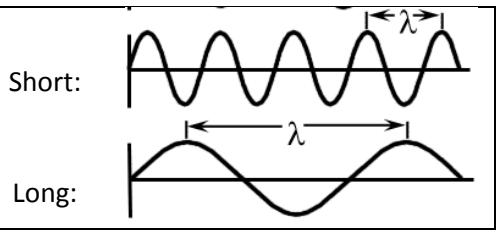
✍ **Thought Question**

Total the three boxes on the top-right of the sheet. These are units of long wave energy transferred by the atmosphere back into space.

_____ + _____ + _____ = _____ units of long wave

This amount of energy when combined with the amount of short wave energy reflected in Part 1 equals 100%. In other words, all incoming solar radiation energy has been returned to space, and your energy budget is now in balance.

✍ **Thought Question**



Short wave radiation is more dangerous than long wave radiation. Why is this good news for us living on Earth?

_____
_____
_____
_____