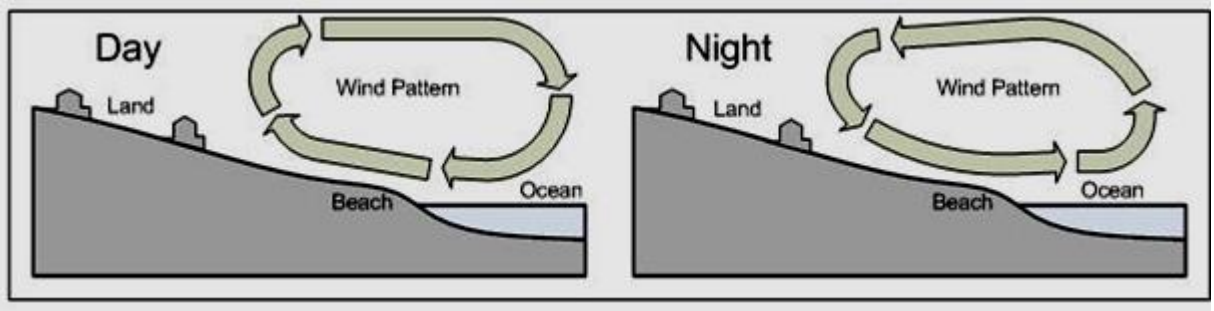
Name: _____ Teacher: _____ Pd. ___ Date: _____

STAAR Science Tutorial 30
TEK 8.10A: Solar Energy & Convection

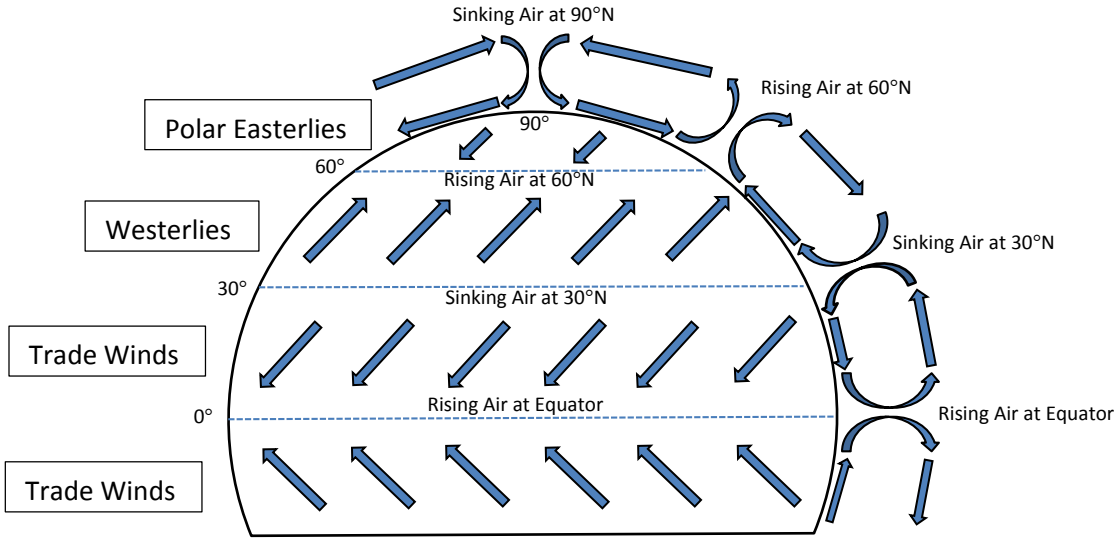
TEK 8.10A: Recognize that the Sun provides the energy that drives convection within the atmosphere and oceans, producing winds and ocean currents.

- Energy from the Sun travels through space to Earth as **radiant (electromagnetic) energy**. This form of energy does not need matter to be transferred from one place to another. See *STAAR Tutorial 23: Energy Forms and Conversion* for a detailed discussion of radiant energy.
- When radiant energy reaches Earth's atmosphere and the surface of Earth, it is either absorbed and converted to thermal energy, or reflected back to space. About 50% is absorbed and converted at the Earth's surface, and 15% is absorbed and converted by the Earth's atmosphere. The rest (35%) is reflected back to space and thus does not heat the Earth.
- The molecules in the matter absorbing the radiant energy begin to vibrate faster—what we sense as heat. Not all substances are heated by radiant energy. Most of the gases in the atmosphere, such as nitrogen, oxygen and argon (99.9% of the atmosphere) are transparent to radiant energy, and do not heat up as the radiant energy passes through them. Only the "**greenhouse gases**" such as water vapor, carbon dioxide, methane, ozone and CFCs gain thermal energy when struck with radiant energy.
- The Earth radiates its stored energy back to space as infrared radiation, at almost the same rate as it absorbs radiant energy from the Sun. In this way, the Earth's average temperature stays nearly constant. However, during the last 100 years, the amount of radiant energy that the Earth absorbs has risen slightly, because of the increased amount of greenhouse gases in the atmosphere. This means that the Earth's average temperature is now slowly rising. See *Tutorial 54: Environmental Change* for a description of the causes and effect of climate change.
- The lowest layer of the atmosphere, the **troposphere**, is where all weather occurs and almost all of Earth's life resides. Because most of the radiant energy coming from the Sun is absorbed at the Earth's surface, temperatures near the surface are usually the warmest. Air temperature in the troposphere typically drops about 6.5°C with every 1000 meters gain of elevation.
- Thermal energy at the surface of the Earth can be transferred to air near the surface by the process of **conduction**. In conduction, the molecules of the water or land at the surface vibrate and touch the air molecules next to them, causing the air molecules to also vibrate. In this way, the air becomes as warm as the surface.
- When the air molecules next to the Earth's surface become warmer and vibrate more quickly, they take up more space (by bouncing off one another more quickly) and thus become less dense.

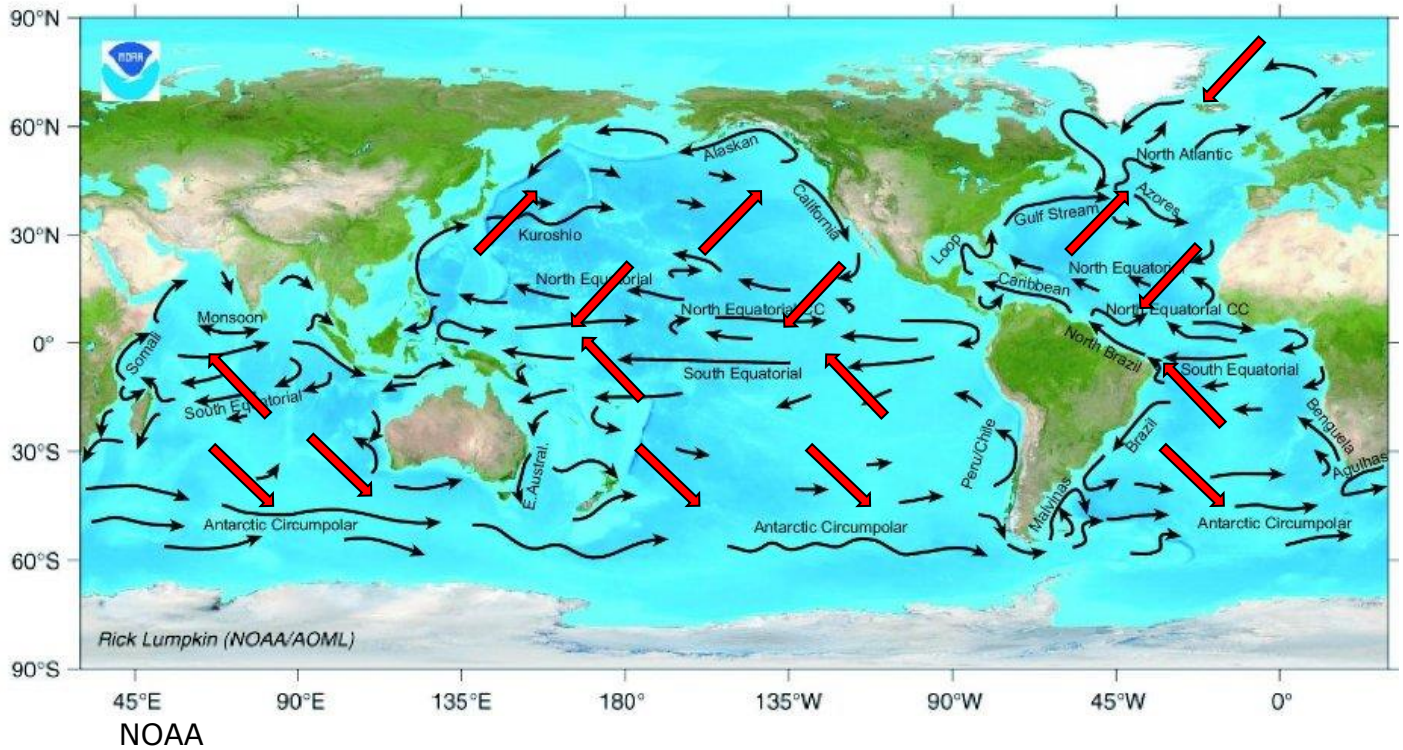
- According to the principle of **buoyancy**, in a fluid (liquid or gas) medium, less dense materials float upward and denser materials sink. This means that the air warmed at the surface of Earth rises, to be replaced by sinking cooler air. This process of moving thermal energy is called **convection**, the transfer of thermal energy by the flow of matter in a fluid.
- Convection currents move thermal energy through the atmosphere both on a local scale and globally.
- **Wind**, a mass of moving air molecules, is caused by convection currents. For example, if you have visited a beach on an ocean or large lake during a sunny day, you may have noticed that the breeze is almost always blowing off the water and onto the land. This **sea breeze** is the result of local convection currents. Sunlight heats the land more quickly than the water, causing the air over the land to rise. This rising air must be replaced by air blowing in off the water. As the warm air rises, it cools off and flows out over the water, to replace the air that flowed from the water to the land. This circular flow of air is a convection current. At night, the sea breeze is replaced by a **land breeze**, because the land cools off very quickly once the Sun sets, while the water stays at about the same temperature and now is warmer. Warm air rises over the water, and is replaced by air flowing off of the now cooler land. The diagrams below show the convection currents of sea and land breezes.



- On a global scale, the wind blows in set patterns created by convection.
    - At the equator, radiant energy hits the Earth most directly, causing the warmest temperatures. Since warm air rises, there is a continuous upward flow of air at the equator, with that air replaced by air at the surface on either side of the equator. Once the warm air rises high in the atmosphere, it begins to cool, and flows both north and south in the upper atmosphere.
    - At a latitude of about 30° north and south of the equator, the now cool air in the upper atmosphere sinks, and once at the surface, flows back towards the equator or towards the pole.
    - The air at the ground generally flows both towards the pole and the equator, and warms since it is near the surface. At about 60° N and S, the now warm air rises again into the upper atmosphere, where it flows either towards the pole or equator.
    - At the poles, the now cold air in the upper atmosphere sinks again, and flows back towards the equator along the ground. The result is a global wind pattern shown on the next page.



- In these global convection currents, the wind that flows north or south seems to turn to the right in the northern hemisphere, and to the left in the southern hemisphere. This is because of the **Coriolis effect**, the result of the Earth spinning under the winds, making it seem as if the winds were turning, when plotted in relation to the ground.
- When the wind blows over the ocean for long periods of time in the same direction, fiction between the water and the air causes the water near the surface to flow in the same direction as the wind. Global surface wind currents (shown in the straight red arrows below) and surface ocean currents flow in similar patterns.



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- In the major ocean basins, the surface currents flow clockwise in the northern hemisphere and counterclockwise in the southern hemisphere. In the Atlantic Ocean, the very warm water of the Gulf Stream current flows from the eastern United States towards northern Europe. As it flows northeastward, it cools and

gets more salty, because of evaporation. When the now cold and salty water reaches Greenland in the northern Atlantic Ocean, the water sinks because of its high density and flows southward at the bottom of the Atlantic towards Antarctica. This convection current is part of a worldwide system of surface and deepwater currents.

Practice Questions

1. All of the energy that causes weather on Earth comes from the _____, in the form of _____ energy.
2. About _____% of the radiant energy that reaches Earth is absorbed by the Earth's surface and about _____% is absorbed by the atmosphere. When the radiant energy is absorbed, it is converted into _____ energy.
3. About _____% of the radiant energy that reaches Earth is reflected back into space. Almost all of the radiant energy that is absorbed by Earth is eventually radiated back to space as _____ radiation, a form of radiant energy.
4. The lowest level of the atmosphere, where all weather occurs, is called the _____.
5. Thermal energy from the surface of the Earth is transferred to the atmosphere by _____.
6. The process of _____, the transfer of thermal energy by the flow of matter in a fluid, causes wind because _____ air rises and _____ air sinks.
7. A _____ _____ occurs at the coast of oceans and other large water bodies during sunny days, because the _____ heats up more quickly than the _____, causing the wind to blow from the _____ to the _____.
8. A _____ _____ occurs at the coast of oceans and other large water bodies at night, because the _____ cools down more quickly than the _____, causing the wind to blow from the _____ to the _____.
9. On a global scale, warm air rises at the _____, cool air sinks at _____ degrees north and south latitude, warm air rises at _____ degrees north and south latitude, and cold air sinks at the north and south _____.

10. Between the equator and 30°N latitude, the wind generally blows from a _____ direction.
11. Between 30°N and 60°N latitude, the wind generally blows from a _____ direction.
12. Between 60°N and the North Pole, the wind generally blows from a _____ direction.
13. Surface ocean currents are pushed by global _____ patterns.
14. Surface currents in the major ocean basins generally circulate in a _____ direction in the northern hemisphere and in a _____ direction in the southern hemisphere.
15. Deep water ocean currents are fed from very _____, _____ water which sinks because it is very dense.