The Sun’s Energy

Every day you see the Sun, so you may take it for granted most of the time. However, life on Earth could not exist without sunlight. How does your life depend on the Sun’s energy? How do you think the Sun’s energy affects the oceans, weather, and other things on our planet?

Solar Radiation

Radiation is a special type of energy that spreads out as it travels. The Sun gives off different types of radiation, including light and heat. Solar radiation travels throughout the solar system. However, only some of the radiation that reaches Earth penetrates our planet’s atmosphere to reach its surface. This diagram illustrates what happens to sunlight as it moves through Earth’s atmosphere.

Energy from the Sun travels very quickly: about 300,000 km/s. (This is the speed of light.) However, solar radiation still takes some time to travel from the Sun to Earth. Earth’s distance from the Sun varies depending on Earth’s position in its orbit. However, on average Earth is about 150,000,000 km from the Sun. As a result, solar radiation takes about 8 minutes to travel from the Sun to Earth. Once this radiation reaches Earth, about 30% is reflected back into space. The remaining 70% is absorbed by Earth’s atmosphere and surface.
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Heat Transfer Processes
Solar radiation lights our world as well as heats it. There are three major processes by which heat can be transferred to an object or substance on Earth. These processes are radiation, conduction, and convection. You have already learned about radiation. Conduction is the process by which heat is transferred from one object or substance to another through direct contact. In other words, the objects touch each other to transfer heat. Conduction happens when the bottom of a pot heats up from touching a hot stove. Convection is the process by which hot material rises and cooler material sinks. When the water in a pot starts to boil, the water at the bottom of the pot, closest to the stove burner, heats up first. This hot water rises to the top of the pot because of convection. This is why you can see bubbles rolling in the pot when the water comes to a full boil.

All three of these processes affect how solar radiation affects Earth’s temperature.
- Light and heat from the Sun are transferred to Earth through radiation.
- 70% of this radiation is absorbed by Earth’s atmosphere and surface. Some of this radiation is transferred to gases in Earth’s atmosphere through conduction. Some of it passes through the atmosphere and is transferred to rocks, water molecules, and other things on Earth’s surface. This is also conduction.
- When air molecules in the atmosphere are heated, the warm air rises, helping to further distribute heat through convection. As the warm air rises, it loses energy and cools. Eventually, the cool air sinks back down toward Earth’s surface. This creates circular movements in the atmosphere called convection cycles.

The ground absorbs sunlight. Convection cycles form as warm air rises, cools in the atmosphere, and sinks toward the ground. At the same time, cool air sinks, warms near the ground, and rises.

You can see convection happening in a lava lamp. Material at the bottom of the lamp rises as it heats up, and then sinks back down as it cools.
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What Do You Think?

How do you think convection cycles in the atmosphere are related to wind? Take a few minutes to think about the question, and then read on to learn the answer!

Wind Currents

When a gas is less dense than another gas, the less-dense gas floats in the denser gas. For example, helium is less dense than air. When you fill a balloon with helium, the balloon rises and floats in the air. Warm air is less dense than cold air because the particles in warm air have more energy to move farther away from each other. As a result, warm air floats in cold air. Warm air rises through convection, cools, and sinks back toward Earth.

These density differences also result in differences in air pressure. Colder, denser air pushes down as it sinks and compresses, resulting in higher pressure at Earth’s surface. Warmer air spreads out as it rises into the atmosphere, resulting in lower pressure above Earth’s surface.

Different areas of Earth’s surface reflect different amounts of heat from solar radiation. For example, sunlight strikes the equator more directly than it strikes Earth’s poles. So, air over the equator is warmer than air over the poles. Local differences also affect air temperature. Dark-colored surfaces, such as pavement, absorb more radiation than lighter-colored surfaces. So, the air above a city tends to be warmer than the air above a nearby field. This differential heating of the atmosphere causes differences in air density and pressure. Differences in temperature create convection cycles as warm air rises and cold air sinks. Areas of higher air pressure move into areas of lower air pressure, pushing these air masses around. We call these movements of air wind.

Particles of cool air sink toward Earth’s surface, creating areas of high pressure. Particles of warm air rise into the atmosphere, creating areas of low pressure. The air pressure at the top of Mt. Everest (measured in kPa, or kilopascals) is more than three times lower than at Earth’s surface.
Ocean Currents

Like gases, liquids are affected by differences in density. When a liquid is less dense than another liquid, the less dense liquid floats in the denser liquid. For example, olive oil, vegetable oil, and mineral oil are all less dense than fresh water, so they all float on the water’s surface. You can try this at home by pouring one of these oils into a container of tap water. Warm water is less dense than cold water because—just like warm air—warm-water particles have more energy. As a result, warm water floats on cold water.

Warm water rises through convection, while cold water sinks. Fresh water is also less dense than salt water because salt water contains more dissolved solids. The higher the salinity, the denser the water will be. Water with lower salinity floats on the surface of water with greater salinity.

The surfaces of Earth’s oceans are more exposed to winds than the deeper oceans. Wind can push the surface water, causing the water to flow and creating surface currents. The gravitational pull of the Moon also influences surface currents by driving the tides. Deeper ocean currents are driven by differential heating of sea water, which leads to convection cycles. The surface of the ocean is open to the sky, allowing it to absorb more solar radiation than the deeper oceans. This means surface water is typically warmer than deeper water. As the surface currents flow away from Earth’s equator toward colder regions, the water cools and sinks. When it reaches warmer depths, it rises again. The following diagram shows how deep ocean currents carry warmer and colder water around the planet.

The “great ocean conveyor belt” consists of the major currents in Earth’s deep oceans. You can see how cold water (the blue lines in the diagram) from the South Pole flows east and then north into the Pacific Ocean, where it gradually warms. The warm water (the red lines) then flows south and west through the Indian Ocean before turning north through the Atlantic Ocean, where it gradually cools. The cold water then flows south through the Atlantic Ocean to repeat the cycle.

**salinity**: a measure of the dissolved solids in a volume of liquid

**tides**: the regular rising and falling of water levels due to the gravitational pulls of the Sun and Moon
Differences in salinity can also drive ocean currents. Fresh water from rivers and streams that flow into the oceans has little to no salinity. This makes fresh water much less dense than the sea water into which it flows. The introduction of fresh water causes differences in salinity in the sea water. This causes the ocean water of higher salinity to sink, and the ocean water of lower salinity to rise. This further drives ocean currents. Ocean currents are also influenced by Earth’s rotation. As sea water flows over Earth’s surface, it is deflected by Earth’s rotation. (This deflection is called the *Coriolis effect.*) Ocean currents in the Northern Hemisphere are pushed to the right, while ocean currents in the Southern Hemisphere are pushed to the left.

**Discover Science: The Gulf Stream**

Ocean circulation has a strong influence on Earth’s climate. This can be seen by following the Gulf Stream, a rapidly flowing ocean current that originates in the Caribbean Sea. The Gulf Stream current carries about 150 times more water than the Amazon River and flows nearly 300 times as fast. It flows fastest near the ocean’s surface, but it still flows rapidly at greater depths.

From its origin in the tropical Caribbean, the Gulf Stream flows northward along the eastern coast of the United States. Once the Gulf Stream reaches North Carolina, it veers eastward across the Atlantic Ocean toward Europe. This turn is partially caused by Earth’s rotation. Once the current turns, it widens and slows. The Gulf Stream carries warm water from the Caribbean northeast through the Atlantic. This warm water helps to heat the local atmosphere along its path and has a strong influence on the climates of North America and northern Europe. If it weren’t for the Gulf Stream, these regions would be significantly colder.
What do you know?
As air moves through Earth’s atmosphere, its temperature and density change. The following diagram shows three different regions of Earth’s atmosphere (A, B, C), bounded the curving gray lines.

1. In the space beside each letter (A, B, C), rank each region by temperature. Label the warmest region 1, the next warmest region 2, and the coolest region 3.
2. Circle the letter of the region where air pressure is greatest. Box the letter of the region where air pressure is least.
3. Draw a convection cycle on the diagram to show how air moves from region to region as its temperature and density change.
Connecting With Your Child

Experimenting With Currents and Solar Radiation

To help your child understand solar radiation and other influences on Earth’s climate and currents, try a few simple experiments together.

1. Some surfaces reflect more radiation, and other surfaces absorb more radiation. Therefore, different surfaces are affected differently by solar radiation. On a clear, sunny day put a plain sheet of white paper and a plain sheet of black paper next to each other outside. Be sure to weigh down the papers so they do not blow away. You should also ensure that the two pieces of paper receive an equal amount of sunlight. Have your child touch each paper when you first lay it out to feel its initial temperature. Then, leave the paper in the Sun for about an hour. Have your child touch each paper again to feel its temperature after sitting in the Sun. Discuss the difference in temperature between the two pieces of paper. (The black paper will be warmer because darker surfaces absorb more solar radiation.)

2. Perform a simple experiment to help your child understand the effect of salinity on water’s density. (Fresh water is less dense than salt water because it contains fewer dissolved solids, such as salt.) Have your child place a raw egg in a glass of normal tap water, which has little to no salinity. The egg will sink because it is denser than the tap water. Take the egg out of the glass, and mix a few spoonfuls of salt into the water until it dissolves. This will make the water denser. Place the egg back in the glass. Now, the egg will float. Discuss how the density of the water changed when salt was added to it. Then, discuss how differences in salinity and density affect ocean currents.

Here are some questions to discuss with your child:

1. Why is there a difference in temperature between the two pieces of paper?
2. Which piece of paper reflects more solar radiation?
3. How did increasing the salinity of the water affect the water’s density?
4. How do differences in salinity affect ocean currents?