Video Five Lesson Plan

The Magic Molecule: Part Two

This lesson plan was produced by the CO_2 Learning Center, a project of the CO_2 Coalition

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A note about our lesson plans:

Our CO_2 Learning Center lesson plans all have the same format, which includes learning standards from the Next Generation Science Standards (NGSS), student learning objectives, background information on the science concepts covered in the book or video, suggested activities including labs to enrich the lesson and reinforce use of the scientific method, and formative and summative questions.

The NGSS are the standards on which most public-school systems have based their curriculum. We do not necessarily endorse the NGSS but have included the relevant standards for circumstances in which a teacher is required to use them. The lesson plans contain everything that a teacher might be required to submit in a formal lesson plan to a school administrator or science department head. Our lesson plans emphasize the use of the scientific method and critical thinking skills.

This lesson plan was created for the CO_2 Coalition's CO_2 Learning Center by Sharon Camp, Ph.D. Analytical Chemistry; B.S., Geology, using Next Generation Science Standards (NGSS).

Understanding NGSS:

LS: Life Science PS: Physical Science ES: Earth Science

1-5 indicates the standard for grade level (1-first grade, 2-second grade, 3-third grade, 4-fourth grade, 5-fifth grade)

MS: Middle School

Please note that only the parts of the outline that are relevant to this lesson have been included. If PS1 *or* ESS2 *(examples from this lesson plan) are shown, these NGSS segments were included as relevant to this lesson for Life Physical Science and Earth Science.*

CO2 LEARNING CENTER

Lesson Plan: The Magic Molecule, Part Two

Grades K-8

Student Learning Goals

After watching the video, students will be able to:

1. Explain what a hydrogen bond is.
2. Explain what heat capacity is and explain how heat capacity allows ocean currents to affect climate around the world.
3. Explain what happens to water molecules when water evaporates.
4. Explain how energy is transferred by conduction.
5. Explain how clouds are formed.
6. Explain how energy is transferred by convection.
7. Explain how convection in the atmosphere affects Earth's climates.

Background Information

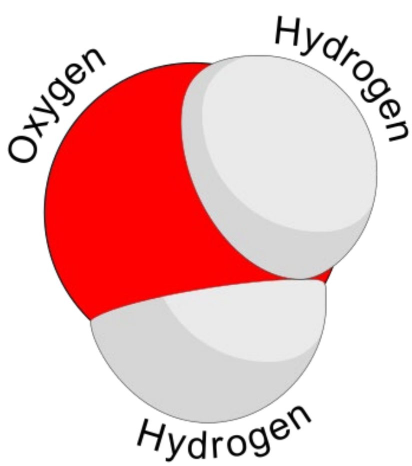
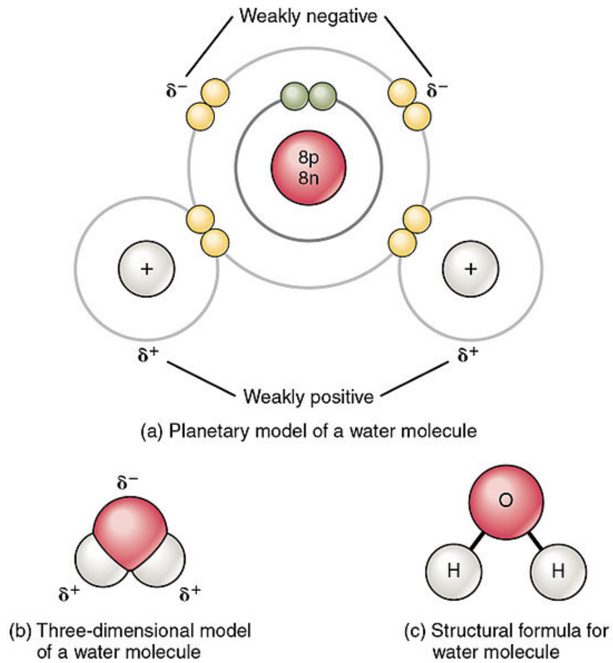


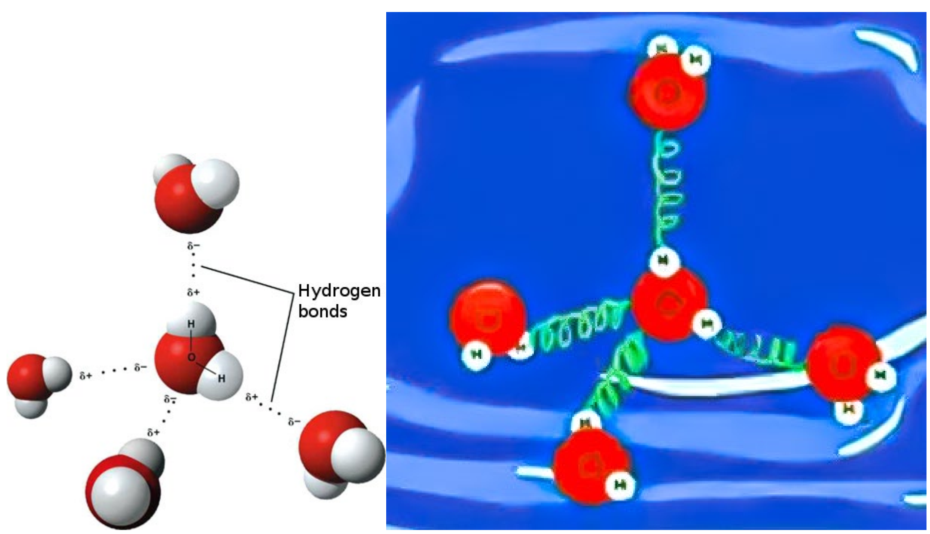
Image Source: Booyabazooka at English Wikipedia, Public domain, via Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Water_molecule_(1).svg

Water is composed of two atoms of hydrogen chemically bound with one atom of oxygen. This type of bond is called a covalent bond, which occurs when atoms share electrons. Each hydrogen atom shares one electron with the oxygen atom, and the oxygen atom shares one electron with each hydrogen. This sharing of electrons provides stability to atoms that are not stable when they exist as single atoms. The atoms do not share the electrons evenly, however. Because of a property called electronegativity, the oxygen atom has a stronger pull on the electrons than either of the hydrogen atoms. This uneven sharing of electrons means that the oxygen will have a slight, or partial, negative charge, while each hydrogen has a partial positive charge. (Electrons have a negative charge while protons and the nucleus have a positive charge.)



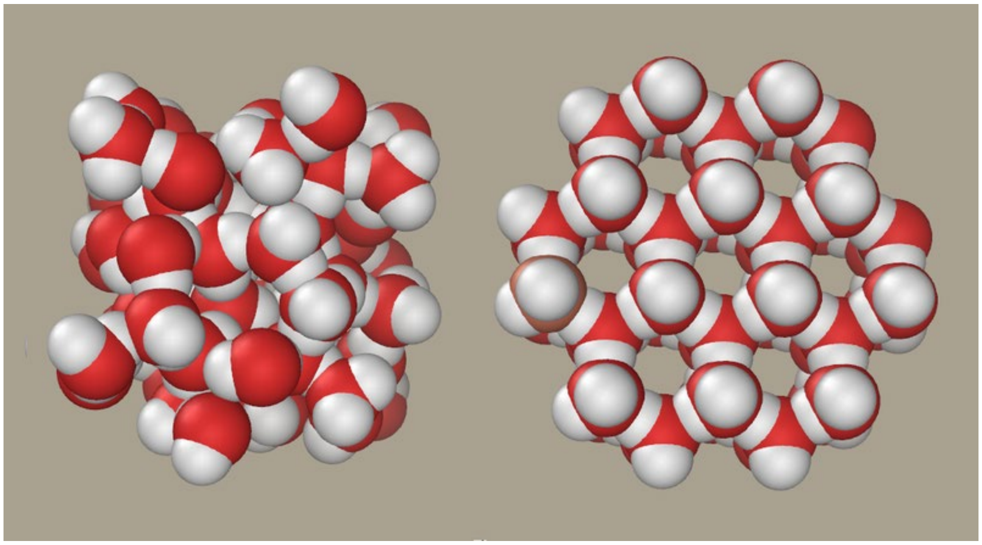
Source: https://commons.wikimedia.org/wiki/File:209_Polar_Covalent_Bonds_in_a_Water_Molecule.jpg, OpenStax College, CC BY 3.0 <https://creativecommons.org/licenses/by/3.0>, via Wikimedia Commons

The bent shape of the water molecule results in a positive side and a negative side, so water is considered a polar molecule. This is similar to a magnet having a north and south pole; the north pole of one magnet is attracted to the south pole of another magnet. Like magnets, opposites attract, and the positive side of one water molecule is attracted to the negative side of another molecule. This attraction is called a hydrogen bond, which is really a misnomer because this attraction is not a true bond. Just as two magnets can be pulled apart, so can two water molecules. But this attraction among water molecules is so strong that it determines almost all of water's physical properties. In the video, these attractive forces are represented by springs.



Source: https://commons.wikimedia.org/wiki/File:3D_model_hydrogen_bonds_in_water.jpg, translated by Michal Maňas (User:snek01), Public domain, via Wikimedia Commons

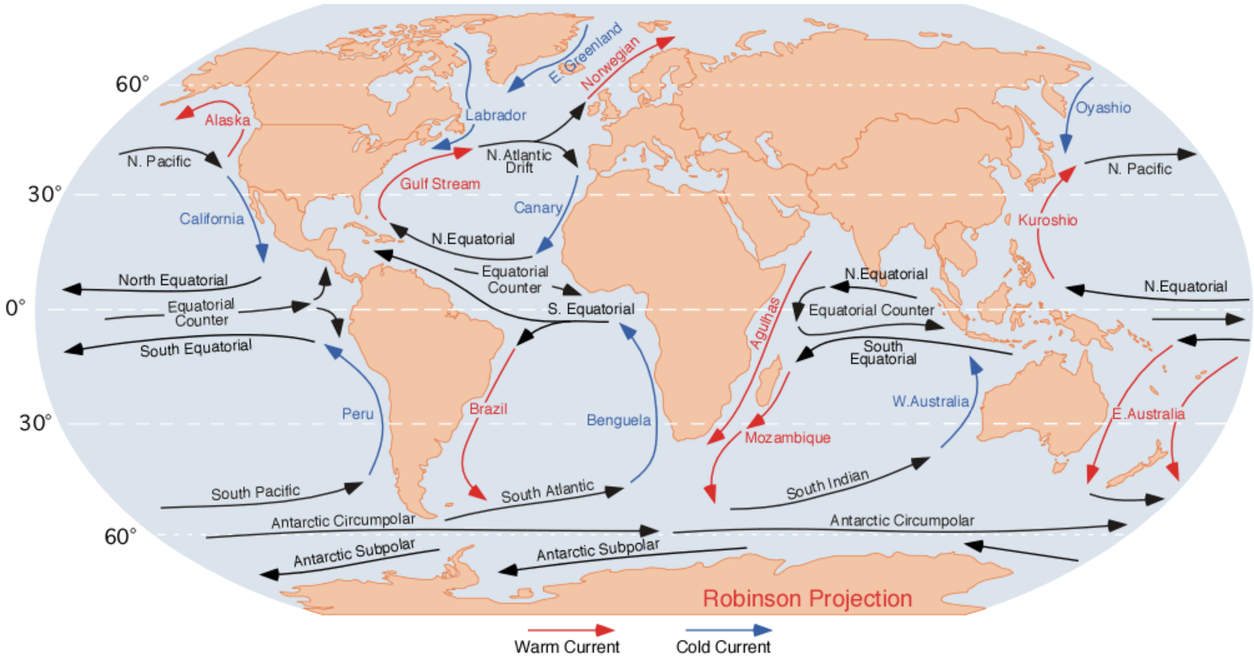
The three states of matter -- solid, liquid and gas -- are affected by temperature or the movement of energy from one system to another. When energy is removed from liquid water, the water molecules move more slowly and can attach to one another forming a crystalline structure. This means the hydrogen bonds shorten, and water then changes from a liquid to a solid (freezing). This structure is less dense than liquid water, so frozen water (or ice) floats on top of water. Water is the only substance in which the solid state is less dense than the liquid state. This amazing property protects aquatic ecosystems from cold temperatures. Imagine if lakes and oceans froze from the bottom up!



Liquid water on left; solid water (ice) on right. Source: https://commons.wikimedia.org/wiki/File:Liquid-water-and-ice.png, P99am, CC BY-SA 3.0 <https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons

When energy is absorbed by liquid water, the water molecules move more rapidly. The liquid water will hold this energy as the temperature rises. The heat capacity of water is defined as the amount of energy required to raise the temperature of a sample of water by 1^{o}C. Hot water holds a tremendous amount of energy, which is easy to understand when one measures the amount of time it takes to boil water. When water boils, the hydrogen bonds holding together all the water molecules have broken, and the molecules move out into the atmosphere and form what is called water vapor. In its vapor form, water molecules exist singly.

Because the heat capacity of water is so high (twice as high as land and 4 times as high as air), the heat energy that is stored in water is called latent heat. This latent heat moderates the climates of the edges of the continents that contact the ocean currents. Large currents on the surface of the ocean transfer the latent heat in water all over the globe. The direction in which the currents flow is based on the position of the continents and whether the current occurs in the northern hemisphere or the southern hemisphere. Currents will warm in the equatorial regions, taking their latent heat towards the poles and warming the continents to which they are adjacent. Conversely, currents will cool in polar regions, taking less latent heat and cooling the continents to which they are adjacent. In this manner, the Gulf Stream moderates the climate on the east coast of North America and the California Current moderates the climate on the west coast.



Ocean Currents. Source: https://commons.wikimedia.org/wiki/File:Corrientes-oceanicas.png
Attribution: Dr. Michael Pidwirny (see http://www.physicalgeography.net), Public domain, via Wikimedia Commons

Water vapor forms when water molecules break the hydrogen bonds that have formed with the neighboring molecules and escape into the air above it. This process is called evaporation. Evaporation can occur at room temperature when water molecules at the surface of the water become energetic enough to escape the hold of the hydrogen bonds and move into the air above.

If water is heated to boiling, the water vapor forms at the bottom of the pot and rises when it has enough energy to make it to the surface. Once the water vapor reaches the surface of the water, it will evaporate.

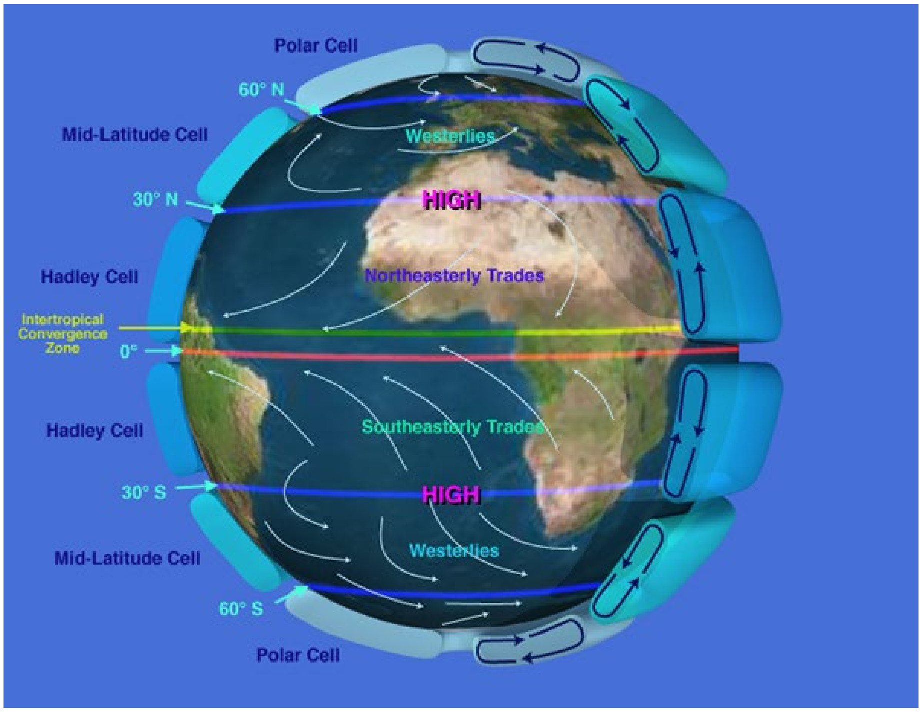
Energy from the Sun is absorbed by living and nonliving things on the ground, which heat up. This heat energy is transferred to water vapor in the air by conduction. Conduction is defined as the transfer of energy through direct contact, as opposed to radiation, which is the transfer of energy through space. Energy from the Sun is radiated to Earth, and then the objects on Earth warm and transfer the Sun's energy through direct contact, or conduction. Since warm air rises, the air with the water vapor will rise to higher elevations where the temperature is cooler. This movement of energy occurs through convection, which is defined as the transfer of heat energy through circular movements in a fluid (liquids and gases are both considered to be fluids).

Clouds form when water molecules condense onto tiny particles, such as dust, to form water droplets. This occurs when the temperature of the air is reduced, allowing the water vapor to change back into a liquid form or to condense. If these water droplets get heavy enough, they fall out of the cloud in the form of rain. If the air is cold enough, the water molecules will form ice. If a very large amount of energy is absorbed by the water vapor, as it would over very warm water or very warm land, the energy is released in the form of a thunderstorm.

When ocean water heats, the water does not transfer energy directly to the air but instead evaporates as it absorbs energy from the Sun. Since the Sun's rays are more direct at the equator, the oceans there will evaporate enough water to make huge bands of clouds that stretch across the planet. This band is called the Intertropical Convergence Zone, or ITCZ.

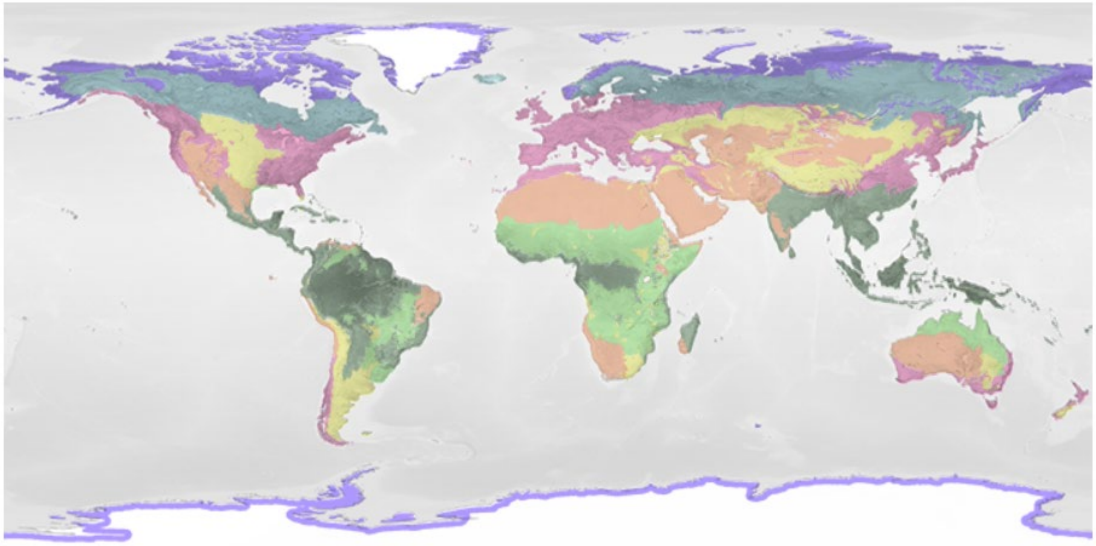
Source: https://earthobservatory.nasa.gov/images/703/the-intertropical-convergence-zone

Convection of the Earth's atmosphere, due to temperature differences between the equator and the poles, is another major factor that affects the movement of water vapor. Individual convection cells form at different latitudes around the planet, and these cells, along with the rotation of the Earth on its axis, determine the direction of the prevailing winds and the direction of the movement of cyclones. Warm air rises from the tropics and moves either northward or southward, depending on its position relative to the equator, carrying its water vapor with it. At about 30^{o} N and S latitudes, the air will cool enough to fall, although the air is very dry at these latitudes. In this way, water vapor is carried over the continents, continually supplying water to the land.



Source: NASA, Public domain, via Wikimedia Commons,
https://commons.wikimedia.org/wiki/File:NASA_depiction_of_earth_global_atmospheric_circulation.jpg

The amount of water available to plants is one of the two most important factors that determine climate around the planet (the other is temperature). Because of the large amount of water available at the tropics and at 60^{o}N and S latitudes, these are the locations of most of the forests on the planet. Similarly, since the air at 30^{o}N and S latitudes is dry, it is at these latitudes where most of the world's large deserts occur.



Source: https://www.earthobservatory.nasa.gov/biome

For Further Information:

1. https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Introductory_Chemistry_(CK-12)/15%3A_Water/15.01%3A_Structure_of_Water
2. https://www.usgs.gov/special-topics/water-science-school/science/facts-about-water
3. https://climatekids.nasa.gov/cloud-formation/
4. https://zoom.earth/
5. https://earthobservatory.nasa.gov/images/703/the-intertropical-convergence-zone
6. https://www.noaa.gov/jetstream/global/global-atmospheric-circulations

Suggested Activities

1) Water Kit Model:

This model kit from 3D Molecular Designs is one of the best on the market. With this kit, the student can understand the difference between the covalent bonds that hold the hydrogen and oxygen atoms together, and the hydrogen bonds that are attractive forces among the molecules. Capillary action and surface tension can also be modeled with this kit, as can the attractions between the water molecules and another polar substance, sodium chloride (or table salt). Their website also includes free teacher materials, student handouts and videos with no purchase necessary. It might be possible to find this kit at a lower price from another source, but it is an excellent investment. https://3dmoleculardesigns.com/classroom_resources/water-kit/#teacher-guides

2) Make a cloud in a bottle:

Using only three materials (a liter bottle, water and a match), a cloud can be easily made in a bottle. Younger children will need to have this activity demonstrated because of the match, but older children should be able to do this activity individually or as a group. To start the activity, ask students if they think it is possible to create a cloud in a bottle. Record their answers. Start by filling a 1-liter bottle three quarters of the way full with warm water. Put the cap on the bottle and squeeze it several times: no cloud will form. Next, take a match, light it, blow it out so that it is smoking and put it in the bottle, putting the cap on rapidly afterward. Now squeeze the bottle several times; a cloud should form in the bottle. Now ask the students why the burning match made a difference. Also ask the students why squeezing the bottle was necessary for the cloud to form. The reason is because of two gas laws, Boyle's Law, which states that decreasing the volume of a gas will increase its pressure, and Gay-Lussac's Law, which states that increasing the pressure of a gas will also increase its temperature. Both the increase in temperature and pressure are necessary to force the water to both vaporize and condense.

https://www.youtube.com/watch?v=G70y90BVes4

3) How much energy does it take to evaporate water?

Source: Barasoaindarra, Public domain, via Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Summer_fog_Tenojoki.jpg

The amount of energy required to evaporate water depends on how much water is present. Water, as does other substances, has a property called heat of vaporization, which is defined as the amount of energy required to change 1 gram of water to form water vapor. For water, the heat of vaporization is 540 cal/g. If you had 1 gallon of water (3785g), how much heat would be required to evaporate it? The calculation is simple: multiply 3785g x 540 cal/g, which is 2,044,000 cal, or about 2,000 food calories, close to the number of calories the average person should consume in one day. The amount of energy stored in water is called the latent heat of water and is released into the atmosphere when water evaporates.

Materials: two small bowls, water, rubbing alcohol, eye droppers or dropper pipets, tablespoon.

Procedure: First pour a tablespoon of rubbing alcohol into one of the bowls and pour a tablespoon of water into the other bowl. Have the students take the eye dropper and drop several drops of water onto the back of their hands. They should rub the water over their skin. W*hen the water touches their skin, how does it feel?* Then, blow on the wet hand. Does their skin feel any different when blowing on the water? Can they sense a difference in temperature while blowing? How does it feel? Next, take the eye dropper and put several drops of alcohol on the back of the other hand, and rub the alcohol over their skin. Does the alcohol feel different when it touches their skin? How? Again, ask them to blow over the area on their hand where they put the alcohol. What sensation do they feel this time? Does their hand feel warmer or colder compared to water when blowing on the liquid? Can they think of a reason why?

Critical thinking: Can the students think of a reason why water fountains are frequently found in towns and cities where the summer temperatures get very high? What service do they provide? Can the students think of a reason why forests are always cooler than the areas around them? (Hint: it's not only because they provide shade.) Lastly, can the students think of a reason why sweating helps to control body temperature? If desired, the students can be assigned to find answers to these questions instead of having them guess in class. Source: https://www.sciencebuddies.org/stem-activities/evaporative-cooling-with-liquids

4) Demonstrate a convection current:

Convection currents occur when there is a temperature difference between the top of a column of a fluid and the bottom. Convection currents in nature occur in water as well as the air and are easily demonstrated.

Materials: clear glass Mason jar, food coloring, ice cube tray, source of heat, warm water.

Procedure: First, ask the students what they expect will happen to a cold ice cube when they put it in warm water. The obvious answer is that it will melt but probe deeper. Will the cold water stay at the top where the ice cube is? This prediction is the hypothesis, which will either be supported or rejected based on observations. Next, make ice with water that has been dyed a deep color with food coloring. After the ice cube is fully frozen, pour very warm water in the Mason jar. It is important to have a big change in temperature to enable convection currents to form and be visible. As soon as the jar has been filled with warm water, put one of the ice cubes on the top of the water and watch it melt. Ask the students to be very precise when writing down their observations. For critical thinking, ask the students what they would expect if there was not a temperature difference between the ice and the water, or if the difference in temperature was smaller. Ask what would happen if the cold water was on the bottom of the jar and the warm water was on top. (If possible, let the students build their experiment by themselves.) Convection currents occur when there is uneven heating, such as when water is heated on a stove. Ask the students how these currents transfer heat energy.

Source: https://thehomeschoolscientist.com/convection-current-experiment/

5) **How does water affect biomes:** Biomes around the planet, as well as climate, are defined by two main factors: the amount of rainfall and the temperature range. Gardeners have known this for a long time because both factors need to be taken into account when plants are chosen for their gardens. Biomes are also defined by the types of plants that grow there, which is also determined by the temperature range and rainfall amounts. Here is an activity that will help students understand where the biomes on the planet are located and how their locations are determined by temperature and water.

   Source: https://www.earthobservatory.nasa.gov/biome

6) **Calculating the relative heat energy in the atmosphere and in the oceans.** *How far down do you have to go in the oceans to find as much heat as in the entire Earth's atmosphere?* That is easy to calculate, if you know how much material (mass) is involved and the specific heats of air and water. Specific heats tell us how much energy (in kilojoules) it takes to raise one kilogram of material by one degree Kelvin or Celsius. For seawater that is about 4.0 kJ/kg-K. For air that is about 1.0 kJ/kg-K. In other words, it takes four times as much energy to heat water as the same mass of air. Hence, water stores four times as much heat as air.

   a. *Step 1*: Imagine a column of air 1 cm by 1 cm, stretching from sea level to the top of the atmosphere. How much does that column weigh? Or equivalently, how much mass of air is in that column? You can find that number by going to any National Weather Service forecast page for any city in the U.S. and checking the barometer reading. Even stations at higher altitudes like Denver will show a barometer reading corrected to sea level. Those tell us whether the air pressure is slightly above or below normal due to the weather pattern. "Normal" sea level pressure is 1013.25 millibars. That is a metric unit equivalent to 1013.25 grams/cm2. And since pressure is just the weight of the air or water above, the tiny column one cm by one cm contains about 1 kilogram of air.

b. *Step 2*: Imagine the same column extending downward into the ocean. How far do you have to dive before you have about one kilogram of water per cm2 above you? With the density of water about 1.0 gram/cm3, you have to go down 1,000 cm or ten meters or about 33 feet.
c. *Step 3*: Assuming that both the air and water columns are at the same temperature, which is true where they meet, how much more heat is in the water column? That is just the ratio of the specific heat of water to that of air or about four.

d. *Step 4*: Calculate how far down you need to go to have the same amount of heat as in the entire Earth's atmosphere. That is just 10m / 4. Because our oceans only cover about 70% of the planet, we should divide that result by 0.7. That gives 3.57 m or 11.7 feet. Then we will want to correct for the fact that the air column gets cooler with height, whereas the water column is going to be close to a constant temperature near the surface. In other words, we have overestimated the heat in the atmosphere by a little in comparison with the ocean. So, we can safely round the 11.7 feet down to 10 feet and call that close enough.

e. The stunning conclusion is that the first 10 feet of the oceans contain as much heat as the entire Earth's atmosphere. Because they are far deeper than that and can easily exchange heat with the atmosphere (unlike the continents), they dominate worldwide temperatures and weather. Those who live near an ocean realize that it moderates their weather because of this thermal effect. The continents are great thermal insulators, and therefore cannot easily give up their stored heat beyond the first few centimeters of soil.

f. The first reference contains a good explanation of water's heat capacity and why it is important: https://www.usgs.gov/special-topics/water-science-school/science/specific-heat-capacity-and-water This reference provides a list of the specific heat capacities of many common substances for comparison: https://en.wikipedia.org/wiki/Table_of_specific_heat_capacities

g. Fun fact: Lake Tahoe in California never freezes over. This is because the lakes's surface area is relatively small compared to the lake's average depth of 1,000 ft. This means that the latent heat contained within the lake is adequate to prevent it from freezing over during winter: https://www.tahoemagazine.com/ice-ice-baby-a-deep-dive-into-why-lake-tahoe-doesnt-freeze-in-the-winter/

Credit to Dr. Gordon Fulks, Ph.D., for recommending this activity. He is a physicist, member of the CO_2 Coalition Education Committee, and the author of Books One through Five.

Formative and Summative Assessment

1. Why are hydrogen bonds not considered to be true bonds? What are some properties of water that are caused by hydrogen bonds?
2. What happens to the energy of a water molecule when it evaporates? What happens to its energy when it freezes?
3. What is heat capacity? How does the heat capacity of ocean currents modify the climates of the coastal areas of continents?
4. What happens to hydrogen bonds in liquid water when it evaporates? Where does the energy come from to change water in lakes and oceans into water vapor?
5. Water is always evaporating from oceans and lakes, but sometimes there are no apparent clouds in the sky. What two things do clouds need to form? Why does precipitation (rain and snow) form or not at different times?
6. List and describe the three ways in which energy is transferred.
7. Explain how convection spreads water vapor around the Earth.

Next Generation Science Standards (NGSS) Learning Objectives

Please note that the standards that cover the material in this lesson plan are only found in the 2nd grade and middle school curricula. The standards here are written exactly as they are written in the NGSS.

2-PS1 Matter and Its Interactions. Students who demonstrate understanding can:

2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. [Clarification Statement: Observations could include color, texture, hardness, and flexibility. Patterns could include the similar properties that different materials share.] This standard includes the following Disciplinary Core Ideas:

PS1.A: Structure and Properties of Matter

- Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties.

2-PS1-4. Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot. [Clarification Statement: Examples of reversible changes could include materials such as water and butter at different temperatures. Examples of irreversible changes could include cooking an egg, freezing a plant leaf, and heating paper.] This standard includes the following Disciplinary Core Ideas:

PS1.B: Chemical Reactions

- Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not.

MS-PS1 Matter and its Interactions. Students who demonstrate understanding can:

MS-PS1-1 Develop models to describe the atomic composition of simple molecules and extended structures. This standard includes the following Disciplinary Core Ideas:

PS1.A: Structure and Properties of Matter

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.

MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. This standard includes the following Disciplinary Core Ideas:

PS1.A: Structure and Properties of Matter.

- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. This standard includes the following Disciplinary Core Ideas:

PS1.A: Structure and Properties of Matter

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2),(MS-PS1-3)
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4)
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (MS-PS1-4)
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (MS-PS1-1)
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (MS-PS1-4)

PS1.B: Chemical Reactions

- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-3)

PS3.A: Definitions of Energy

- The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects.

PS1.B: Chemical Reactions

- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactant. (MS-PS1-3)

PS3.A: Definitions of Energy

- The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects.

MS-PS3 Energy. Students who demonstrate understanding can:

MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. [Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.]
This standard includes the following Disciplinary Core Ideas:

PS3.A: Definitions of Energy

- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

PS3.B: Conservation of Energy and Energy Transfer

- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

MS-ESS2 Earth's Systems. Students who demonstrate understanding can:

MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. [Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] This standard includes the following Disciplinary Core Ideas:

ESS2.C: The Roles of Water in Earth's Surface Processes

- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
- Global movements of water and its changes in form are propelled by sunlight and gravity.

Source: https://www.nextgenscience.org

Sharon R. Camp, Ph.D., Analytical Chemistry; B.S., Geology; Senior Education Advisor

What is the CO_2 Coalition?

The CO_2 Coalition was established in 2015 as a 501(c)(3) for the purpose of educating thought leaders, policymakers, and the public about the important contribution made by carbon dioxide to our lives and the economy.

The CO_2 Coalition is a group of the top scientists, engineers and energy experts who study and report on the important contribution made by carbon dioxide to our lives and the economy.

Learn more at CO2Coalition.org and CO2LearningCenter.com.