CO_2 LEARNING CENTER

Book Four Lesson Plan

The Big Bad Woof

This lesson plan was produced by the CO_2 Learning Center, a project of the CO_2 Coalition, and meets the Next Generation Science Standards for Grades 2 – 8.

Lesson Plan: Book Four
Grades K-8

A Great Pyrenees dog named Zeus belongs to sisters Sophia, Ariana and Elyssa, neighbors of a scientist, Mr. Gordon. Zeus is worried that a changing climate will make it too warm for animals with thick fur coats like him. Mr. Gordon reassures Zeus that he will be fine. When it is hot, all he needs to do is seek water and shade. He tells Zeus that other animals like him, such as polar bears, walruses and seals, are thriving and increasing in numbers. Elyssa is concerned that the Earth is warming rapidly from our burning fossil fuels. Mr. Gordon says that is not true and explains the role of water in all its forms (solid, liquid and gas) in moderating our climate. There is plenty of water in the Earth's oceans and lakes to do this.

> *"'The Big Bad Woof' teaches us about climate, greenhouse gases, and how water, the 'Magic Molecule,' plays a major role in regulating climate and keeping us cool on hot days." – Jan Breslow, MD*
>
> Dr. Jan Breslow is a pediatrician, who has done research into heart disease. After 10 years at Boston Children's Hospital, the main Harvard Medical School Pediatrics Teaching Hospital, he became Professor at Rockefeller University in New York City. There, his research over almost 40 years was recognized by many awards, including election to the United States National Academies of both Sciences and Medicine. He also served as President of the American Heart Association.

The CO_2 Learning Center lesson plans were created by Dr. Sharon Camp. Dr. Camp received a B.S. in Geology from the University of Georgia and a Ph.D. in Analytical Chemistry from Georgia Tech. She has 20 years' experience teaching high school, including Earth Science, Biology, Chemistry, Physics and AP Environmental Science. She is currently a reader for the yearly national AP Environmental Science exam.

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

MS: Middle School

Lesson Plan: Book Four

Grades 2-8

Student Learning Goals

After reading the comic book, students will be able to:

1) Identify ways in which polar bears have adapted their eating habits to changes in climate and increased competition for food.
2) Identify another greenhouse gas other than CO_2.
3) Explain why water holds so much heat.
4) Explain how ocean currents affect climate.
5) Explain why ice keeps things cold.
6) Explain why evaporating water reduces body temperature.
7) Explain why deserts get hotter than rainforests during the day but colder than rainforests at night.
8) Describe all the things that happen to sunlight when it strikes the Earth's atmosphere.
9) Explain why cumulus clouds reflect sunlight.
10) Explain why rain and thunderstorms release heat from the atmosphere.
11) Explain why water is the magic molecule of climate.

Background Information

Photo Source: https://pixabay.com/photos/polar-bear-bear-sea-bear-white-404314/

Polar bears have been the subject of much controversy when it comes to a warming climate. There have been a lot of articles that state that polar bear populations have been suffering from melting ice in the polar areas, but the truth is that there are no complete and thorough population counts of polar bears.

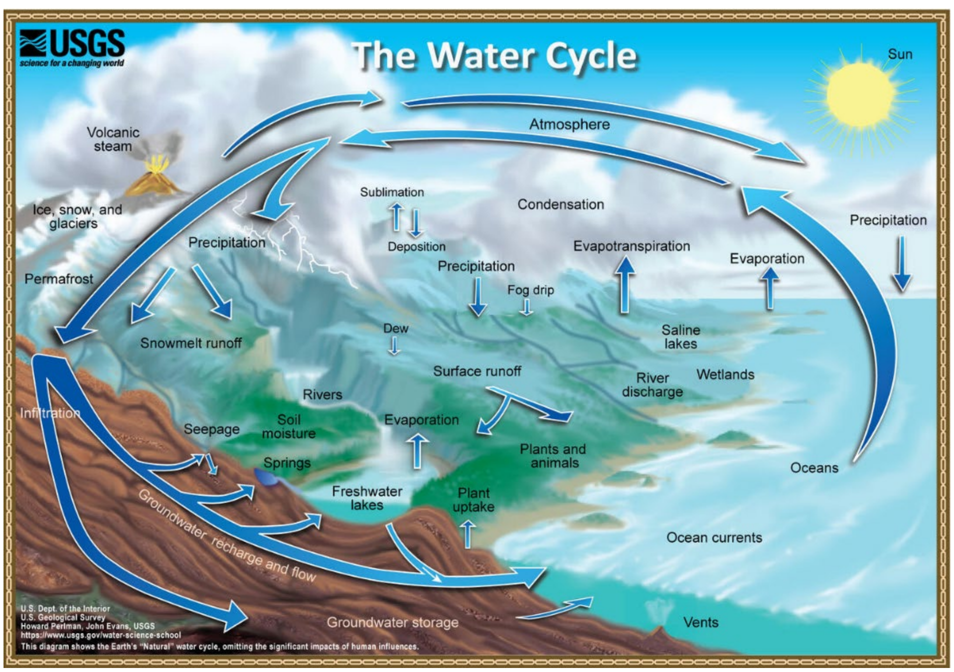
This is partly because the bears' habitat includes areas that are hostile to people, or they are in areas where few people live or can access easily. Both circumstances have contributed to the difficulty in counting polar bear populations accurately.[1]

The current estimate of the polar bear population is between 22,000 and 31,000, which is a very wide range. The International Union for Conservation of Nature (IUCN) currently lists the polar bear as "Vulnerable" under their assessment criteria.[2] Since polar bears became protected under the Convention on the International Trade of Endangered Species (CITES) and also the Marine Mammal Protection Act (MMPA) about 50 years ago, their populations have continued to grow to close to tripling since 1960 estimates.[3] Apparently, despite the gradual warming of Earth's climate, polar bears seem to be doing just fine.

Tripling their population, however, has increased competition among the bears for common food sources. They, like other types of bears and many omnivores, will change their diet depending on what is available. Having a varied diet also helps reduce competition for food. Their preferred diet is ringed and bearded seals, but they have been known to eat other types of seals, smaller whales, young walruses, small rodents, berries and even garbage.[4]

Conflicts between bears and people are becoming more common as their populations continue to rise. As bears wander into villages looking for food, more conflicts with people occur. Although there are many articles that blame climate change for bear attacks and reduced food sources, there are plenty of other explanations for these observations.

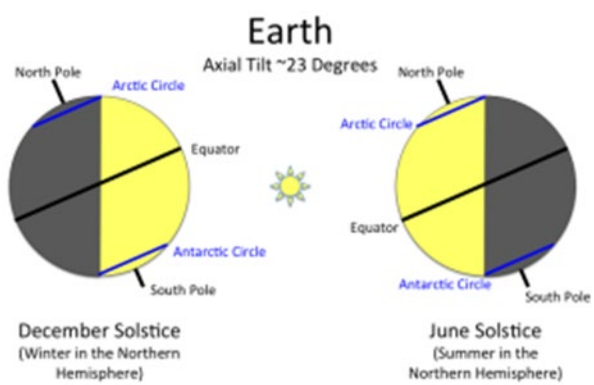
In the book, Mr. Gordon makes the point that it is water that drives the climate. There are many properties of water that allow it to control so much of the planet's climate. Earth's hydrologic (or water) cycle makes it, and its atmosphere, unique among all the other planets in the solar system.



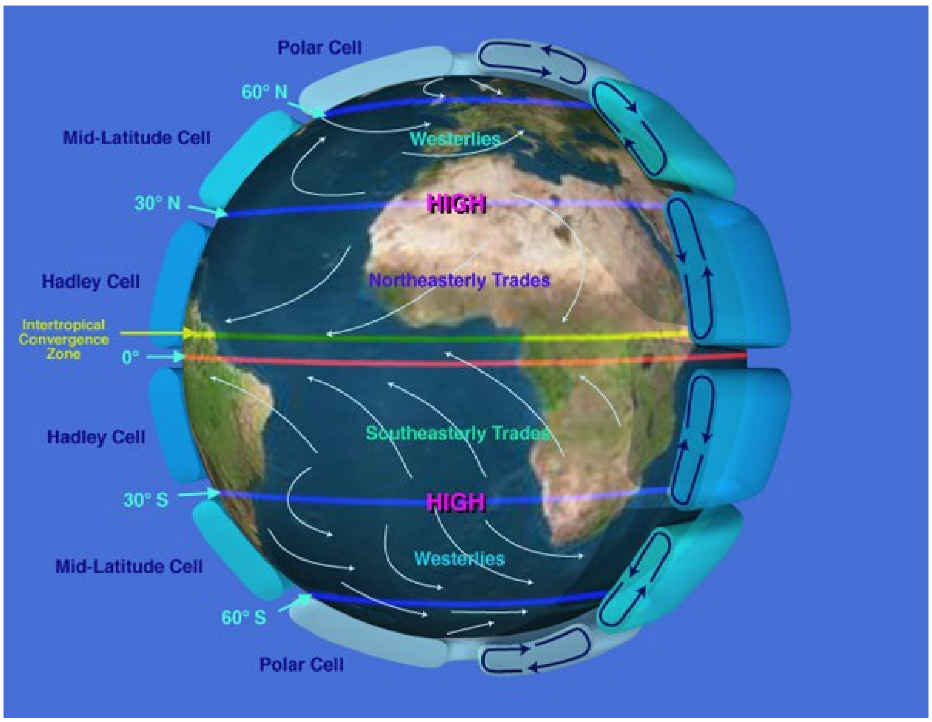
Source: USGS, The Natural Water Cycle, https://www.usgs.gov/media/images/natural-water-cycle-jpg.

The factors that affect climate are varied and complex. The angle of the Earth's axis relative to the Sun is probably the most important factor since it is the changes in this angle that occur as the Earth revolves around the Sun that causes the changes in the seasons.[5] Temperature variations around the Earth are caused by the tilt of the Earth's axis, which determines whether or not the climate is cold (around the poles), warm (around the equator), or somewhere in between.

Convection of the Earth's atmosphere, due to temperature differences between the equator and the poles, is another major factor that affects climate.[6] 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.



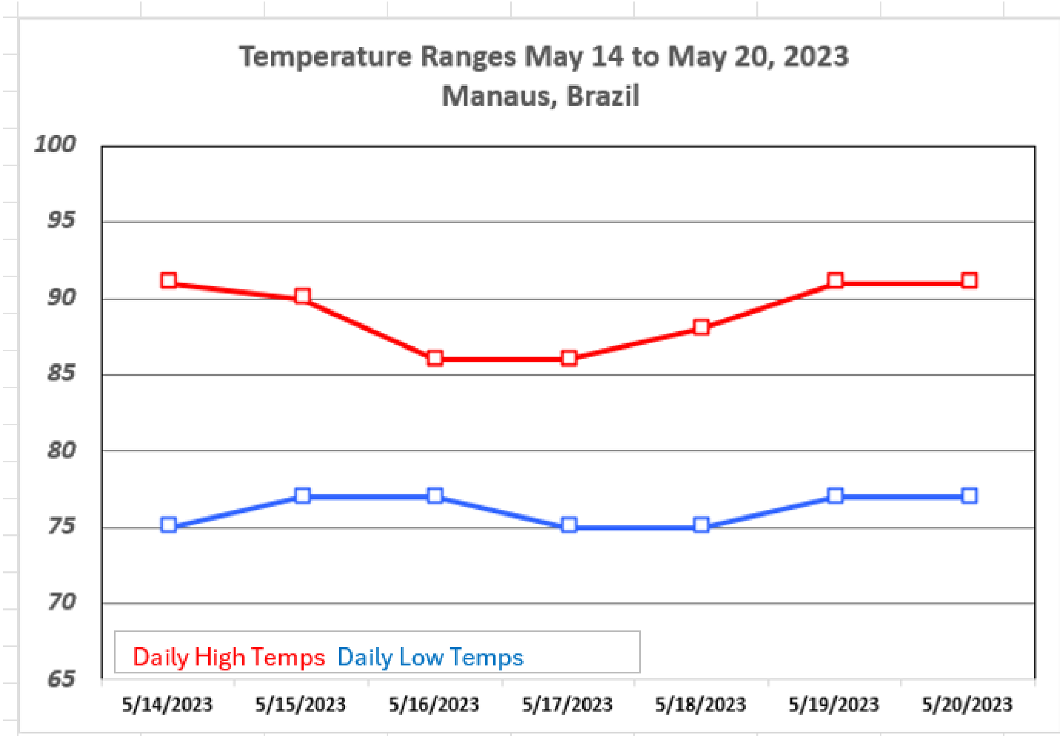
Source: MIT/Alissa Earle; https://blogs.nasa.gov/pluto/2015/10/23/a-planet-for-all-seasons/

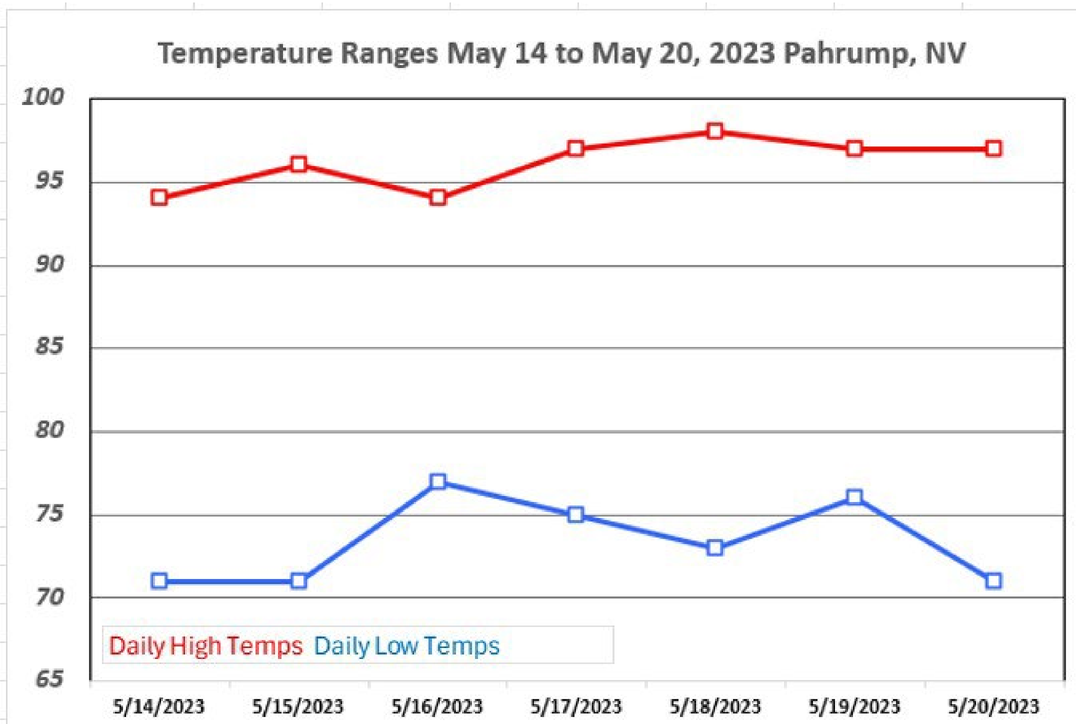


Source: NASA, Public domain, via Wikimedia Commons, https://commons.wikimedia.org/wiki/File:NASA_depiction_of_earth_global_atmospheric_circulation.jpg

Another important factor is the presence or absence of atmospheric water combined with temperature. Major biomes, or areas that support similar types of plants, are determined by local climate, which is determined by a combination of water and temperature. Deserts are characterized by small amounts of rainfall, while rainforests are characterized by large amounts of rainfall. Temperature is of minor importance, as evidenced by the fact that rainforests can be tropical, or high temperature, or they can be temperate, or moderate temperature. Deserts can be found at all temperatures: polar, temperate, and tropical.

The amount of humidity, or water vapor in the air, determines how long it will take the air to cool down. Areas of high humidity, such as rain forests, have temperature variations of 10-20 degrees Fahrenheit during the day, whereas areas of low humidity, such as deserts, can have temperature swings of as much as 20-30 degrees Fahrenheit from morning to evening. The two graphs below represent a rainforest (Manaus, Amazonas, Brazil) and a desert (Pahrump, NV, USA, near Death Valley, CA).[7] The spring average daily temperature range in Manaus was 10 degrees less than Pahrump. Manaus is closer to the Equator (at 3.1°S latitude), and in general, temperatures increase closer to the Equator because the Sun's rays are more direct there. But the average high temperature in Pahrump, which is located at 36.1°N latitude, is much warmer than Manaus. Without the moderating effect of water vapor in the air, the temperature swings are greater in the temperate desert than in the tropical rainforest.



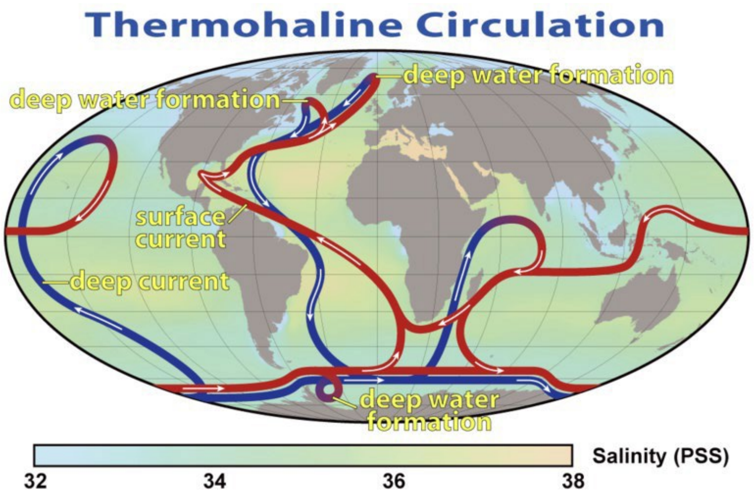


Clouds affect the temperature on the Earth's surface because they reflect light from the Sun. The fraction of solar energy that is reflected into space is called albedo. If half the planet is covered by clouds, then the albedo is at least 0.5, meaning that only half of the sunlight is available to keep the Earth warm. The rest is reflected into space. Should clouds only cover a third of the planet, there will be much more heating of the surface. Should there be no clouds at all, there would be an albedo closer to zero and there would be twice the heating from the Sun as with an albedo of 0.5. Heating from the Sun is greatly affected by clouds, much more than it is by carbon dioxide.[8]

Heat energy that is radiated is also known as infrared radiation or IR. Infrared radiation not only comes from the Sun, but also anything warm will also give off IR, including people. Night-vision goggles allow the wearer to "see" the heat coming off an object. Types of snakes called pit vipers (such as rattlesnakes and other venomous snakes) have areas on their faces that can also detect IR. This special feature allows them to hunt their prey easily at night.

Clouds are not the only thing that increases Earth's albedo; it could be snow. During the glacial advances, vast Northern Hemisphere snow cover cooled the northern latitudes so much that snow remained year-round for nearly 90,000 years. Clouds are also part of a negative feedback mechanism with water vapor. The hotter the surface gets (in the presence of water) the more humid it becomes, eventually lofting vast amounts of water vapor into the upper troposphere where it condenses into cumulus clouds that reflect the incoming solar radiation, thereby providing shade that cools the area. This is covered in the book as a thunderstorm. The Earth also cools because heat carried by the hot, humid air is convected to higher altitudes where it is released. High-level ice clouds, called cirrus clouds, behave differently. They provide a pseudo-greenhouse effect, letting a lot of sunlight pass through them but absorbing heat radiation from below.

Also having a large effect on climate are ocean currents. The Gulf Stream and the California Current are well known. However, there are many currents all over the world, which help to moderate the climate close to the shores of continents. The thermohaline circulation of ocean currents is driven by differences in density, temperature and salinity of ocean water.[9]



Source: Robert Simmon, NASA. Minor modifications by Robert A. Rohde
also released to the public domain - NASA Earth Observatory

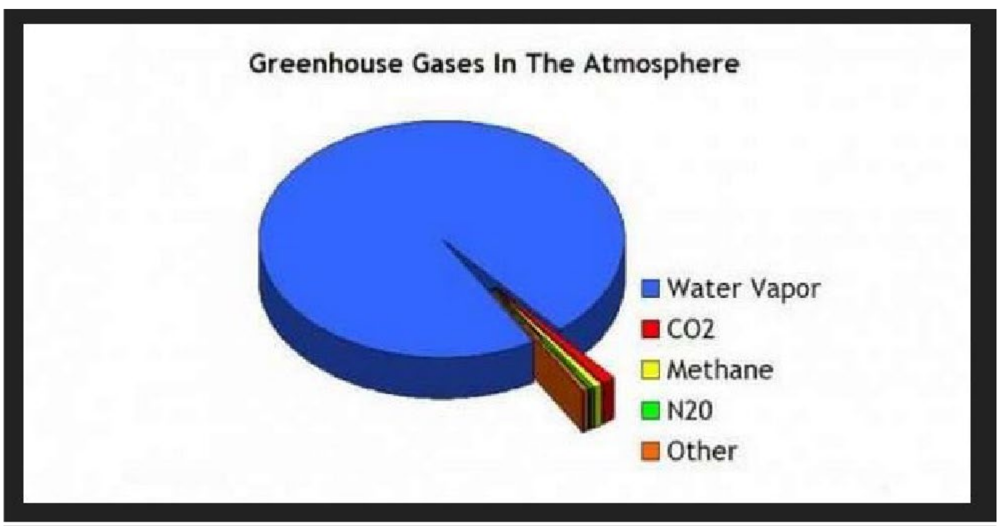
The currents start at the poles, where the water freezes and ice forms. As ice forms, salt is pushed back into the liquid water, whose salinity is increased. The combination of increased salinity and cold temperatures makes the water denser, so it sinks below the surface. As the water travels to equatorial regions, it warms and rises to the surface. The direction and path of the currents are controlled by Earth's rotation and the position of the continents. The Gulf Stream is a warm surface current that moderates the temperature along the East Coast of the United States, preventing temperature extremes that are common in the Midwest. The California Current moderates the temperature on the West Coast in the same way.

El Niño is a patch of warm water that stretches across the equatorial Pacific from the west coast of Peru to the western Pacific Ocean. Even though the process of how El Niño forms is beyond the scope of this lesson plan, it is important to know that the tremendous amount of energy stored in this warmer-than-normal expanse of water can affect the climate worldwide. Although not the only large expanse of ocean affecting the climate, El Niño is the best known.[10]

So why does water have such a large effect on our climate? The primary reason is because of the amount of energy that is absorbed or released when water changes phase.[11] Every phase of water is present on Earth: gas, liquid, and solid. Importantly, water absorbs more heat energy than almost every other substance to change phase. Copper, which is a metal that is used frequently to clad the bottom of cooking pots, takes very little energy to heat up. Compared to copper, it takes 10 times more energy to heat up an equivalent amount of water and 5 times as much energy to heat up an equivalent amount of ice.[12]

This means that the oceans absorb a tremendous amount of heat energy from the Sun and then store it. It takes four times as much energy to heat water than it does an equivalent amount of air, so air is readily heated by warm water. The top 10 feet of the oceans and lakes combined contain more energy than all the Earth's atmosphere. When water changes from ice to a liquid and then to water vapor, energy is absorbed because the water molecules need more energy to move further apart. Evaporating water has a cooling effect because it absorbs energy from the air, making it feel cooler. This is why it feels cooler next to a waterfall or a water fountain. Just the opposite is true when water vapor turns to liquid water; the air feels warmer because the energy contained in the water vapor is released to the environment when the water molecules move closer together. Steam radiators warm a room because heat energy is released into the room when the steam cools and condenses. During a thunderstorm, the energy that is released when it rains is radiated back into the atmosphere.

The Earth's atmosphere is composed mostly of nitrogen (78%) and oxygen (20.95%), followed by argon (0.9%).[13] Even though water vapor varies across the globe, its average atmospheric concentration is 1%. The other greenhouse gases include carbon dioxide at 0.04%, methane at 0.00018%, and nitrous oxide at 0.00003%. The graph below shows how minuscule the other gases are in comparison with water vapor. Carbon dioxide does slow heat radiation from escaping, but it is much less important than water vapor.



Source: https://nssdc.gsfc.nasa.gov/planetary/factsheet/earthfact.html

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2) https://www.iucnredlist.org/species/22823/14871490
3) https://polarbearscience.com/2023/02/23/published-field-study-observations-not-population-size-prove-polar-bears-are-thriving/
4) https://seaworld.org/animals/all-about/polar-bear/diet/

5) https://spaceplace.nasa.gov/seasons/en/
6) https://www.noaa.gov/jetstream/global/global-atmospheric-circulations
7) Original graphs based on data obtained from www.wunderground.com
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11) https://www.usgs.gov/special-topics/water-science-school/science/specific-heat-capacity-and-water
12) https://en.wikipedia.org/wiki/Table_of_specific_heat_capacities
13) https://www.sciencelearn.org.nz/resources/2959-greenhouse-gases-and-the-atmosphere

Suggested Activities

1. **Demonstrating specific heat capacities of copper and water.** The specific heat capacity, also known as specific heat, is the amount of energy required to heat 1gram of any substance by 1^{o}C. Energy can be measured in calories, joules, British Thermal Units (BTUs) or kilowatt-hours. For the purposes of this exercise, energy will be measured in joules. One calorie (not a food calorie, which is abbreviated as a Cal or a kcal) is defined as the amount of energy it takes to heat 1 g of water by 1^{o}C. Scientists, however, most frequently use joules. One calorie is equal to 4.184 joules, so the specific heat of water is 4.184 J/g ^{o}C. Since copper was used as an example in the background information given above, the specific heat of copper, 0.385 J/g ^{o}C, will be used for comparison. The large difference in specific heat between the two substances can be easily demonstrated with a copper-clad pot or pan, water and butter. **Materials:** two pats of butter, a small copper-clad saucepan, 2 cups of water, timer. **Procedure:** This can be a demonstration for small children. First, put one pat of butter on the dry saucepan, and put the saucepan on the stove and start the timer. Heat the saucepan on medium heat until the butter completely melts. Record the amount of time on the timer. Allow the saucepan to cool and repeat the experiment, except this time put the water in the saucepan and put the butter pat on the water so that it floats. The temperature of the water will have to rise high enough to melt the butter. Put the saucepan on the same eye on the stove, start the timer, and heat the saucepan over medium heat until the butter melts. Record the time. If desired, the saucepan can be replaced with a glass beaker. If a beaker is used instead, the specific heat of borosilicate glass is 0.83 J/g ^{o}C. Questions:
   a. Why does it take longer to melt the butter in the water than it took to melt the butter directly in the saucepan?
   b. How much longer did it take to melt the butter in the hot water?
   c. Compare the specific heat of copper to that of water. How much greater is the specific heat of water? Is this proportional to the amount of time it took to melt the butter in water compared to the time it took to melt the butter in the saucepan? Why or why not?

2. **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. Step1: Imagine a column of air one cm by one 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 USA 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 a 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 10 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 at an average depth of 1,000 ft, the small surface area of the lake 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/

Source: Photo by Sharon R. Camp

(Credit to Dr. Gordon Fulks, Ph.D., for recommending this activity. He is a physicist and co-founder of the CO_2 Coalition Education Committee. He is also the author of CO_2 Learning Center Books One through Five.)

3. **What causes the seasons:** Students (and many adults) believe the Earth's seasons change because of the changing distance of the Earth from the Sun as it revolves during the year. It is, instead, because of the tilt of the Earth's axis, the fact that Earth is round, and the changing angle at which sunlight strikes the surface of the Earth. NASA has a good video and a wonderful lesson plan to help students understand the season-tilt relationship between the Earth and the Sun. Here is the NASA video: https://nasaeclips.arc.nasa.gov/spotlite/seasons/seasons_nasa-spotlite--what-causes-seasons-july-2017

Here is an excellent lesson plan for 3rd – 5th graders:
file:///C:/Users/sharo/Downloads/nasa-eclips_-4d-guide-lites-seasons-3-5-spotlite-interactive-lesson-508.pdf

Here is a video that shows how the teacher can do a demonstration in class:
https://www.youtube.com/watch?v=EkR5w9LCPho

4. **Show how the Sun is always in the southern sky as observed from the northern hemisphere:** As viewed from the U.S., the Sun is always in the southern sky. The students may have noticed that the Sun's angle changes as the months go by, where it is lower in the sky in the winter and higher in the sky in the summer. There is a very simple activity that will illustrate this to the students. **Materials:** sidewalk chalk, compasses, tape measures, notepads. **Procedure:** Have the students go outside, preferably on a cloudless day, and divide them into pairs. If there is an uneven number of students, the teacher can work with one student. One student will provide the shadow while the other student will take the measurements. Both students should have individual notepads to record measurements. The students need to collect the following data: the date, the time of day, the length of the shadow and the direction in which the shadow is pointing. Have one student stand in such a way so that the student's shadow is longest. The other student should make two chalk marks: one at the bottom of the shadow (feet) and one at the top of the shadow (head). Have the students work together to record the length of the shadow and the direction in which it is pointing. At a time designated by the teacher (something close to an hour works well), have the students go out and repeat the procedures. The same student should provide the shadow each time a measurement is made. The feet of the student should be in the exact same position that they were originally. If possible, the students can go out multiple times during the day to watch the shadow grow and shrink; this activity would provide them with data that they could graph to show how the length of the shadow changes with the time of day. These measurements should be started as early in the year as possible and should continue at least once a month (more if desired) until the students have had the opportunity to see how the angle of the Sun changes with the seasons based on the changes in the length and direction of their shadows. The changes in direction can be graphed as individual arrows plotted on a graph with the months at the bottom (independent variable), and the angle as the dependent variable (allow the top of the graph to represent due south).

5. **Demonstrate how the changes in density of water will cause it to sink and rise.** The density differences of salt water and freshwater, along with the differences in densities between warm water and cold water, are sometimes confusing to students. It is the difference in these densities, however, that causes the thermohaline circulation that affects climate worldwide. There are a couple of simple demonstrations the teacher can do to help illustrate why water will sink or rise. **Materials:** plastic school folder, two 9-oz clear plastic cups or Mason jars, table salt, tap water, a kitchen scale that measures grams, and a 100-mL (or other size) graduated cylinder. (The scale and the graduated cylinder can be purchased on Amazon.) **Procedure:** First, ask students what density is (it

is a property of matter that is equal to mass/volume). Oil is less dense than vinegar, so it will float on top of vinegar. Likewise, ice is less dense than water and so will float also. Ask the students to predict which is denser: warm water or cold water and ask them to justify their hypotheses. To test their predictions, take some very warm water dyed red and put it in one cup. Take some very cold water (ice water) dyed blue and put it in another cup. This demonstration works best if both cups are completely filled with water so that there is no space at the top. Put the plastic folder (or a smaller piece cut from the plastic folder) on top of one of the cups, carefully flip it and place it exactly on top of the other cup without spilling the water. **This will take practice before the demonstration is shown!** Here is a video of the same concept for a different application: https://cotton.ces.ncsu.edu/2018/07/a-simple-science-experiment-temperature-inversion/ The warm water will stay on top, and the cold water will mix with the warm water if it is on top. Have the students explain which water is denser and how they know. Just as in the cups, cold ocean water will sink below warm ocean water. But temperature is not the only thing that affects the density of water: the amount of salt dissolved in water will also change its density. To demonstrate this property, put 100 mL of water into a bowl and dissolve 3.6g of table salt in it. It will take a while for the salt to dissolve, so be sure to stir the water until no salt crystals are visible at the bottom of the bowl. (It is possible to double or triple the amounts of salt and water if needed but keep the proportions the same to imitate ocean water.) Dye the saltwater yellow and dye the freshwater green, then do the same demonstration as above, substituting salt and fresh water of the same temperature for hot and cold fresh water. Again, have the students predict which one will be denser and explain why. It is also possible to make hot and cold salt water and have the students predict the outcomes. If enough time is available, the students can design their own experiments that test a combination of all the variables (hot, cold, salt and fresh), The students can hypothesize what combination will end in which result, draw graphs (if varying temperature and/or salinity), and make conclusions from their observations. Also, students could be divided into groups based on what combination of variables they would like to test, then give a presentation to the class where they can discuss their experimental methods and results.

6. **Critical Thinking: Compare and contrast two articles on polar bears.** Many times, especially on controversial subjects, there will be multiple articles and sources of information, and many times the authors of these articles will provide conflicting information. So how does a student know which source is more trustworthy? Many times, it has to do with the quality of the data that is presented and how much that data has been modified by the researcher (such as digital smoothing, taking averages when actual data isn't available, or using models to predict outcomes instead of relying on observations to draw conclusions). Two articles from different sources were cited in the background information that related to polar bear populations, one from the World Wildlife Fund and one from Polar Bear Science. But the information from the two articles is slightly different, and one had better support for the conclusions than the other. Have the students write a report, consisting of several paragraphs, that compare and contrast the two articles. Things the students should look for while evaluating the

articles are supporting research, links to or presentation of actual data as opposed to just statements or indefinite references, and observational bias or bias apparent in the writing of the article. Have the students write a conclusion as to which article has better and more convincing information and why.

(Credit to John Droz, Jr., for recommending this activity. He is a member of the CO_2 Coalition Education Committee, a physicist and a citizen advocate.)

Formative and Summative Questions

1) Why is it difficult to estimate the sizes of polar bear populations?
2) What adaptations have polar bears made to changes in their climate and increased competition for food?
3) Identify the two major greenhouse gases that are found in the atmosphere.
4) Water holds more heat per mass than almost any other substance on the planet. What is this heat called? Why does water hold so much heat?
5) How do ocean currents moderate the climate in coastal areas of the continents?
6) How does ice help keep things cold?
7) Deserts get much colder at night than rainforests do, and they get much hotter during the day. Why?
8) What are some of the things that happen to sunlight when it strikes the Earth's atmosphere?
9) Which clouds reflect more sunlight, cumulus or high-level clouds? Why are they different? How do they affect the temperature on Earth?
10) How do rain and thunderstorms release heat energy from the atmosphere?
11) Mr. Gordon called water the "magic molecule of climate." What are some facts about water that justify his statement?

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

Next Generation Science Standards (NGSS) Learning Objectives

The standards here are written exactly as they are written in the NGSS.

2-ESS2-3 Earth's Systems. Students who demonstrate understanding can:

2-ESS2-3. Obtain information to identify where water is found on Earth and that it can be solid or liquid. This standard includes the following Disciplinary Core Ideas:

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

- Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.

3-ESS2-2 Earth's Systems. Students who demonstrate understanding can:

3-ESS2-2. Obtain and combine information to describe climates in different regions of the world. This standard includes the following Disciplinary Core Ideas:

ESS2.D: Weather and Climate

- Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years.

4-PS3-2 Energy. Students who demonstrate understanding can:

4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. This standard includes the following Disciplinary Core Ideas:

PS3.A: Definitions of Energy

- Energy can be moved from place to place by moving objects or through sound, light, or electric currents.

PS3.B: Conservation of Energy and Energy Transfer

- Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.
- Light also transfers energy from place to place.
- Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy.

5-ESS2-2 Earth's Systems. Students who demonstrate understanding can:

5-ESS2-2. Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. This standard includes the following Disciplinary Core Ideas:

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

- Nearly all of Earth’s available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics. Students who demonstrate understanding can:

MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.] This standard includes the following Disciplinary Core Ideas:

LS2.A: Interdependent Relationships in Ecosystems

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1)
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1)

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

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. [Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawing and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.] This standard includes the following Disciplinary Core Ideas:

PS1.A: Structure and Properties of Matter:

- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- 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.
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

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. (secondary)

- The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system's material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material.
- Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. (secondary)

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:

- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.

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

MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. [Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps, and globes, or digital representations.] This standard includes the following Disciplinary Core Ideas:

ESS2.D: Weather and Climate

- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.

- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

Source: https://www. nextgenscience.org

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, policy makers, 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.