Greenhouse in a Bottle

Modified from *CO2 in a Bottle* activity from the California Institute for Biodiversity 2012 *Climate Change Teacher Guide*. We would like to thank the California Institute for Biodiversity for generously granting us permission to base our activity on their model.

Synopsis of the Activity

Through the use of a physical model and a computer simulation, learners explore the effects of atmospheric heat-trapping gases on Earth's climate.

Audience

This activity is designed for the general public and is best accessed by learners in middle school or older. It is best done with small groups of visitors**.**

Setting

This activity works well as a cart anywhere in an informal science setting as long as a power source is available for plugging in a microwave and computer.

Activity Goals

Learners will gain a deeper understanding of:

a. Some of the gases that act as heat-trapping gases
b. How heat-trapping gases trap heat in the atmosphere
c. What happens to temperature when there is an increase in the amount of heat-trapping gases

Concepts

1. Some gases in Earth's atmosphere behave as heat-trapping gases, maintaining the planet at a habitable temperature. Carbon dioxide is a major heat-trapping gas.
2. Heat-trapping gases trap the sun's energy on Earth.
3. As the concentration of heat-trapping gases, especially CO_2, increases in Earth's atmosphere, more of the sun's heat energy is trapped on Earth, and Earth's temperature increases.
4. Human industry is responsible for the increasing concentration of heat-trapping gases in Earth's atmosphere, especially CO_2 and methane.
5. The concentration of CO_2 in Earth's atmosphere and Earth's temperature have been rising since the start of the Industrial Revolution.

Climate Literacy Principles

Some of the following Principles will be more relevant to different audiences, depending on their prior knowledge and the direction of the conversation between the audience and the facilitator.

1. The sun is the primary source of energy for Earth's climate system.
   a. Sunlight reaching the Earth can heat the land, ocean, and atmosphere. Some of that sunlight is reflected back to space by the surface, clouds, or ice. Much of the sunlight that reaches Earth is absorbed and warms the planet.
   b. When Earth emits the same amount of energy as it absorbs, its energy budget is in balance, and its average temperature remains stable.

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2. Climate is regulated by complex interactions among components of the Earth system.
   c. The amount of solar energy absorbed or radiated by Earth is modulated by the atmosphere and depends on its composition. Greenhouse gases— such as water vapor, carbon dioxide, and methane— occur naturally in small amounts and absorb and release heat energy more efficiently than abundant atmospheric gases like nitrogen and oxygen. Small increases in carbon dioxide concentration have a large effect on the climate system.
   d. The abundance of greenhouse gases in the atmosphere is controlled by biogeochemical cycles that continually move these components between their ocean, land, life, and atmosphere reservoirs. The abundance of carbon in the atmosphere is reduced through seafloor accumulation of marine sediments and accumulation of plant biomass and is increased through deforestation and the burning of fossil fuels as well as through other processes.

4. Climate varies over space and time through both natural and man -made processes.
   f. Natural processes driving Earth's long-term climate variability do not explain the rapid climate change observed in recent decades. The only explanation that is consistent with all available evidence is that human impacts are playing an increasing role in climate change. Future changes in climate may be rapid compared to historical changes.
   g. Natural processes that remove carbon dioxide from the atmosphere operate slowly when compared to the processes that are now adding it to the atmosphere. Thus, carbon dioxide introduced into the atmosphere today may remain there for a century or more. Other greenhouse gases, including some created by humans, may remain in the atmosphere for thousands of years.

6. Human activities are impacting the climate system.
   a. The overwhelming consensus of scientific studies on climate indicates that most of the observed increase in global average temperatures since the latter part of the 20th century is very likely due to human activities, primarily from increases in greenhouse gas concentrations resulting from the burning of fossil fuels.
   b. Emissions from the widespread burning of fossil fuels since the start of the Industrial Revolution have increased the concentration of greenhouse gases in the atmosphere. Because these gases can remain in the atmosphere for hundreds of years before being removed by natural processes, their warming influence is projected to persist into the next century.
   c. Human activities have affected the land, oceans, and atmosphere, and these changes have altered global climate patterns. Burning fossil fuels, releasing chemicals into the atmosphere, reducing the amount of forest cover, and rapid expansion of farming, development, and industrial activities are releasing carbon dioxide into the atmosphere and changing the balance of the climate system.

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Materials:

For the whole activity:
Station sign that reads: *Greenhouse in a bottle*

For the Computer Game portion of the activity:

- A computer
- Downloaded copy of the Phet Greenhouse Effect simulation (http://phet.colorado.edu/en/simulation/greenhouse)
- Images:
    - A: atmosphere from space
    - B: where CO_2 comes from
    - C: plants/seaweed and photosynthesis
    - D: absorbed, reflected, transmitted diagrams
    - E: portions of sunlight absorbed, reradiated etc by different factors on Earth
    - F: Electromagnetic spectrum
    - G: Keeling Curve

For the Greenhouse in a Bottle portion of the activity:

- 1x 1 liter clear plastic soda bottle
- 1x thermometer (preferably on some support)
- 1x drinking straw
- 4x Alka Seltzer tablets
- water, enough to fill the yogurt container to about half full
- 1x small yogurt container with lid
- Dirt (has to be dry), enough to fill the bottom of the soda bottle to about 2 fingers depth
- Microwave
- Pair of scissors

Getting Ready:

For the whole activity:
Put up station sign so that it is easily visible to people passing by.

For the Computer Game portion of the activity:

1. Make sure the Phet simulation runs properly on your computer. You may need to close and reopen it after a while.
2. Print out the images A-G. You may wish to laminate them or put them in a protective sleeve, but this is optional. Place the images in a folder so that they are easily accessed during the activity.

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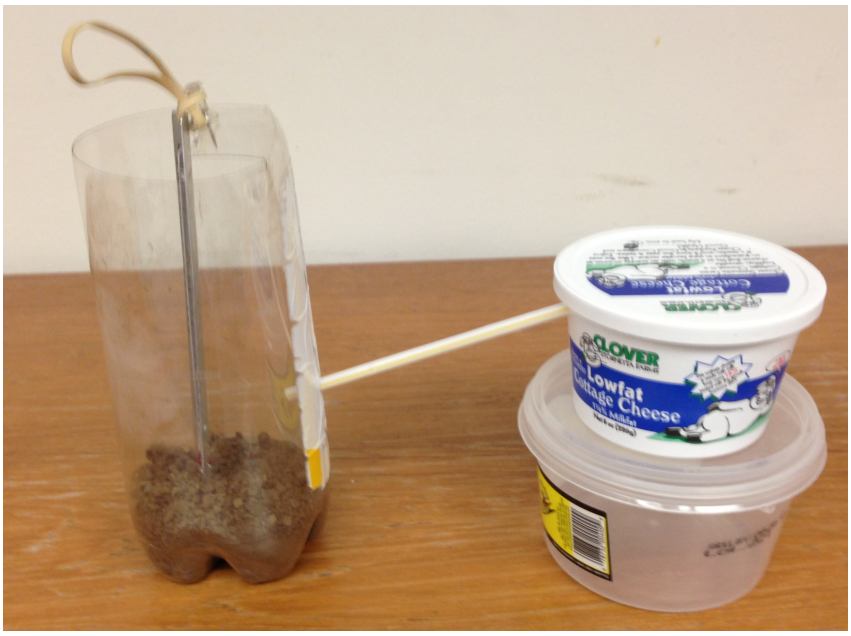
For the Greenhouse in a Bottle portion of the activity:

Set up the apparatus as shown below

1. Slice the top part off the soda bottle so that it'll fit in the microwave. Leave a part of the lip higher so that it can be folded over; this will act as the support for the thermometer
2. Put the dirt in the soda bottle, about 2 fingers deep
3. Set up the thermometer so that it can be placed just above the dirt, and away from the sides. Use the folded lip for support. A pushpin can be helpful here, and a rubber band to attach the thermometer to the pushpin.
4. Punch a small hole in the soda bottle ~3 fingers width above the soil line, with the pair of scissors. This is where the straw will be inserted
5. Punch a small hole in the yogurt container near the top.
6. Fill the yogurt container about half full of water.
7. Insert the straw into the hole in the container on one end, and into the soda bottle on the other end. (Remove the thermometer and straw before heating the bottle and soil in the next step.)



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Doing the Activity:

Invite Learners to participate.
When learners approach the station, greet them and let them know that you are exploring gases in our atmosphere and how they affect Earth's climate.

Ask some of the following guiding questions to invite learners to participate and access their prior knowledge. Accept all responses and follow the lead and interests of the learners.

- What have you heard about Earth's atmosphere?
- How would you describe what the atmosphere is? (You might suggest they could talk about the kinds of gases found there and/or where the atmosphere is located.)
- Have you heard of greenhouse or heat-trapping gases? What do you think the effect of gases like that in our atmosphere might be? What makes you think that?

Tell the learners that you have two activities at this station that they could do to discover more about heat-trapping gases in our atmosphere. It doesn't matter which activity is done first.

- One activity is a computer game or simulation to learn about heat-trapping gases and how they trap heat.
- The other activity is an experiment to investigate what happens to temperature in the atmosphere when there is an increase in the amount of heat-trapping gases.

Ask the learner which activity they might like to start with. Depending on what you discover about the learners' knowledge and interests as you engage them in conversation during the activities, determine how much information and which images you might like to share with them.

Computer game
1. Discuss models. Explain that scientists often use models to help them answer questions and come up with explanations about how the world works. A model is very similar to, but not exactly like the real thing. Models are helpful in answering questions about the natural world, especially when the questions concern things that are too big or too small to see, or are so complicated that we need to investigate pieces of the system one at a time and then learn about how the different parts of the system work together.

2. Discuss Earth's atmosphere. Ask learners to describe what they know about the atmosphere and where it is located. Depending on what they say, follow up with some of the following information and decide whether you would like to show **Image A (atmosphere from space)** or draw freehand on a sheet of chart paper as the discussion progresses.

- The atmosphere is all around us and up to about 10 km/6 miles.
- It is made up of the following gases: oxygen O_2, carbon dioxide CO_2, nitrogen N_2, water H_2O vapor etc.

Ask: what have you heard about carbon dioxide (CO_2)? How does CO_2 get into the atmosphere? Depending on what they say, share some or all of the following information:

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- Animals breathe out CO_2, factories, cars, and airplanes put CO_2 into the atmosphere as they use fossil fuels, cement-making releases CO_2, and deforestation releases CO_2 when trees are burned. **Image B (where CO_2 comes from)**
- Trees and other plants, seaweeds, and all photosynthetic organisms take in CO_2 and release O_2 as they photosynthesize. **Image C (plants/seaweeds and photosynthesis)**

3. Discuss relationship of Sun and Earth. Ask, how would you describe the relationship between the Sun and the Earth (or how is the Earth affected by the Sun)? Depending on what the learner says, share some or all of the following information:

- Sun provides light and heat to the Earth
- Light can be absorbed, reflected, transmitted **(show Image D)**
- Earth is warmed as energy from the Sun is absorbed, but the heat doesn't just stay in the soil and other surfaces on Earth – much of it goes back into the atmosphere (**show Image E:** portions of sunlight absorbed, reradiated etc by different factors on Earth.)
- Without the atmosphere, much of the energy coming to Earth from the Sun would be lost back into space.

4. Introduce guiding question for computer model. Say we are going to use the computer model to try to answer the following questions (show question sheet).

- How does the atmosphere capture and retain the heat to keep Earth habitable for the organisms living here?
- What would happen to the temperature on Earth if we didn't have an atmosphere?

5. Give learners the opportunity to try out the computer simulation. Demonstrate how to do the Greenhouse Phet simulation. Describe the difference in the red and yellow dots as representing heat and light energy coming originally from the Sun. Give them some challenges such as designing an atmosphere and other planets and atmospheres. Decide if there is interest and time to have the learners complete the *Heat trapping gases* and the *Test an Atmosphere* worksheets

6. Debrief computer model.

- Ask learners to turn to each other and describe what they learned about the relationship between temperature and the kind of atmosphere a planet has.
- What gases seemed to have the greatest effect on the temperature of the planet? [from the simulation: CH_4, CO_2, and water]. These are called heat-trapping gases or greenhouse gases. These gases are important because they help to trap the Sun's heat energy on Earth.
- Depending on the learner's level of knowledge and interest, include the following information: Explain that the heat is trapped by the gas and that it absorbs at infrared wavelengths, but not visible wavelengths. **Image F (Electromagnetic spectrum)**
- Ask learners to talk to each other about: In what ways does the computer model seem to accurately represent Earth's atmosphere and heat-trapping gases? (heat energy is trapped by the gases; many of Earth's heat-trapping gases are represented) In what ways is it inaccurate? (not all of Earth's heat-trapping gases are represented;

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it only shows a small part of Earth; there are far fewer photons represented than there are in the real atmosphere)

7. Challenge question: What would you predict would happen if more and more heat trapping gases were put into the atmosphere? Have learners discuss this challenge question with each other first and then ask for a volunteer to share their ideas. Ask, what makes them think that would happen.

- **Show Keeling curve (Image G)** and have learners describe what they see. Mention that the curve shows seasonal changes in the amount of CO_2 in the atmosphere due to photosynthesis—during winter months in the Northern hemisphere, less CO2 is taken in by plants because there are less leaves on the trees; during summer months, more CO2 is taken in by plants because there are more leaves on the trees. Remind learners that CO_2 is a heat trapping gas and scientists have made observations and collected and analyzed data, which is used as evidence that CO_2 has been increasing in the atmosphere.
- How has CO_2 changed since about 1960? What do you think might have caused these changes?
- Where might this CO_2 be coming from? Take all answers. You might want to show **Image B again and point out factories, cars/planes, deforestation, cement-making.**

<u>Greenhouse in a Bottle Investigation</u>

1. *Introduce the investigation.* Remind learners to think back to the Phet simulation if they have already done that activity. Then say, "let's use another model where we can actually measure the temperature of the atmosphere as CO_2 increases." If learners haven't done the Phet simulation yet, tell them that the evidence shows that CO_2 is increasing in the atmosphere. In this investigation we'll look at, what is the relationship between increasing CO_2 and the temperature on Earth?

2. *Introduce the model shown above.* Show the model and describe the set up. There is soil in the bottom of the bottle to represent land, and the top of the bottle is open so that the air in the bottle is atmospheric air. There's a thermometer hanging from the top of the bottle into the air of the bottle to measure the air temperature. Momentarily, you'll place the bottle with soil into the microwave for several seconds to represent the bottle being heated by the "sun." The straw connecting the yogurt container to the bottle will bring CO_2 generated in the yogurt container into the air over the soil in the bottle. We'll make CO_2 in the yogurt container by plopping some Alka Seltzer tablets into the water and letting them dissolve. The bubbles released by the Alka Seltzer tablets and water are CO_2 bubbles.

3. *Make predictions.* Have learners predict what they think will happen to the temperature of the "atmosphere" when the soil in the bottle is heated by the "sun" (microwave). Then have them predict what will happen when we add additional heat trapping gas [CO_2 from Alka Seltzer] to the atmosphere in the bottle. Remind them what the Alka Seltzer is representing [increasing CO_2 in the atmosphere].

4. *Do the investigation.*

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- Heat the soda bottle and soil in the microwave for about 15-17 seconds or so—long enough that it is hot, but not so long that it melts the bottle. *Remove the thermometer first!*
- Reattach the thermometer and straw to the soda bottle.
- The thermometer reading will rise. Keep a note of the temperature until it stabilizes (wait ~30s). Make a note of the temperature with learners.
- Quickly put 4 Alka Seltzer tablets into the yogurt container with water, and close the lid. CO_2 will be generated and piped into the soda bottle.
- Note the temperature again. Does it rise? Wait until the temperature settles, and take another reading.
- Have learners compare the reading before and after the Alka Seltzer was introduced. [the temperature rises after the Alka Seltzer is placed in the water] Ask, "How might you explain the temperature change?"
- Keep observing the temperature. Observe how long it takes before the temperature starts dropping.

5. *Debrief the investigation.* Ask a volunteer to recap the results of the investigation. [The temperature stabilized after the bottle was removed from the microwave. Then it rose once the CO_2 was added to the bottle atmosphere through the straw.] Then have learners turn and talk to a partner and discuss, "What does this model show us about the relationship between increasing CO_2 in the atmosphere and the temperature on Earth?" and "What do you think this has to do with climate change?" Give learners a chance to share out. If necessary, share that as CO_2 levels rise in the atmosphere, Earth's air temperatures rise just like in our model.

6. *Discuss the model.* Ask learners to share some ways they think the model is accurate and ways they think it might be inaccurate. [Accurate: the air over the top of the soil is atmospheric air; the heat energy is emitted from the ground (soil); carbon dioxide leads to warming; Inaccurate: the bottle is much simpler than the real Earth since there is only dirt, no rock or water in the bottle; the CO_2 dissipates]

What can you do?

Tell learners that they can take action to slow the release of heat-trapping gases into the atmosphere. Ask learners to consider what they might be able to do about the increase in heat-trapping gases. Present them with the ***What can you do?* worksheet** and the **suggested actions from the Environmental Protection Agency**. Ask the learners to consider which of these actions might be doable for them.

If there are other stations related to fossil fuels or the effects of climate change nearby, suggest that learners visit those to follow up on this station activity.

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Science Background

Since the late 19th century, Earth's global average surface temperature has risen about 1.5°F. It is predicted that Earth's temperature will continue to rise between 2° and 11.5°F during the 21st century, depending on a number of different global scenarios (see IPCC scenarios below) that can impact temperature. So, what is causing Earth's temperature to rise? Scientists from all the national science academies of all the major industrialized nations agree that most of the global average increase in temperature is human induced, with increases in the concentration of heat-trapping gases in the atmosphere being largely responsible.

Heat-trapping gases (CO_2, CH_4, nitrous oxide, and water vapor) comprise less than 1 percent of Earth's atmosphere, but they make a large contribution to our planet's climate. Heat-trapping gases and greenhouse gases are the same thing, but scientists have started using the term *heat-trapping gases* because that name does a better job of describing what the gases do. When solar radiation enters the atmosphere, some of it is reflected by the atmosphere and Earth's surface. However, about half of the solar radiation is absorbed by Earth's surface, converted to heat energy, and emitted back to the atmosphere as infrared radiation. Most of that infrared radiation is absorbed and re-emitted by heat-trapping gas molecules, while some of it passes through the atmosphere out into space. Maintaining the infrared radiation within the atmosphere is what helps make Earth's climate habitable as it keeps the atmosphere, surface, and ocean warm. As heat-trapping gases build up in the atmosphere due to human activity, more of the infrared radiation is absorbed, thereby increasing Earth's temperature. Water vapor is the biggest contributor to the greenhouse effect, with CO_2 ranking second. However, CO_2 is the heat-trapping gas with which scientists are most concerned because, unlike water vapor, its concentration in the atmosphere is directly increased by human activity.

Closed-up cars or greenhouses get hot on sunny days through a different mechanism than that which is responsible for heating the atmosphere through the greenhouse effect. Glass allows light energy to enter and be absorbed by interior surfaces. The interior surfaces heat up and warm the air in the car or greenhouse (or other glass covered surface). The glass then prevents the warm air from escaping. Glass does not reflect heat back toward the interior surfaces.

Some of the most important monitoring of CO_2 levels occurs at Mauna Loa Observatory, at the peak of Mauna Loa volcano in Hawaii. Although these sensors are in one location, they help scientists understand CO_2 levels throughout the entire Northern Hemisphere. Since it only takes 1–3 months for winds to circulate air all over the globe, this means that local CO_2 levels at Mauna Loa are representative of CO_2 levels in the entire Northern Hemisphere.

One of the most striking things about the recent increase in Earth's atmospheric CO_2 level is how quickly this increase has taken place. From 1958 to 2010, the amount of CO_2 in the atmosphere increased by over 70 parts per million (ppm). This rate of change averages to about 1.5 ppm per year, although over the years the rate of change has been increasing steadily. At the time of this publication, the annual rate of change was up to 3 ppm. Earth's

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CO_2 level has increased and decreased quite a bit throughout Earth's history, but no known changes in the past 750,000 years have happened as quickly as this recent change. The rate of change is the amount of change per unit time. If you were to graph atmospheric CO_2 levels on the *y*-axis and time on the *x*-axis, the rate of change at a particular point in time is the slope of the line at that time.

The background section is taken from Ocean Sciences Sequence: The Ocean–Atmosphere Connection and Climate Change. Used by permission from the Regents of the University of California. For more information and additional resources from this instructional material, see: http://mare.lawrencehallofscience.org/curriculum/ocean-science-sequence/oss68-overview.

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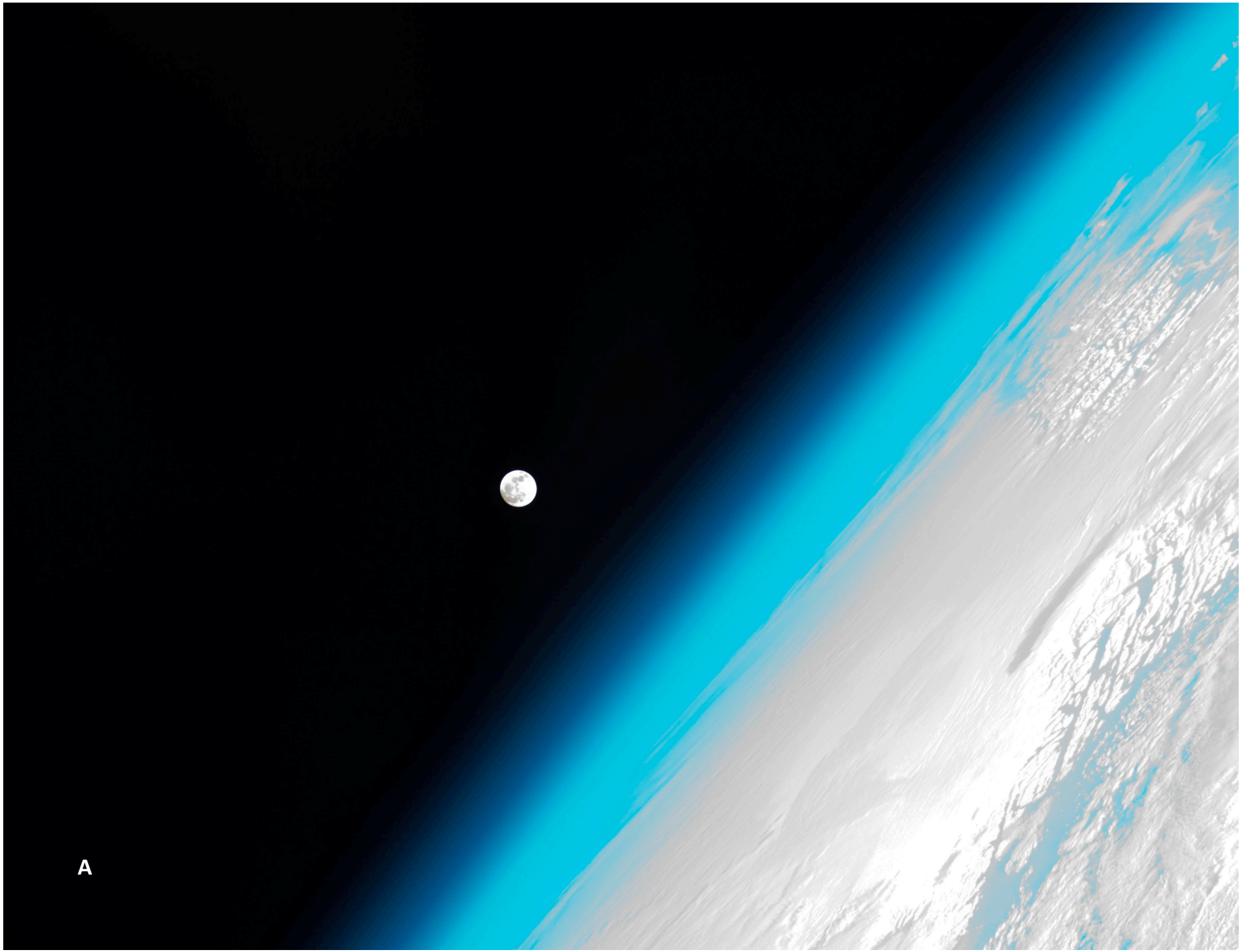
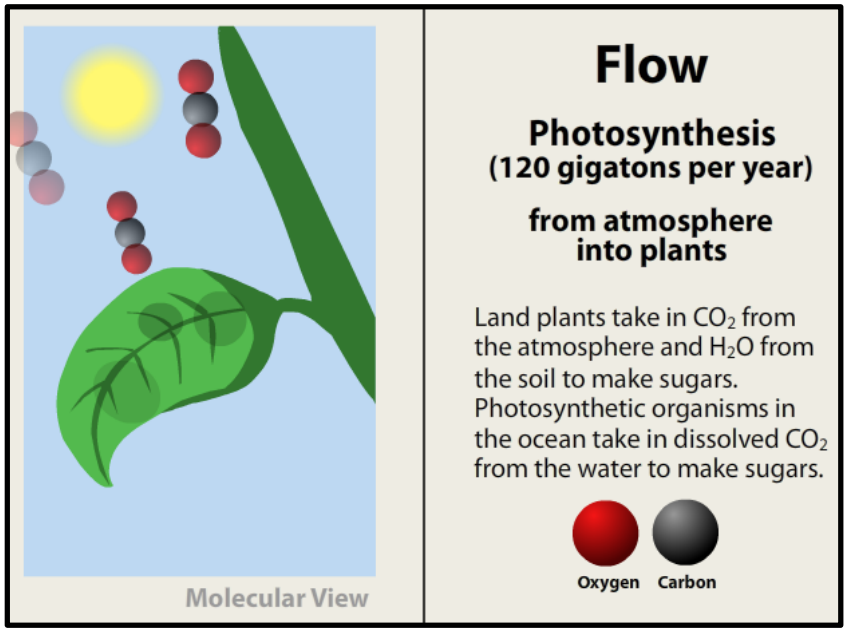
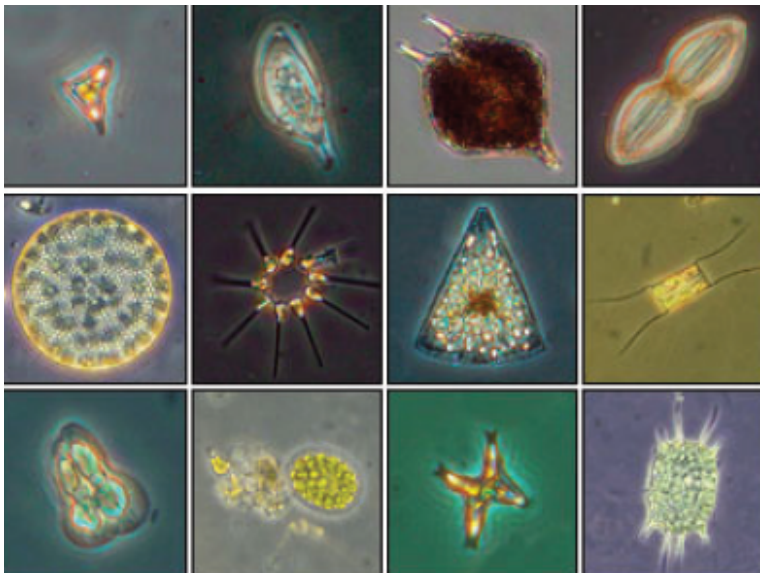

A

Photo credits, clockwise from top left: Alex Needham, EPA.gov, http://www.free-picture.net/airplane/a-47-airplane.jpg.html, http://zoyler.com/top-10-heaviest-animal-in-the-world/, Frank Vassen, Seighean

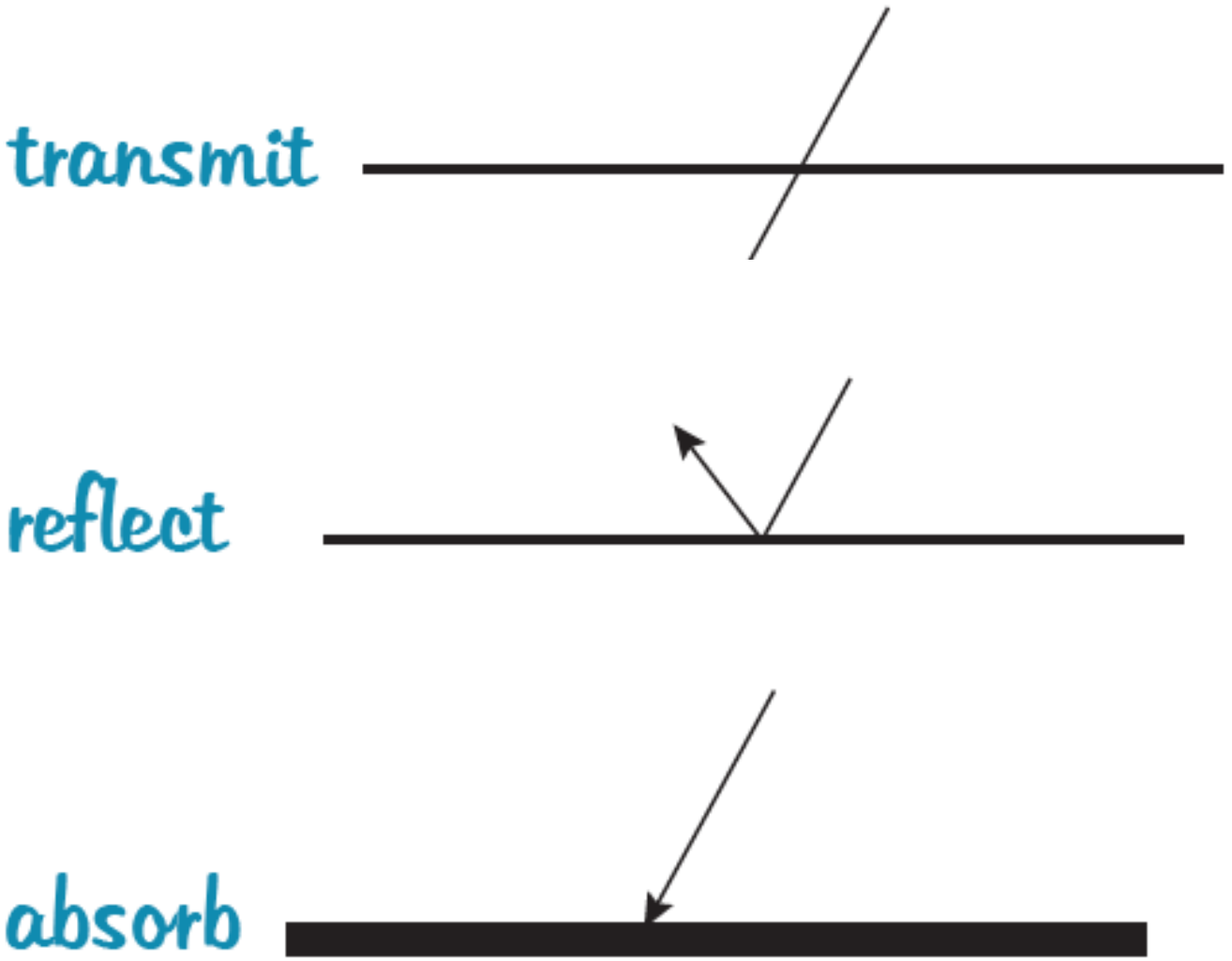
B

water $6\ H_2O$ + carbon dioxide $6\ CO_2$ + sunlight **light energy** → sugar $C_6H_{12}O_6$ + oxygen $6\ O_2$





http://en.wikipedia.org/wiki/File:Seaweed_600.jpg



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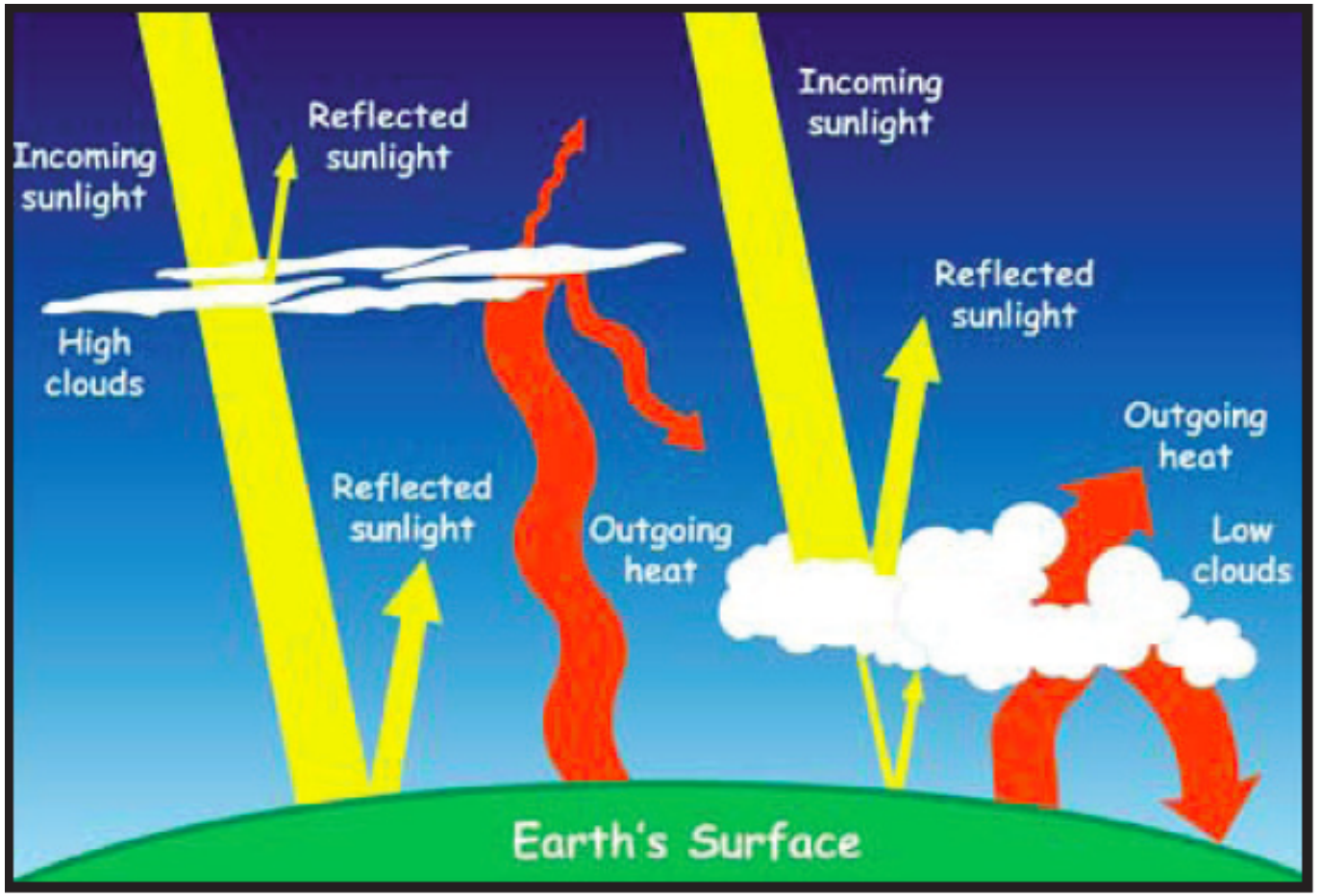
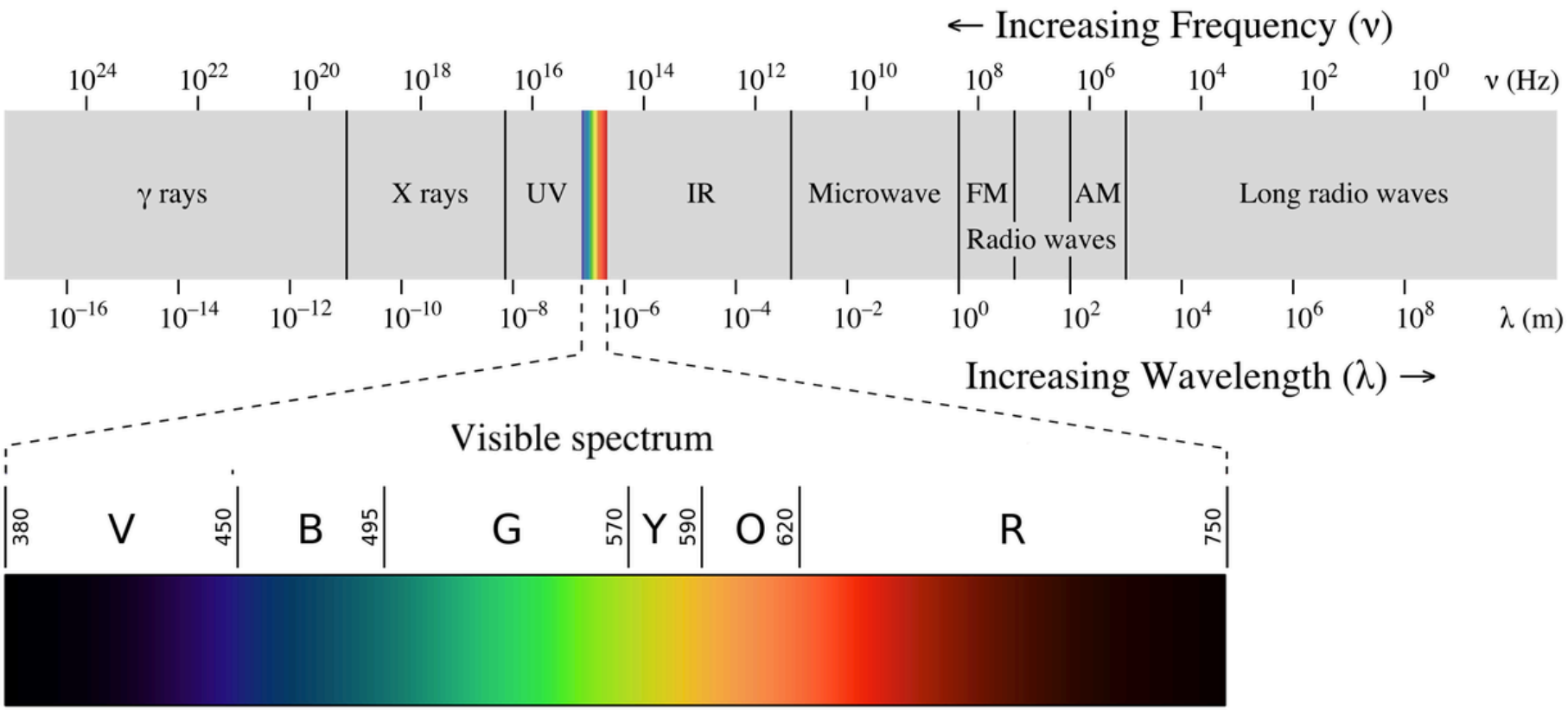


Solar Energy Absorbed		Solar Energy Reflected	
Clouds	3%	Clouds	20%
Atmosphere	16%	Atmosphere	6%
Land and ocean	51%	Land	4%
TOTAL ABSORBED	70%	TOTAL REFLECTED	30%

E



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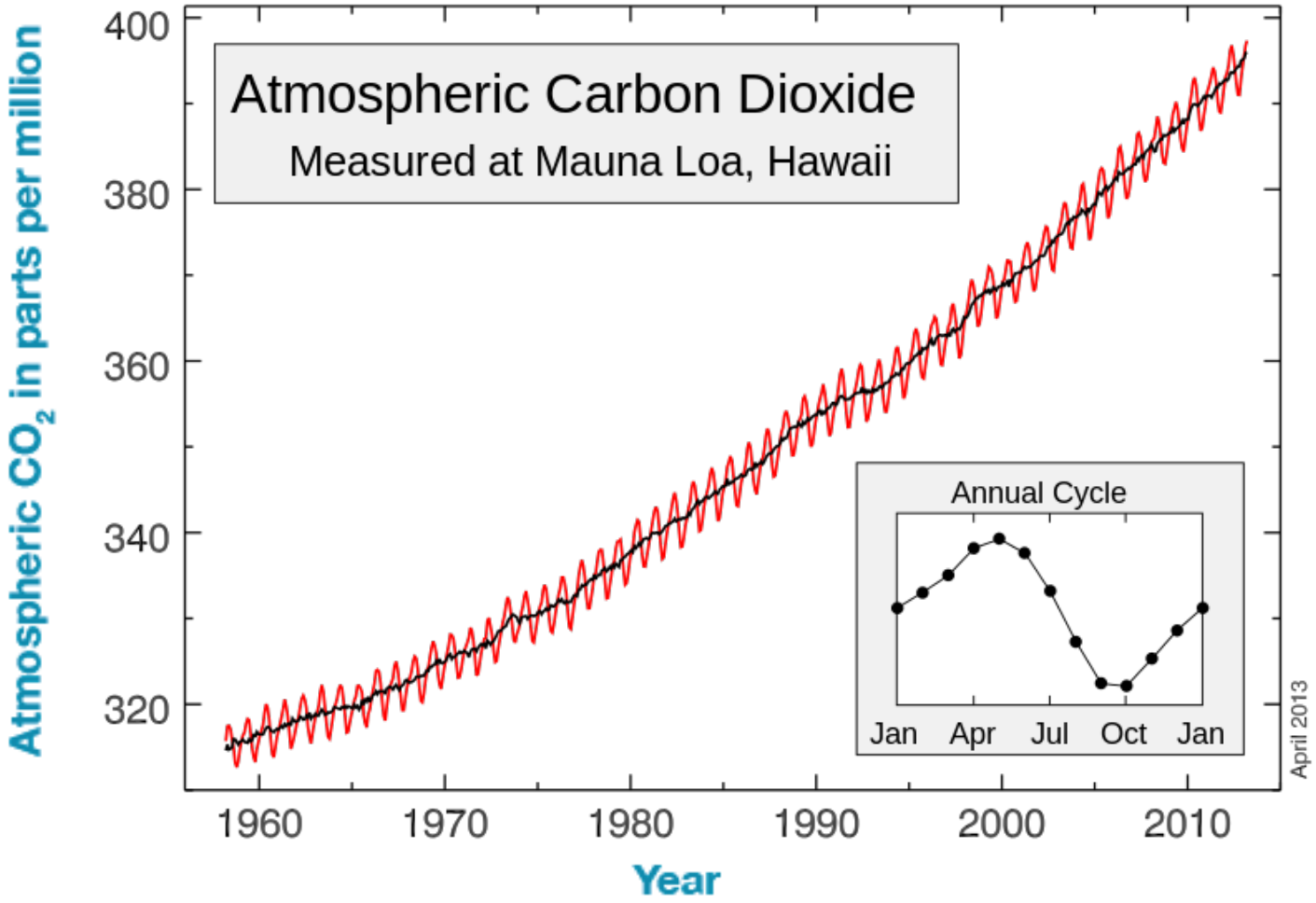
F

Keeling Curve: CO_2 Levels in the Atmosphere



G

Questions to Explore

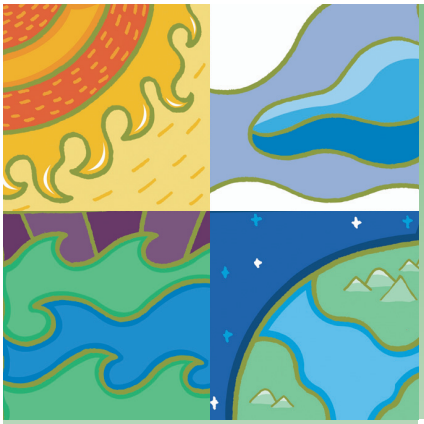
- How does the atmosphere capture and retain the heat to keep Earth habitable for the organisms living here?

- What would happen to the temperature on Earth if we didn't have an atmosphere?

What can I do about the increase in heat-trapping gases?

What can you do?

Something I can do	What steps do I have to take to make this happen?	When will I start?



Climate Change & You

WHAT YOU CAN DO on the road

The burning of fuels releases carbon dioxide into the atmosphere and contributes to climate change. By taking actions to reduce the amount of fuel you use, you can reduce your greenhouse gas emissions, reduce the nation's dependence on oil, and save money.

Resources

Federal Fuel Economy Guide: **www.fueleconomy.gov/**

Federal Bicycle and Pedestrian Program: **www.fhwa.dot.gov/environment/bikeped/**

Public Transportation Web site: **www.publictransportation.org/**

EPA's Green Vehicle Guide: **www.epa.gov/greenvehicles/**

DOE's Alternative Fueling Station Locator: **http://www.afdc.energy.gov/afdc/locator/stations/**

EPA's Climate Change: What You Can Do on the Road Web site: **www.epa.gov/climatechange/wycd/road.html**

1. Buy smart

Before buying a new or used vehicle (or even renting), check out EPA's Green Vehicle Guide and the jointly run EPA/DOE Fuel Economy Guide. These resources provide information about the emissions and fuel economy performance of different vehicles. The Green Vehicle Guide provides detailed information on emissions (including air pollution and greenhouse gas scores for each model), and the Fuel Economy Guide focuses on fuel efficiency (including side-by-side fuel economy comparisons and a customized fuel cost calculator).

2. Drive smart

To improve fuel economy and reduce greenhouse gas emissions, go easy on the brakes and gas pedal, avoid hard accelerations, reduce time spent idling, and unload unnecessary items in your trunk to reduce weight. If you have a removable roof rack and you are not using it, take it off to improve your fuel economy by as much as 5 percent. Use overdrive and cruise control on your car if you have those features.

3. Tune your ride

A well-maintained car is more fuel-efficient, produces lower greenhouse gas emissions, is more reliable, and is safer! Keep your car well-tuned, follow the manufacturer's maintenance schedule, and use the recommended grade of motor oil. Also check and replace your vehicle's air filter regularly.

4. Check your tires

Check your tire pressure regularly. Under-inflation increases tire wear, reduces your fuel economy by up to 3 percent, and leads to increased emissions of greenhouse gases and air pollutants. If you don't know the correct tire pressure for your vehicle, you can find it listed on the door to the glove compartment or on the driver's side door pillar.

5. Give your car a break

Use public transportation, carpool, or walk or bike whenever possible to avoid using your car. Leaving your car at home just two days a week will reduce greenhouse gas emissions by an average of 1,600 pounds per year. Whenever possible, combine activities and errands into one trip. For daily commuting, consider options such as telecommuting (working from home via phone or over the Internet) that can reduce the stress of commuting, reduce greenhouse gas emissions, and save you money.

6. Use renewable fuels

Both E85 and biodiesel are renewable fuels that can reduce greenhouse gas emissions from your vehicle. E85 is a fuel blend containing 85 percent renewable ethanol, and can be used in certain vehicles called flex fuel vehicles (FFVs). Biodiesel is a renewable fuel made from agricultural resources such as vegetable oils. DOE's Alternative Fueling Station Locator can help you locate both E85 and biodiesel fuel stations in your area.

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Climate Change & You

WHAT YOU CAN DO *at home*

Making a few small changes in your home and yard can lead to big reductions of greenhouse gas emissions and save money.

Resources

ENERGY STAR Change A Light program: **www.energystar.gov/changealight**

EPA's Green Power Web site: **www.epa.gov/greenpower**

EPA's Reduce, Reuse, and Recycle Web site: **www.epa.gov/msw/reduce.htm**

EPA's WaterSense Web site: **http://www.epa.gov/watersense/**

EPA's GreenScapes program: **www.epa.gov/epaoswer/non-hw/green/index.htm**

EPA's Climate Change: What You Can Do at Home Web site: **www.epa.gov/climatechange/wycd/home.html**

EPA's Household Emissions Calculator: **www.epa.gov/climatechange/wycd/calculator/ind_calculator.html**

1. Change five lights

Replace your five most frequently used light fixtures or the bulbs in them with ENERGY STAR qualified options and you will help the environment while saving about $60 a year on energy bills. ENERGY STAR qualified lighting provides bright, warm light but uses at least 2/3 less energy than standard lighting, generates 70 percent less heat, and lasts up to 10 times longer.

2. Look for ENERGY STAR qualified products

When buying new products, such as appliances for your home, get the features and performance you want AND help reduce greenhouse gas emissions and air pollution. Look for ENERGY STAR qualified products in more than 50 product categories, including lighting, home electronics, heating and cooling equipment, and appliances.

3. Heat and cool smartly

Simple steps like cleaning air filters regularly, installing adequate insulation, and having your heating and cooling equipment tuned annually by a licensed contractor can save energy and increase comfort at home, and at the same time reduce greenhouse gas emissions.

4. Use green power

Green power is electricity that is generated from renewable energy sources such as wind and the sun that don't contribute to climate change. Consider buying green power or modifying your house to generate your own renewable energy. EPA's Green Power Web site provides information on both options.

5. Reduce, reuse, and recycle

Reduce the amount of waste you generate and water you consume whenever possible. Pursue simple water saving actions such as not letting the water run while shaving or brushing teeth. If there is a recycling program in your community, recycle your newspapers, beverage containers, paper, and other goods. Reducing, reusing, and recycling in your home helps conserve energy and reduces pollution and greenhouse gases from resource extraction, manufacturing, and disposal.

6. Be green in your yard

Composting your food and yard waste reduces the amount of garbage that you send to landfills and reduces greenhouse gas emissions. EPA's GreenScapes program provides tips on how to improve your lawn or garden while also benefiting the environment.

7. Calculate your household's carbon footprint

Use EPA's Personal Greenhouse Gas Emissions Calculator to estimate your household greenhouse gas emissions resulting from energy use, transportation, and waste disposal. This tool helps you understand where your greenhouse gas emissions come from and identify ways to reduce your greenhouse gas emissions.

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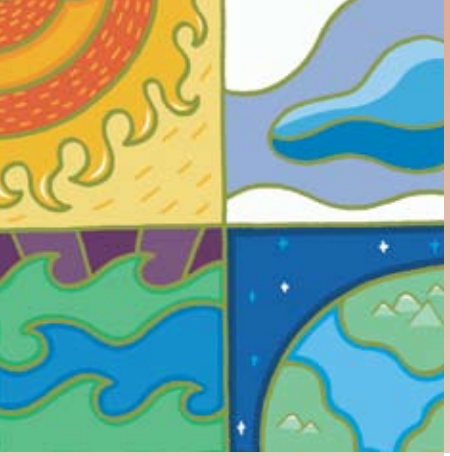

Climate Change & You

WHAT YOU CAN DO *at the office*

Business and home offices use a significant amount of electricity for heating and cooling, lighting, and operating equipment. Here are a number of easy ways to reduce greenhouse gas emissions and help make the air cleaner.

1. Manage office equipment energy use better

Office equipment and electronics use energy even when idle or on stand-by. To save energy and reduce greenhouse gas emissions at work, always activate the power management features on your computer and monitor, unplug laptop power cords when not in use, and turn off equipment and lights at the end of the day. Consider using a power strip that can be turned off when you're done using your computers, printers, wireless routers, and other electronics.

2. Look for ENERGY STAR qualified products for the office

When buying new products for your office at work or at home, get the features and performance you want and help reduce emissions of greenhouse gases and air pollutants. Look for ENERGY STAR qualified office equipment, such as computers, copiers, and printers, in addition to more than 50 product categories, including lighting, heating and cooling equipment, and commercial appliances.

3. Ask your office building manager if your office building has earned the ENERGY STAR

ENERGY STAR-labeled buildings provide safe, healthy, and productive environments that use about 35 percent less energy than average buildings. Their efficient use of energy also reduces the total operational cost of the building.

4. Use less energy for your commute

Switch to public transportation, carpooling, biking, telecommuting, and other innovative ways to save energy and reduce greenhouse gas emissions on your way to and from work. Encourage your employer to offer commuter benefits that address limited or expensive parking, reduce traffic congestion, improve employee recruiting and retention, and minimize the environmental impacts associated with drive-alone commuting. If you do drive, find out the fuel efficiency of your vehicle using EPA's and DOE's Fuel Economy Web site, and make more environmentally informed choices when purchasing your next vehicle by using EPA's Green Vehicle Guide.

5. Reduce, reuse, and recycle

Recycle office paper, newspapers, beverage containers, electronic equipment, and batteries. Reducing, reusing, and recycling in your office helps conserve energy, and reduces pollution and greenhouse gas emissions.
You can reduce, reuse, and recycle at the office by using two-sided printing and copying, buying supplies made with recycled content, and recycling used printer cartridges. For your old electronics, investigate leasing programs to ensure reuse and recycling or donate used equipment to schools or other organizations.

Resources

ENERGY STAR:
www.energystar.gov

Federal Fuel Economy Guide:
www.fueleconomy.gov

EPA's Green Vehicle Guide:
www.epa.gov/greenvehicles

EPA's Reduce, Reuse, and Recycle Web site: **www.epa.gov/msw/reduce.htm**

EPA's Electronics Recycling Web site: **www.epa.gov/eCycling**

ENERGY STAR Buildings Web site: **www.energystar.gov/buildings**

EPA's Climate Change: What You Can Do at the Office Web site:
www.epa.gov/climatechange/wycd/office.html

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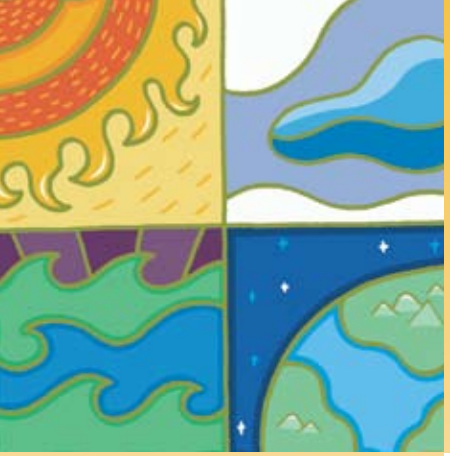

Climate Change & You

WHAT YOU CAN DO *at school*

Students, educators, and school administrators can all play a key role in reducing greenhouse gas emissions.

Resources

EPA's Climate CHECK Tool: **www.epa.gov/climatechange/wycd/downloads/ClimateCHECK_1.0.zip**

EPA's Global Warming Wheel Card Kit: **www.epa.gov/climatechange/downloads/ActivityKit.pdf**

ENERGY STAR for K-12 School Districts: **www.energystar.gov/index.cfm?c=k12_schools.bus_schoolsk12**

EPA's Reduce, Reuse, and Recycle Web site: **www.epa.gov/msw/reduce.htm**

EPA's Climate Change: What You Can Do at School Web site: **www.epa.gov/climatechange/wycd/school.html**

EPA's Climate Change Kid's Web site: **www.epa.gov/climatechange/kids/**

1. Power down your classroom

Remember to turn off computers, lights, and other devices that use energy when no one is in the classroom. Turning off just one 60-watt incandescent bulb that would otherwise burn eight hours a day can save about 1,000 pounds of carbon dioxide over the lifetime of the bulb.

2. Learn about climate change science, impacts, and solutions

Explore the many resources available to learn about climate change. Investigate what other schools and organizations are doing to educate their audiences on climate change. EPA's Climate Change Web site provides educational resources on the What You Can Do at School page.

3. Calculate your school's carbon footprint

Use EPA's Climate Change Emission Calculator Kit (Climate CHECK) (for high schools) or EPA's Global Warming Wheel Card Kit (for middle schools) to investigate the link between everyday actions at your school, greenhouse gas emissions, and climate change. These interactive tools help students learn about climate change and how to address it.

4. Ask your school administrators if your school has earned the ENERGY STAR

The least efficient schools use three times more energy than the best energy performers. By partnering with ENERGY STAR for K-12 program, school districts can serve as environmental leaders in their community, become energy efficient, reduce greenhouse gas emissions, and save 30 percent or more on energy bills.

5. Reduce, reuse, and recycle

Recycle school or classroom paper, newspapers, beverage containers, electronic equipment, and batteries. Reducing, reusing, and recycling at school and in the classroom helps conserve energy, minimize pollution, and reduce greenhouse gases. You can reduce, reuse, and recycle at school or in the classroom by using two-sided printing and copying, buying supplies made with recycled content, and recycling used electronics and printer cartridges.

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Name _____ Date _____

Heat-Trapping Gases

Find out what happens when light and heat hit different gases in the atmosphere. Record what happens when each gas is tested in the computer simulation. Heat-trapping gases mainly *transmit* light and *absorb* heat.

Place a check in the left-hand box of the table if any gas you test turns out to be a heat-trapping gas.

Heat-trapping gas (✓)	Gas		What happens? (circle one)		
	CH_4 (methane)	***Light*:**	transmit	reflect	absorb
		***Heat*:**	transmit	reflect	absorb
	CO_2 (carbon dioxide)	***Light*:**	transmit	reflect	absorb
		***Heat*:**	transmit	reflect	absorb
	H_2O (water vapor)	***Light*:**	transmit	reflect	absorb
		***Heat*:**	transmit	reflect	absorb
	N_2 (nitrogen)	***Light*:**	transmit	reflect	absorb
		***Heat*:**	transmit	reflect	absorb
	O_2 (oxygen)	***Light*:**	transmit	reflect	absorb
		***Heat*:**	transmit	reflect	absorb

Name _____ Date _____

Test an Atmosphere

1. Create an atmosphere

By choosing a combination of gases, you and your partner can create an "atmosphere" to test. Select from one to five of the gases listed below by placing a check in the box next to the gas's name. For each gas you choose, select the number of molecules you'd like to test, for a total of 10 molecules.

Select (✓)	Gas	Number of molecules
	CH_4 (methane)	
	CO_2 (carbon dioxide)	
	H_2O (water vapor)	
	N_2 (nitrogen)	
	O_2 (oxygen)	
		Total = 10

2. Predict

When heat photons go into your atmosphere, do you predict your atmosphere will *transmit*, *reflect*, or *absorb* most of the heat? Explain why you predict that.

_____

_____

_____

_____