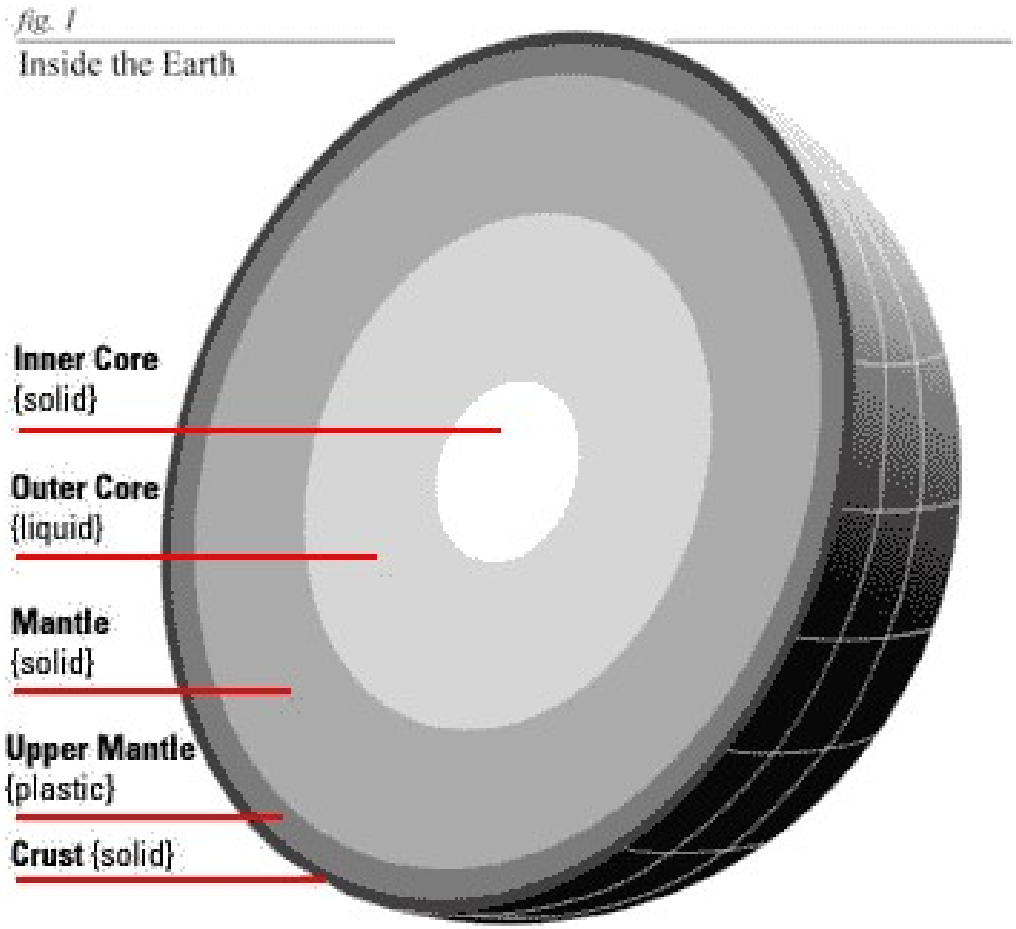
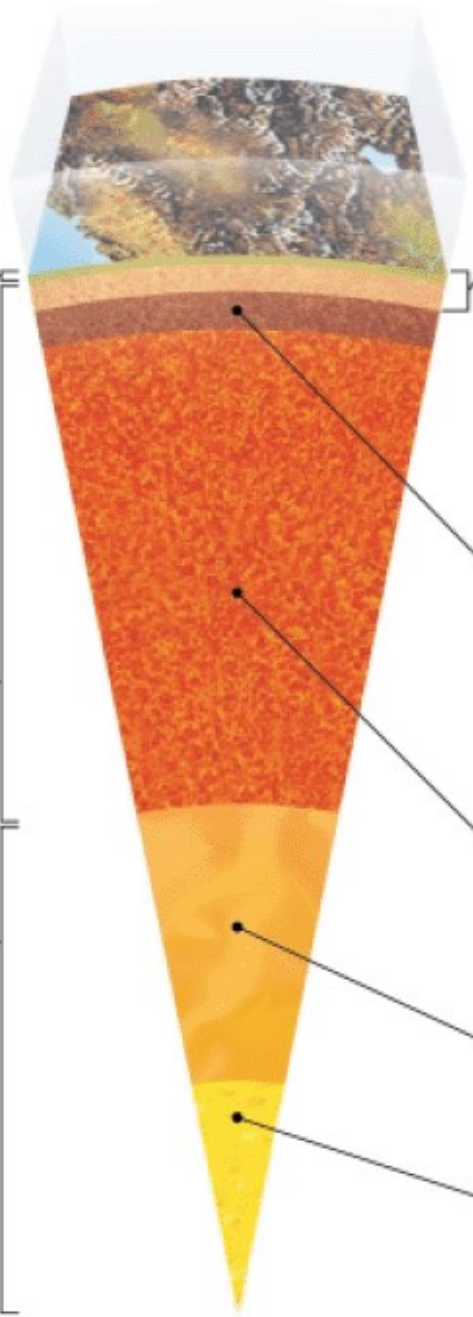
Our Dynamic Earth

Geosphere

- The <u>solid</u> part of Earth
- Layers:
  - Crust
  - Mantle
  - Core





Crust 5–70 km thick; the solid, brittle, outermost layer of the Earth; continental crust is thick and made of lightweight materials, whereas oceanic crust is thin and made of denser materials

Mantle 2,900 km thick; the layer of the Earth between the crust and the core; made of dense, iron-rich minerals

Core 3,428 km radius; a sphere of hot, dense nickel and iron at the center of the Earth

Lithosphere 15–300 km thick; the cool, rigid, outermost layer of the Earth; consists of the crust and the rigid, uppermost part of the mantle; divided into huge pieces called tectonic plates, which move around on top of the asthenosphere and can have both continental and oceanic crust

Asthenosphere 250 km thick; the solid, plastic layer of the mantle between the mesosphere and the lithosphere; made of mantle rock that flows very slowly, which allows tectonic plates to move on top of it

Mesosphere 2,550 km thick; the "middle sphere"; the lower layer of the mantle between the asthenosphere and the outer core

Outer Core 2,200 km thick; the outer shell of Earth's core; made of liquid nickel and iron

Inner Core 1,228 km radius; a sphere of solid nickel and iron at the center of the Earth

Earth's Interior

- The Crust
  - Only 1% of the entire Earth's mass
  - Made of lowest density rocks
- The Mantle
  - About 64% of the mass of Earth
  - Contains rocks of medium density
  - Has 3 sub layers
- The Core
  - About 35% of Earth's mass
  - Two sub layers
  - Contains highest density materials

The Mantle

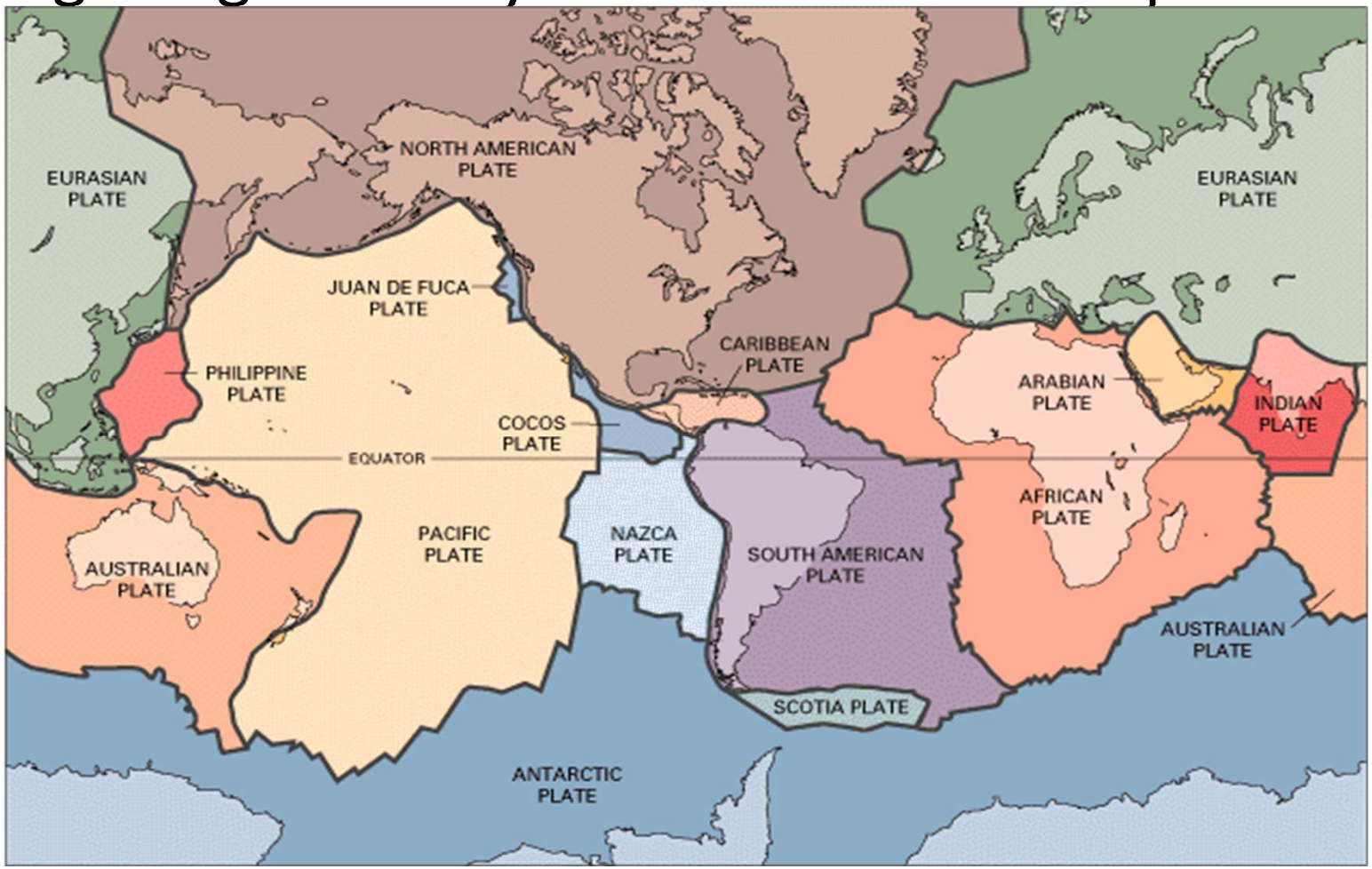
- Sub layers
  - Lithosphere
    - Earth's crust and the rigid, uppermost part of the mantle
    - Movement in the lithosphere causes earthquakes, volcanoes, and mountains
  - Asthenosphere
    - Mostly solid mantle rock that moves very slowly
    - Causes movement in the lithosphere
  - Mesosphere
    - "Middle sphere", between the asthenosphere and the core

The Core

- Sub layers
  - Outer core
    - dense liquid layer (nickel and iron)
    - 7200 - 9032 °F (4000-5000°C)
  - Inner Core
    - Spinning, which creates the Earth's magnetic poles
    - Immense pressure
    - The most dense layer
    - Solid nickel and iron
    - 9032 – 10,832 °F (5000-6000 °C)

Tectonic Plates

- Large pieces of lithosphere
- "Float" on the asthenosphere
- Most geologic activity occurs where these plates meet



Volcanoes

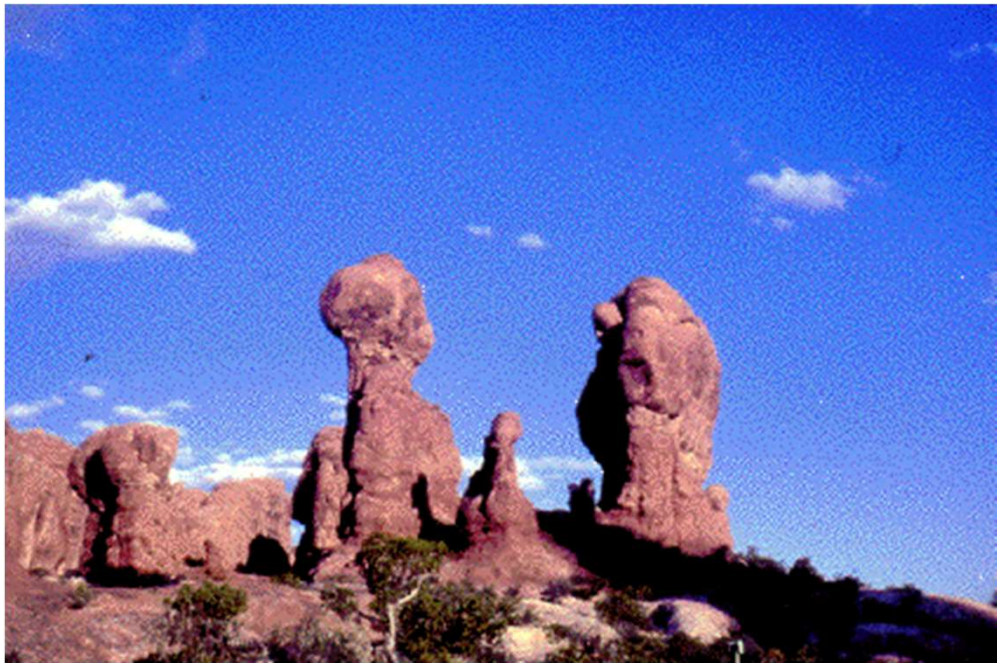
- Mountains built by magma (melted rock)
- As tectonic plates slide across each other, allows magma from below to be released
- Can cause local effects – damage to towns and farmland by magma, mudslides, hot ash and dust
- Can cause global effects – clouds of gas and ash enter the atmosphere and reduce the amount of sunlight that hits the Earth, cooling the average global temperature

Sad, but true…

- The biggest volcanic eruption occurred in 1815 on Indonesian Island of Tambora.
- 10,000 people died from the eruption
- 82,000 more people died from disease and starvation afterwards!

Weathering

- The breakdown of rocks by weather and water

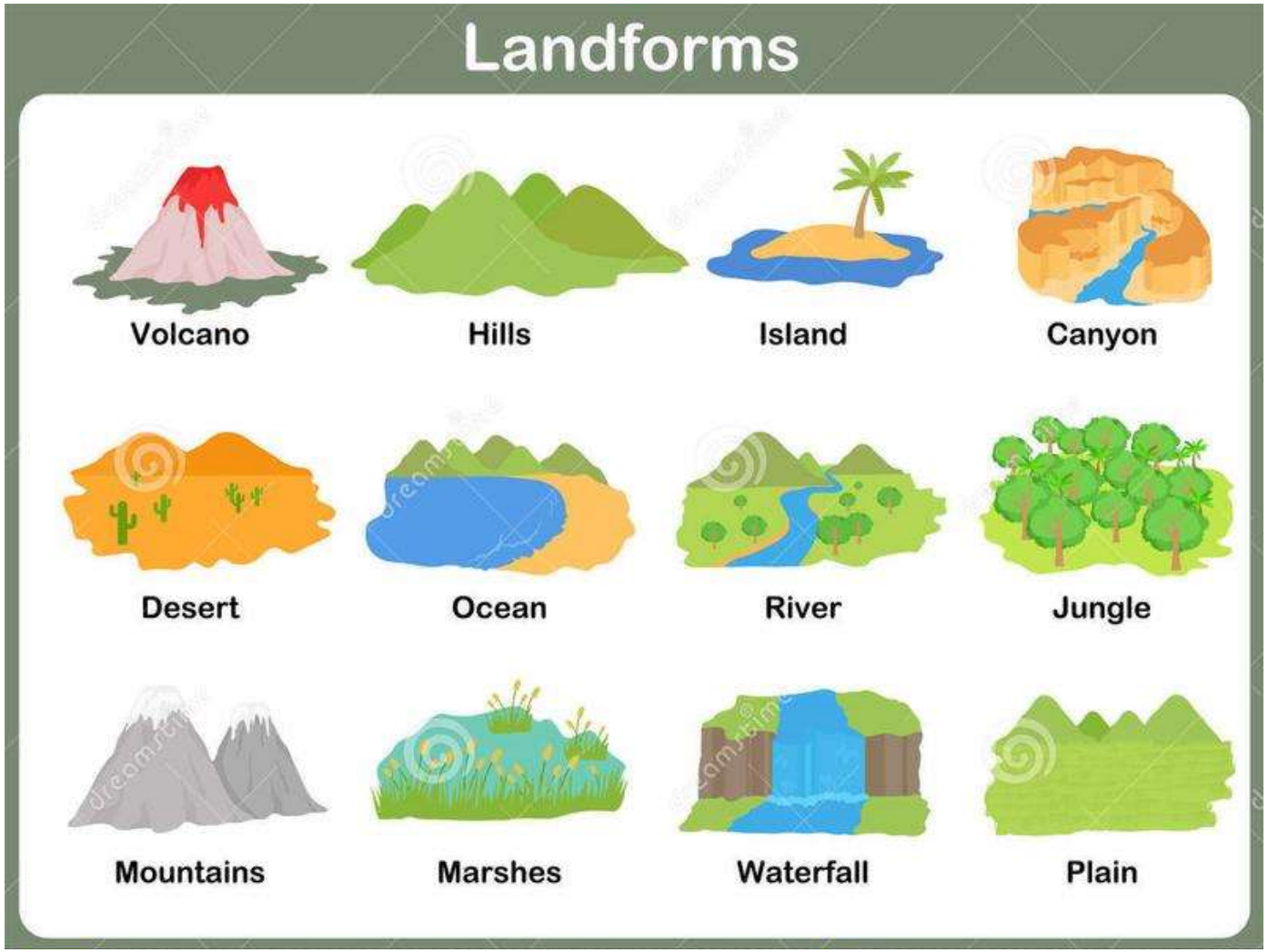


Erosion

- Process of carrying off the broken-down material from weathering
  - Erosion from rivers and oceans are constantly shaping the land
  - Wind erosion can blow away top soil reducing plant growth

Earth's Land Formations

- All formed from the effects of tectonic plate movement, weathering, and erosion!



Review Questions

1. What are the four layers of Earth?

   _____

   _____

2. Which layer of Earth is the thickest?

   _____

3. Where does most of the geologic activity on Earth occur?

   _____

4. What creates all of Earth's landforms?

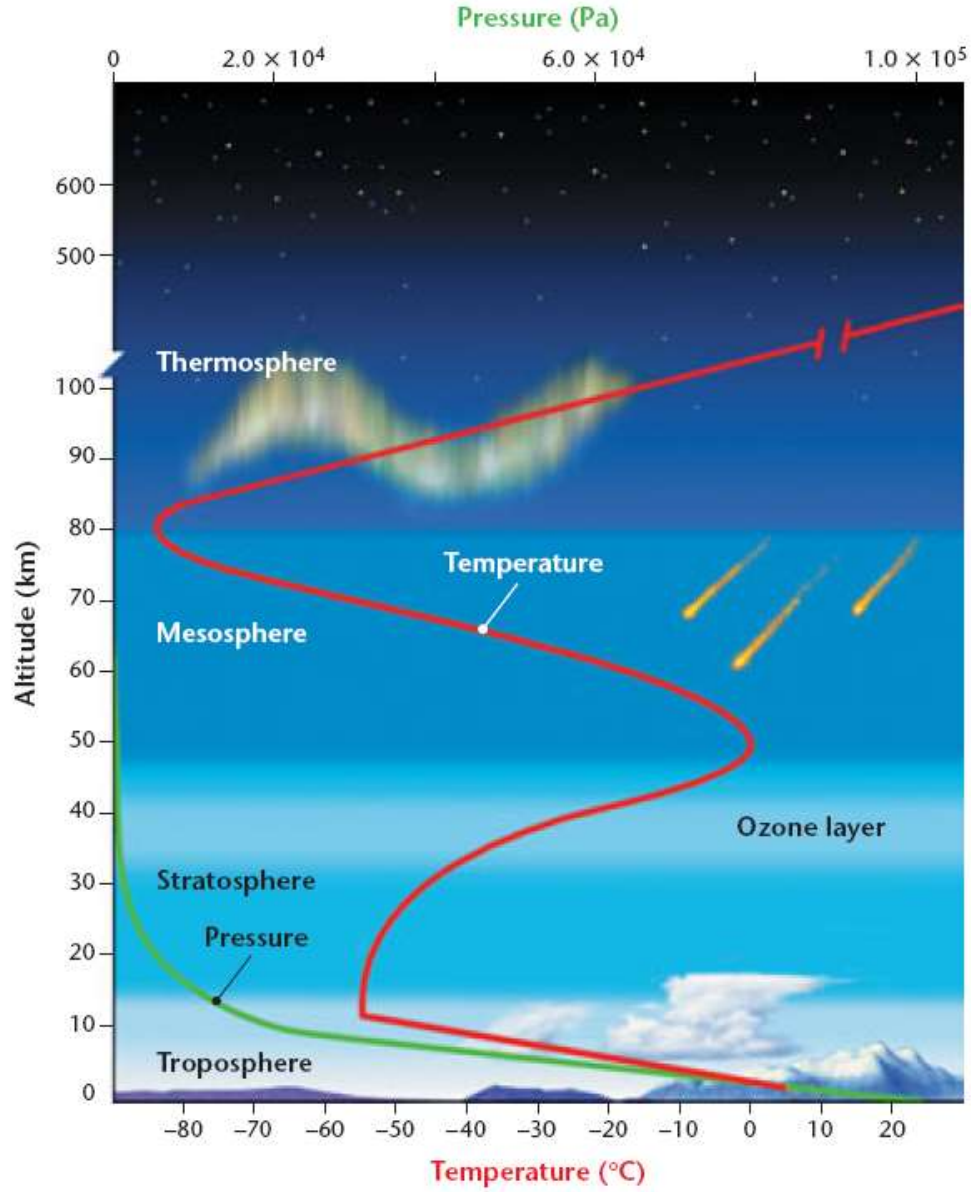
   _____

Atmosphere

- Layer of air that surrounds earth
- Made of:
  - 78% Nitrogen
  - 21% Oxygen
  - 1% Water vapor, dust particles, other small particles
  - .04% Carbon Dioxide
- Energy from the sun
  - Travels through the atmosphere in waves
  - Only a small portion is in the visible light spectrum

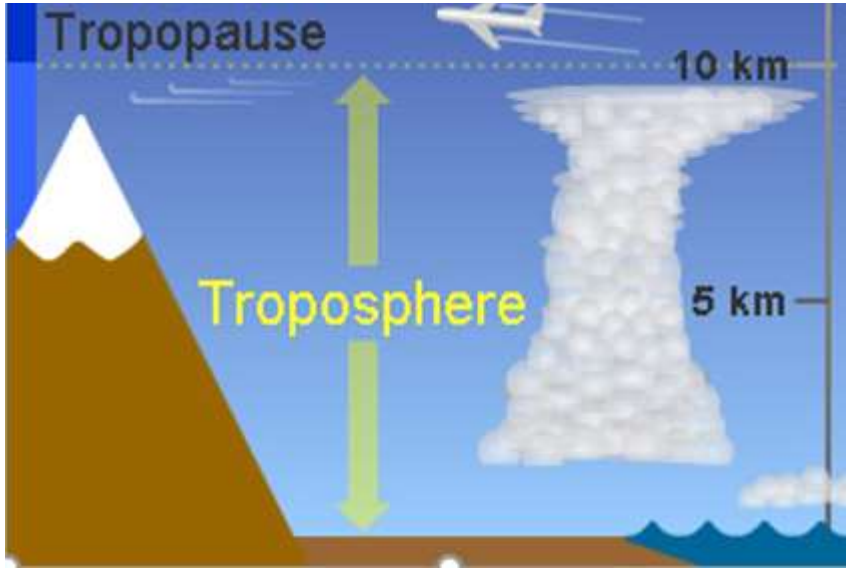
4 Layers of the Atmosphere

- Troposphere
- Stratosphere
- Mesosphere
- Thermosphere



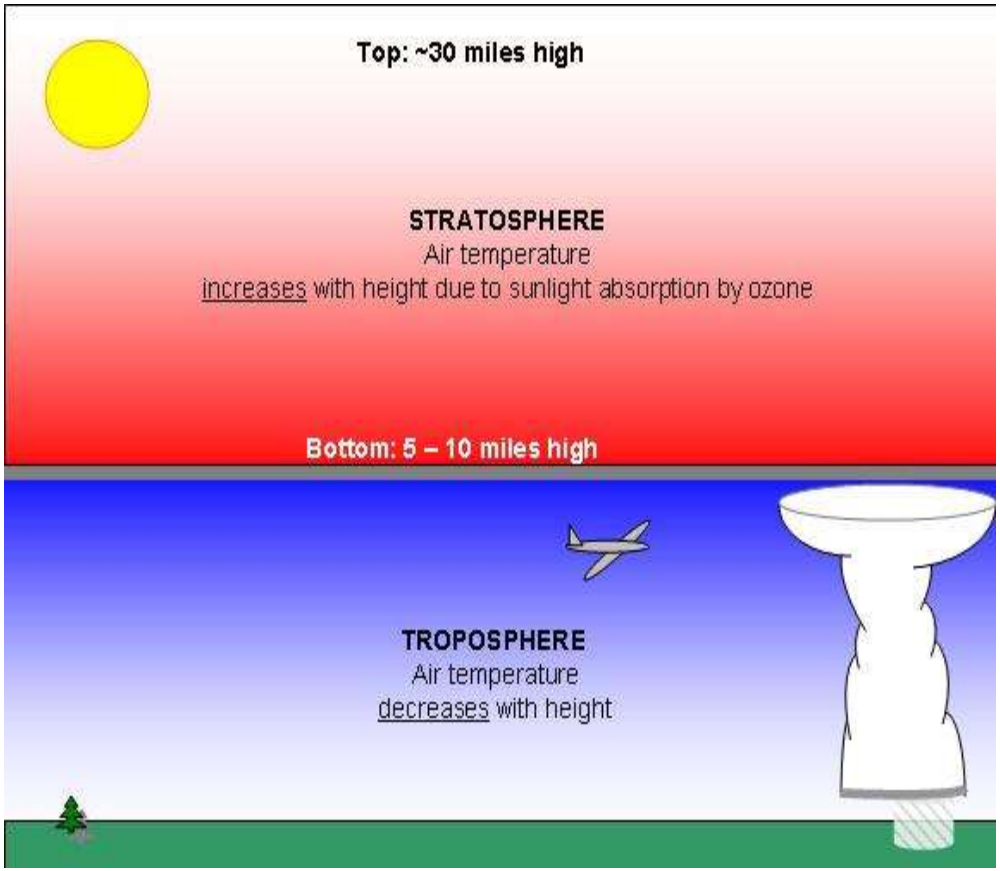
Troposphere

- Layer of the atmosphere that touches the surface of Earth.
- Virtually all human activities occur here.
- Closest to Earth's surface
- Densest layer
- The majority of our weather occurs here.



Stratosphere

- Above the troposphere
- 10- 30 miles high
- Contains 90% of the ozone layer
- Most commercial airline traffic occurs in the lower part of the stratosphere.



Mesosphere

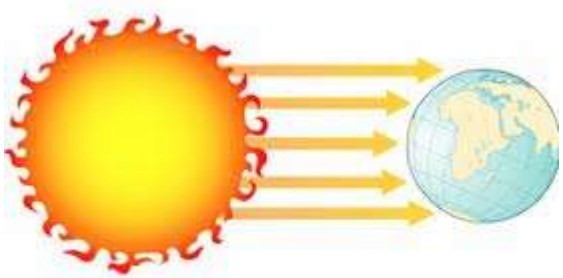
- 30 – 50 miles high
- Coldest layer: -100°C (-148°F)

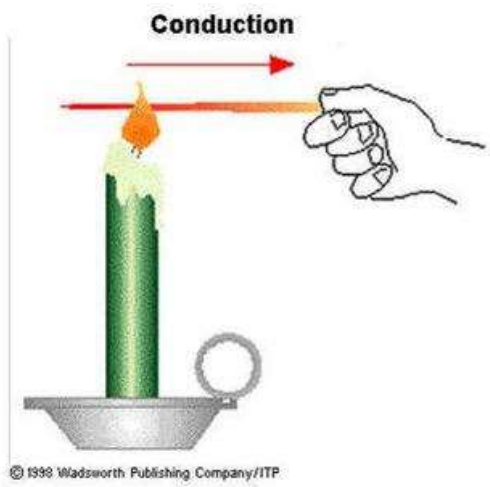
Thermosphere

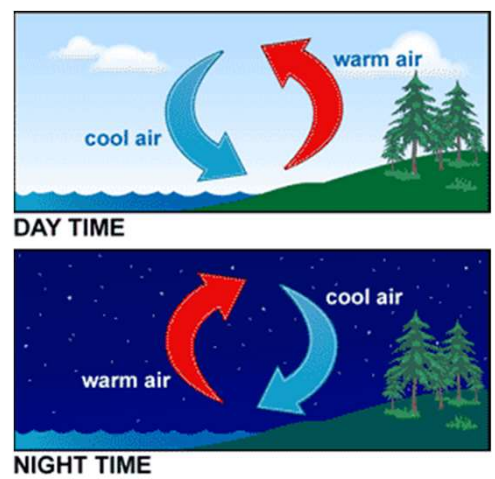
- Also known as the ionosphere.
- Highest layer
- 2000°C (3632°F)
- Ions reunite with electrons and produce light.
  - This happens near the poles.
  - North Pole – Aurora Borealis
  - South Pole – Aurora Australis

Atmospheric Energy Transfer

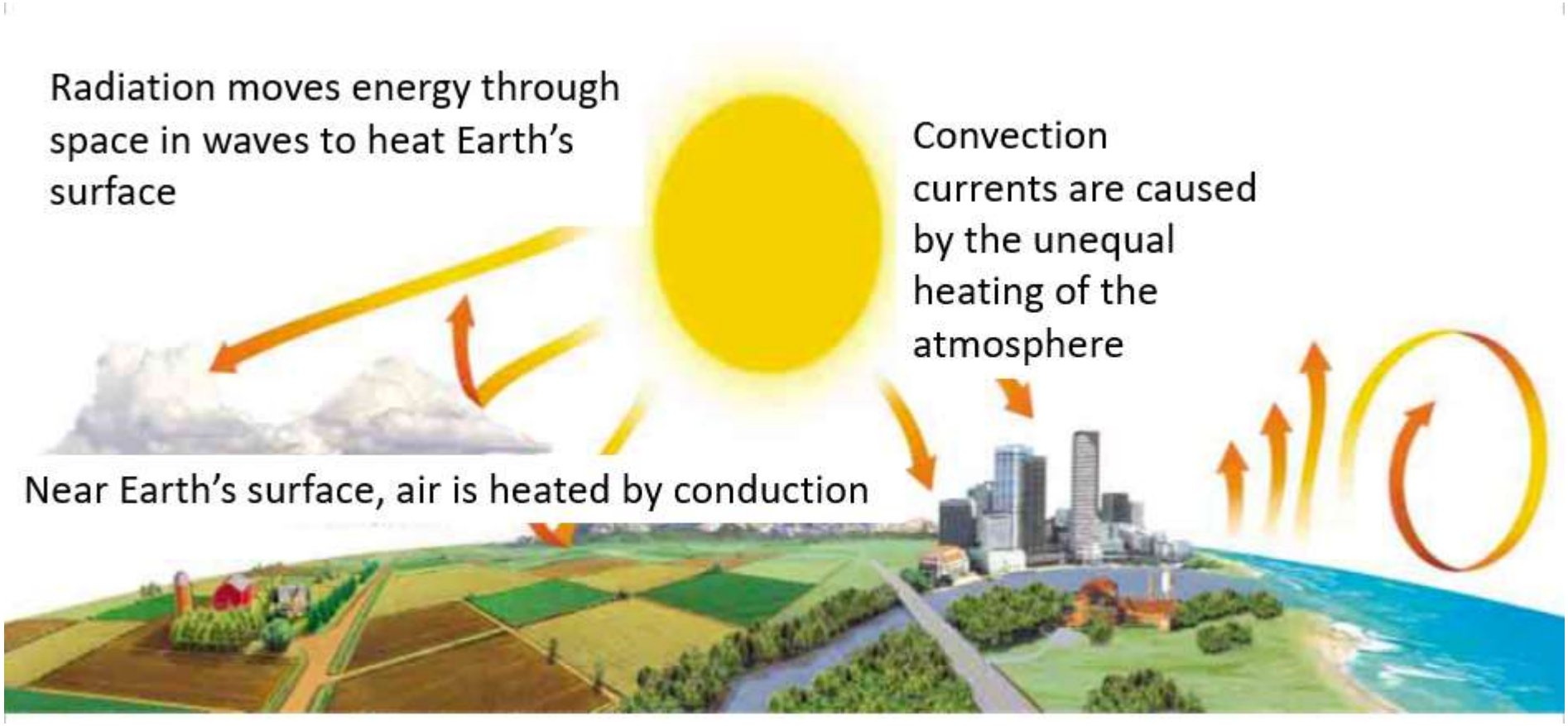
- Radiation
  - The transfer of energy across space
- Conduction
  - The flow of heat from a warmer object to a colder object in direct physical contact
- Convection
  - The transfer of heat by currents (hot air rises and cold air sinks)







Atmospheric Energy Transfer



Review Questions

5. Which layer of the atmosphere is closest to Earth?

   _____

6. Why is the thermosphere called the ionosphere?

   _____

7. What are the three types of energy transfer?

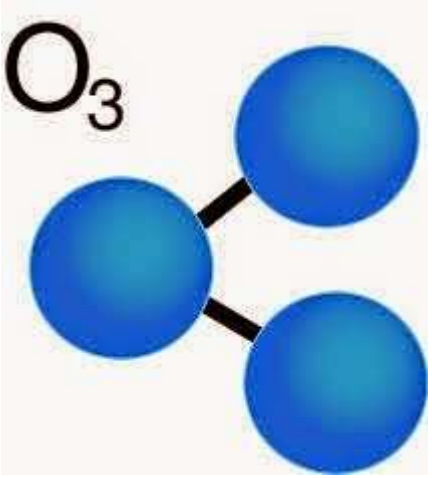
   _____

8. Which layer contains most of the ozone layer?

   _____

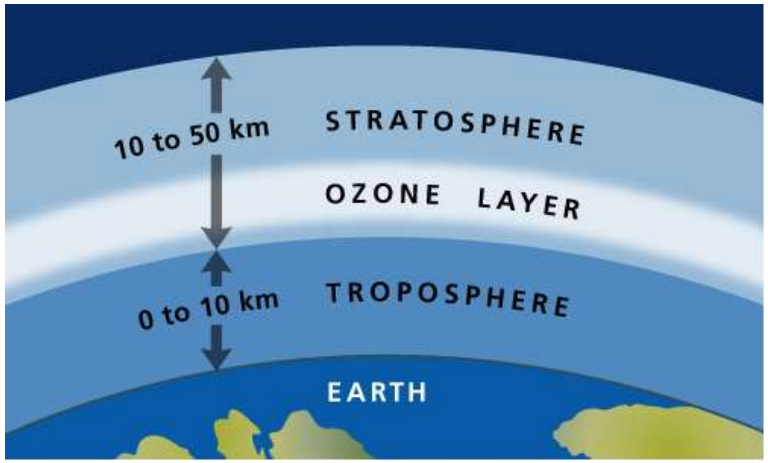
Ozone

- Ozone has 3 oxygen atoms - O_3
- If ozone is found in the stratosphere, it forms a beneficial and protective layer.
- If ozone is found near Earth's surface in the troposphere, it is a pollutant.
- A good way to remember the difference:
  - "Good up high, bad nearby".



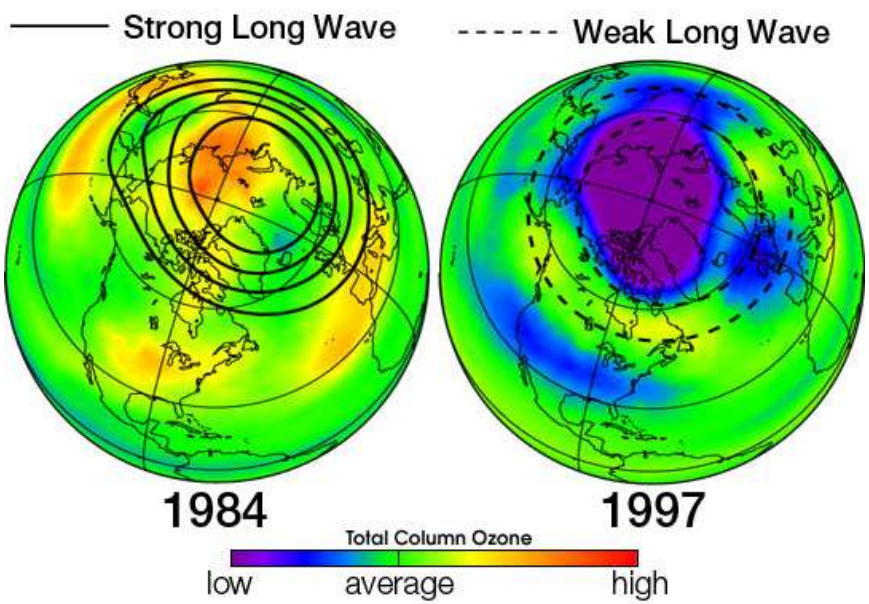
Ozone Layer

- Located in the stratosphere
- Filters out UV radiation from sun
- Without the ozone layer, there would be no UV filtering which would kill most of life on earth!
- The reduction of ozone layer causes an increase of UV radiation at ground level.
  - An excess of UV rays has been linked to skin burns, skin cancer, cataracts, and harm to some crops and marine organisms.



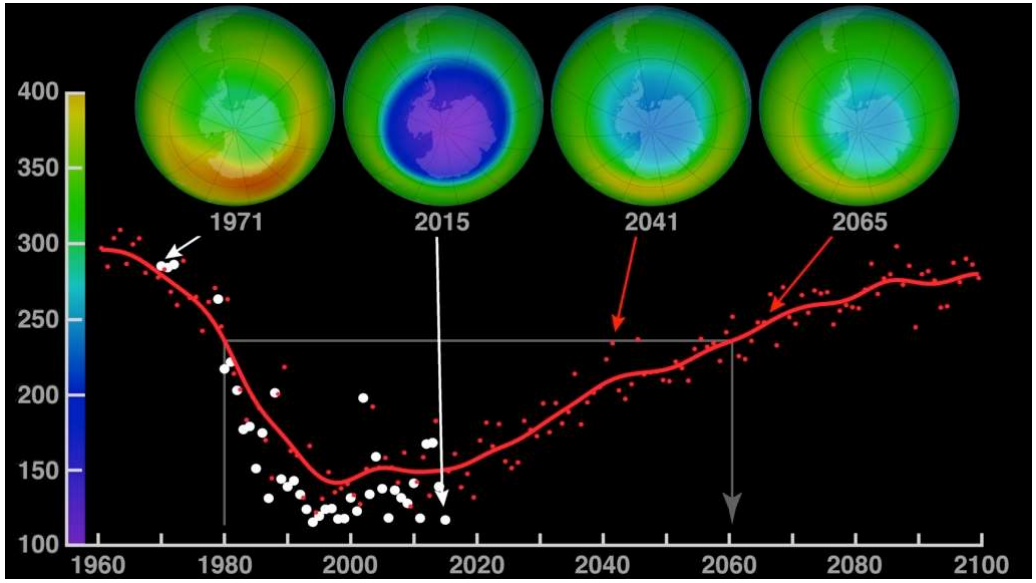
Ozone Layer Depletion

- The ozone layer naturally thins and thickens throughout the year, especially over the poles.
- In the late 1970s, scientists discovered that the ozone layer was thinning far more drastically than noted previously.
- Believing that ozone depletion was mainly due to excessive human usage of chemicals such as chlorofluorocarbons (CFCs), scientists began examining ways to slow or reverse the depletion.



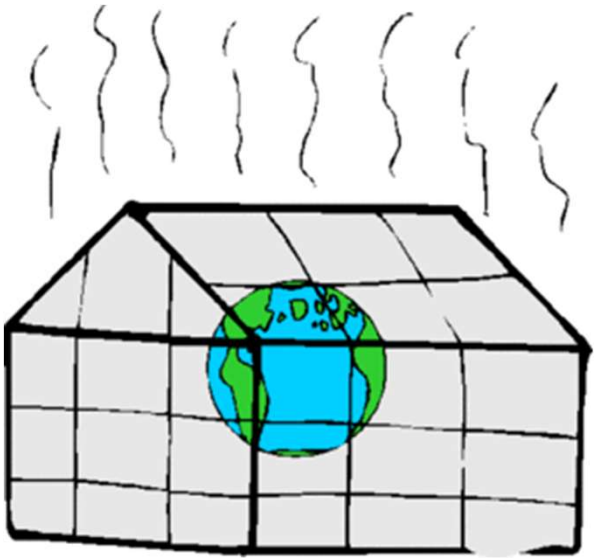
Montreal Protocol

- The **Montreal Protocol on Substances That Deplete the Ozone Layer** is an international treaty designed to protect the ozone layer by phasing out many substances believed to be responsible for ozone depletion.
- The treaty was opened for signature on September 16, 1987 and entered into force on January 1, 1989
- The Montreal Protocol has been effective and the ozone hole is diminishing.



Greenhouse Effect

- Gasses in the atmosphere function like a greenhouse by trapping heat from the sun.
  - Greenhouse gasses (GHG) include:
    - Water Vapor – H_2O
    - Carbon Dioxide – CO_2
    - Methane – CH_4
    - Nitrous Oxide – N_2O
    - Ozone – O_3



- The concentration, ability to absorb radiation, and the amount of time spent in the atmosphere varies with each gas.

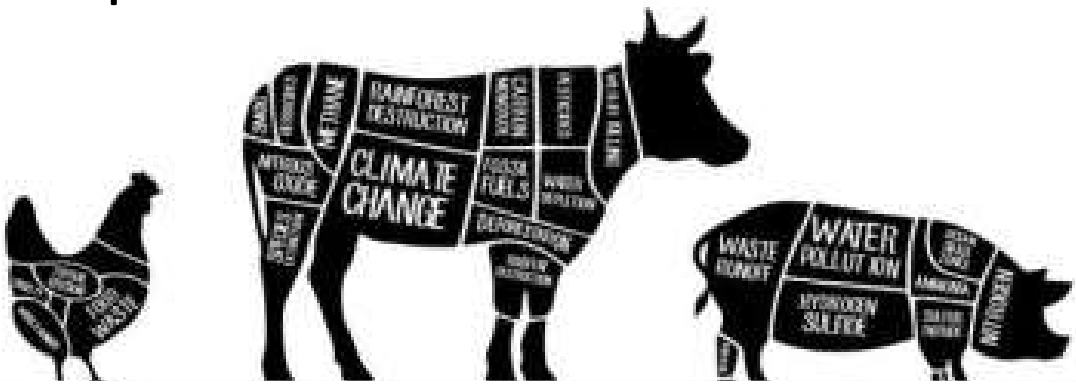
Greenhouse Effect

- Natural sources of greenhouse gasses (GHG) include:
  - Volcanism
  - Cellular Respiration
  - Denitrification
  - Evaporation

- Anthropogenic (human-caused) sources of GHG include:
  - Fossil Fuel Combustion
  - Agriculture
  - Deforestation
  - Landfills
  - Industrial Chemicals

Greenhouse Effect

- In the United States:
  - Burning fossil fuels for transportation and to generate electricity produces most of our carbon dioxide emissions.
  - Agriculture (cow flatulence- really!) and natural gas exploration produces most of our methane emissions.



- Some CO_2 and CH_4 in the atmosphere is necessary for life (photosynthesis, heating), but too much of these gasses causes the atmosphere to heat up too much.

Review Questions

9. Why is the ozone layer beneficial?

_____

10. Was the Montreal Protocol successful?

_____

11. What is the greenhouse effect?

_____

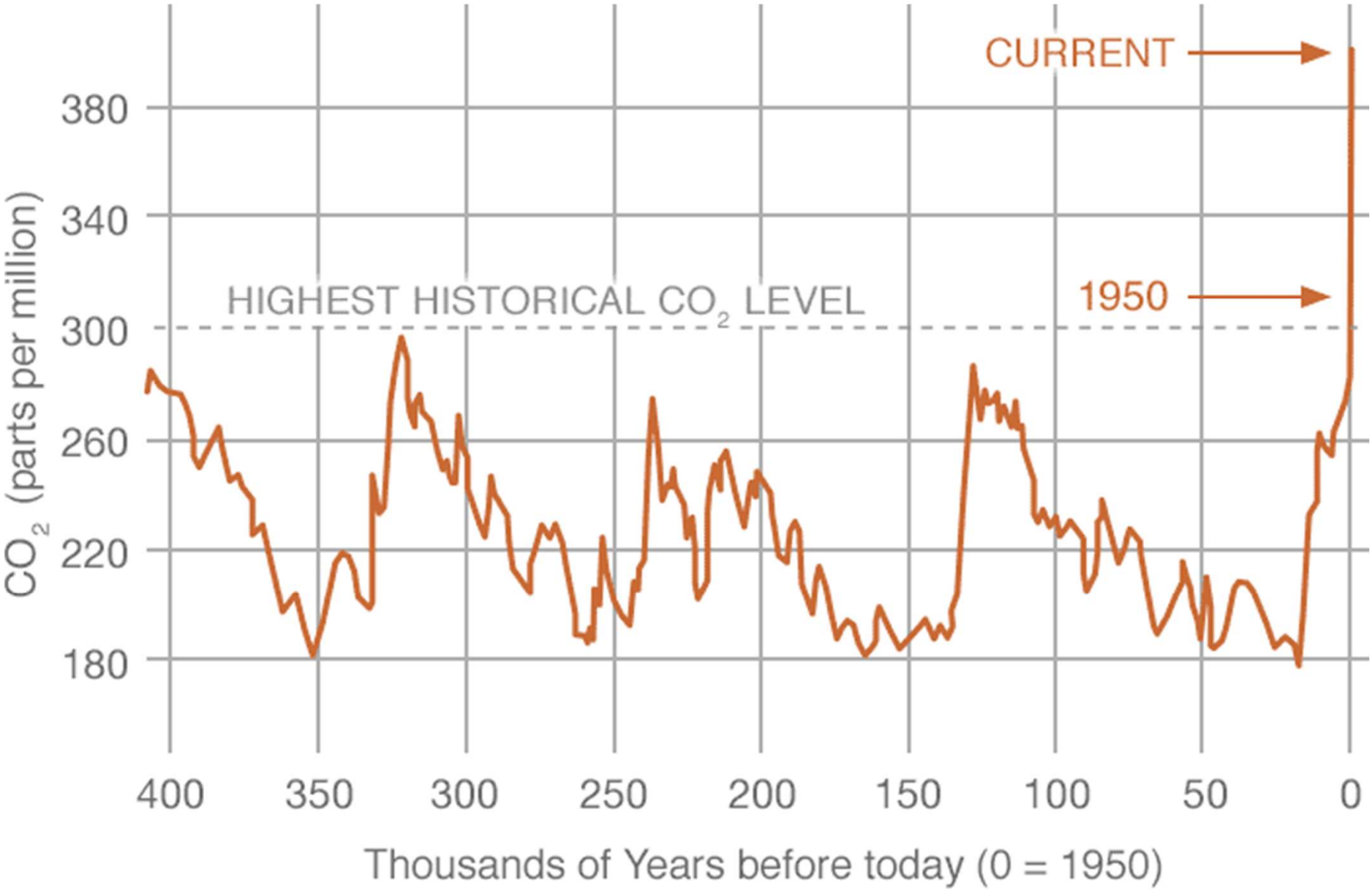
12. What are some natural sources of GHG?

_____

13. What are some anthropogenic sources of GHG?

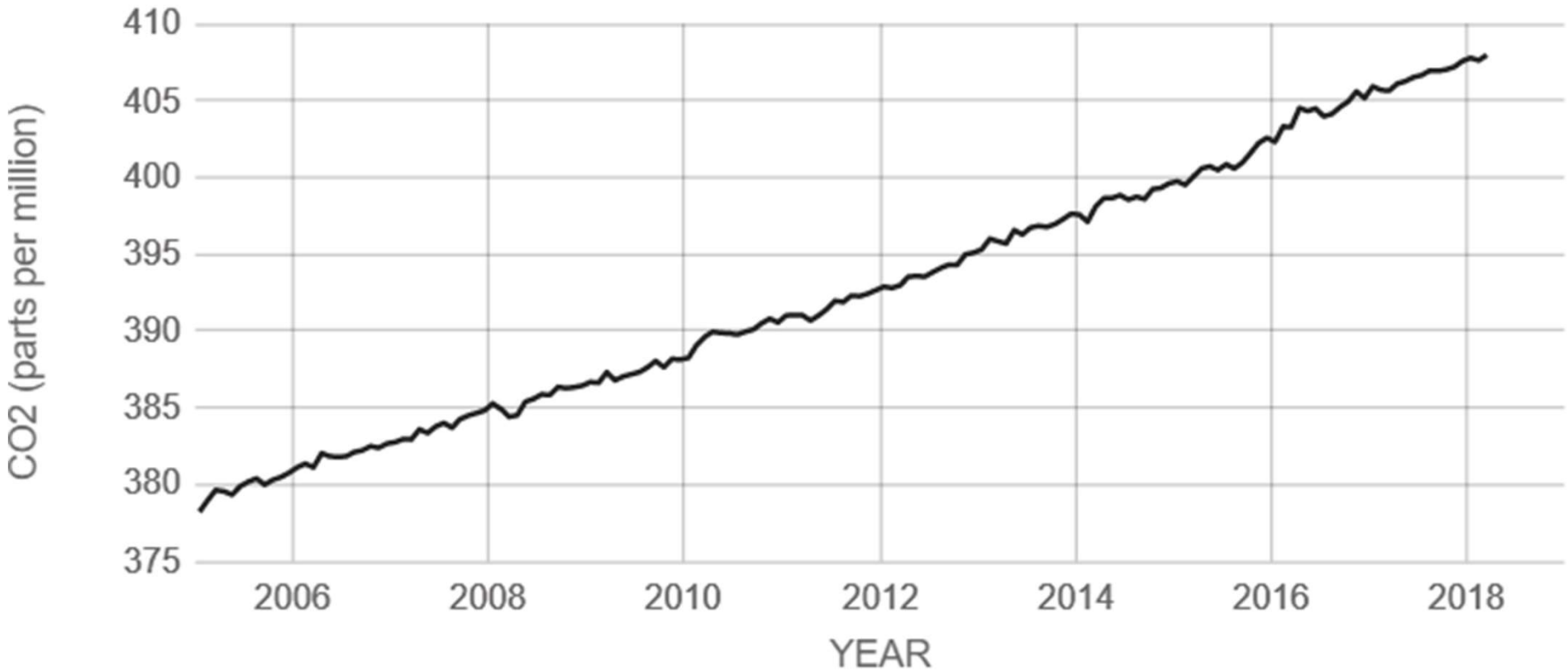
_____

Atmospheric CO_2 Levels – taken from ice core data



Source: climate.nasa.gov

Atmospheric CO_2 Levels – Direct Measurements



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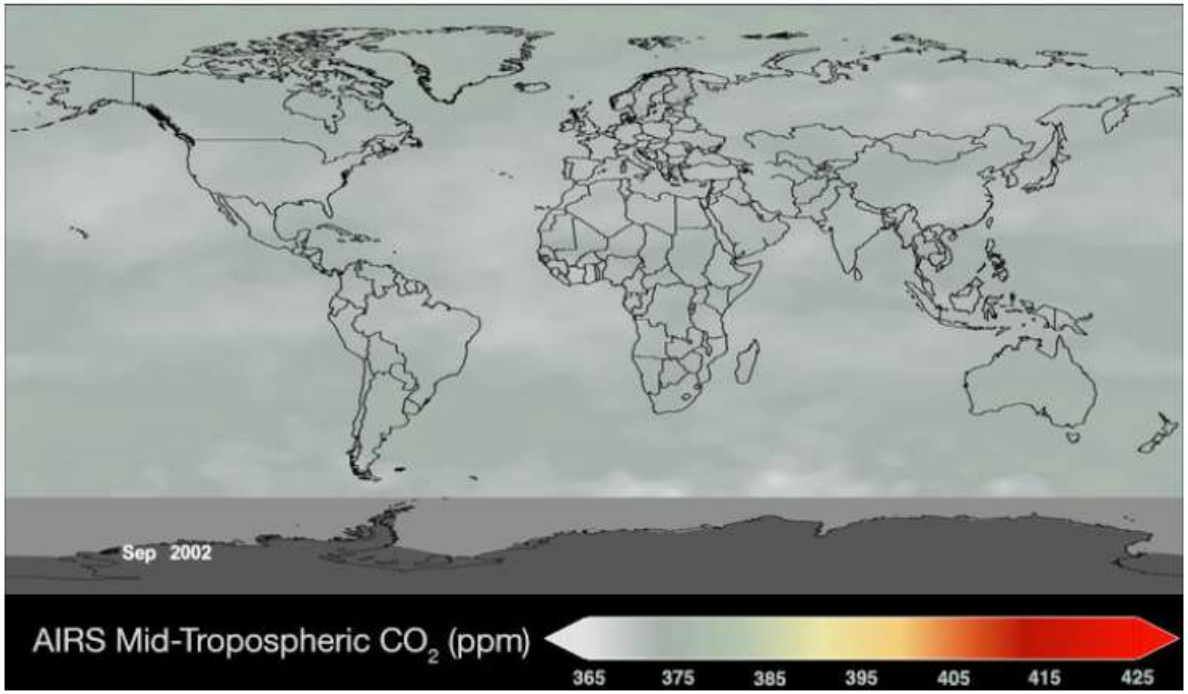
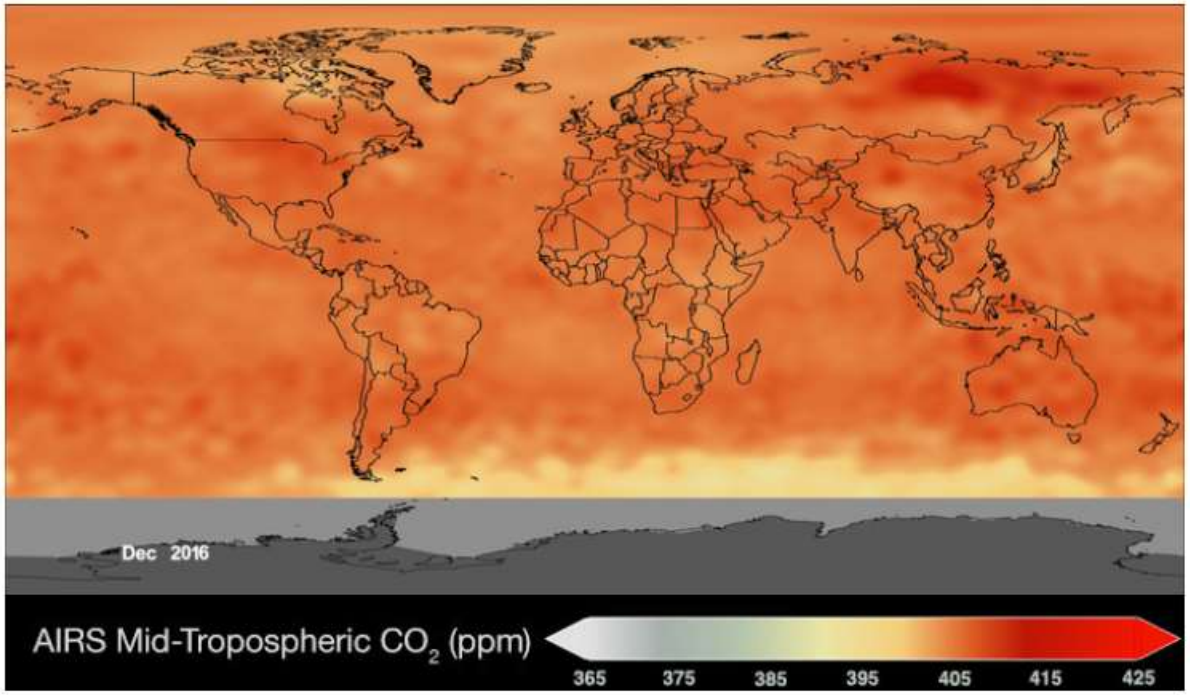


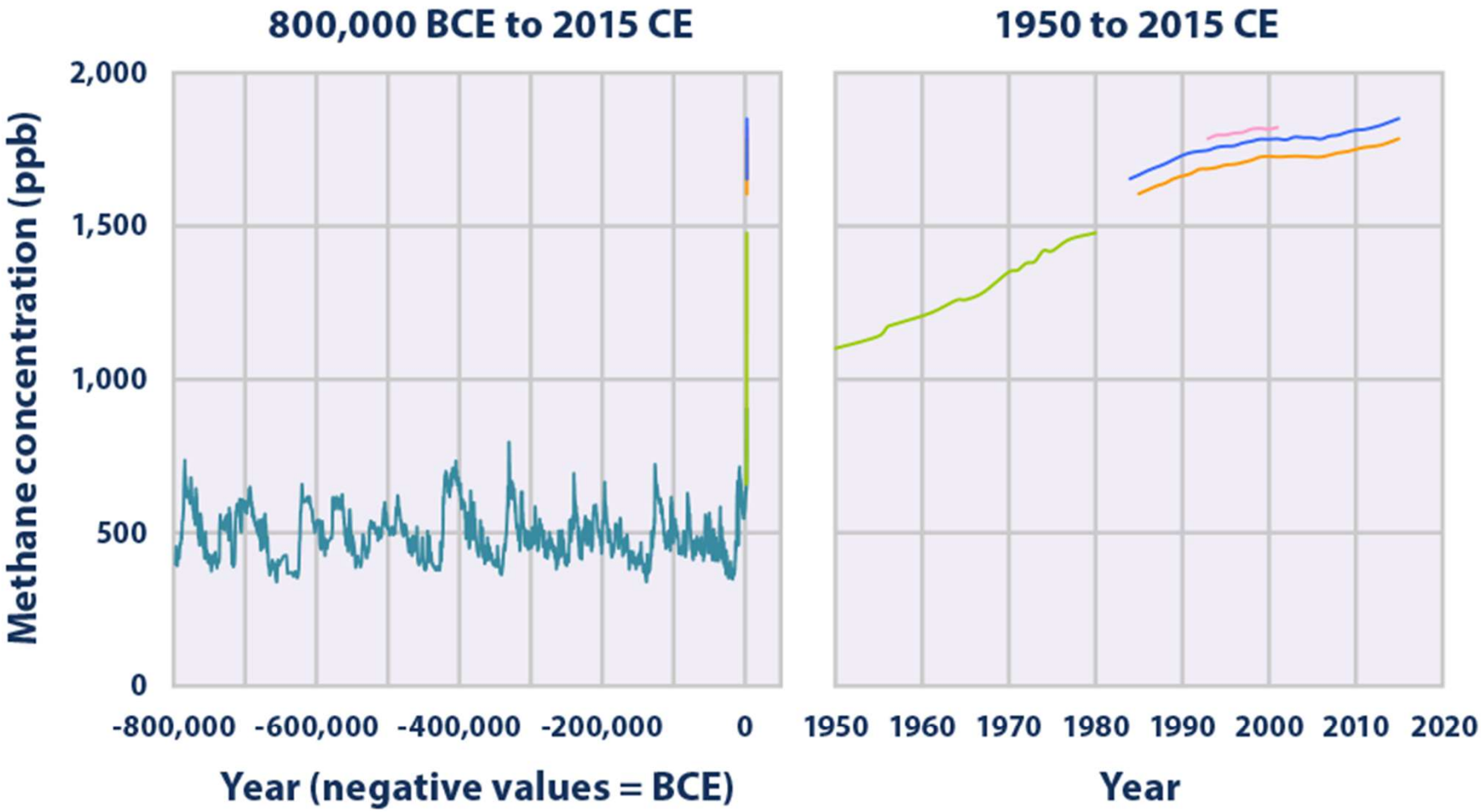
Atmospheric CO_2 levels in 2002…

Compared to 2016



Source: climate.nasa.gov

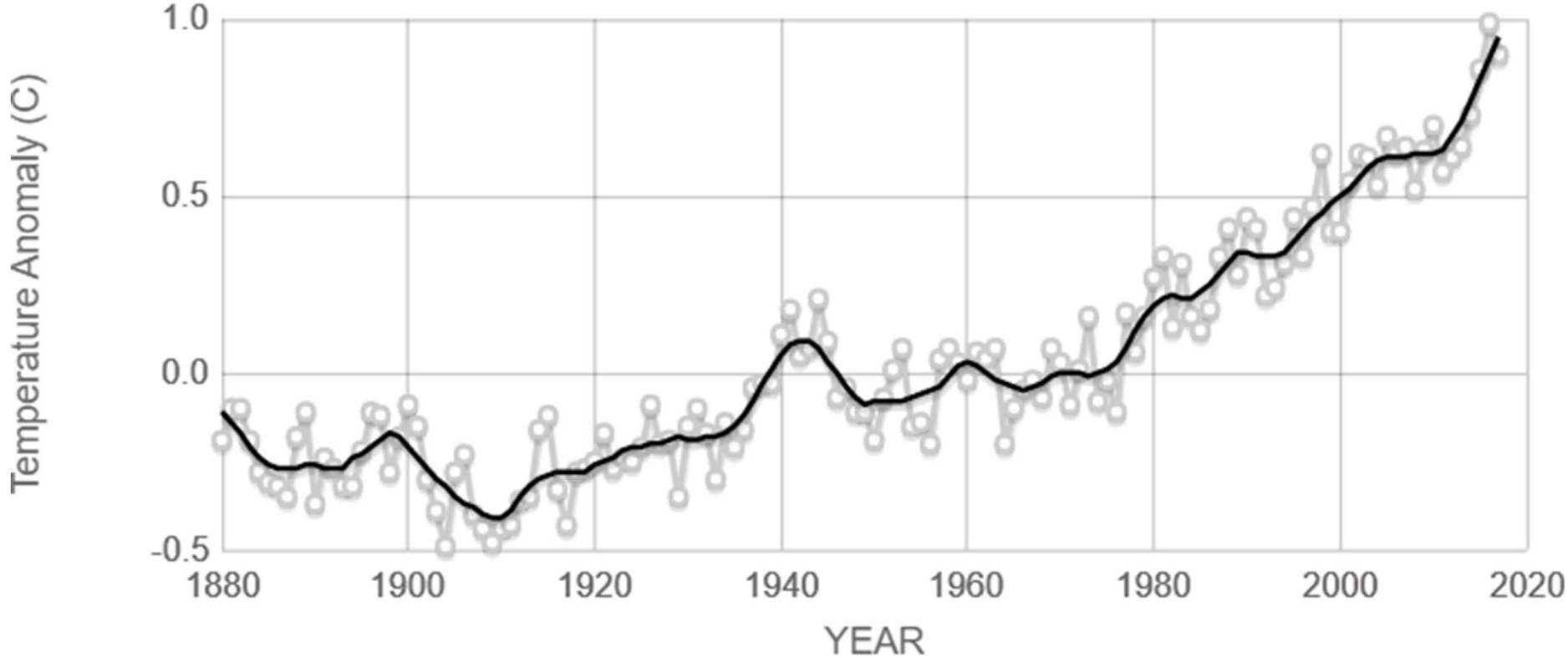
Global Atmospheric Concentrations of Methane Over Time



Data source: Compilation of five underlying datasets. See www.epa.gov/climate-indicators for specific information.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-indicators.

Average Yearly Temperature Variation

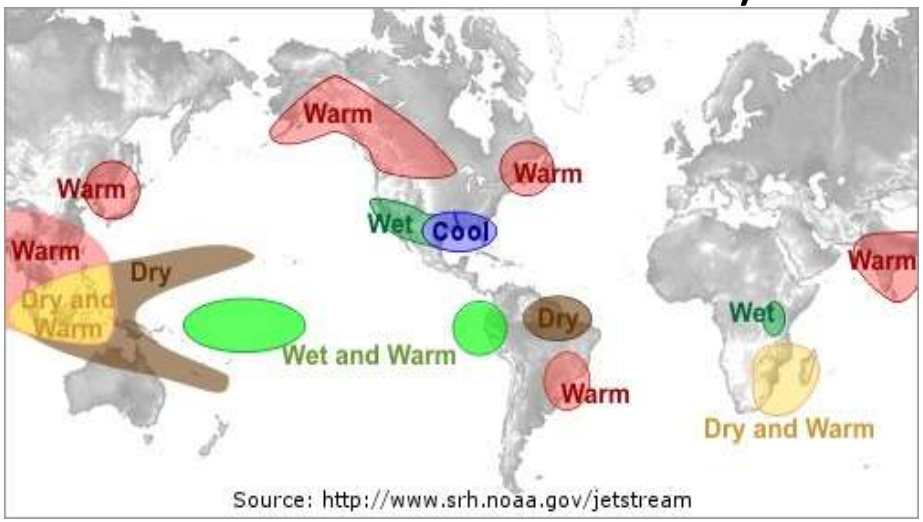


Source: climate.nasa.gov

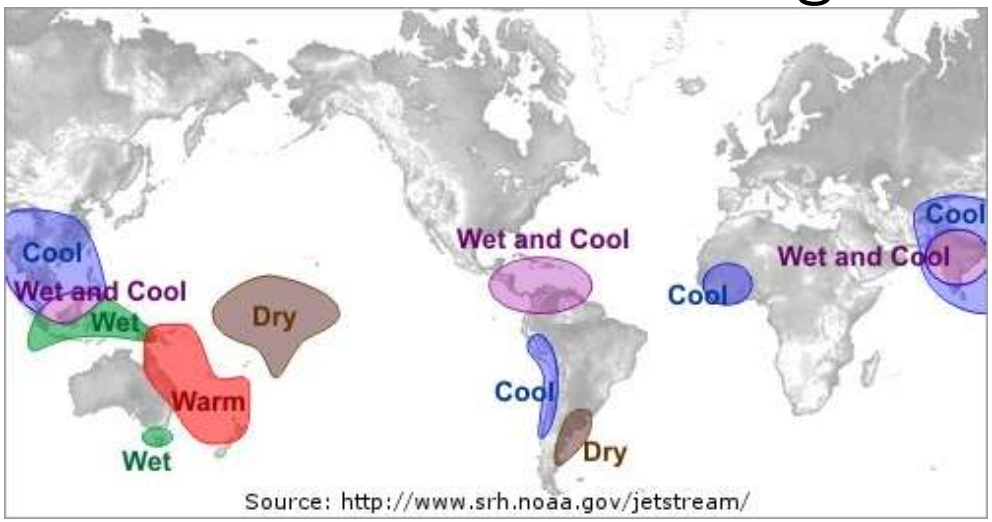
Short-Term Natural Climate Change

- El Niño Southern Oscillation (ENSO)
  - Occurs irregularly every 2-7 years
  - Unusually warm ocean currents in the E. Pacific causes heavy rains and flooding in some parts of the world (like S. America) and droughts in other parts (like Australia)

December – February



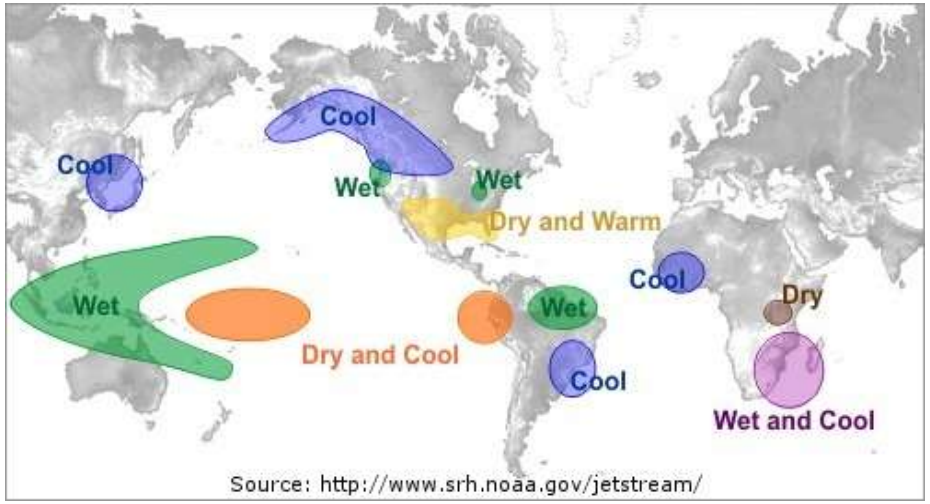
June - August



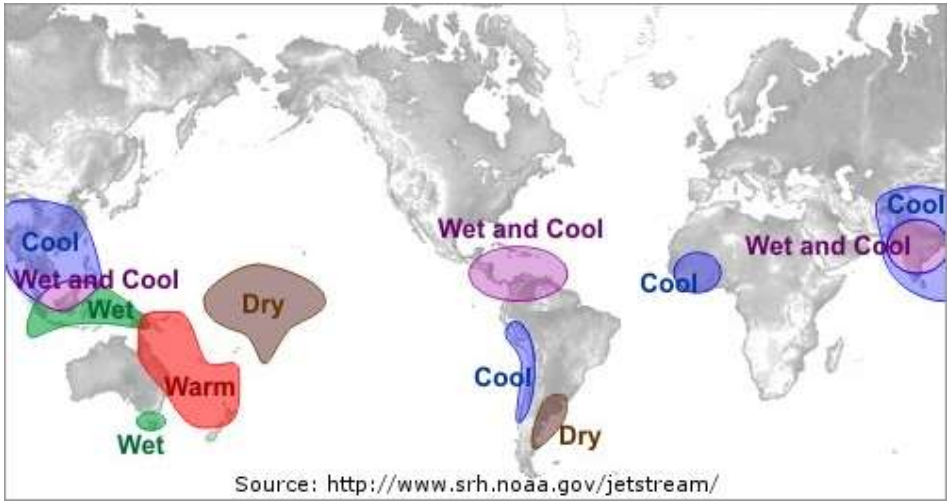
Short-Term Natural Climate Change

- La Niña
  - Essentially the opposite of El Niño.
  - Ocean currents cool and the climate patterns reverse.

December – February

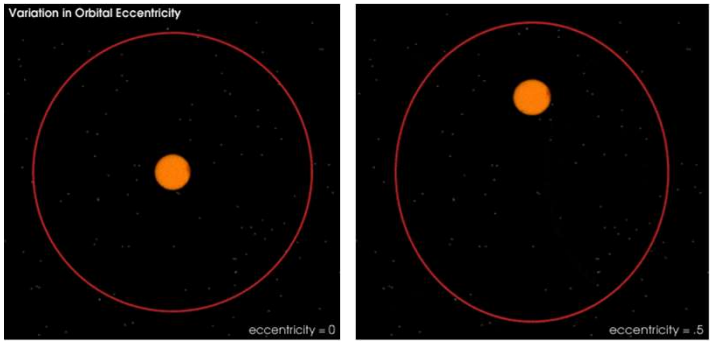


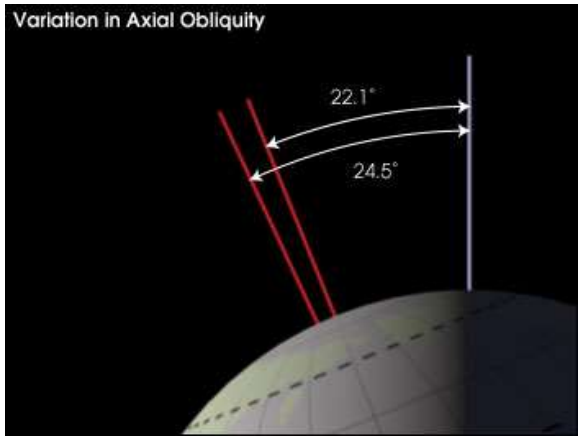
June - August

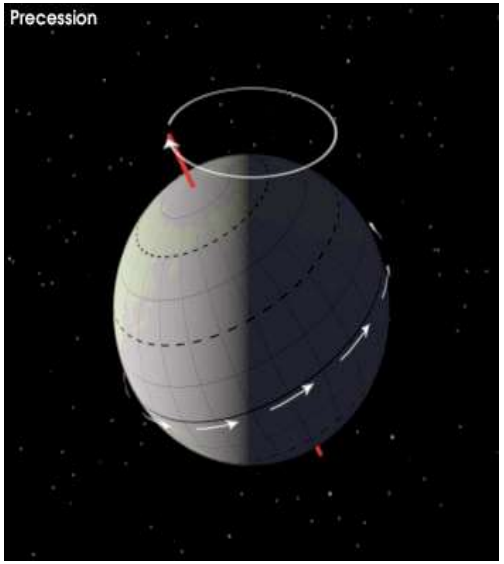


Long-Term Natural Climate Change

- Milankovitch cycles explain long-term natural changes to the climate, such as ice ages.
- These cycles are caused by natural variations in the Earth-sun geometry.
- These cycles can take up to 100,000 years to complete!







Review Questions

14. What are the effects of El Niño?

    _____

15. What is the opposite of El Niño?

    _____

16. Why is El Niño considered a short-term change?

    _____

17. What long-term cycles might explain the occurrence of ice ages?

    _____

Hydrosphere

- Parts of the earth made of water
- Includes:
  - Oceans
  - Lakes
  - Rivers
  - Underground Water
  - Clouds

Why Water?

- Life on Earth could not exist without water for obvious reasons!
- Large bodies of water also help Earth retain heat.
  - Water absorbs and releases heat slower than land.
  - Therefore, ocean temperatures fluctuate less than land temperatures.
  - Ocean currents influence the weather and climate of nearby land masses.

Hydrosphere

- 70% of Earth is covered in water!
- AKA – “water planet”
- 97% is salt water
- 2/3 of freshwater is frozen

Fresh Water

- A little more that 3% of all water on Earth
- Less than 1% of all freshwater is available for human needs
- Most is unusable; frozen in icecaps and glaciers
- The rest is found in lakes, rivers, wetlands, soil, rock layers and atmosphere

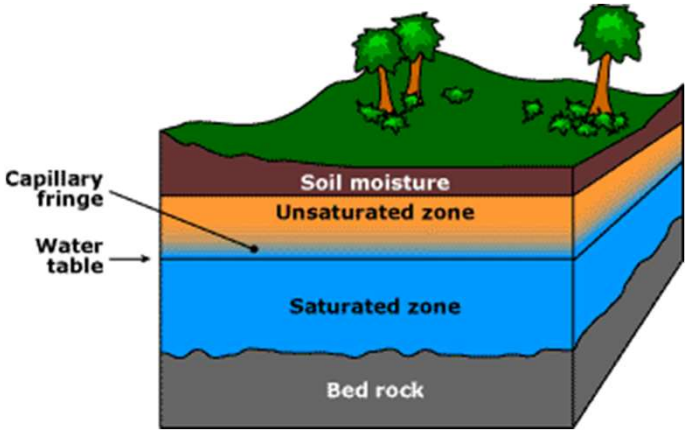
Two Types of Fresh Water

Surface Water

- Found in:
  - Lakes
  - Rivers
  - Streams
  - Rain Runoff

Ground Water

- Found underground and moves through small spaces.
- An underground layer of porous rock with water in it is an **aquifer**.



Review Questions

18. Why is water important to Earth's temperature?

_____

19. How much of Earth is covered in water?

_____

20. How much of Earth's water is freshwater? How much of that is usable?

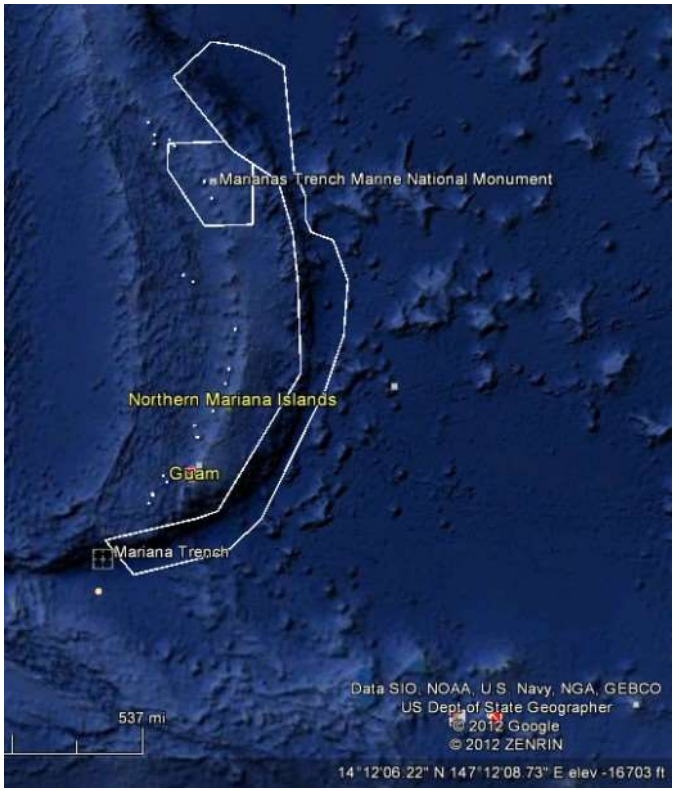
_____

21. What are the two types of freshwater called?

_____

Saltwater

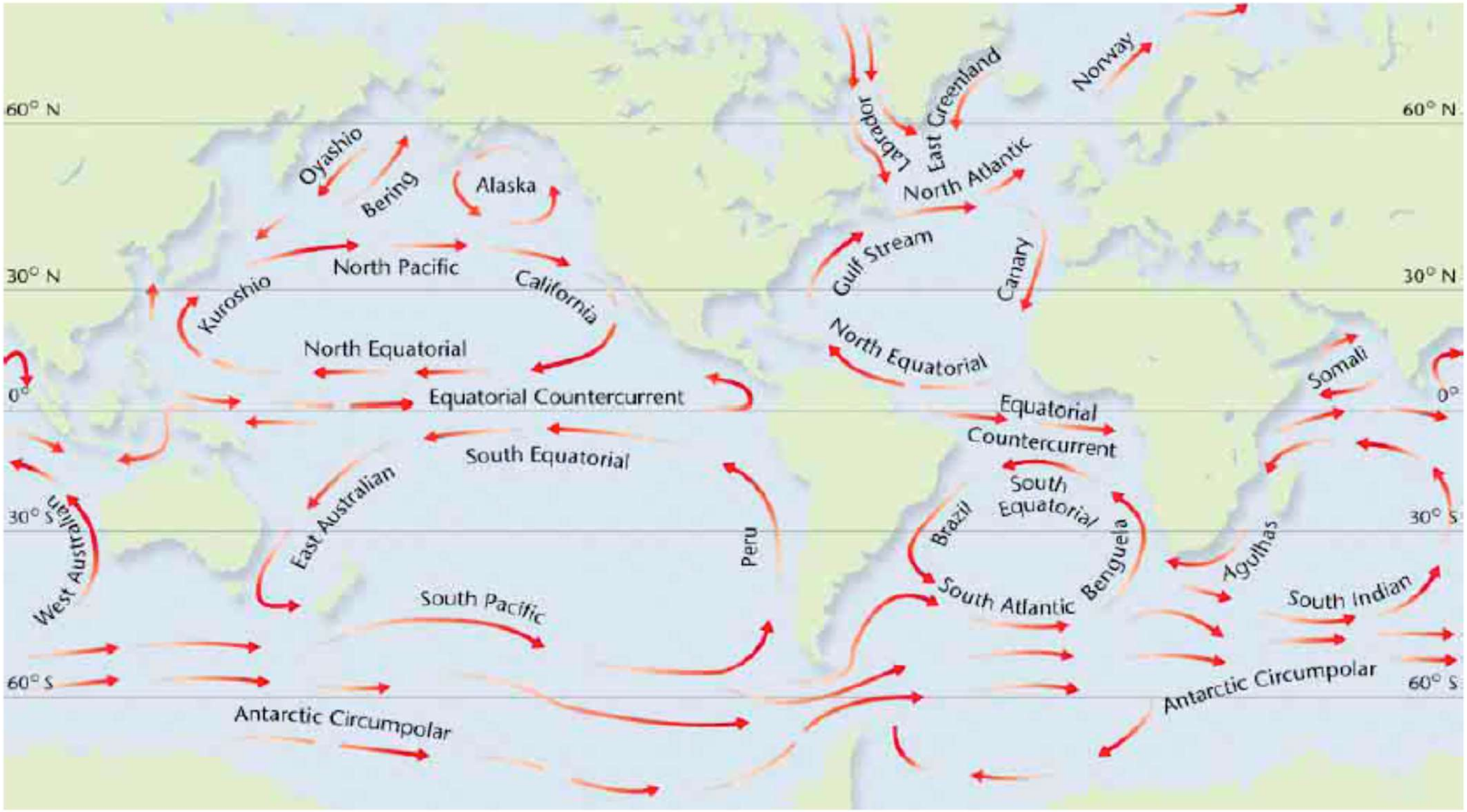
- 70% of Earth's surface
- Four Oceans – Pacific, Atlantic, Indian, Arctic
- Average depth is 4,280 m (over 2.5 miles)
- Deepest point is 11,033 m below sea level (almost 7 miles) – Marianas Trench



Salinity

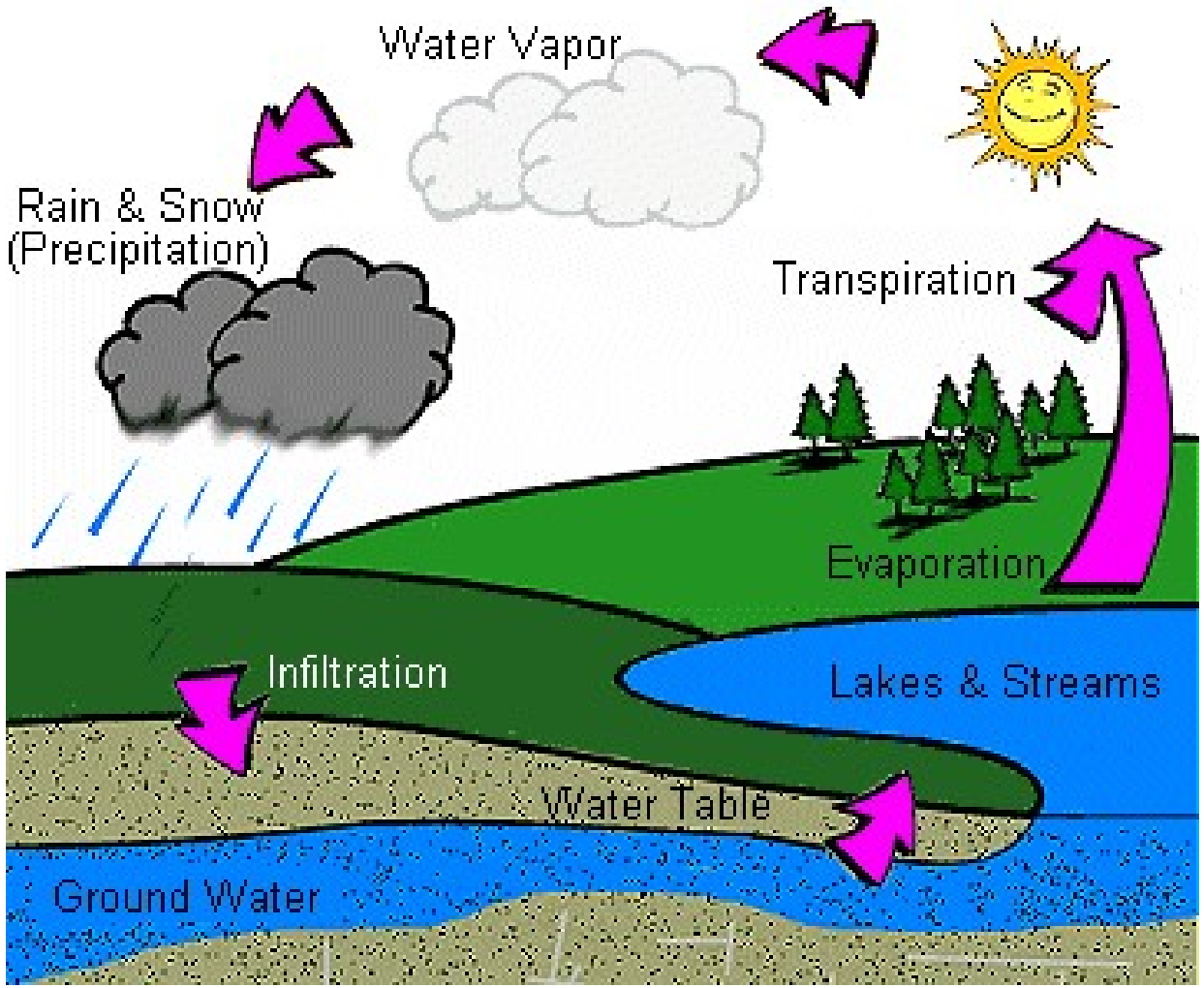
- Salinity – the concentration of all the dissolved salts in a body of water
  - Make Up:
    - Chlorine – 55%
    - Sodium – 30.6%
    - Magnesium – 7.7%
    - Sulfur – 3.7%
    - Calcium – 1.2%
    - Potassium – 1.1%
    - Other – 0.7%

Surface Currents of the World



Water Cycle

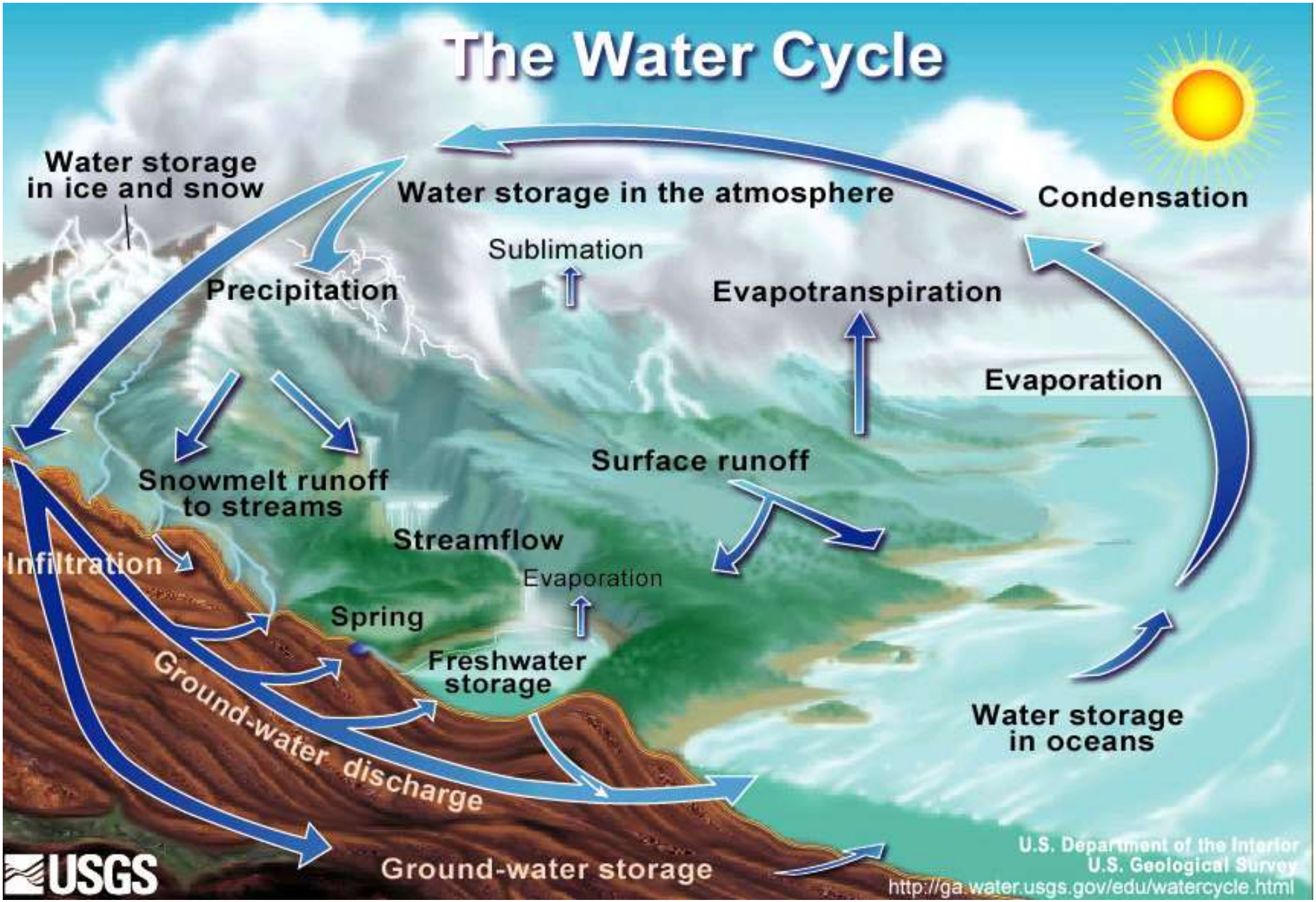
- Evaporation
- Precipitation
- Transpiration
- Condensation
- Sublimation



Water Cycle

- Evaporation
  - Liquid water is heated and becomes water vapor
- Condensation
  - Water vapor in the atmosphere forms droplets on dust particles (clouds)

- Precipitation
  - Large water droplets in the atmosphere fall as rain, snow, sleet, or hail
- Transpiration
  - Water vapor is released by plants


The Water Cycle
Water storage in ice and snow
Water storage in the atmosphere
Condensation
Sublimation
Precipitation
Evapotranspiration
Evaporation
Surface runoff
Snowmelt runoff to streams
Streamflow
Infiltration
Evaporation
Spring
Freshwater storage
Ground-water discharge
Water storage in oceans
Ground-water storage
USGS
U.S. Department of the Interior
U.S. Geological Survey
http://ga.water.usgs.gov/edu/watercycle.html

Biosphere

- Encompasses all of the parts of Earth than support life
- All living things obtain the energy they need to live here

Review Questions

22. What is the deepest place on Earth called?

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23. What is salinity?

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24. How does water change states in the water cycle?

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25. In which “sphere” does all life on Earth obtain energy?

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