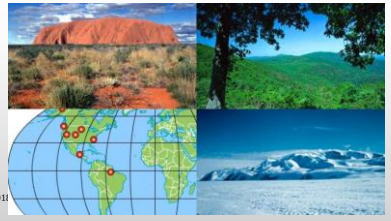
Climate
&
Climate Change



BRAINSTORM:

1. What is the difference between weather and climate?
2. What are factors that affect climate?

http://image.slidesharecdn.com/climate-factorsdefinition-130423113230-phpapp01/95/climate-factors-definition-1-638.jpg?cb=1366838048

Objectives

1. Diagram the movement of Carbon through the four "spheres" of the Earth's systems; lithosphere, hydrosphere, atmosphere and biosphere.
2. Diagram the water cycle within the hydrosphere.
3. Apply the terms "positive feedback" & "negative feedback" to ice ages, global warming & climate change.
4. Compare and contrast the greenhouse effect and global warming. This means I can:
   A. Explain why the greenhouse effect is necessary for life on earth.
   B. Explain what 4 main gases are associated with the greenhouse effect and how human activities have altered their levels and contributed to global warming.
5. Explain causes and effects of climate change. This means I can:
   A. Differentiate natural vs. human actions that lead to climate change.
   B. Explain human influence on climate and list several human activities that could be causing global warming.
6. List and describe the effects of climate change on; temperature, sea level changes, severe weather events (storms, drought…), ocean acidification.
7. Describe strategies to limit human impact on climate.

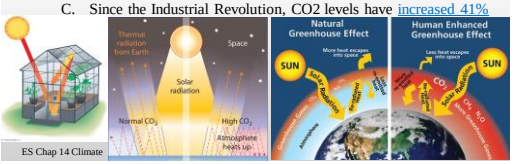
Weather vs. Climate

- **Weather** = Conditions of atmosphere at a particular time and place, for a short period of time (days).
- **Climate** = Long-term average of weather (Averaged over 30 years)
- **Example:**
  - What is the current weather in Bettendorf?
  - How would you describe the climate of Bettendorf?

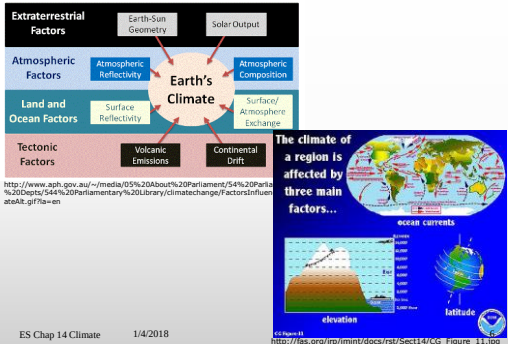
Greenhouse Effect vs. Global Warming

Greenhouse Effect vs. Global Warming

1. Greenhouse Effect –
   A. Traps just enough heat to keep Earth at a habitable temperature
   B. We NEED the Greenhouse Effect
2. Global Warming
   A. Increase in Earth's global temperatures BEYOND the Greenhouse Effect
   B. Primarily due to increased CO_2 levels due to humans burning fossil fuels.
   C. Since the Industrial Revolution, CO_2 levels have increased 41%



Factors Affecting Climate



http://www.aph.gov.au/~/media/05%20About%20Parliament/54%20Parliamentary%20Depts/544%20Parliamentary%20Library/climatechange/FactorsInfluenceAlt.gif?la=en

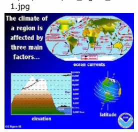
http://ias.org/ihp/imint/docs/rst/Sect14/CG_Figure_11.jpg

Factors Affecting Climate

Many factors affect climate:

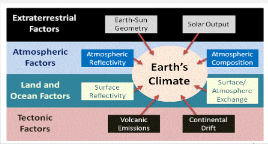
1. Sun
   - A. Radiation ***given off*** by the Sun
   - B. Latitude affects amount radiation ***received***
   - C. Solar radiation ***absorbed*** or ***reflected***
2. Volcanic eruptions
3. Elevation (mountains)
4. LARGE bodies of water (oceans)
   - A. Coastline vs. inland
   - B. Ocean currents
5. Wind (global patterns)

http://fas.org/irp/imint/docs/rst/Sect14/CG_Figure_11.jpg



How might the above affect climate?

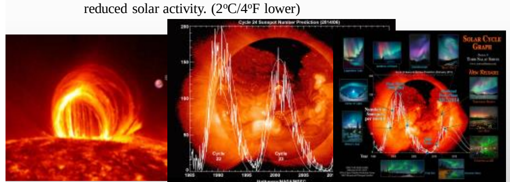
We will go through them one-by-one.



http://www.aph.gov.au/~/media/05%20About%20Parliament/54%20P

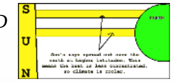
Sun: #1 Radiation ***Given Off*** by Sun

1. **Sun: #1 Radiation *GIVEN OFF* by the sun**
   - A. The amount of radiation ***given off*** by the Sun varies
   - B. Many sunspots causes warmer temperatures
   - C. Few sunspots causes lower temperatures
     - "The Little Ice Age" from 1350- 1900 in Northern Hemisphere was due to reduced solar activity. (2ºC/4ºF lower)



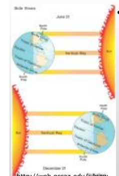
http://i.ytimg.com/vi/HFT7ATLQQx8/maxresdefault.jpg https://upload.wikimedia.org/wikipedia/commons/...away_Cycle_24_Prediction.png http://www.aurorahunter.com/images/misc/Todd-Solar-Cycle-02-2013.jpg

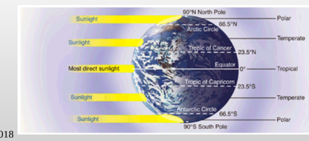
Latitude & Solar Radiation *RECIEVED*



Sun: #2 Latitude affects radiation *RECIEVED*

- A. The further you travel from the equator the cooler it gets. Why?
  - Because Earth is curved and the sun's rays hitting at a higher latitude are LESS direct, meaning they are spread out over a greater area.
    - Equator has DIRECT rays (LOW latitude numbers)
    - Poles have INDIRECT rays (HIGH latitude numbers)
  - Because Earth is tilted in its orbit around the sun.
    - During part of the year, each pole is tilted away from the sun and receives NO sunlight.



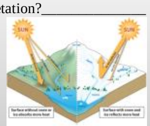


http://geog.gmu.edu/.../man/gph111/topic_units/Ear

Solar radiation ***absorbed*** or ***reflected***

Sun: #3 Surface Features determine if radiation is *REFLECTED* or *absorbed*

- A. What color do you wear on a sunny day to stay cool? Why?
  - White clothes reflect sunlight.
- B. What is hotter for your feet on a sunny day; asphalt or cement? Why?
  - Instead of reflecting light, black absorbs sunlight and becomes very warm.
- C. Predict the relative amount (lots, very little) of sunlight reflected for:
  - Snow, ice? ________
  - The poles are cold not just because of their latitude and the low amount of sunlight received, but also because their ice reflects much of the sunlight that is received.
  - Water, soil, vegetation?______________

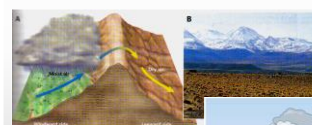


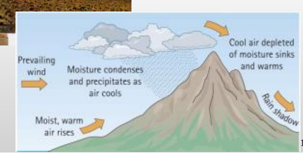
Volcanic Eruptions

2. **Volcanic Eruptions**
   - A. Large eruptions release **aerosols** into atmosphere.
     - Aerosols = small particles
     - Examples of volcanic aerosols: ash & dust
   - B. Aerosols block solar radiation and cause short-term cooling for only a few years.
     - Short term because the aerosols gradually settle out and don't stay in the atmosphere.

Elevation (Mountains)

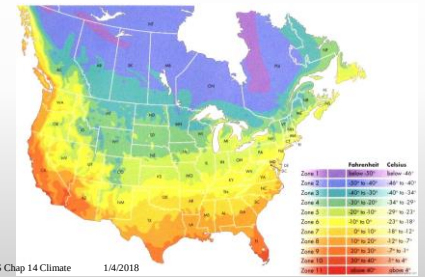
3. **Elevation**
   - A. Mountain climates are cooler, as atmospheric temperature decreases with height
   - B. High elevations may allow snow to form in the tropics
   - C. One side of the mountain is drier than the other





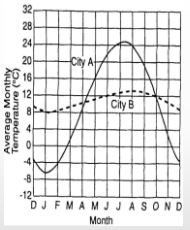
Inland vs. Coastal Winter Temps (Map)

- Find Iowa – what is the lowest temperatures typically found in the winter?
- Now travel to the East Coast at the SAME latitude – what is its lowest temperatures?
- Now travel to the West Coast at the SAME latitude – what is its lowest temperatures?
- States at the same latitude should receive the same amount of solar radiation. What might explain why there's difference inland vs. coast?



LARGE Bodies of Water

4. LARGE bodies of water (oceans, seas)



The graph below shows the average monthly temperatures for two cities, A and B, which are both located at 41°N latitude and should receive the same amount of solar radiation.

- **Why is there a difference in the average yearly temperature range for the two cities?**

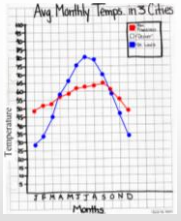
- Because City A is located inland (continental) and City B is located near water (marine)

LARGE Bodies of Water

A. Coastline Climate vs. Inland

- Water heats and cools more slowly than land, therefore it doesn't get as cold in the winter or as warm in the summer as land does.
- **Coastline cities** are "insulated" by the breezes coming off the water & don't get as hot in the summer or as cold in the winter. They have a more "moderate" climate
- **Inland cities** have a more extreme climate, both hotter in summer and colder in winter, than cities on the coast at the same latitude.

Coastline vs. Inland Climate

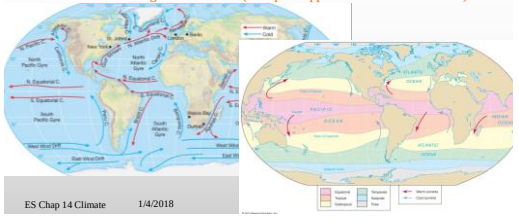


Ocean Currents

B. Ocean Currents

- Ocean currents move Earth's heat energy around
- The effect of ocean currents on the climate depends on the direction the current comes from
  - From the equator, warm water is moved towards the poles
  - From the poles, cold water is moved towards the equator

C. On the map to the right, does the current direction appear to affect size of climate zone along the coastlines?(Compare opposite sides of each ocean)



Ocean Current Diagram in Note Outline

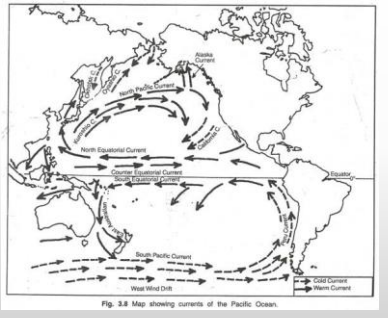
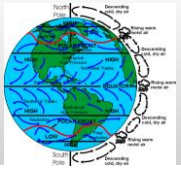
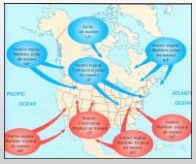


Fig. 3.8 Map showing currents of the Pacific Ocean.

Latitude & Global Wind Patterns

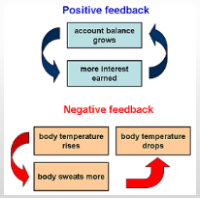
5. **Wind: Global Wind Patterns**
   A. Global wind patterns which affect precipitation.
      - Much rain & rainforests at LOW latitudes (ie 0° Equator)
      - Little rain & deserts with little vegetation at 30° Latitude
   B. Mid-latitudes (ie. Iowa) – Our weather comes from the west
   C. Tropical – Hurricanes come from the east.



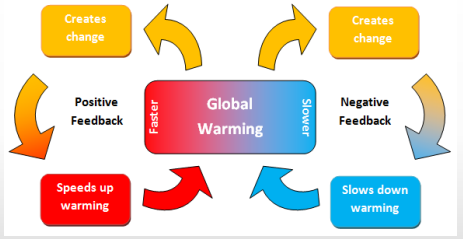


Positive vs. Negative Feedback Loops

- **Positive** Feedback Loop: Exaggerates & makes changes more extreme.
- **Negative** Feedback Loop: Brings system back to "normal".

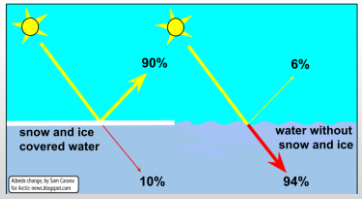


Climate Change: Positive vs. Negative Feedback Loops



Ice Age Positive Feedback Loop

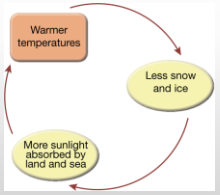
1. Low sunspot activity = lower temperatures
2. Low temperatures = more snow & ice accumulation
3. Snow & ice reflect more solar radiation = Earth's temperature becomes even cooler
4. "Positive Feedback Loop" = Exaggerates the change and cold temperatures became even colder during the Ice Age.



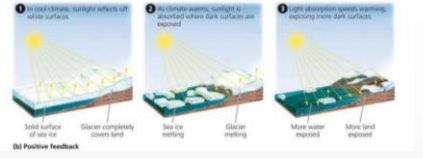
Is This Exaggerated Cooling Happening Now? NO!!

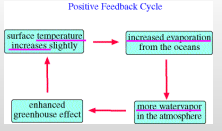
NOW, as climate is warming, the **reverse** is happening:

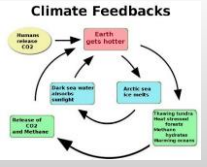
- Warmer temperatures = decrease in snow & ice coverage.
- Melting = Soil & water surfaces reflect less radiation
- Less reflection = more sunlight is absorbed = a warmer Earth
- Another Positive Feedback Loop - this time causing "exaggerated" warming.



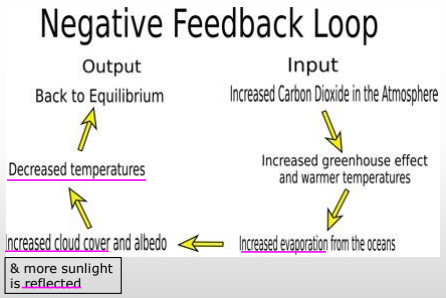
Positive Feedback – Global Warming







Negative Feedback – Global Warming

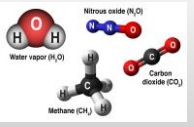


Greenhouse Gases – Carbon Dioxide, CO_2

Greenhouse Gases & Their Sources

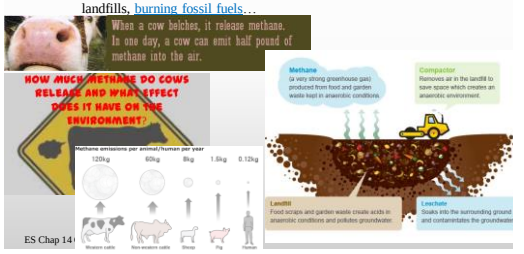
There are 4 main greenhouse gases: CO_2, CH_4, N_2O, & water vapor

1. Carbon Dioxide, CO_2
   - A. Today, only 5% of CO_2 in the atmosphere comes from natural processes such as animal breathing, etc.
   - B. 95% of ATMOSPHERIC CO_2 comes from human activity such as combustion (burning) of fossil fuels for electricity, transportation, industry…
   - C. Most abundant human caused GHG



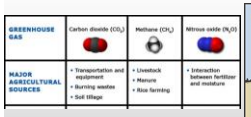
Greenhouse Gases – Methane, CH_4

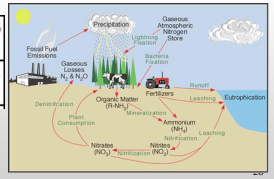
2. Methane, CH_4
   - A. Compared to CO_2, much less CH_4 is in the atmosphere.
   - B. BUT it can trap 20 times more heat than CO_2
   - C. YET, it has a short lifespan and breaks down
   - D. Source of includes; livestock digestion & gas, waste decomposition in landfills, burning fossil fuels…



3. Greenhouse Gases – Nitrous Oxide, N_2O

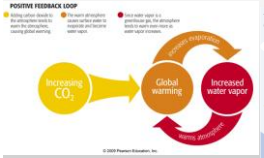
3. Nitrous Oxide, N_2O
   - A. Only small amount in the atmosphere
   - B. BUT it can trap 300 times more heat than CO_2
   - C. Natural sources: Soil and oceans release N_2O into atmosphere
   - D. Human sources: Agriculture, fuel combustion in motor vehicles





Greenhouse Gases – Water Vapor, H_2O

4. Water Vapor, H_2O
   - A. Is the most abundant GHG in the atmosphere
   - B. Has the biggest impact on temperature compared to all the other GHGs
   - C. Traps 2/3 of all the heat trapped in the atmosphere
   - D. Water vapor is constantly moving between the hydrosphere, atmosphere, and biosphere.
   - E. Changes in its movement between the four systems could have big impact on the warming and cooling of the atmosphere.
     - ➢ Yet, water vapor levels have been constant throughout history, so it doesn't appear to be responsible for the warming Earth is undergoing.



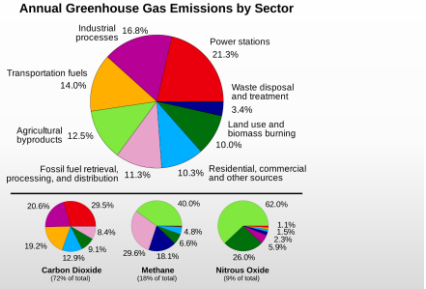
Water vapor & clouds – trap more heat? vs. Block/reflect sunlight?? Complicated & uncertain effects.

Human-Caused Greenhouse Gases

TABLE 16.1 HUMAN-CAUSED GREENHOUSE GASES AND THEIR CONTRIBUTION TO INCREASING THE GREENHOUSE EFFECT

Atmospheric gas	Human-caused sources of gas	Pre-industrial (circa 1750) concentration (ppbv*)	Present concentration (ppbv*)	Current rate of increase or decrease (% per year)	Relative contribution to increasing the greenhouse effect (%)	Infrared radiation absorption per molecule (number of times greater than CO_2)
Carbon dioxide (CO_2)	Combustion of fossil fuels	280,000	387,0000	+0.5	60	1
Methane (CH_4)	Leakage, domestic cattle, rice agriculture	700	1750	+1.0	15	25
Nitrous oxide (N_2O)	Combustion of fossil fuels, industrial processes	270	315	+0.2	5	200
Tropospheric ozone (O_3)	Byproduct of combustion	0	10–80	+0.5	8	2000
Chlorofluorocarbon (CFC-11)	Refrigerants, industrial uses	0	0.26	−1.0	4	12,000
Chlorofluorocarbon (CFC-12)	Refrigerants, industrial uses	0	0.54	0.0	8	15,000
Total					100	

*ppbv = parts per billion by volume (not by weight).

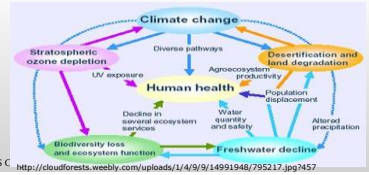


Effects of Climate Change

Effects of Climate Change

It is believed that increased levels of Greenhouse Gases is leading to the following changes:

1. Temperature changes
2. Sea level changes
3. Weather event frequency changes
4. Ocean acidification changes

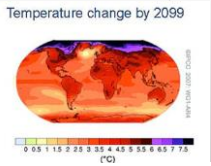


http://cloudforests.weebly.com/uploads/1/4/9/9/14991948/795217.jpg?457

Temperature Change

Temperature Change

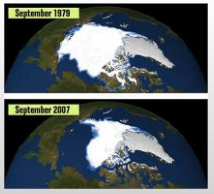
1. Both land & ocean temperatures are increasing.
2. Land temperatures are increasing more than water temperatures. WHY?
   A. Water can absorb more thermal (heat) energy without changing its temperature.
   B. Water heats up more slowly than land.
3. More heat waves are affecting the mid-latitudes (Us in Iowa!)
4. Amount of sea ice, glaciers, permafrost has decreased due to melting.
   A. As permafrost thaws it releases CO_2 & CH_4, BUT it is difficult to know how much is being released – significant or not?



Sea Level Change

Sea Level Change

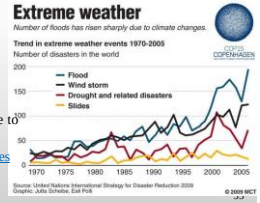
1. Sea level has risen worldwide 12-22cm.
2. As oceans warm, the water particles move faster and the water's volume expands – rises.
3. Melting of glaciers and ice sheets releases water, causing sea level to rise.



Weather Event Frequency Changes

Extreme Weather Event Frequency Changes

1. What is an extreme weather event?
   A. Extreme weather event = drought, hurricanes, increased frequency of heavy rainfall
2. Mid-latitude U.S. changes:
   A. Increased heavy precipitation
   B. Winter snow sometimes now falls as rain.
3. Mediterranean & Africa
   A. Droughts have increased
4. Other:
   A. Hurricanes:
      - Increased hurricane intensity/strength (not number of hurricanes) due to warmer ocean waters
      - Move further towards poles before stopping

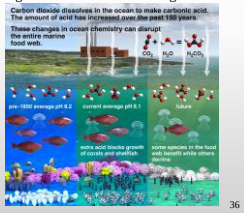


Ocean Acidification Changes

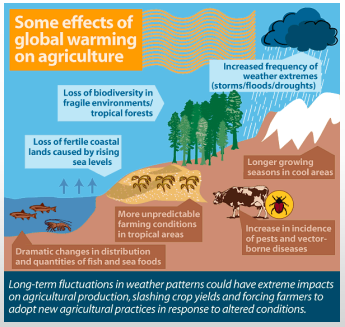
Ocean Acidification Changes

1. Oceans, as discussed previously, are a natural reservoir for carbon
2. In the past, oceans have been able to absorb extra amounts of CO2 as it was produced.
3. As CO2 is absorbed, the ocean becomes more acidic
   A. Scientists predict increased acidity will affect the formation of coral, shells, crabs, snails, clams and thereby affecting the entire reef system
4. Oceans will NOT be able to keep absorbing CO2 at the rates it is being added to the atmosphere.

MUSIC VIDEO: Climate change:
https://www.youtube.com/watch?t=52&v=fL9RMYM1DD8



Effects of Global Warming on Agriculture



Strategies to Limit Climate Change

Strategies to Limit Climate Change

Strategies are aimed at reducing CO_2 emissions. Strategies include:

1. Using energy sources that do not emit carbon; wind, solar, hydropower
2. International awareness, but there is a conflict between developed vs. developing nations.
   - A. Developing nations.
     - ➢ They have less money to pay for the controls needed. Money spent to limit greenhouse gas production would hurt their efforts to their citizens and country out of poverty.
     - ➢ Developing countries argue that the current climate change was caused by developed countries – developed countries should pay.
   - B. Developed countries:
     - ➢ Think developing nations would have an economic advantage if developing countries don't have to follow the same regulations.
   - C. Personal awareness
     - ➢ What is YOUR "carbon footprint"? How can you decrease it?

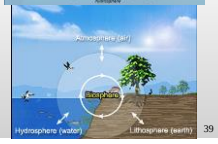
The Four Spheres/Systems of Earth

The Four Spheres/Systems of Earth

Earth can be divided into 4 systems that each has a specific role in keeping Earth going, the storage of carbon, and weather and climate.

The 4 systems/spheres of Earth are:

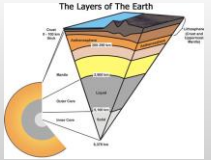
1. Lithosphere
2. Hydrosphere
3. Biosphere
4. Atmosphere



Read the last two pages of your note outline and answer the corresponding questions in your outline for each system and for the carbon cycle.

Lithosphere

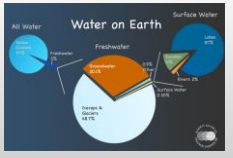
1. What makes up the lithosphere? (List 4 components)
   Rocks, minerals, volcanoes & fossil fuels
   **The lithosphere is the solid, rocky outer surface of the earth.
2. What is the major cycle in the lithosphere?
   The rock cycle: rocks change from 1 type of rock to another (sedimentary, igneous, metamorphic)
   ***Rocks contain most of the carbon found on Earth.
3. When fossils in sedimentary rocks are put under intense heat and pressure, what do they turn into? Be specific and detailed.
   The fossils turn into fossil fuels: petroleum, coal and natural gas



Hydrosphere

1. How much of the Earth is covered by bodies of water?
   70% covered by oceans, lakes, rivers…
   (It's why it is called "the blue planet" from space)
2. What is water in the atmosphere called?
   Water vapor
3. What happens when water vapor in the atmosphere is cooled?
   It falls as precipitation – rain, snow, hail

   Other notes: Most of the carbon in the hydrosphere is found in the oceans; carbon in shells, coral, carbon dioxide plants need fo photosynthesis…



Biosphere

1. List 4 examples of parts of the biosphere.
   Plants, animals, fungi, microorganisms
2. "Bio" means life. Are only living organisms included in the biosphere? Explain.
   No, the biosphere also contains things that were alive a short time ago and things that are taken from living organisms.
3. Life cycles and food chains are important cycles found **within** the biosphere. What cycles from **outside** the biosphere are important to the biosphere? List 3.
   Water cycle
   Nitrogen cycle
   Carbon cycle

**The biosphere has large amounts of carbon found in carbohydrates and proteins inside living organisms.

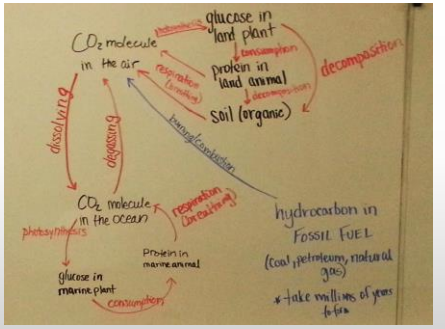
Atmosphere

1. When it is said that the atmosphere acts like a greenhouse, what does that mean?
   Like a greenhouse keeps plants warm, the atmosphere surrounds the earth and keeps it warm, at a temperature that life can survive.
2. What are the 2 main gases, and their percentages, in the atmosphere?
   Nitrogen 78%, Oxygen, 20%
3. Greenhouse gases:
   A. What 3 gases very good at trapping heat?
      Carbon dioxide (CO_2), Methane CH_4, water vapor
   B. Greenhouse gases (GHGs) make up what percent of the atmosphere?
      Less than 1%
   C. How much does their concentration need to change to make a difference in Earth's climate? Very small change is all that is needed

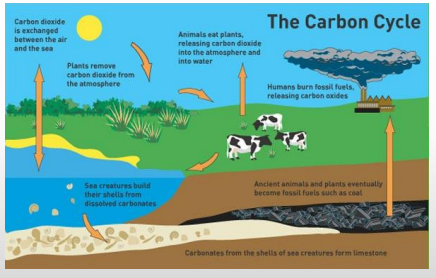

Carbon Cycle

1. Which "sphere" contains the most carbon, and what is it found in?
   Lithosphere – in the rocks
2. In what are "hydrocarbons" found, and what are they formed from?
   Found in fossil fuels. Formed from fossils put under heat and pressure
3. Carbon in the hydrosphere.
   A. What part of the hydrosphere contains the most carbon?
   B. Describe 2 forms the carbon found in that location.
   The ocean has most of the carbon in the hydrosphere. 2 forms are carbonate and carbon dioxide.
4. Carbon in the biosphere:
   A. How much carbon is found in the biosphere?
   B. In what form is it found? List 2.
   The biosphere has large amounts of carbon found in carbohydrates and proteins inside living organisms.
5. Carbon in the atmosphere:
   A. How much carbon does the atmosphere have compared to the other 3 systems/spheres? The smallest amount
   B. In what 2 forms is most of the carbon in the atmosphere?
      Carbon dioxide (CO_2) and methane (CH_4)

Lab Carbon Cycle – Flow Diagram w/4 Spheres



Carbon Cycle Diagram



Spheres Reading