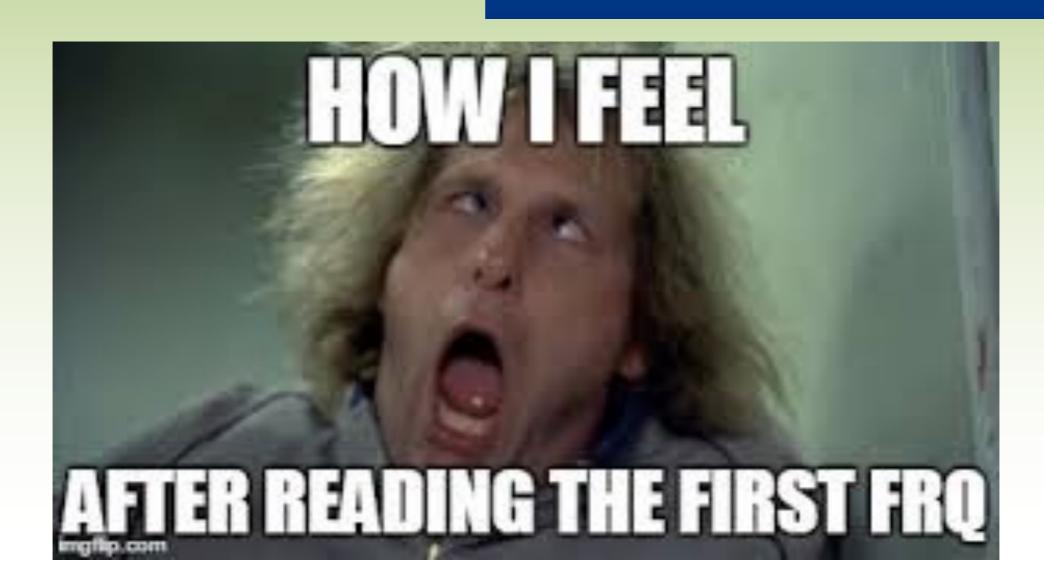
## **AGENDA:**

## **BELLWORK**

- Collect lab notebooks
- Practice FRQ
- Notes and "life as a drip" activity



99% of solar energy is reflected or passes through producers without being absorbed.

Sun

1% of solar energy striking producers is captured by photosynthesis (GPP).



60% of GPP is lost to respiration.

What portion of the electromagnetic spectrum is this?

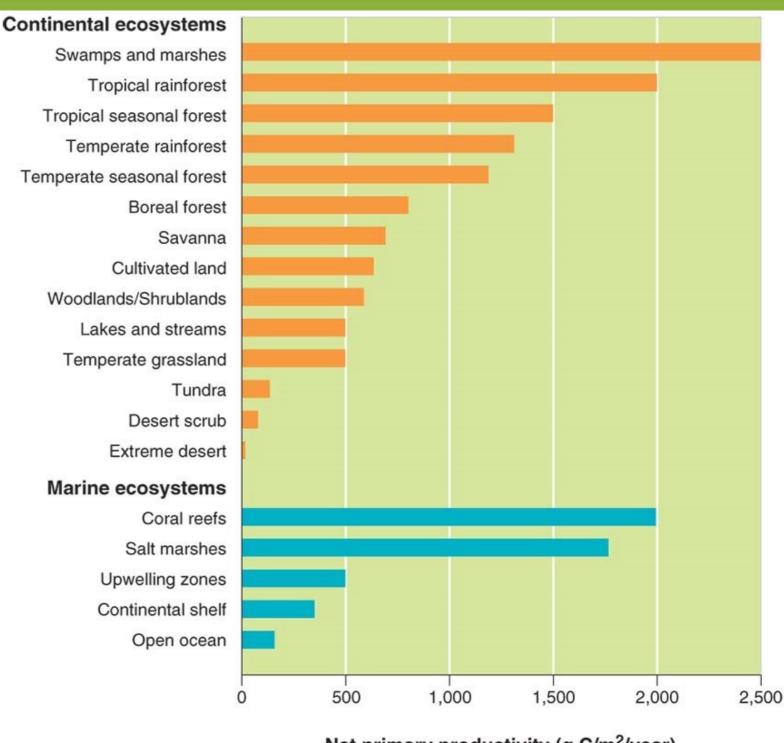
40% of GPP supports the growth and reproduction of producers (NPP).

**Figure 3.7** Environmental Science for AP<sup>®</sup> © 2012 W.H. Freeman and Company

## **Ecosystem Productivity**

Productivity is
highest where
temperatures are
warm and water and
solar energy are
abundant

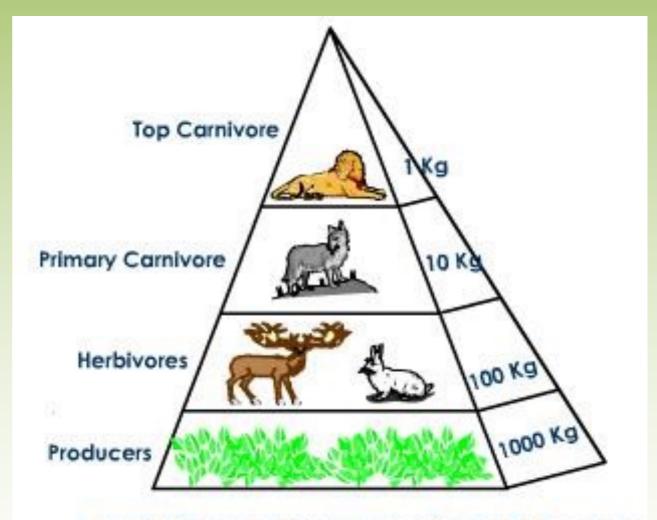
NPP varies
 tremendously among
 different areas of the
 world



Net primary productivity (g C/m<sup>2</sup>/year)

## **Energy Transfer Efficiency and Trophic Pyramids**

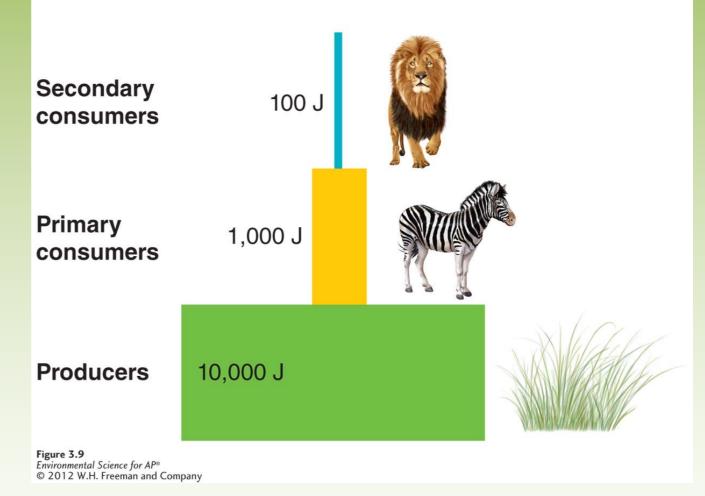
- **<u>Biomass-</u>** The energy in an ecosystem is measured in terms of biomass.
- <u>Standing crop-</u> The amount of biomass present in an ecosystem at a particular time.



Upright Pyramid of biomass in a Terrestrial Ecosystem

## **Energy Transfer Efficiency and Trophic Pyramids**

- Ecological efficiency- The proportion of consumed energy that can be passed from one trophic level to another.
  - **Trophic pyramid-** The representation of the distribution of biomass among trophic levels.



## Matter cycles through the biosphere

- **<u>Biosphere-</u>** The combination of all ecosystems on Earth.
- <u>**Biogeochemical cycles-</u>** The movement of matter within and between ecosystems involving biological, geologic and chemical processes.</u>

Lets start by talking about WATER!!! What happens to water in each of the following processes?

- Condensation
  - Water vapor cools from gas to become a liquid
- Evaporation
  - Liquid water becomes water vapor
  - Incorporation
  - Water becomes part of the cells of an animal or plant
- <u>Melting</u>
  - Frozen water becomes liquid water
- Precipitation
  - Water falls from clouds as rain, hail, or snow

- <u>Respiration</u>
  - Water vapor is exhaled from an animal
- <u>Run-off</u>
  - Water runs along the earth surface
- Soil Saturation
  - Water can no longer be absorbed by the soil
- Sublimation
  - Ice turns directly into water vapor
- Transpiration
  - Water is carried through plants from roots to small pores on the underside of leaves, where it changes to vapor
- <u>Urination</u>
  - Animal pee pee! Duh!



## ACTIVITY: Diagram the Water Cycle



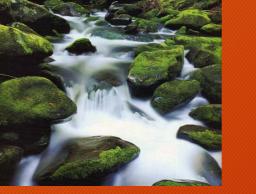
















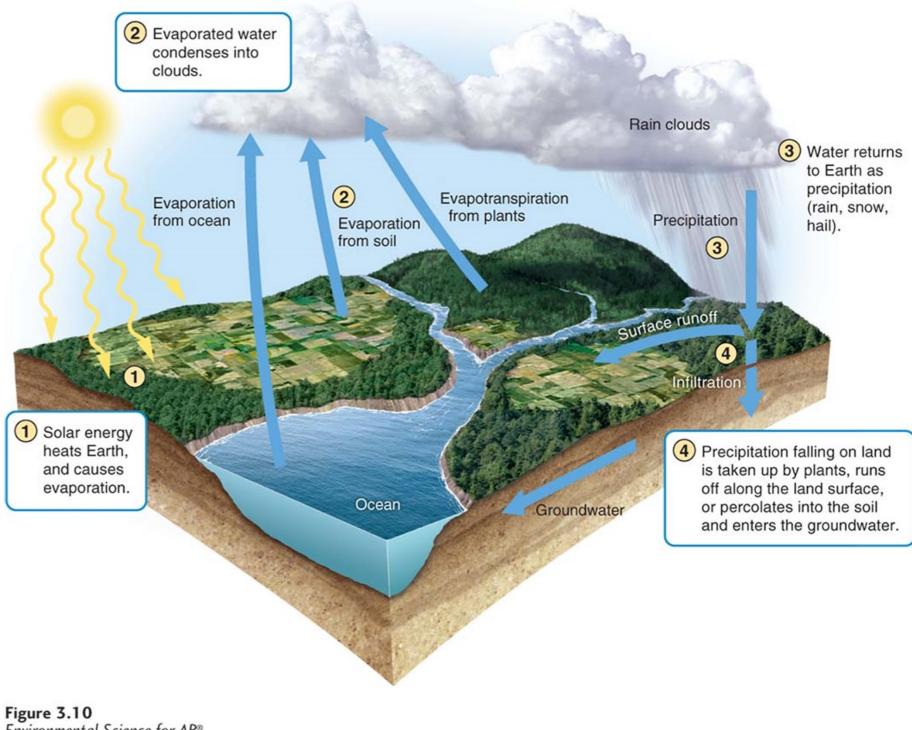
- In groups of 2 diagram the water cycle
- Be sure to label the <u>processes</u> that occur when water moves from one source to the next
- Include: animals, clouds, glaciers, ground water, lakes, oceans, plants, rivers, and soil
- Answer the following questions below on the back of your diagram(YES you are turning this in!):
  - 1. Where do you think the MOST water is? Why?
  - 2. Where do you think water is cycled through quickly? Explain.
  - 3. Where do you think water stays for a long time before it cycles through? Explain.

## ACTIVITY: Your life as a drip!

- You are a sweet and precious little drop of water and you'll be recording your adventure through the water cycle!
- Start at one of the 9 stations located around the room:
  - Soil, clouds, oceans, glaciers, animals, ground water, lakes, plants, and rivers
- Roll the die to determine where you will travel next
- After you have completed your journey make a tally of how many visits you made to each place you traveled and write a paragraph explaining your experience.
  - WHY does water stay in particular locations longer than others?
  - WHY does water cycle through particular locations faster than others?



## Water Cycle



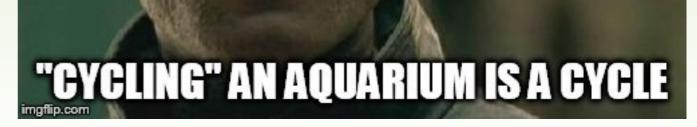
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## • Water plants/treatments

## **BELLWORK**

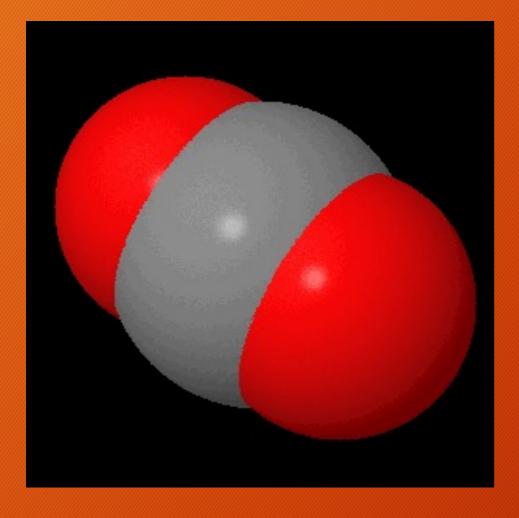
- Nutrient cycles
- Class time to study Ch. 3 vocab. or work on homework

## How does the Nitrogen cycle work?



WHAT IFITOLD YOU

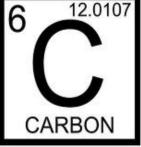
### The Carbon Cycle!



- Why is carbon so important?
  - All molecules essential to life contain carbon
  - Carbon makes up 0.038% of the atmosphere as CO<sub>2</sub>

# What happens to carbon in each of the following processes?





- Photosynthesis
  - $6CO_2 + 6H_2O_{\longrightarrow} C_6H_{12}O_6 + 6O_2$
- Respiration
  - $C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2 + energy$
- **Dissolving carbon** 
  - In the ocean carbon can be found in the form of carbonate (CO<sup>2-</sup><sub>3</sub>), bicarbonate (HCO<sup>-</sup><sub>3</sub>), and dissolved organic carbon from decay
- Release of dissolved carbon
  - Dissolved carbon is released as CO<sub>2</sub>
- Formation of limestone
  - Carbon is incorporated in limestone in the form of CaCO<sub>3</sub>

#### Growth of organisms

 Carbon is incorporated into the body of a plant or organism

#### Death of organisms

- Carbon in the body of a plant or organism is ingested by decomposers, becomes part of the soil, or is incorporated into sedimentary rock
- Humification
  - Organic carbon that cannot be broken down by bacteria and fungi becomes part of the humus layer of soil
- <u>Decomposition</u>
  - Carbon is used by bacteria and fungi for respiration and is released into the atmosphere as CO<sub>2</sub>
- Pressurization
  - Organic carbon is buried deep into the soil and becomes fossil fuels

## The Carbon Cycle Game!!!

 Play in groups of 3 - 4
 We will stop after 20 minutes to discuss

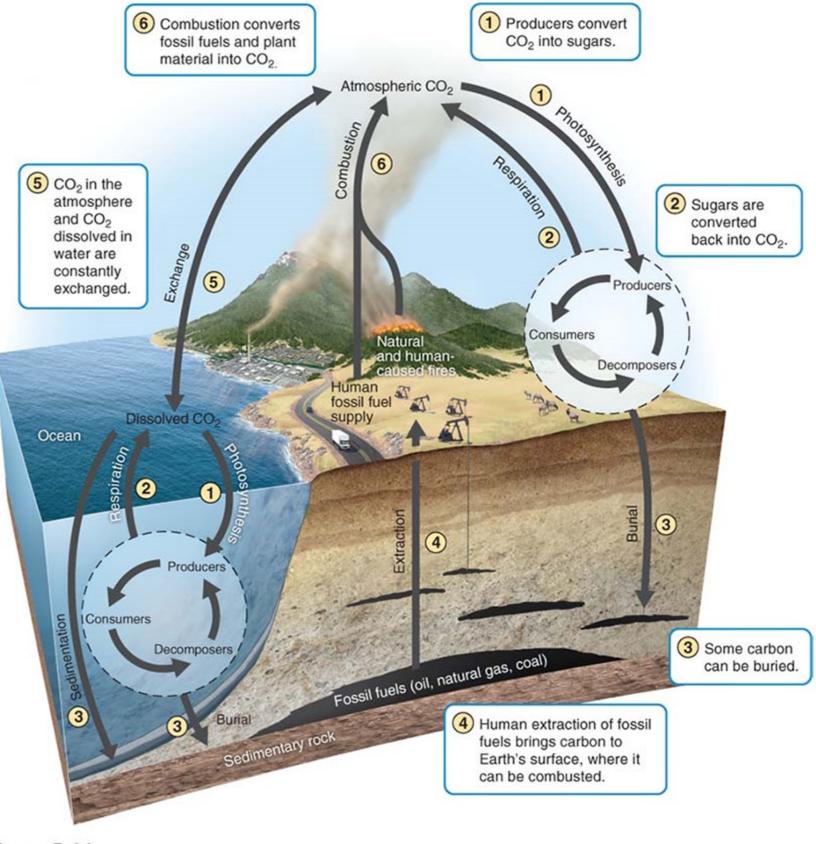
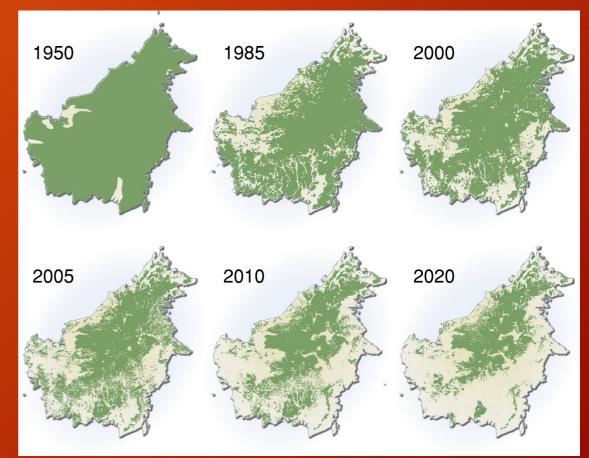


Figure 3.11 Environmental Science for AP® © 2012 W.H. Freeman and Company

### How do humans affect the carbon cycle?

- Burning fossil fuels puts more CO<sub>2</sub> into the atmosphere
- Deforestation is removing <u>carbon</u> <u>sinks</u>
- Soil tilling leads to rapid decomposition and oxidation of soil organic matter which releases CO<sub>2</sub> into the atmosphere

#### $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

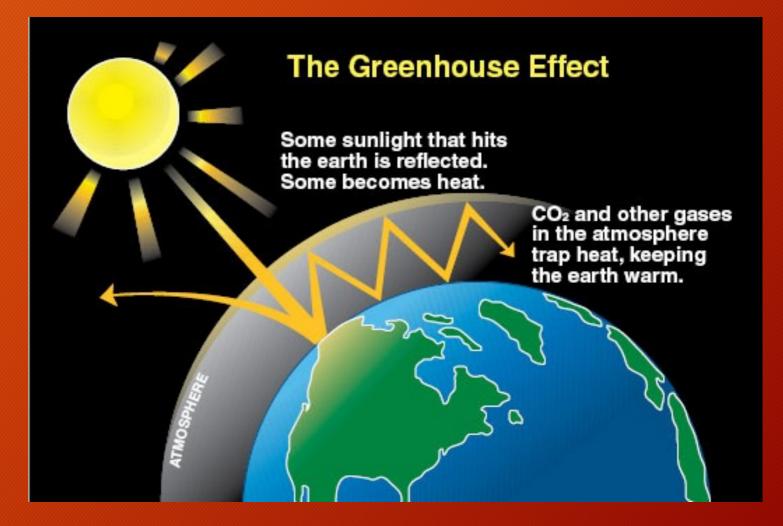


#### **Deforestation of Borneo**



## What are the negative effects of increasing atmospheric $CO_2$ ?

- CO<sub>2</sub> is a greenhouse gas
- Increasing atmospheric CO<sub>2</sub> traps heat from the sun and warms the surface of the earth



## The Phosphorus Cycle





 Phosphate is the body's source of chemical energy



Phosphorus

- Every metabolic action in the body requires chemical energy – adenosine triphosphate (ATP)
- Phosphate is a key building block for many essential intracellular compounds – nucleic acids, phospholipids, enzymes, nucleoproteins
- Is considered a <u>limiting factor</u> because plants will use up all the available phosphorus they

# What happens to phosphate in each of the following processes?

#### • Rock erosion

- Water carries inorganic phosphate (PO<sup>3-</sup><sub>4</sub>) into the soil
- Absorption and assimilation
  - Plants absorb phosphate through roots and animals get phosphate from their food - once in the cells phosphates are incorporated into biological molecules (nucleic acids and ATP)

#### Animal waste and decomposition

• Animal poo and phosphate release from decomposers releases inorganic phosphate into the soil

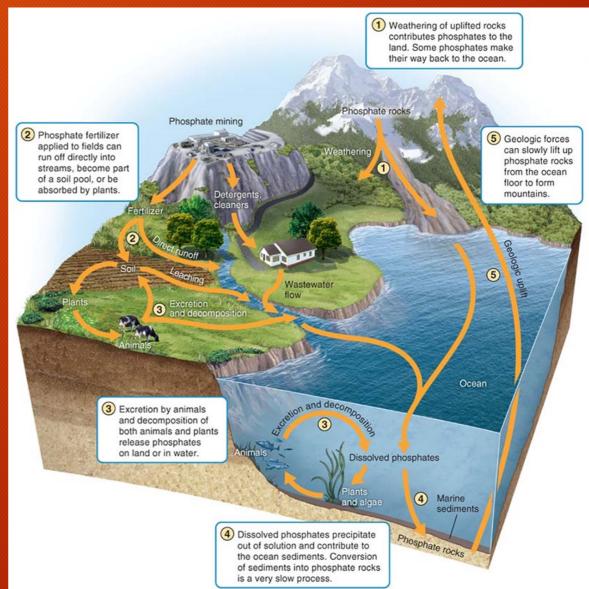
#### Burial and compaction

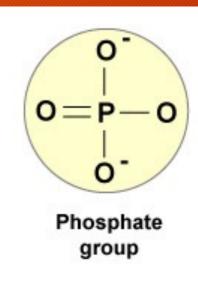
 Phosphates deposited on the seafloor and/or in soil can be compacted and buried where they may remain for millions of years

#### • <u>Geologic uplift</u>

 The movement of tectonic plates exposes buried and compacted phosphates in new land surfaces

- Where is phosphorus NOT cycling through?
  - The atmosphere!!!





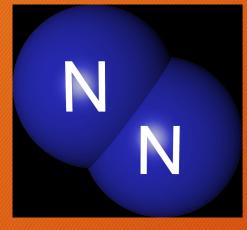
### How do humans affect the Phosphorous cycle? Eutrophication!

- Fertilizers containing phosphorous run off into bodies of water during storms creating excess phosphorus
- What's the first thing that happens?
  - Algae rapidly use up the phosphorous leading to an algae bloom
- What are the detrimental effects of an algae bloom?
  - Thick algae prevents light from reaching the bottom reducing photosynthesis
  - Benthic organisms die and provide dead organic matter to decomposers leading to more respiration (less oxygen)
  - Hypoxic conditions become toxic for all forms of aquatic life

What is this process called?Eutrophication

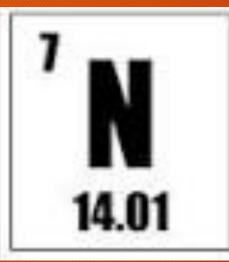


## Is there another nutrient that can cause eutrophication?





- Essential part of biological molecules (e.g. proteins and nucleic acids)
- Is considered a <u>limiting factor</u> because plants will use up all the available nitrogen they can find



# What happens to nitrogen in the following processes?

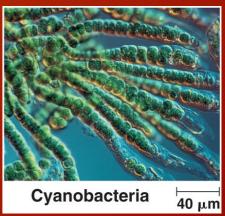
#### • Nitrogen Fixation

- Conversion of gaseous nitrogen to ammonia
- What processes can cause atmospheric nitrogen fixation?
  - Combustion, volcanic activity, and lightening provide enough energy to break apart atmospheric N<sub>2</sub>
- What processes in the soil and aquatic systems can cause nitrogen fixation?
  - Nitrogen-fixing bacteria use the enzyme <u>nitrogenase</u> to split N<sub>2</sub> and create NH<sub>3</sub>
  - Soil:
    - Rhizobium
  - Water:
    - cyanobacteria

$$N_2 + 8 H^+ + 8 e^- \longrightarrow 2 NH_3 + H_2$$

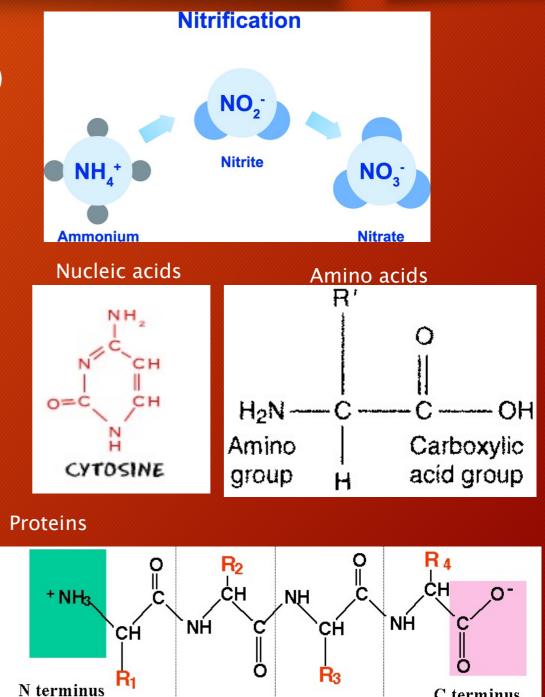






### What happens to nitrogen in the following processes?

- Nitrification
  - Conversion of ammonia  $(NH_3)$  or ammonium  $(NH_4)$ to nitrate
  - Two part process:
    - 1. Bacteria convert  $NH_3$  or  $NH_4^+$  to nitrite (NO<sub>2</sub>)
    - 2. Bacteria oxidize  $NO_2^{-1}$  to nitrate ( $NO_3^{-1}$ )
- Assimilation
  - Plant roots absorb NO<sup>-</sup><sub>3</sub>, NH<sub>3</sub>, or NH<sup>+</sup><sub>4</sub> and incorporate the nitrogen in these molecules into proteins and nucleic acids
  - Animals consuming plant tissues take plants nitrogen compounds (amino acids) and convert them to animal compounds (proteins)



C terminus

## What happens to nitrogen in the following processes?

#### <u>Ammonification</u>

- Conversion of biological nitrogen compounds into NH<sub>3</sub> and NH<sup>+</sup><sub>4</sub> ... which is pee pee!
- Also comes from decomposing organisms

#### • **Denitrification**

- The reduction of  $NO_3^{-1}$  to gaseous  $N_2^{-1}$
- Process performed by denitrifying bacteria which live where there is little to no oxygen







## The Nitrogen Cycle

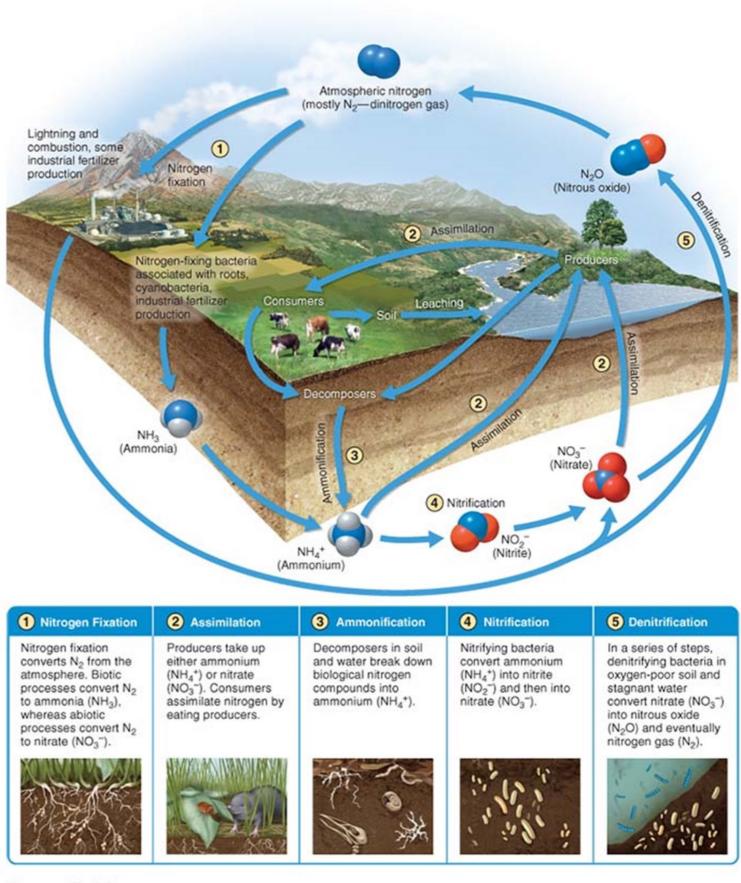


Figure 3.12 Environmental Science for AP® © 2012 W.H. Freeman and Company

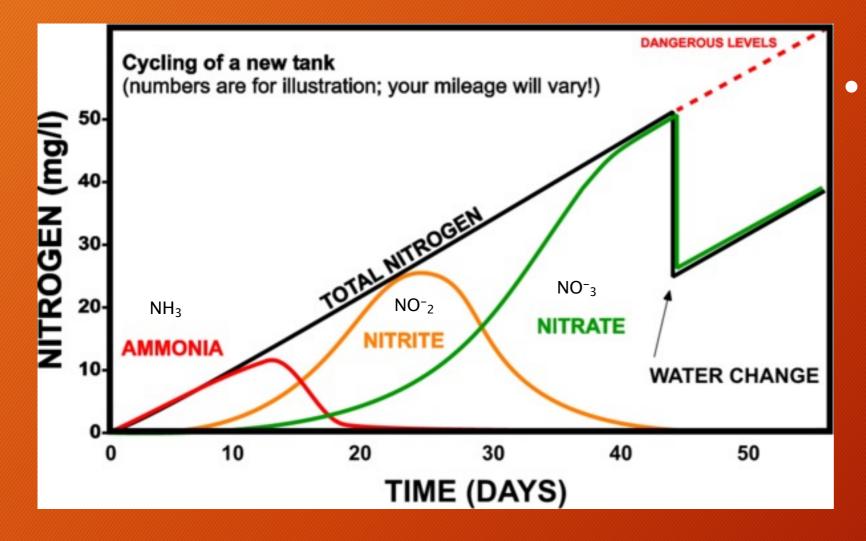
## Setting up the tank: What predictions can we make?



- So once we add our first fish to the tank, what nitrogen levels do you expect to see rise first, second, and third?
- Discuss with the person next to you and make a graph of your predictions:
  - Change in the levels of the 3 various forms of nitrogen over time
  - Think about how you will control NO<sup>-</sup><sub>3</sub> levels:
    - Denitrification requires bacteria that prefer to live where there is little to no oxygen so we won't have them in our tank and high levels of NO<sup>-</sup><sub>3</sub> can become very toxic to aquatic life!

HINT: 1)ammonification, 2)nitrification, 3)denitrification

## What does your graph look like?



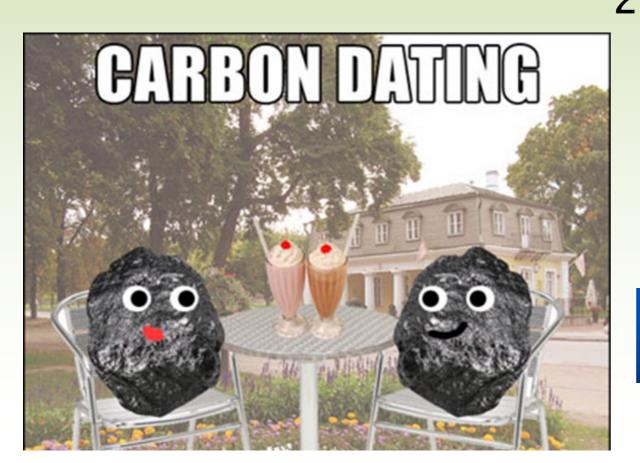
 Your homework is to graph the data on the handout of the levels in ammonia, nitrite, and nitrate from last year's fish tank

## Agenda:

- Complete Ch. 3 notes
- Class time for homework

### **Bell Work:**

1. Explain why organisms in higher trophic levels have smaller populations in terms of energy.

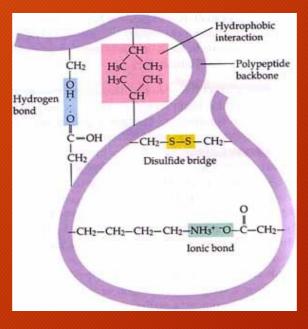


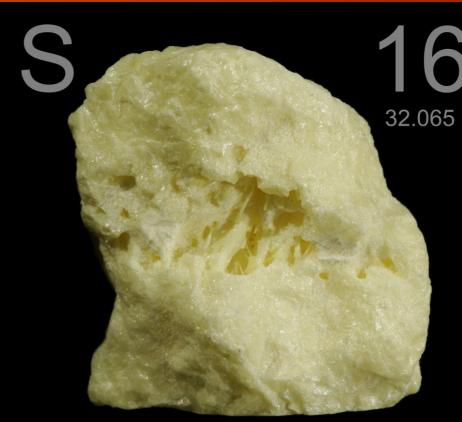
2. If you know the Net primary production and the rate of plant respiration of an ecosystem, how would you calculate gross primary production (GPP)?

## The Sulfur Cycle

- Why is sulfur important?
  - important part of proteins since it can be found in the some amino acids
  - Dimethyl sulfide (DMS) helps condense water into droplets in clouds
  - Mostly located in sedimentary rocks and minerals







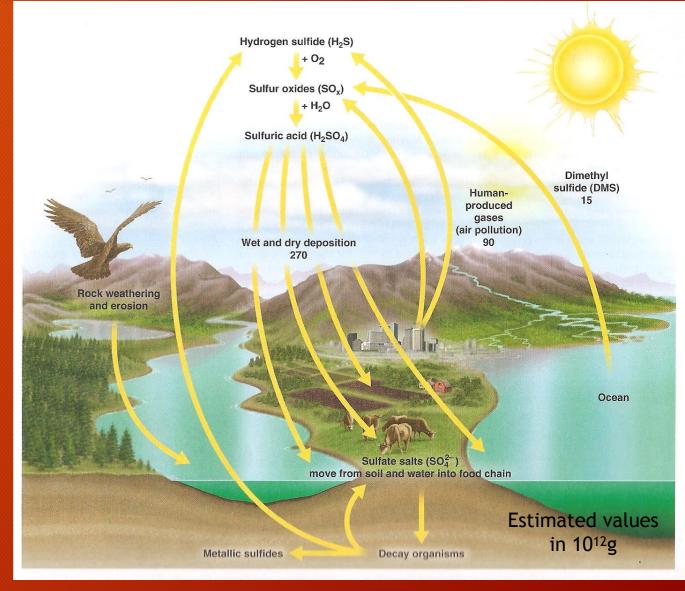


Sulfur

## The Sulfur Cycle

Scientists are still piecing together how the global sulfur cycle works! But here's what we know so far:

- Most of the global sulfur is in sedimentary rocks which erode over time to release sulfur-containing compounds into the ocean
- Sulfur is released into the atmosphere by sea spray, forest fires, dust storms, and volcanoes
- Very little sulfur present in the atmosphere but the movement of sulfur to and from the atmosphere is substantial
- Plants absorb sulfur from the soil and incorporate it into proteins and animals absorb sulfur from their food



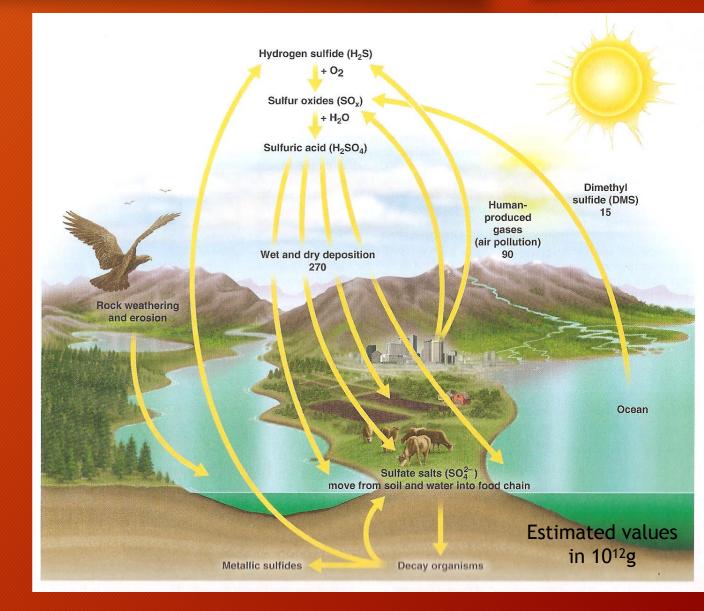
Scientists are still piecing together how the global sulfur cycle works! But here's what we know so far:

 Marine algae release large amounts of a compound that bacteria convert to dimethyl sulfide (DMS) which helps condense water into droplets in clouds

The Sulfur

Cycle

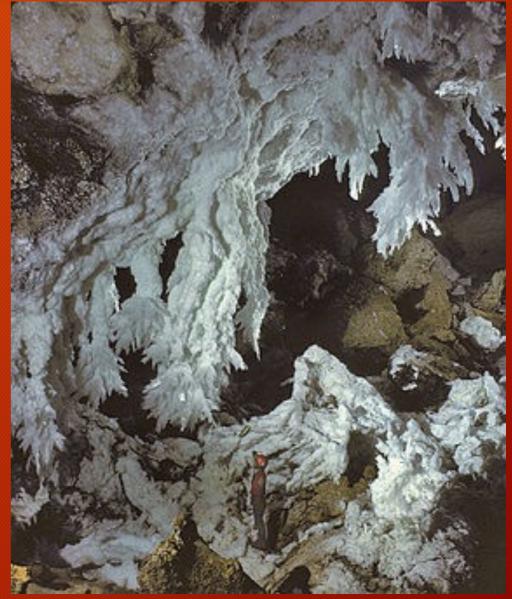
 In the atmosphere DMS is converted to sulfate, most of which is deposited in the ocean



# Why do you think we know so little about the sulfur cycle?



- Case in Point: Lechuguilla Cave
  - Eddy Country, New Mexico
  - 480m (1604ft) below sea level
  - Consists of lemon-yellow sulfur deposits and gypsum (CaSO<sub>4</sub>·2H<sub>2</sub>O) chandeliers
  - Took 2 years to acquire permission from local authorities for BBC's Planet Earth to film the caves and its unlikely a film crew will ever be allowed in the caves again



## Cave of Crystals AKA Giant Crystal Cave

- Chihuanaua, Mexico
- 300m (980ft) below sea level
- 58°C (136°F) and 90 99% humidity
  - Humans can only endure 10min. Of exposure in these conditions without proper equipment
- Consists of <u>giant</u> gypsum (CaSO<sub>4</sub>·2H<sub>2</sub>O) crystals (up to 55 tons!)
- Discovered in 2000 by miners mining operations kept the caves clear of water and accessible
- The crystals have stopped growing due to the removal of water and exposure to cool air
- Further exploration requires destroying the crystals







# What's that ancient form of photosynthesis in which organisms use hydrogen sulfide?

Chemosynthesis:  $12H_2S + 6CO_2 \longrightarrow C_6H_{12}O_6 + 6H_2O + 12S_6$ 

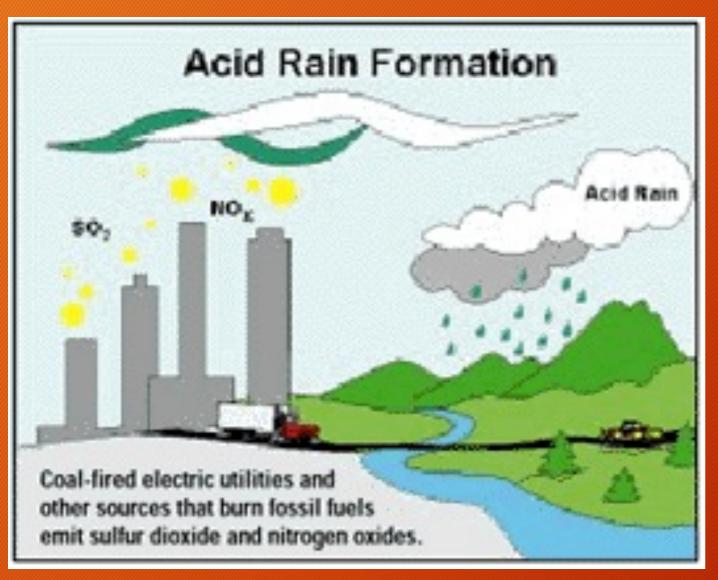


What organisms perform chemosynthesis?



- Theorized that life may have originated here:
  - It has been proposed that amino-acid synthesis could have occurred deep in the Earth's crust and that these amino-acids were subsequently shot up along with hydrothermal fluids into cooler waters, where lower temperatures and the presence of clay minerals would have fostered the formation of peptides.. The building blocks of life!!!

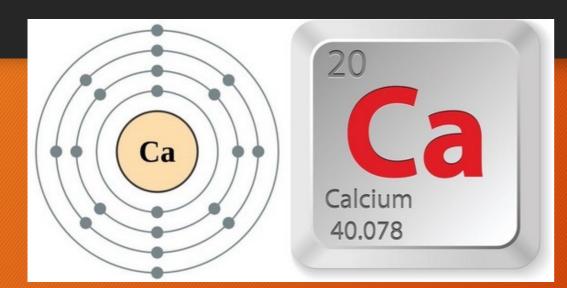
### How are Humans affecting the sulfur cycle?



 Emissions from these, along with nitrogen emissions, react with chemicals in the atmosphere
 → SULFATE SALTS → ACID RAIN

 Damage the natural environment (affects both plants and animals) as well as man-made environments (weathering/corrosion of buildings)

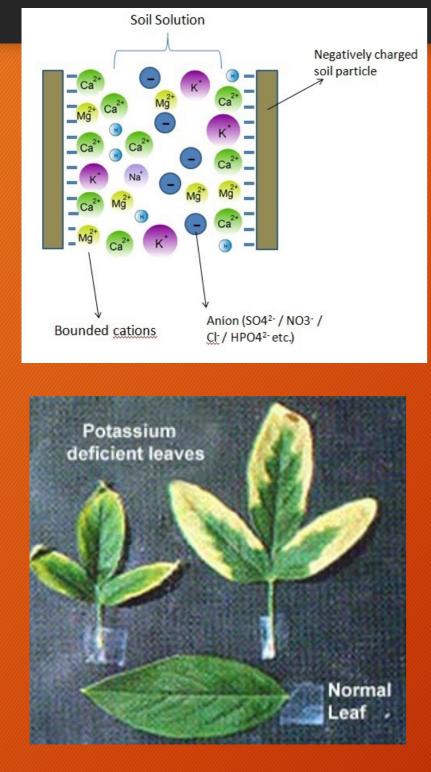
#### Calcium, Magnesium, and Potassium





- Macronutrients derived primarily from rocks and decomposed vegetation
- None present in gaseous phase but can be deposited from the air in small amounts as dust
- All 3 can be dissolved in water as positively charged ions:
  - Ca<sup>2+</sup>
  - Mg<sup>2+</sup>
  - K+

#### Calcium, Magnesium, and Potassium



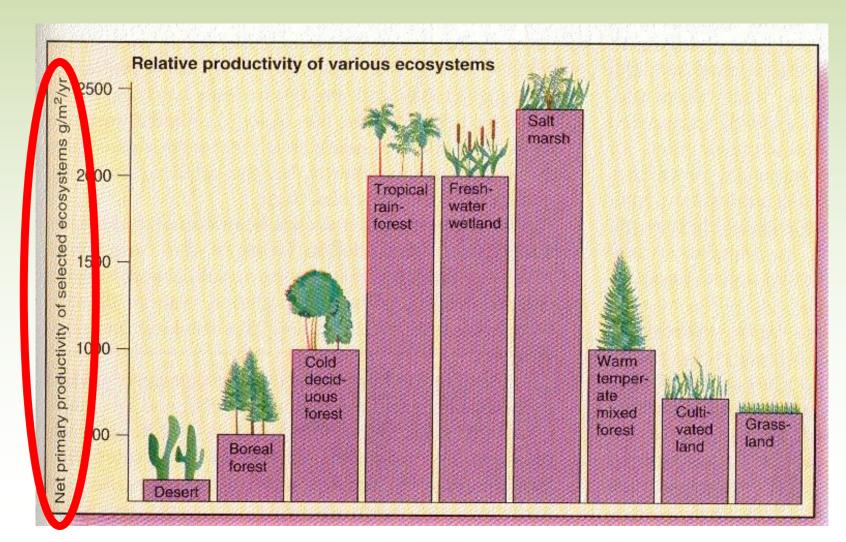




- Because of + charge they are attracted to - charges present on the surface of most soils
- Calcium and magnesium occur in high concentrations in limestone and marbles as well as the soils overlaying these rock types
- Potassium is only weakly attracted to soil particles and thus can be leached away by water
  - Leaching potassium can constraint the growth of plants and animals

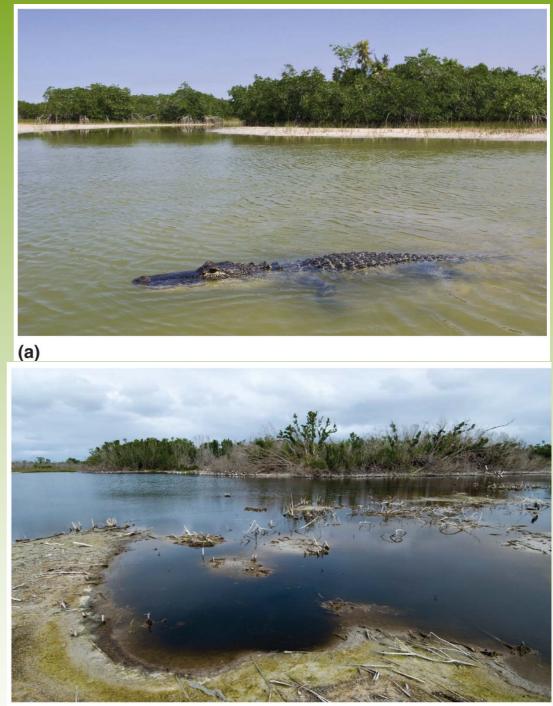
## **Ecosystem Productivity**

- **Gross primary productivity (GPP)-** The total amount of solar energy that the producers in an ecosystem capture via photosynthesis over a given amount of time.
- <u>Net primary productivity (NPP)-</u> The energy captured (GPP) *minus the energy respired* by producers.



## **Ecosystems respond to disturbance**

- Disturbance- An event caused by physical, chemical or biological agents that results in changes in population size or comunity composition.
- Natural: hurricanes, ice storms, tornados, etc.
  - Anthropogenic: human settlements, agriculture, air pollution, etc.



(b)

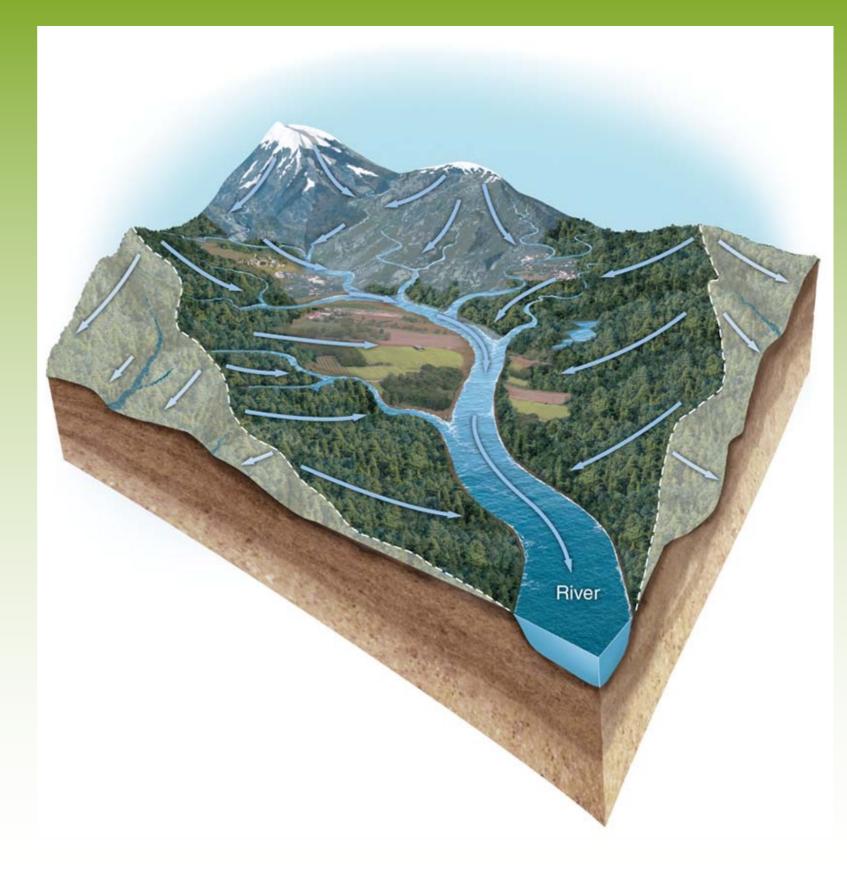
(a) Photo of Chandeleur Islands prior to Hurricane Katrina

(b) Photo of islands after Hurricane Katrina showing massive erosion and loss of sand dunes and vegetation

## Watershed Studies

## • Watershed- All of

the land in a given landscape that drains into a particular stream, river, lake or wetland.



## Resistance versus Resilience

- <u>Resistance-</u> A measure of how much a disturbance can affect its flows of energy and matter.
- <u>Resilience-</u> The rate at
  which an ecosystem
  returns to its original
  state after a disturbance.
- <u>High resistance example:</u>
   Disturbance influences
   populations and
   communities but has no
   effect on energy and
   matter flow
- High resilience example:
   After a disturbance
   ecosystem returns to the
   original flows of energy
   and matter rapidly

### Resistance versus Resilience

#### • <u>Restoration</u>

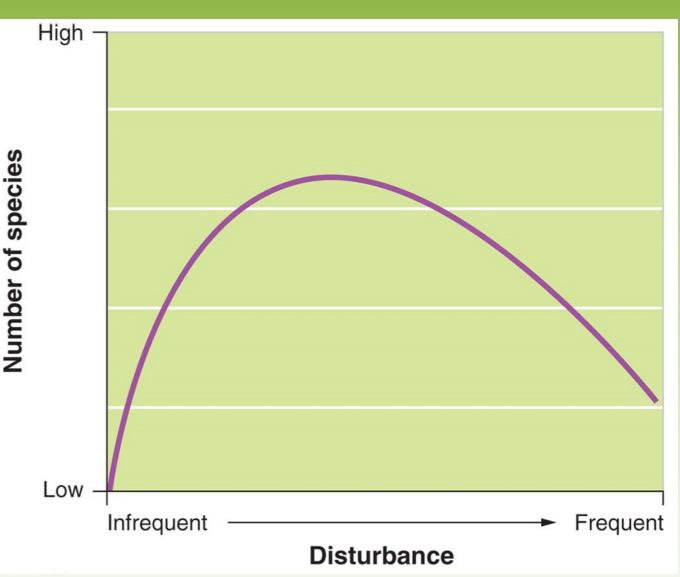
ecology- A new scientific discipline that is interested in restoring damaged ecosystems



Draining of wetlands can destroy a wetland ecosystem. Damage can be mitigated by using heavy machinery to build new wetlands that serve the same function.

# The Intermediate Disturbance Hypothesis

• The intermediate disturbance hypothesis- states that ecosystems experiencing intermediate levels of disturbance are more diverse than those with high or low disturbance levels.

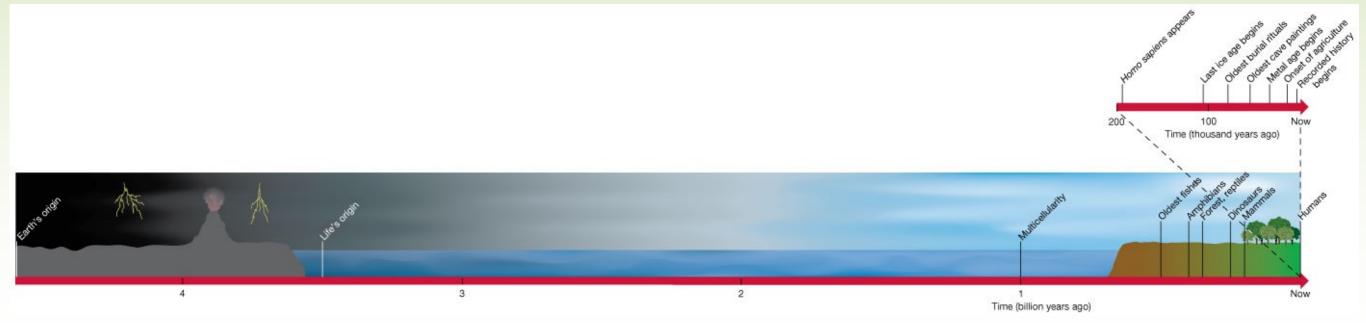


Rare disturbances favor the best competitors which outcompete other species. Frequent disturbances eliminate most species except those that have evolved to live under such conditions. At intermediate levels of disturbance, species from both extremes can persist.

## **Ecosystems Provide Valuable Services**

- Instrumental value it has worth as an instrument or tool that can be used to accomplish a goal
- Intrinsic value it has worth independent of any benefit it may provide to humans
  - Relative to the origin of the earth 4.5 billion years ago, how long have humans been here?





- <u>**Provisions-</u>** Goods that humans can use directly.</u>
- Lumber, food crops, medicinal plants, natural rubber, and furs
  - Bark of Pacific Yew contains a chemical with anti-cancer properties



- <u>Regulating services-</u> The service provided by natural systems that helps regulate environmental conditions.
  - Tropical rainforests play a major role in regulating the amount of carbon in the atmosphere



**Figure 3.21** Environmental Science for AP® John Pontier/Earth Scenes/Animals Animals

- Support systems- The support services that natural ecosystems provide such as pollination, natural filters and pest control.
  - Pollinators such as the honeybee play an essential role in ensuring the pollination of food crops such as cherries



Figure 3.22 Environmental Science for AP® Steffan and Alexandra Sailer/Ardea/Earth Scenes/Animals Animals

#### • Cultural services-

Ecosystems provide cultural or aesthetic benefits to many people.

Grand Tetons National
 Park provides
 aesthetic beauty
 valued by humans



**Figure 3.24** Environmental Science for AP® Buddy Mays/Corbis





