Bell Work:

Agenda:

- Continue notes
- Class time for homework
- Class time for exam corrections

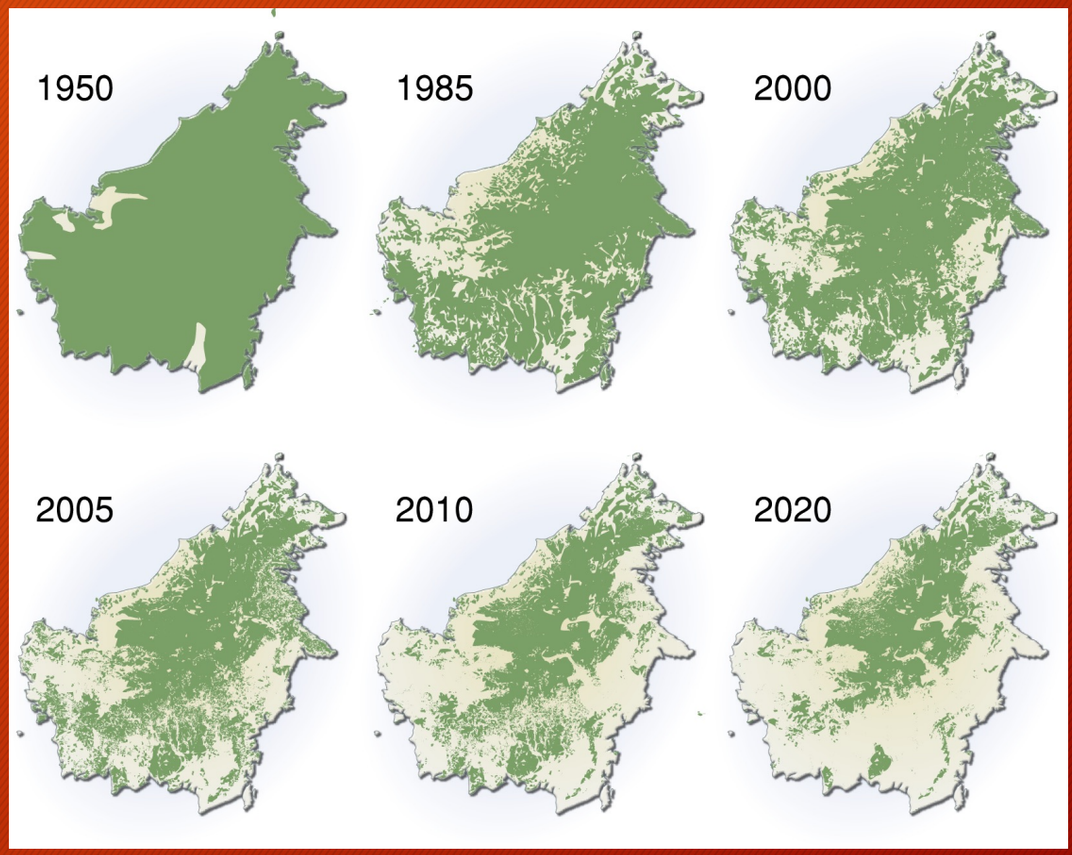
How do humans affect the carbon cycle?

- Burning fossil fuels puts more CO_2 into the atmosphere

- Deforestation is removing <u>carbon sinks</u>

- Soil tilling leads to rapid decomposition and oxidation of soil organic matter which releases CO_2 into the atmosphere

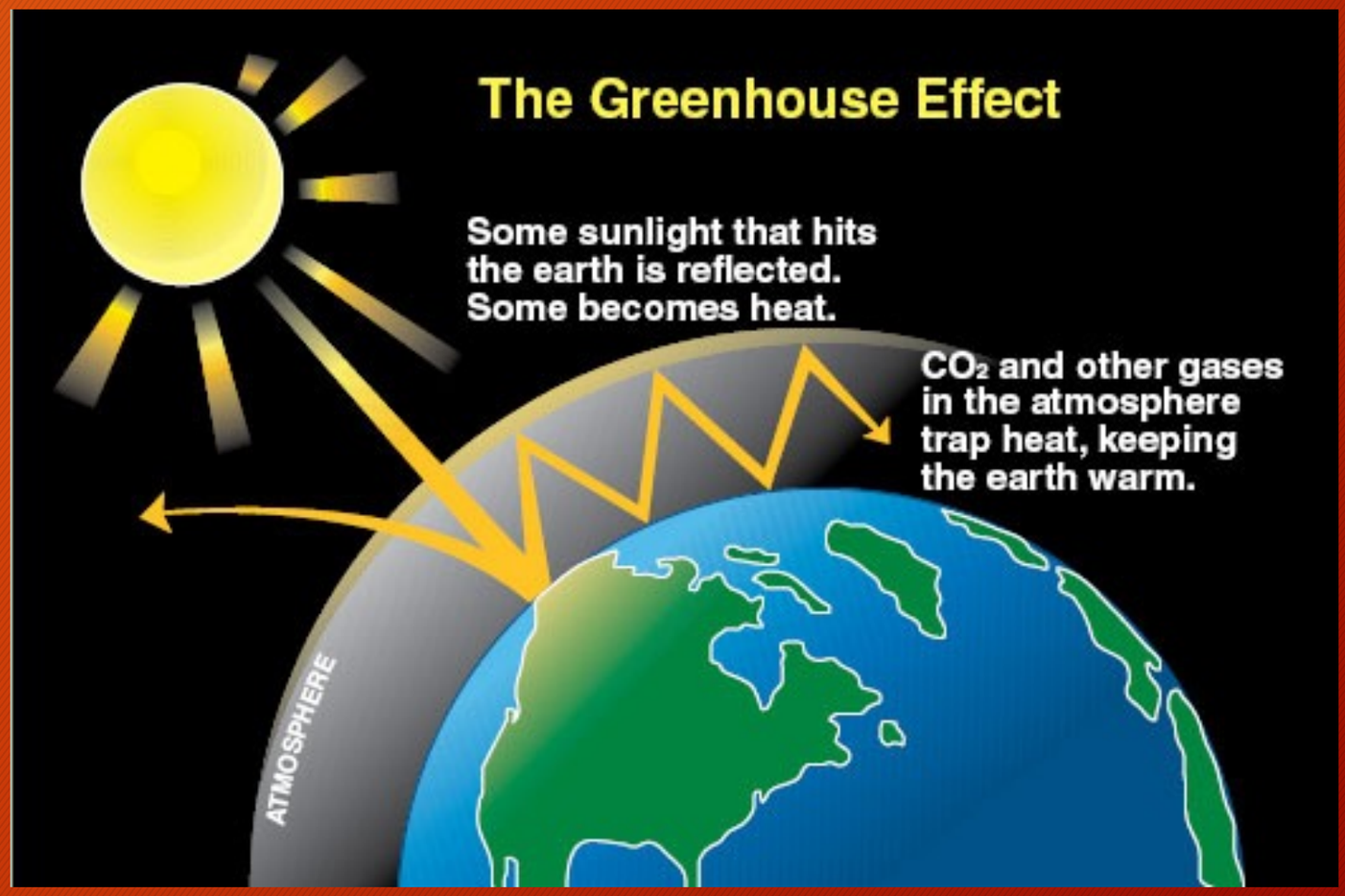
$$CH_4 + 2\,O_2 \longrightarrow CO_2 + 2\,H_2O$$



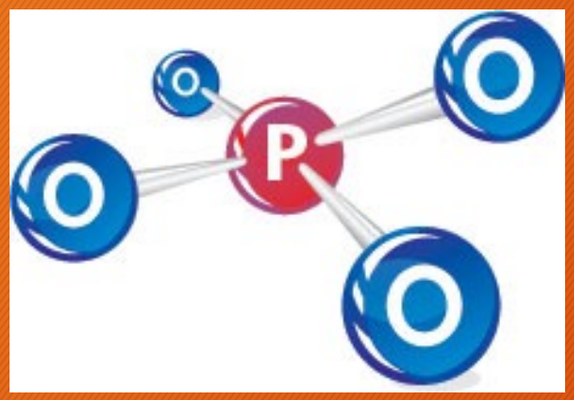
Deforestation of Borneo

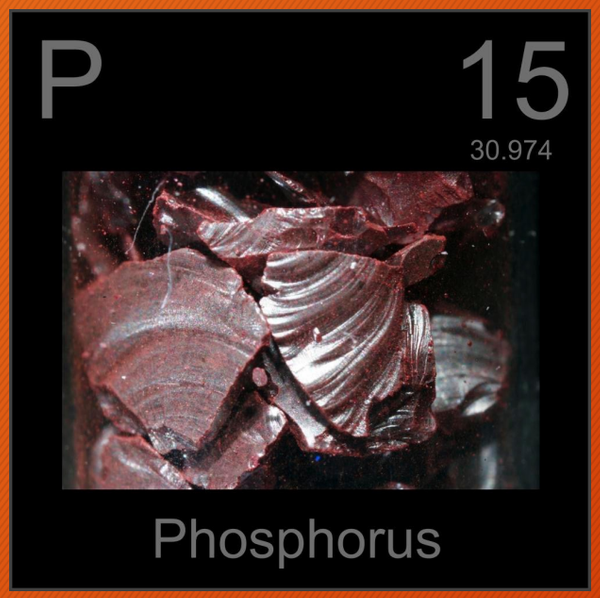
What are the negative effects of increasing atmospheric CO_2?

- CO_2 is a <u>greenhouse gas</u>
- Increasing atmospheric CO_2 traps heat from the sun and warms the surface of the earth



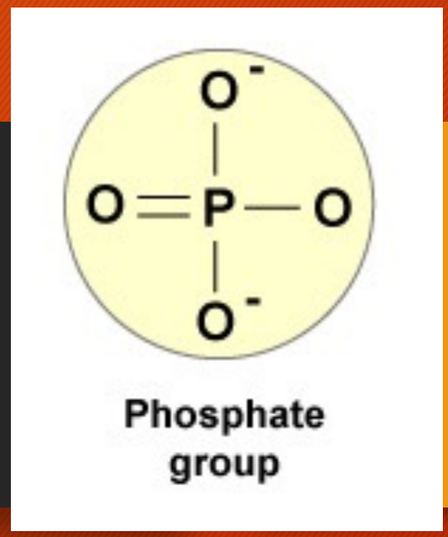
The Phosphorus Cycle





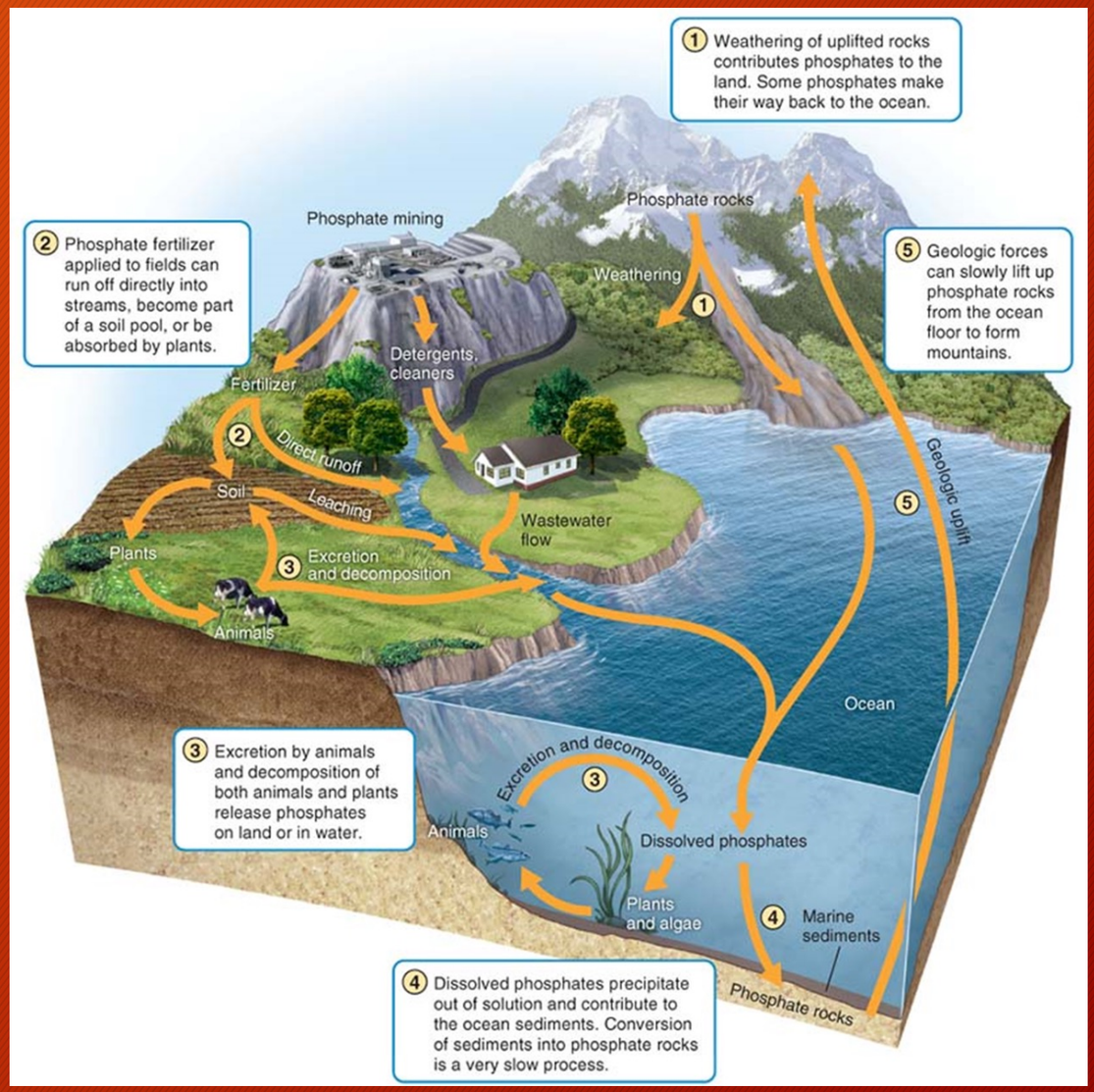
- Why is phosphate so important?
  - Phosphate is the body's source of chemical energy
  - Every metabolic action in the body requires chemical energy – adenosine triphosphate (ATP)
  - Phosphate is a key building block for many essential intracellular compounds – nucleic acids, phospholipids, enzymes, nucleoproteins
  - Is considered a **limiting factor** because plants will use up all the available phosphorus they

What happens to phosphate in each of the following processes?



- <u>Rock erosion</u>
  - Water carries inorganic phosphate (PO^{3-}_4) into the soil
- <u>Absorption and assimilation</u>
  - 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)
- <u>Animal waste and decomposition</u>
  - Animal poo and phosphate release from decomposers releases inorganic phosphate into the soil
- <u>Burial and compaction</u>
  - 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

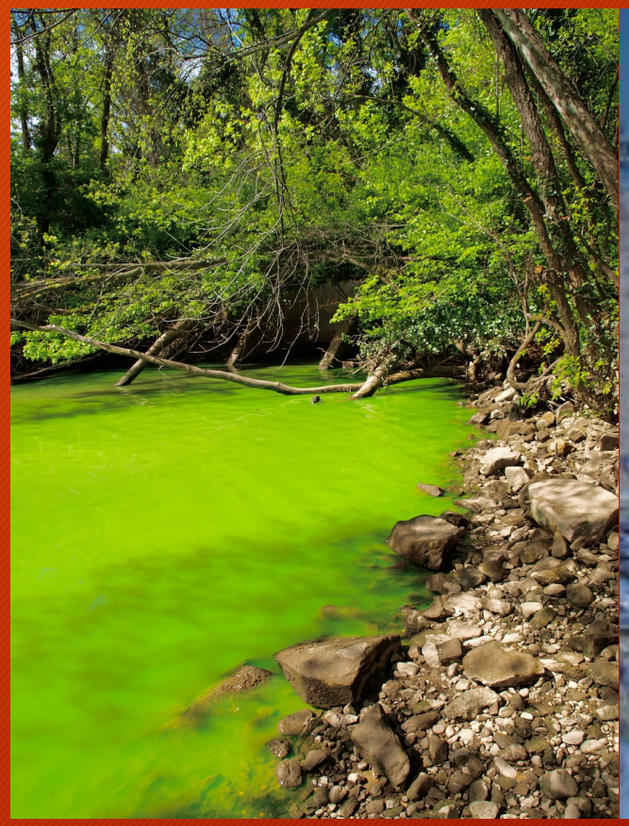
- Where is phosphorus NOT cycling through?
  - The atmosphere!!!



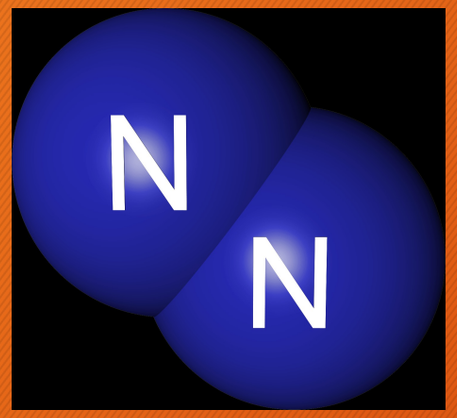
How do humans affect the Phosphorous cycle? Eutrophication!

- 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

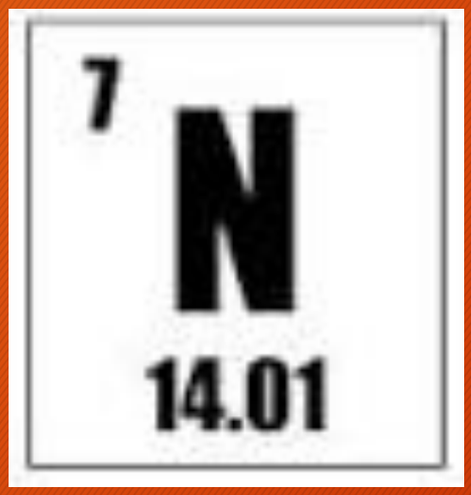
- What is this process called?
  - Eutrophication



Is there another nutrient that can cause eutrophication?



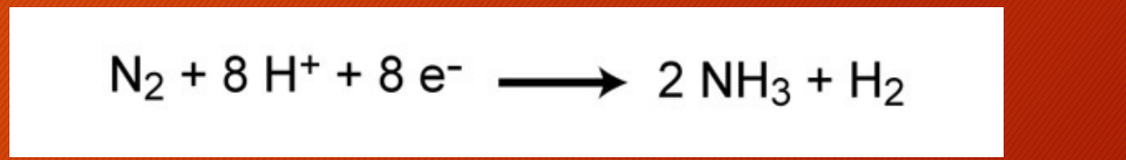
- Why is nitrogen important?
  - Essential part of biological molecules (e.g. proteins and nucleic acids)



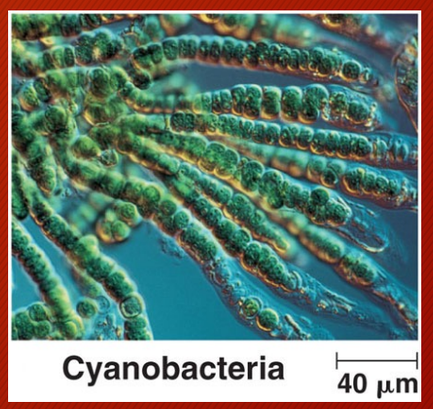
- Is considered a **<u>limiting factor</u>** because plants will use up all the available nitrogen they can find

What happens to nitrogen in the following processes?

- <u>Nitrogen Fixation</u>
  - 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_2

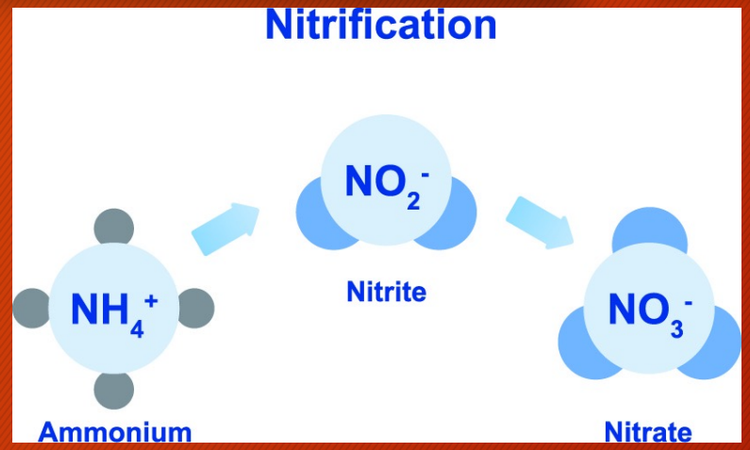


- What processes in the soil and aquatic systems can cause nitrogen fixation?
  - Nitrogen-fixing bacteria use the enzyme <u>nitrogenase</u> to split N_2 and create NH_3
  - Soil:
    - Rhizobium
  - Water:
    - cyanobacteria



What happens to nitrogen in the following processes?

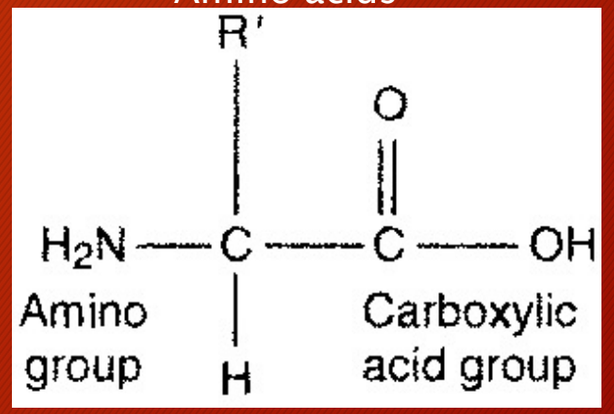
- <u>Nitrification</u>
  - Conversion of ammonia (NH_3) or ammonium (NH^+_4) to nitrate
  - Two part process:
    1. Bacteria convert NH_3 or NH^+_4 to nitrite (NO^-_2)
    2. Bacteria oxidize NO^-_2 to nitrate (NO^-_3)



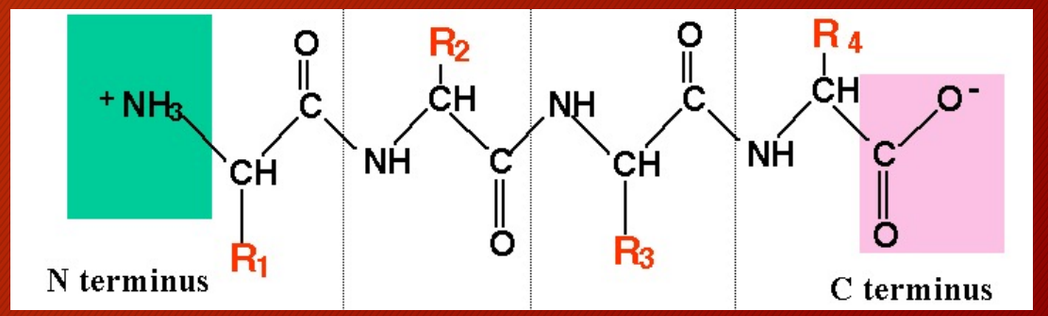
- <u>Assimilation</u>
  - Plant roots absorb NO^-_3, NH_3, or NH^+_4 and incorporate the nitrogen in these molecules into proteins and nucleic acids
  - Animals consuming plant tissues take plants nitrogen compounds (amino acids) and convert them to animal compounds (proteins)

Nucleic acids

Amino acids



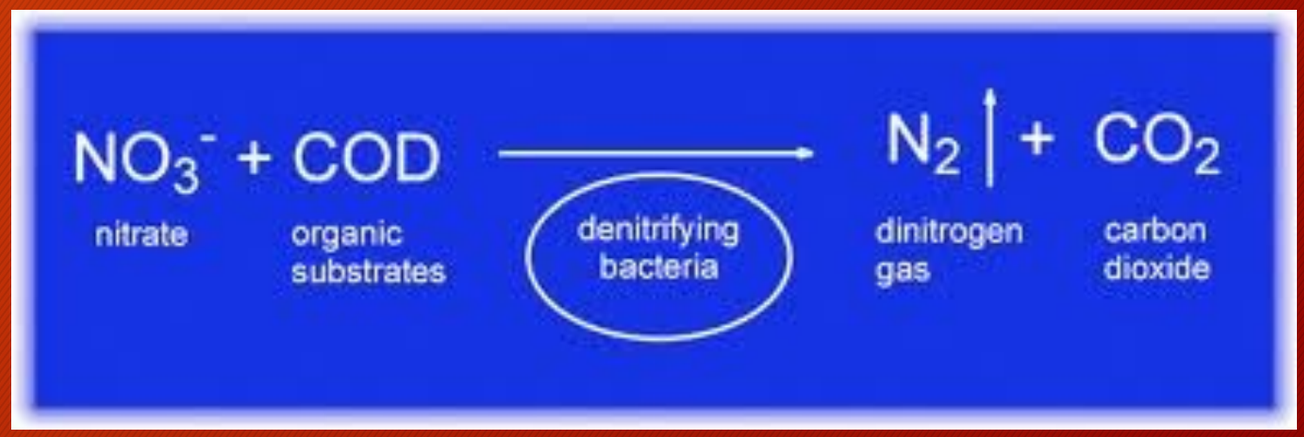
Proteins



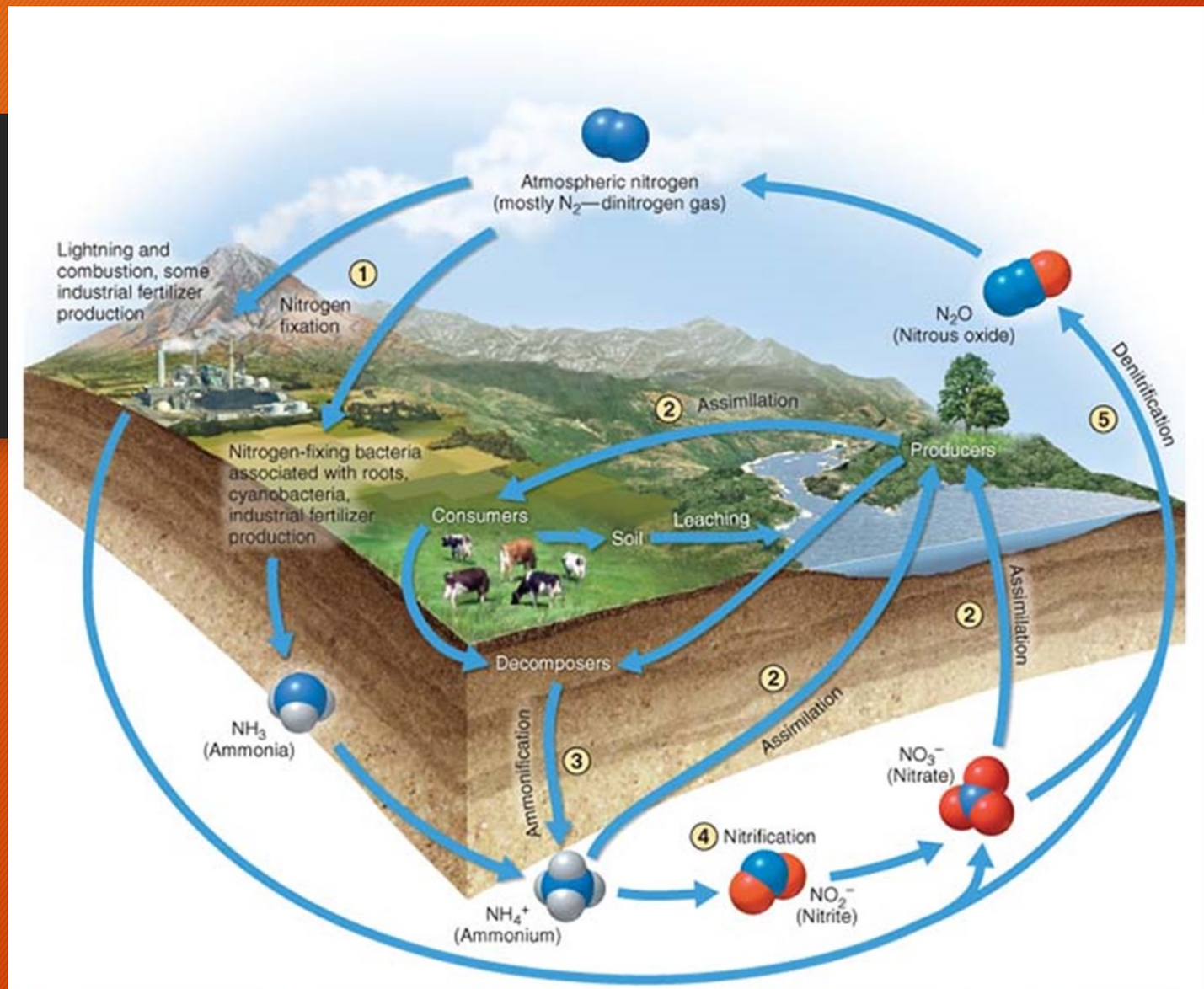
What happens to nitrogen in the following processes?

- <u>Ammonification</u>
  - Conversion of biological nitrogen compounds into NH_3 and NH^+_4 … which is pee pee!
  - Also comes from decomposing organisms

- <u>Denitrification</u>
  - The reduction of NO^-_3 to gaseous N_2
  - Process performed by denitrifying bacteria which live where there is little to no oxygen



The Nitrogen Cycle



1 Nitrogen Fixation	2 Assimilation	3 Ammonification	4 Nitrification	5 Denitrification
Nitrogen fixation converts N_2 from the atmosphere. Biotic processes convert N_2 to ammonia (NH_3), whereas abiotic processes convert N_2 to nitrate (NO_3^-).	Producers take up either ammonium (NH_4^+) or nitrate (NO_3^-). Consumers assimilate nitrogen by eating producers.	Decomposers in soil and water break down biological nitrogen compounds into ammonium (NH_4^+).	Nitrifying bacteria convert ammonium (NH_4^+) into nitrite (NO_2^-) and then into nitrate (NO_3^-).	In a series of steps, denitrifying bacteria in oxygen-poor soil and stagnant water convert nitrate (NO_3^-) into nitrous oxide (N_2O) and eventually nitrogen gas (N_2).
				

Figure 3.12
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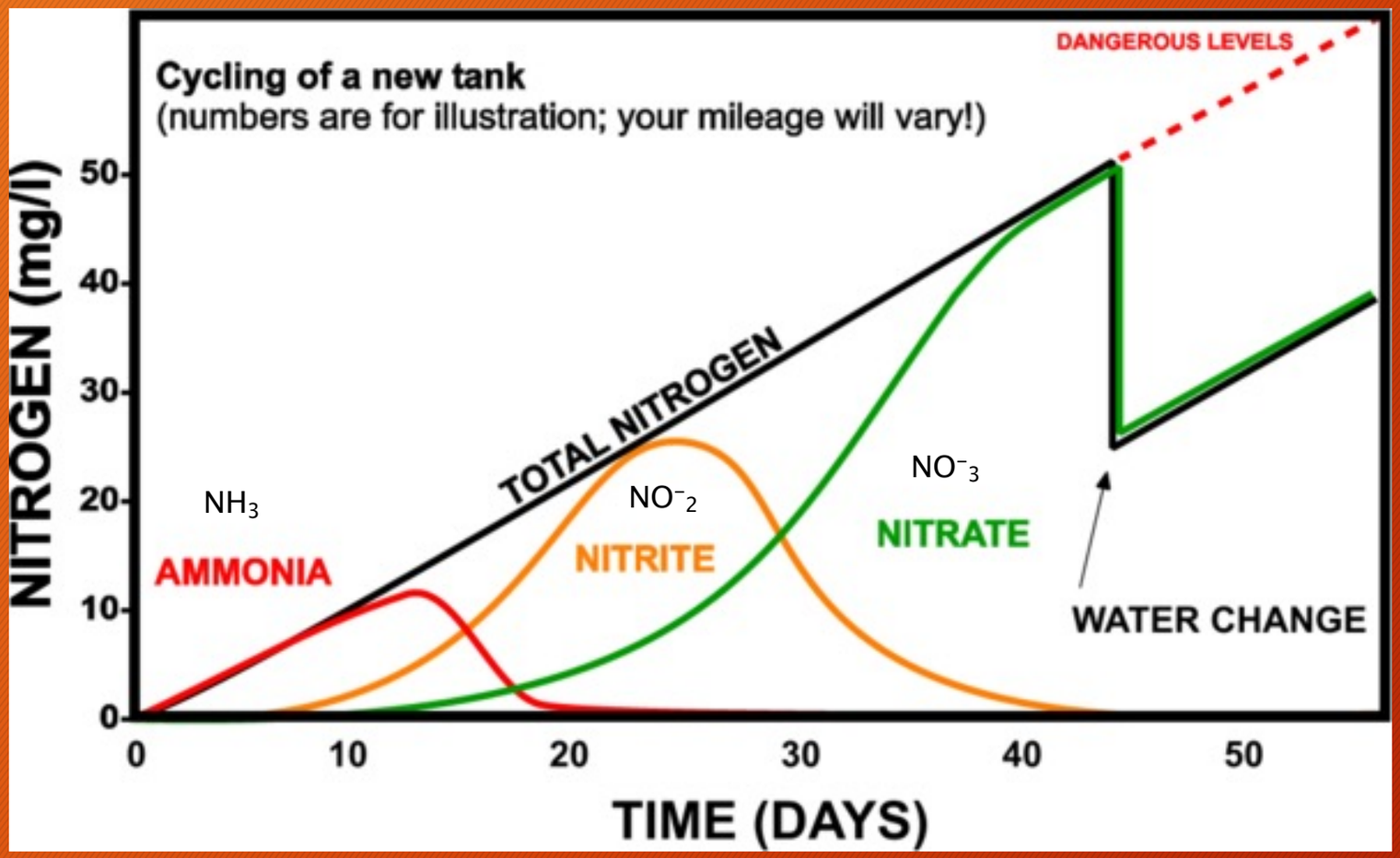
Setting up the tank: What predictions can we make?

- 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^-_3 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^-_3 can become very toxic to aquatic life!

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

What does your graph look like?

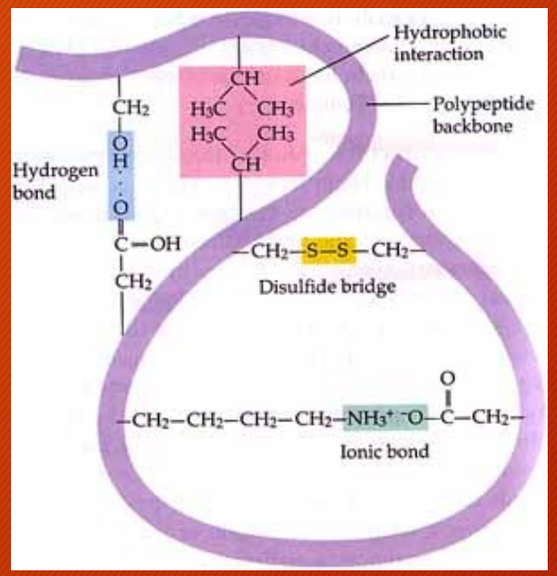


- Your homework is to graph the data on the handout of the levels in ammonia, nitrite, and nitrate from last year's fish tank

The Sulfur Cycle

- Why is sulfur important?
  - important part of proteins since it can be found in the some amino acids

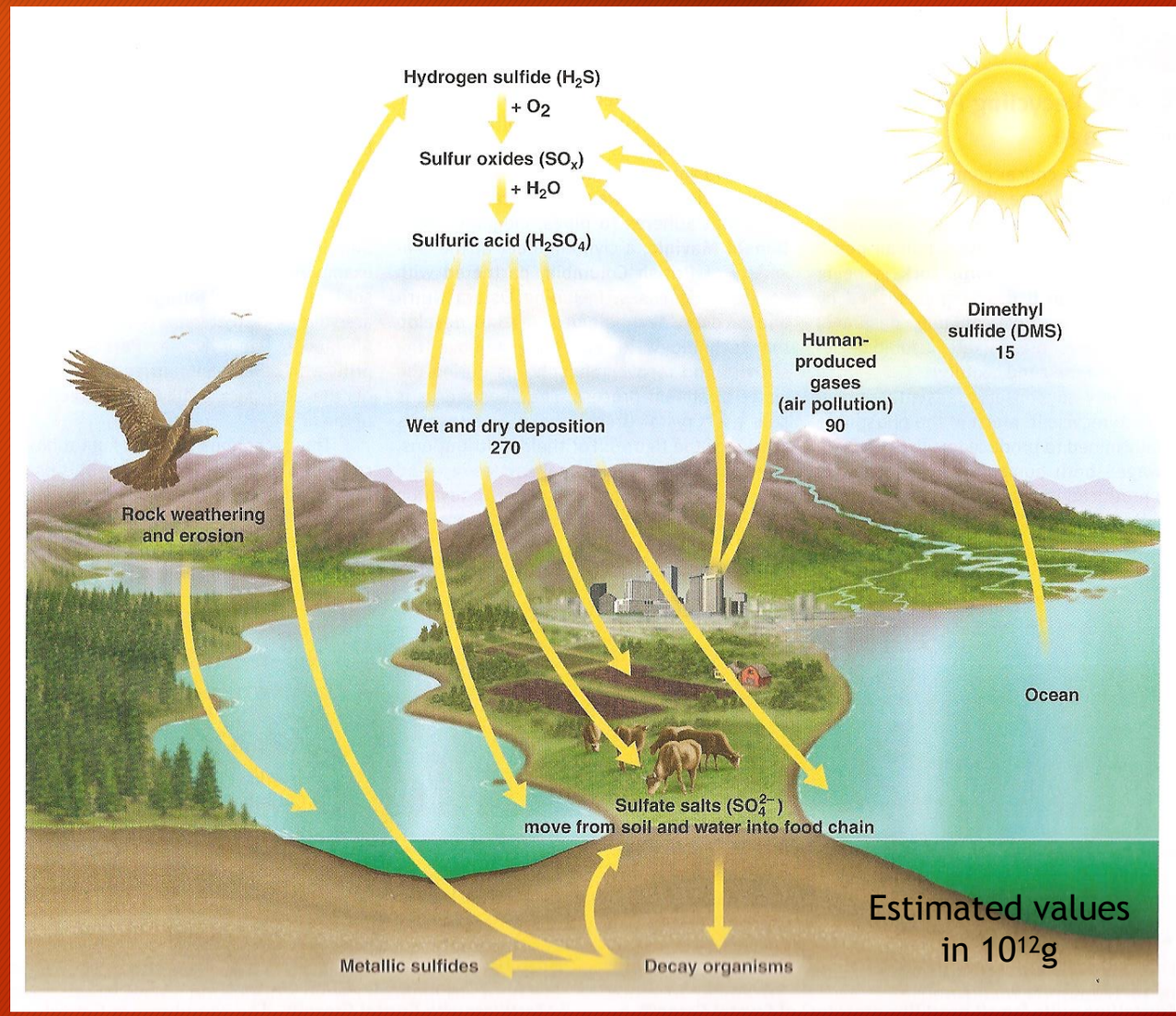
- Dimethyl sulfide (DMS) helps condense water into droplets in clouds
- Mostly located in sedimentary rocks and minerals



The Sulfur Cycle

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

- **<u>Most of the global sulfur is in sedimentary rocks</u>** 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

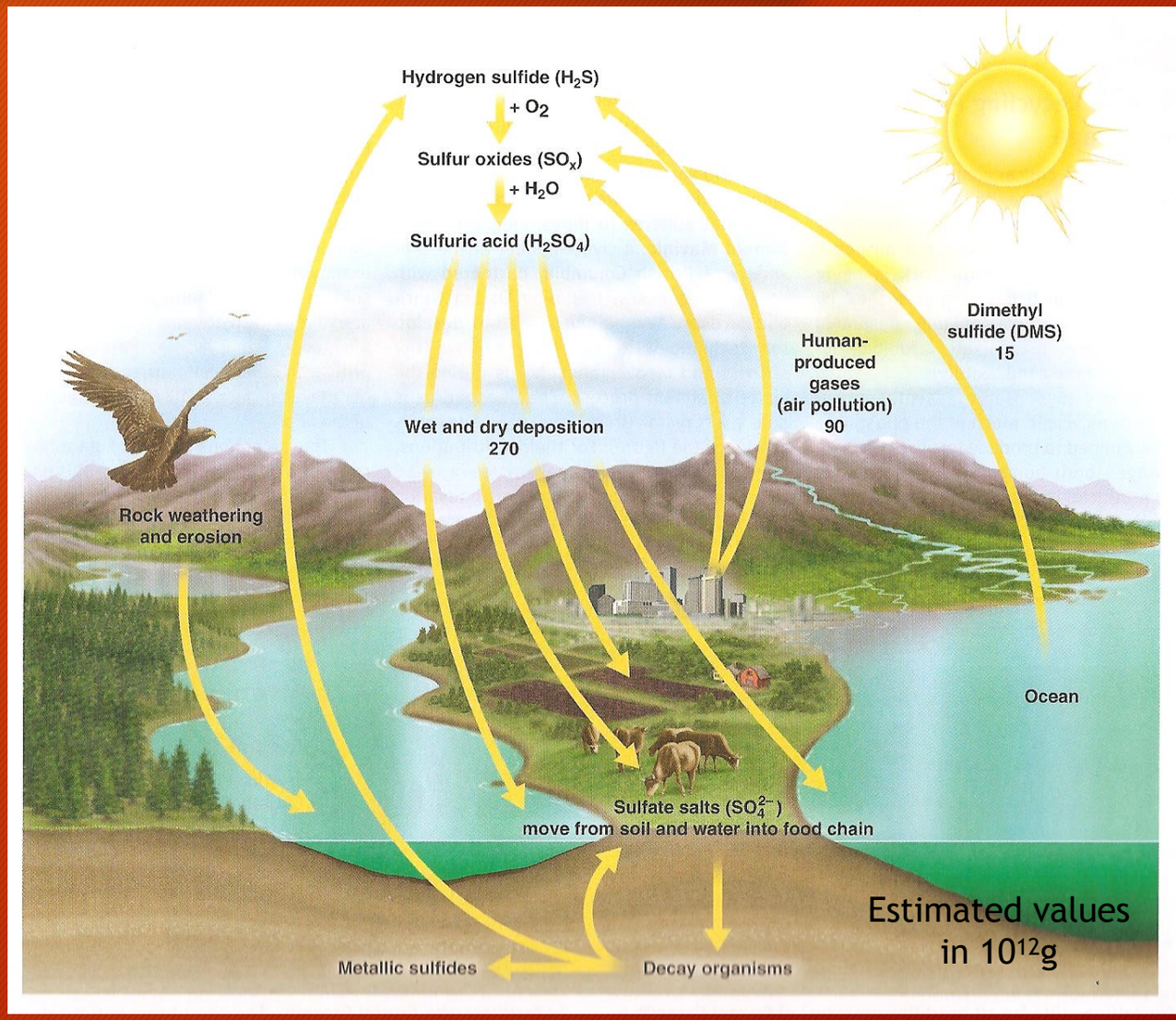


The Sulfur Cycle

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

- 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 ($CaSO_4 \cdot 2H_2O$) 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 ($CaSO_4 \cdot 2H_2O$) 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?

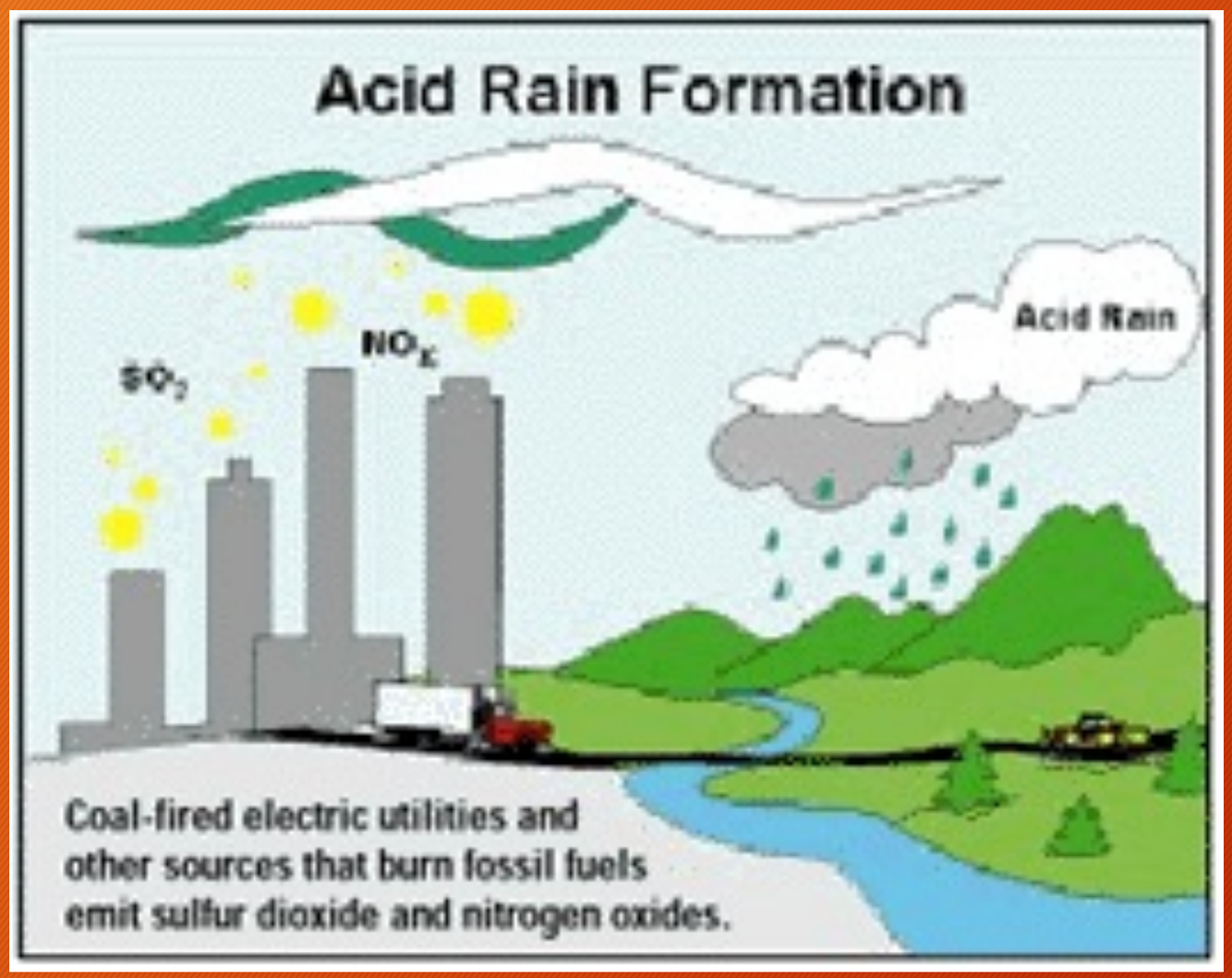
Chemosynthesis:

$12H_2S + 6CO_2 \longrightarrow C_6H_{12}O_6 + 6H_2O + 12S$

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?

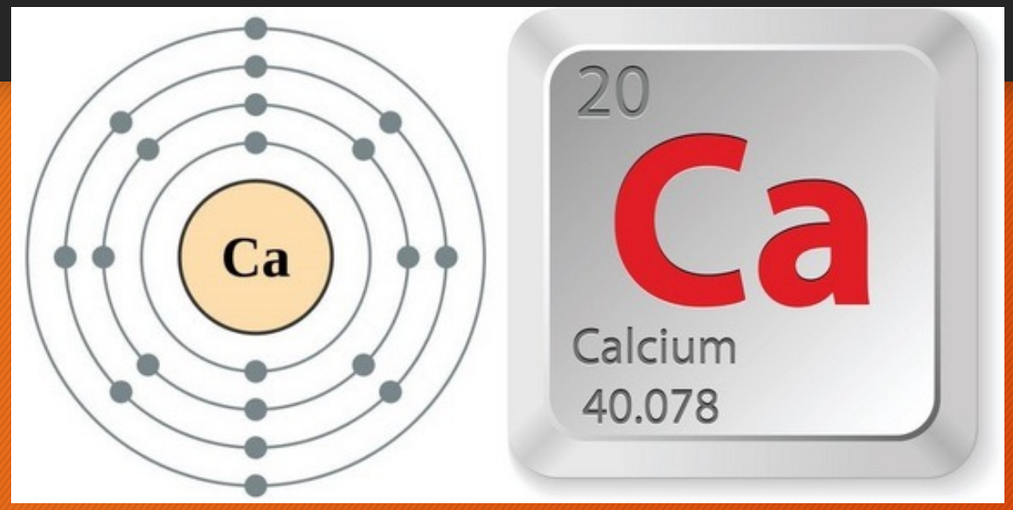


- Emissions from these, along with nitrogen emissions, react with chemicals in the atmosphere

  → SULFATE SALTS → ACID RAIN

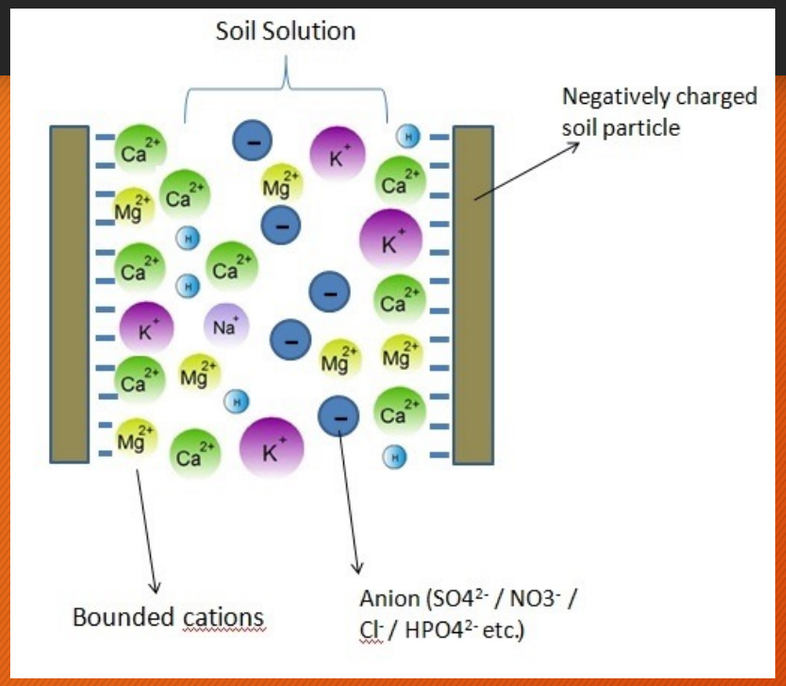
- Damage the natural environment (affects both plants and animals) as well as man-made environments (weathering/corrosion of buildings)

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^{2+}
  - Mg^{2+}
  - K^{+}

Calcium, Magnesium, and Potassium

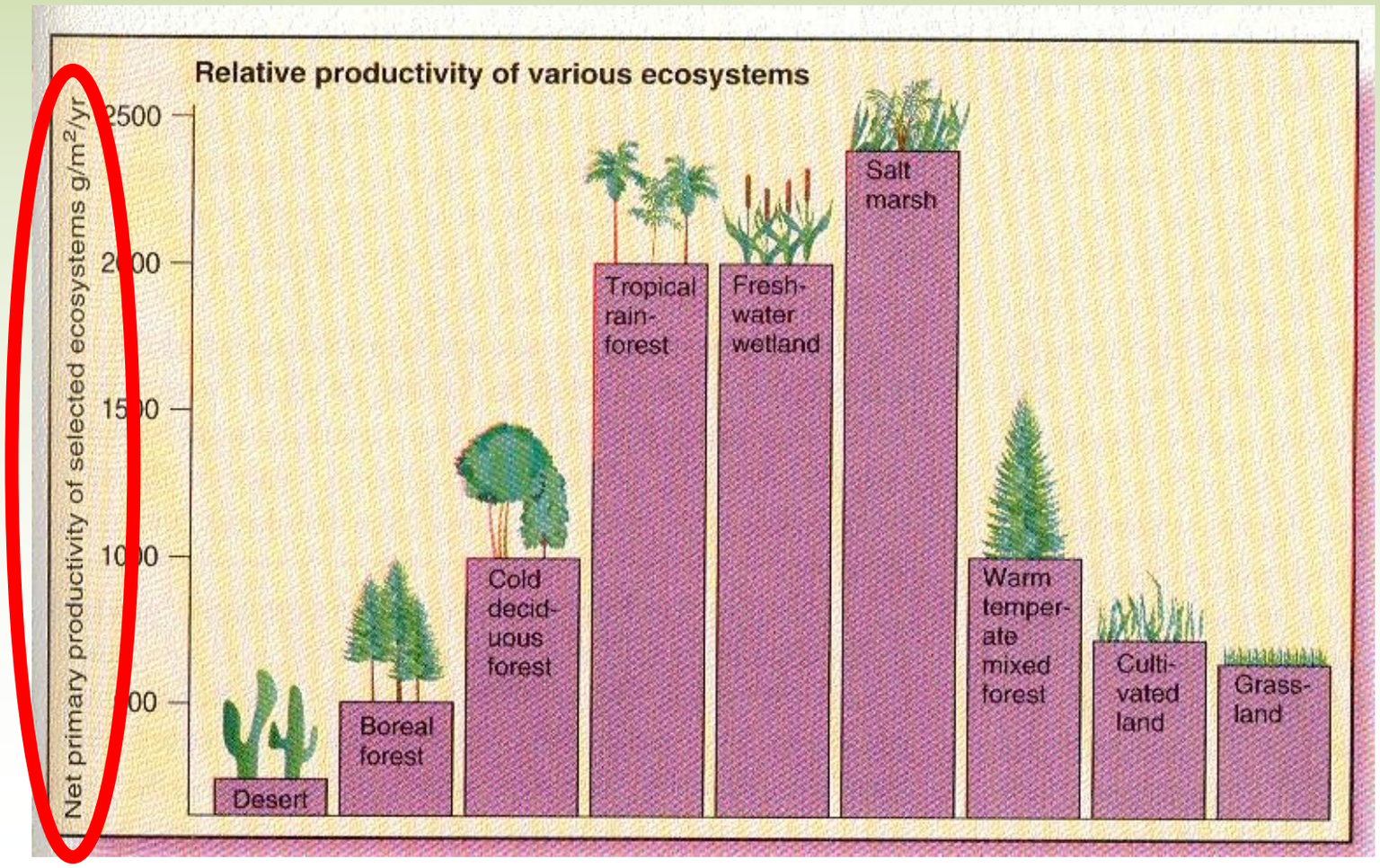


- Because of + charge they are attracted to – charges present on the surface of most soils
- Calcium and magnesium occur in high concentrations in limestone and marbles as well as the soils overlaying these rock types
- Potassium is only weakly attracted to soil particles and thus can be leached away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

Ecosystem Productivity

- **<u>Gross primary productivity (GPP)-</u>** 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.

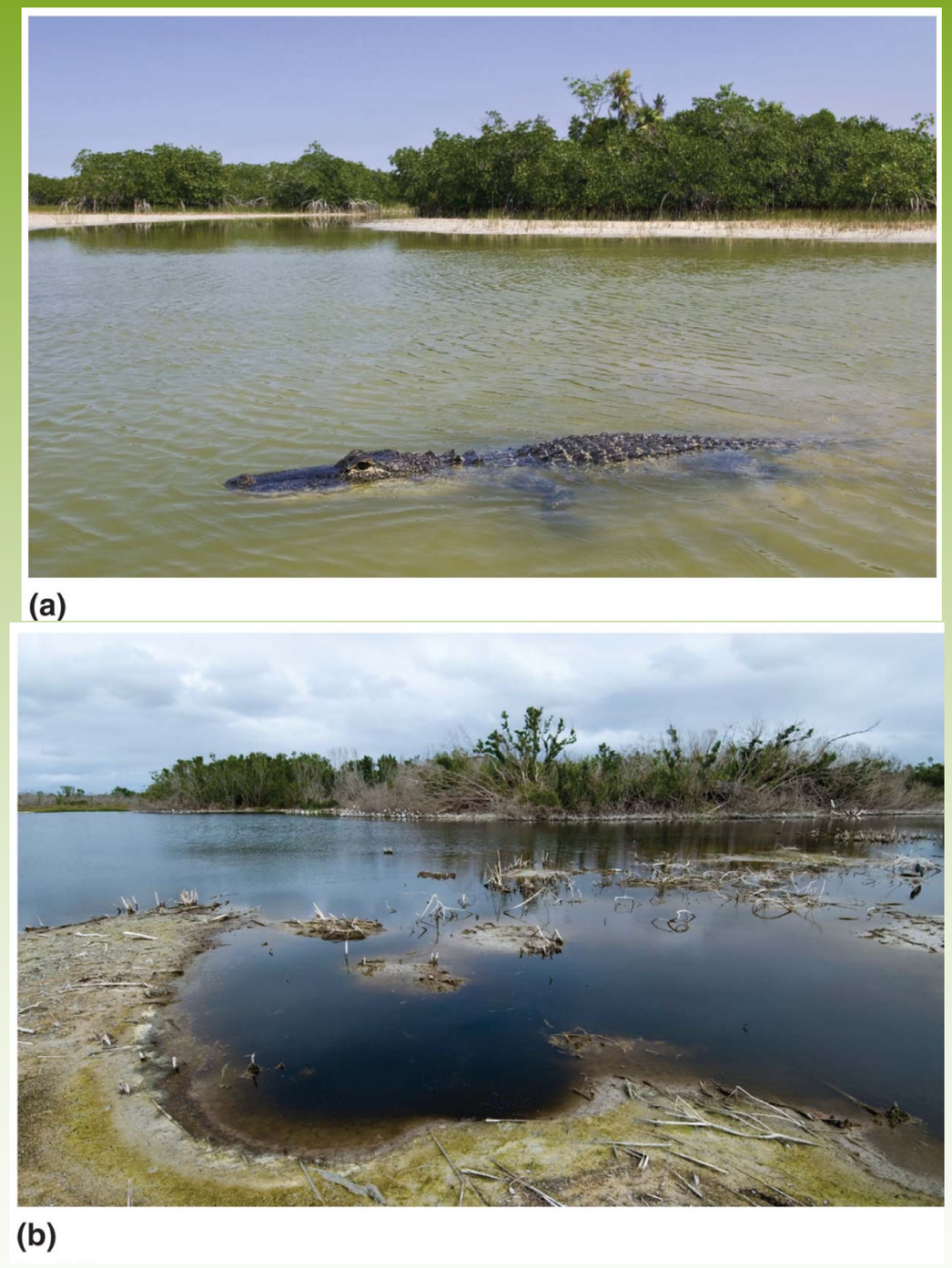


Ecosystems respond to disturbance

- **Disturbance-** An event caused by physical, chemical or biological agents that results in changes in population size or community composition.

- Natural: hurricanes, ice storms, tornados, etc.

- Anthropogenic: human settlements, agriculture, air pollution, etc.



(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

- **<u>Watershed-</u>** All of the land in a given landscape that drains into a particular stream, river, lake or wetland.

Resistance versus Resilience

- **Resistance-** A measure of how much a disturbance can affect its flows of energy and matter.

- **Resilience-** The rate at which an ecosystem returns to its original state after a disturbance.

- **High resistance example:** 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

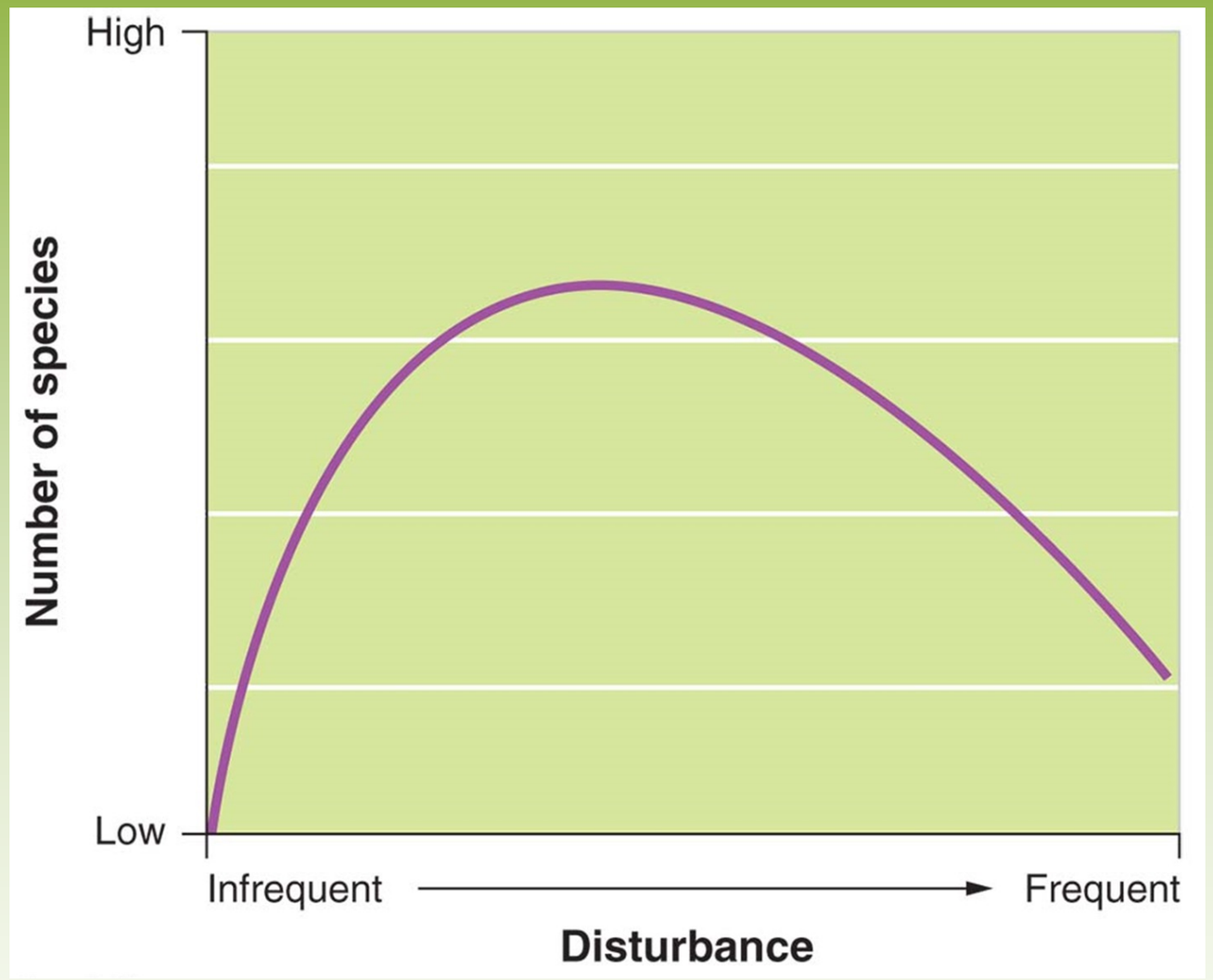
Resistance versus Resilience

- **<u>Restoration ecology-</u>** 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

- **<u>The intermediate disturbance hypothesis-</u>** states that ecosystems experiencing intermediate levels of disturbance are more diverse than those with high or low disturbance levels.



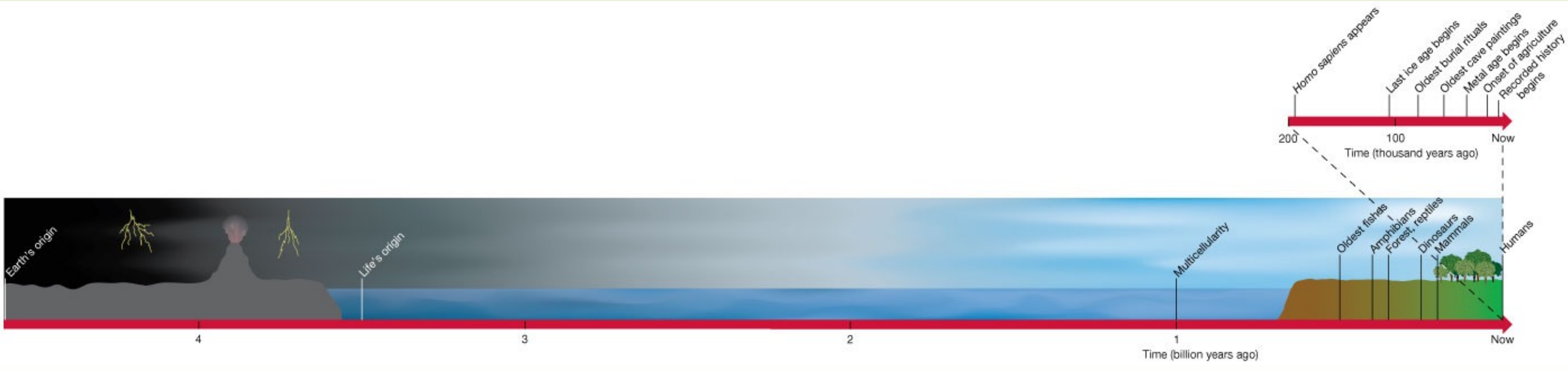
Rare disturbances favor the best competitors which outcompete other species. Frequent disturbances eliminate most species except those that have evolved to live under such conditions. At intermediate levels of disturbance, species from both extremes can persist.

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?



Instrumental Values of Ecosystems

- **<u>Provisions-</u>** Goods that humans can use directly.

- Lumber, food crops, medicinal plants, natural rubber, and furs

- Bark of Pacific Yew contains a chemical with anti-cancer properties

Instrumental Values of Ecosystems

- **<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

Instrumental Values of Ecosystems

- **<u>Support systems-</u>** 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

Instrumental Values of Ecosystems

- **<u>Cultural services-</u>** 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


IT'S DONE
IT'S OVER
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