1:30 – 2:15 Lecture: Ecosystem Function – Biogeochemical cycles

2:30 – 3:20 Video: How Nature Works – Grasslands

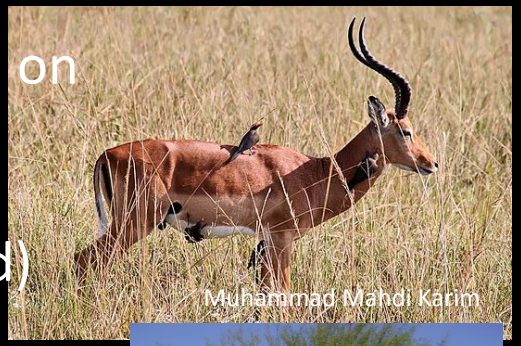
1. Biome research and presentation
   - Individual summary due Next Tuesday, May 7
   - Are all the team members contributing?
   - Presentation date: Tues, May 14 and Thu, May 16
   - Guidelines on pages 5, 6 of syllabus. Do you have it?
2. Quiz 1
   - Thursday, May 2
   - Based on Lectures, videos, activities

Symbiosis

<u>Close, long-term relationship</u> between two organisms of <u>different species</u> in an ecosystem

Mutualism: Both organisms benefit and depend on each other

- Humans and beneficial gut bacteria
- Impala (pest control) and Oxpecker bird (food)



Parasitism: One organism benefits (parasite) at the expense of the other (host)

- Humans and mosquitoes
- Acacia tree and Cuscuta aka dodder plant (food)

Commensalism: One organism benefits, the other is neither harmed nor benefitted

- Humans and mites (food)
- Zebra shark and Remora shark (hitches a ride)

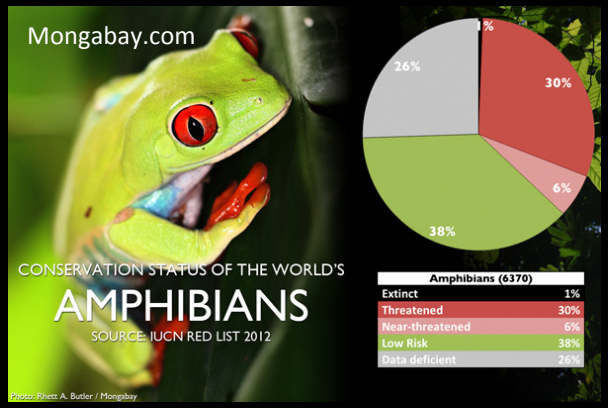
Important Species in Ecosystems

Keystone Species: A species that is crucial for the health of an ecosystem.

E.g., Corals in a Coral Reef ecosystem, Apex predators in terrestrial ecosystems

Indicator Species: The health of this species indicates the health of the over all ecosystem.

E.g., Amphibians in wetland ecosystems



Ecosystems – Function

Energy & Nutrient Flow in Ecosystems

Bio-geochemical cycles

Matter and Energy Laws

LAW OF CONSERVATION OF MATTER:

Matter can neither be created nor destroyed

- **The NUMBER AND TYPE OF ATOMS ARE THE SAME before/after chemical reaction**

Two main forms of energy:

Potential (e.g., gravitational, electrical, chemical, light) and Kinetic (e.g. wind, heat).

LAW OF CONSERVATION OF ENERGY (1st Law of Thermodynamics)

Energy can neither be created nor destroyed

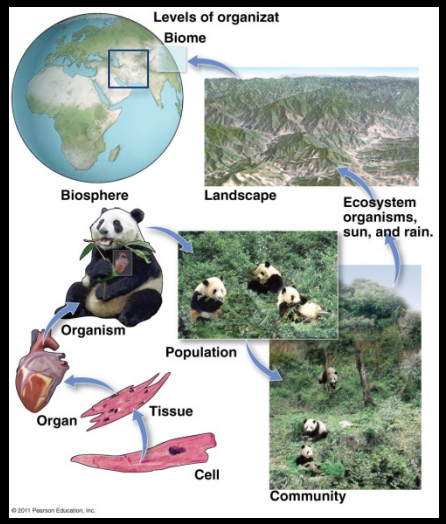
- **Energy can be transformed between the various forms**
- **E.g., Photosynthesis transforms chemical and light energy to chemical energy**
- **E.g., Cell respiration transforms chemical energy to chemical energy + heat**

LAW OF INCREASING ENTROPY (2nd Law of Thermodynamics)

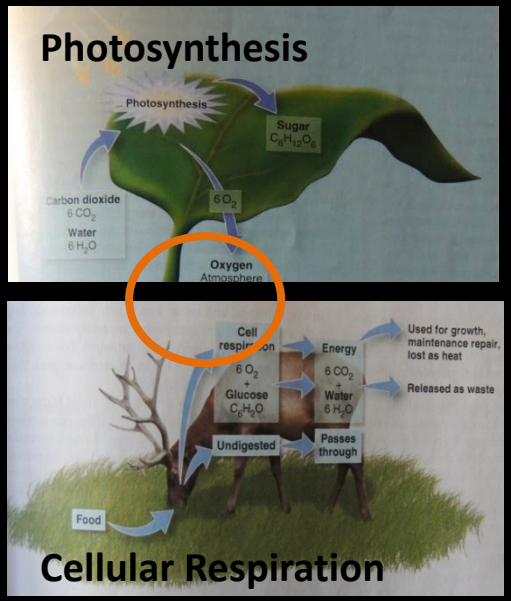
Entropy of a closed system can never decrease

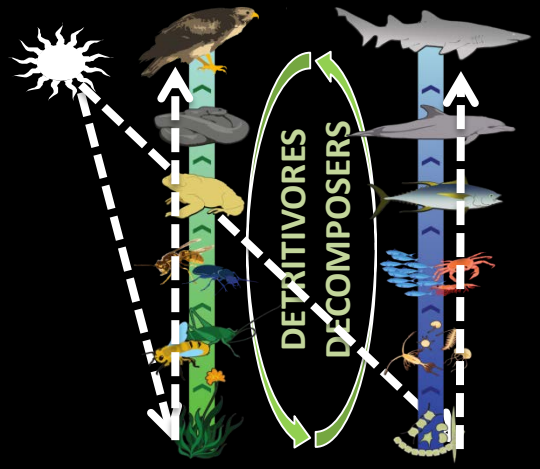
- **The amount of usable energy in a system decreases every time energy is transformed**
- **Energy has to be supplied to the system for it to continue to work**
- **E.g., Ecosystems are sustainable so long as the sun's energy is available (sometimes energy is supplied by heat generating processes on Earth, e.g., volcanic activity under the sea)**

Nutrient and Energy Cycling in the Biosphere



Ecological Hierarchy





ONE WAY transfer of energy
CYCLING of nutrients
Food Chain: Involves *organisms*

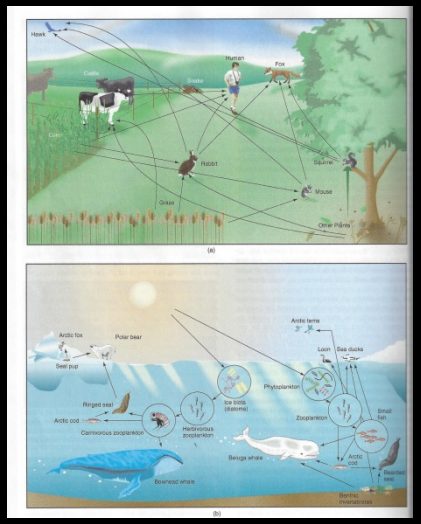
Consumers (heterotrophs)

Producers (autotrophs)

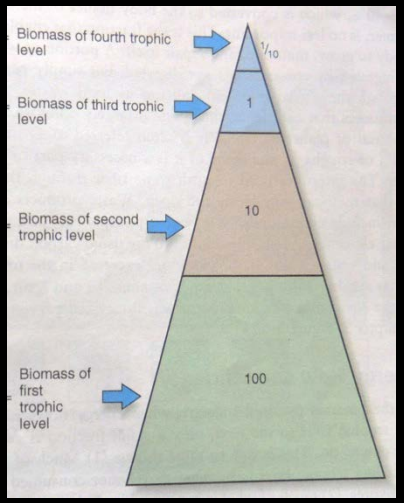
Detritivores (heterotrophs)
Detritus = Waste

Decomposers (heterotrophs)

Trophic levels & categories:
1: Producer, 2: Primary Consumer (aka Herbivore in land-based), 3: Secondary Consumer (aka Carnivore in land-based), 4: Tertiary Consumer, …
(Omnivore: Herbivore & Carnivore)

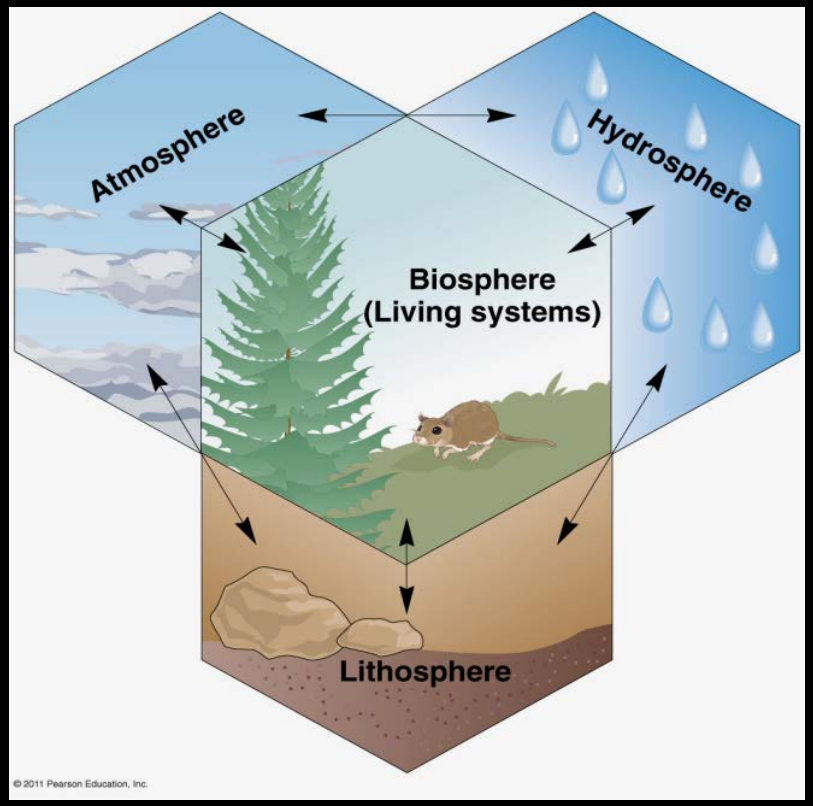


Food Web



Efficiency of Nutrient and Energy Transfer; Biomass

Nutrient Cycling and Earth's Systems



Are there other key nutrients required by living systems?

- **Yes! Photosynthesis alone is not enough!**
- **What are they?**

How do the nutrients become available to the Biosphere?

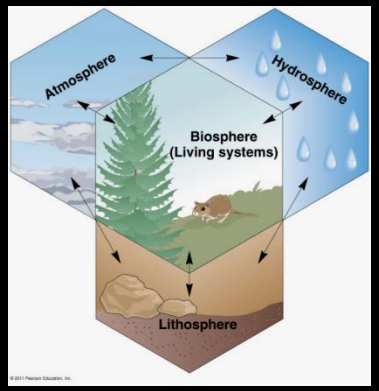
- **Through Bio-geochemical cycles**
- **What are these cycles?**

The Key Nutrients

Chemical Basis of Life on Earth

Nutrient	Symbol	Used in
Carbon	C	DNA, Proteins, Carbohydrates
Oxygen	O	DNA, Proteins, Carbohydrates
Water	H_2O	All cells and circulatory system
Nitrogen	N	DNA, Proteins
Phosphorus	P	DNA, Proteins
Sulfur	S	Proteins
Minerals (Calcium, Iron, Sodium, Potassium, …)	Ca, Fe, Na, K	Proteins, as ions in electrochemical processes

BioGeochemical Cycles



- **<u>Processes</u>** in the Earth's Systems that
- **Produce (Sources)** and/or **Consume (Sinks)** key nutrients
- To make them **Available** for Life systems
- And keep them in **BALANCE**

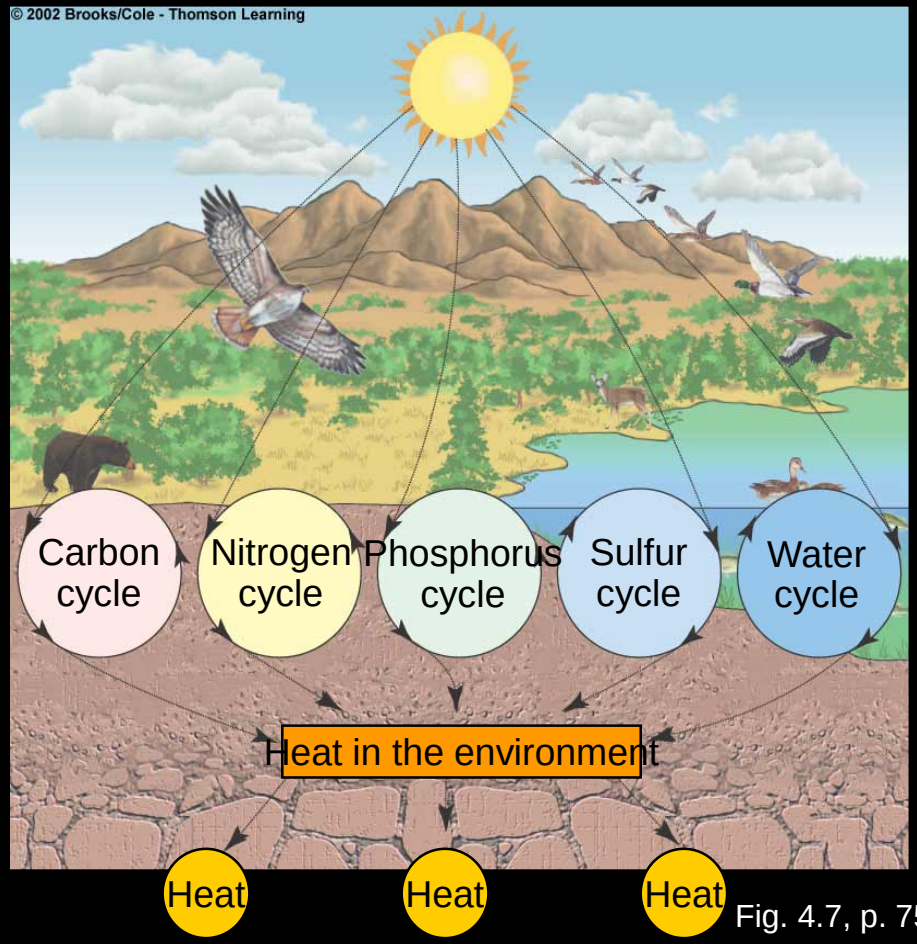
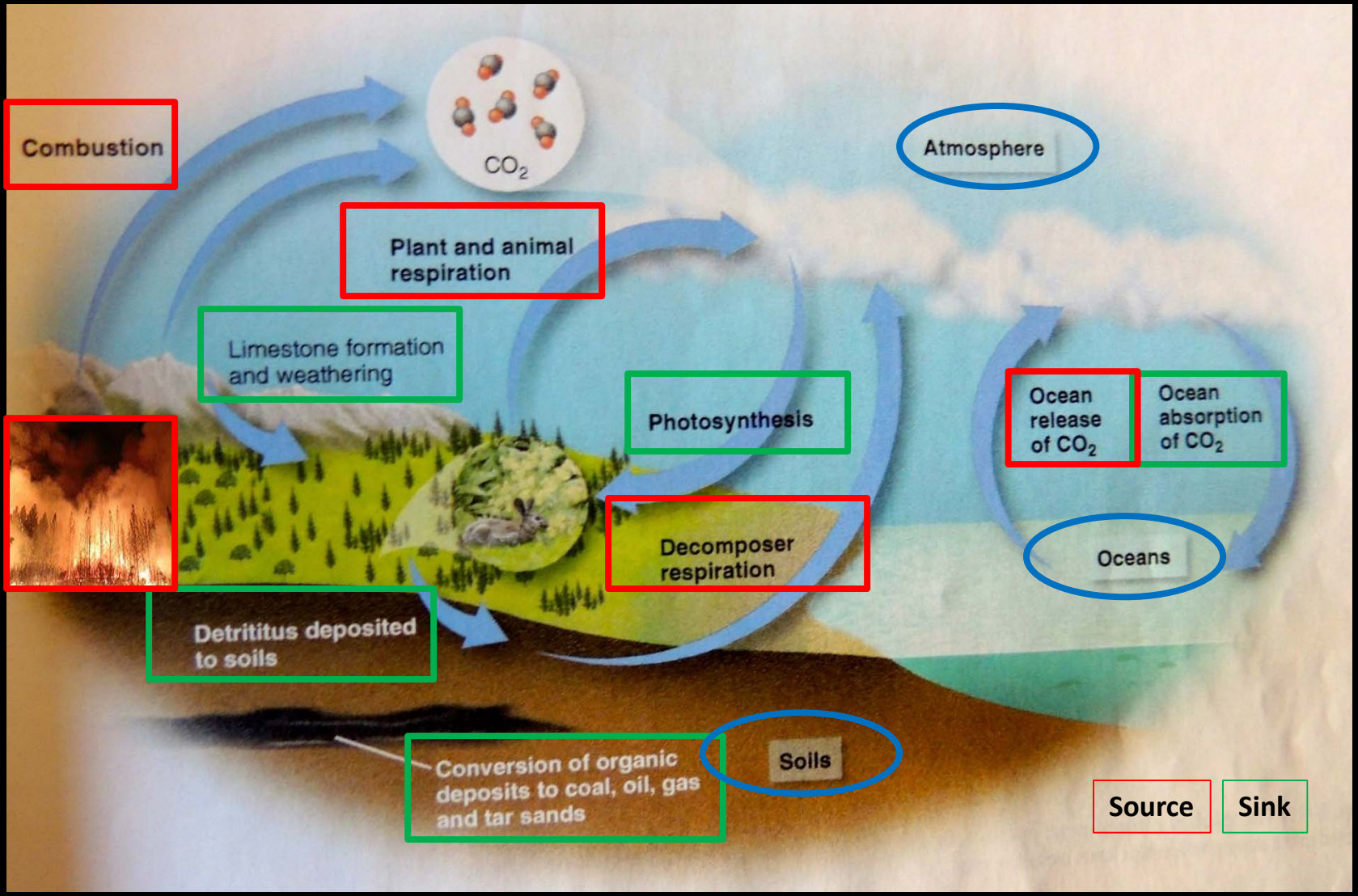


Fig. 4.7, p. 75

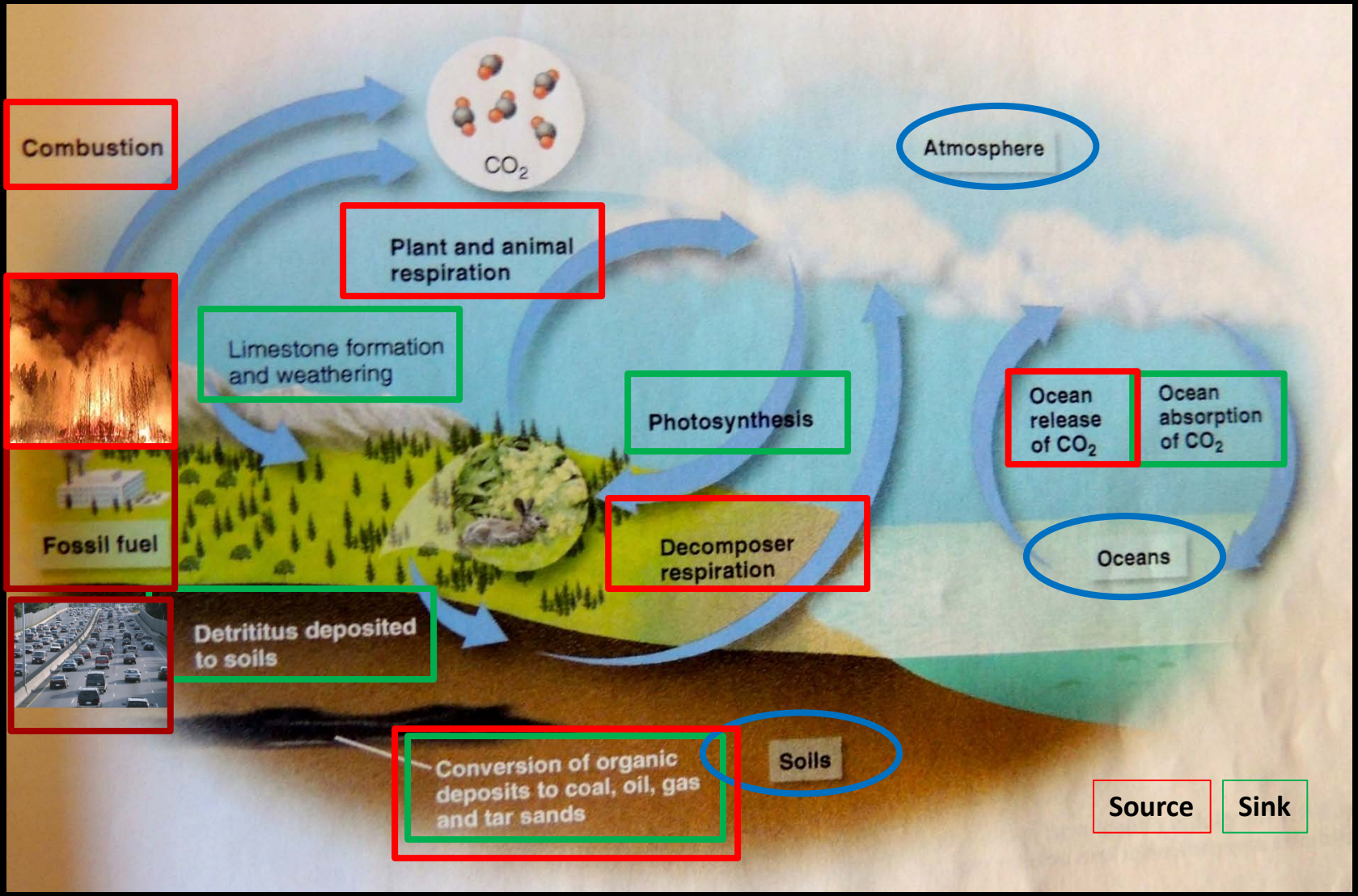
The Carbon Cycle



Involves Energy and Matter Transfer Between all the Earth Systems

What are the sources and sinks for atmospheric Carbon

The Carbon Cycle



Human Impact

Human Impact

Excess Greenhouse Gases (GHG) in Atmosphere

Carbon containing **GHG:** **Carbon dioxide (CO_2)** and **Methane (CH_4)**

Large sources of Carbon

- **Burning fossil fuels** for Energy, Transportation, Buildings release CO_2
- **Industrial Meat Production, Oil & Gas Operations** release CH_4
- **Deforestation by logging and burning** for agriculture and urbanization is a **"Double Harm"**
  - *Combustion releases CO_2*
    Rotting plants release CH_4
  - *Reduced Photosynthesis*
    Decreases C absorption

Consequences

- **Climate Change**
  - Warming of Atmosphere + Warming of Land and Oceans
  - Change Air Currents and Water Currents in the Oceans
- **Ocean Acidification**
  - More CO2 in Atmosphere = More CO2 in Ocean = More Carbonic Acid in Ocean
  - Corals pushed beyond **Limits of Tolerance for Acidity**
  - Corals Bleach and Leads to a **Trophic Cascade**

Nitrogen Cycle

All life needs Nitrogen - N

Abundant source: Atmospheric N_2 gas

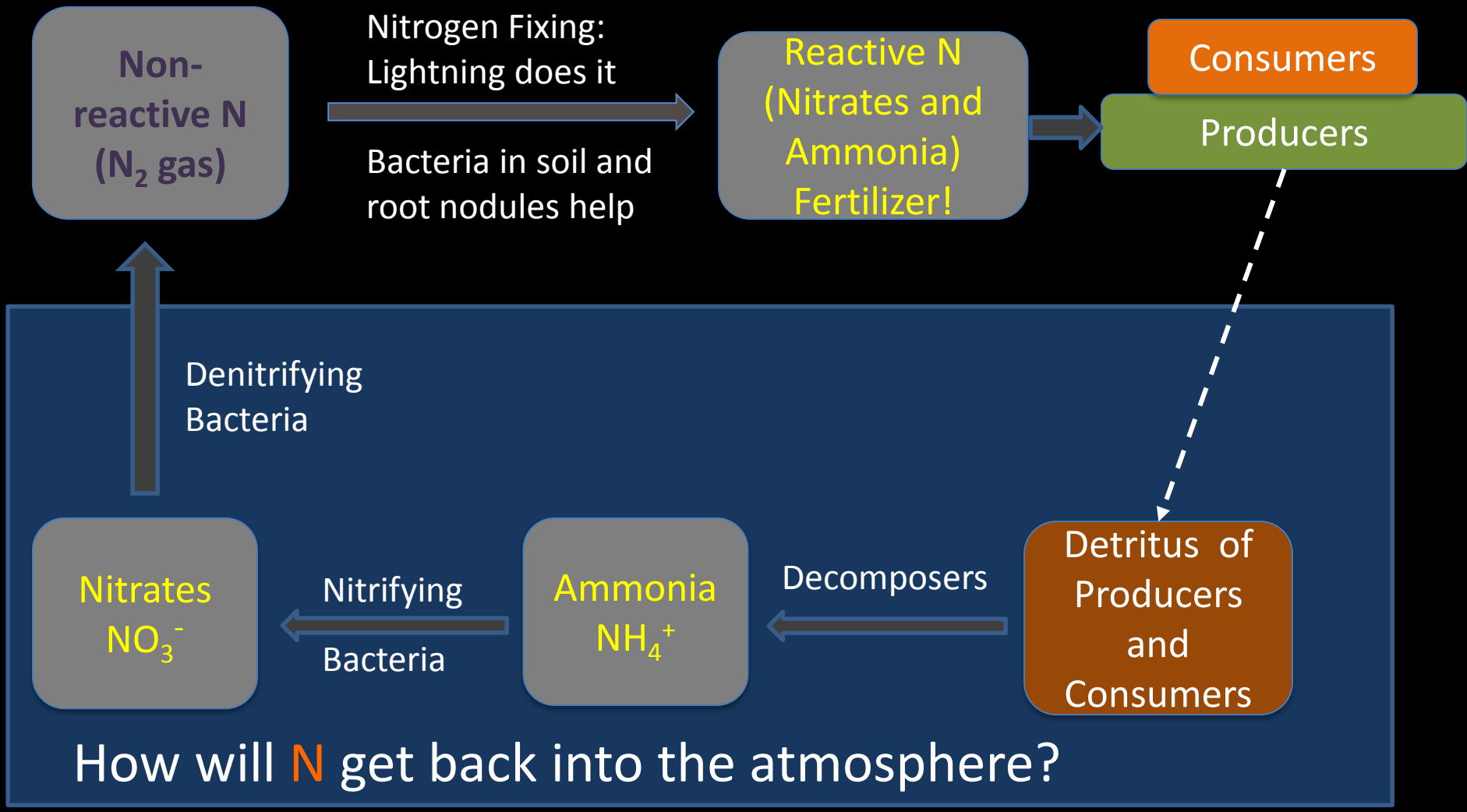
- **Is a Molecule N-N**
- **N-N bond is triple strength**
- **Very unreactive, not easily used in biochemical reactions**

So most organisms cannot use this form directly

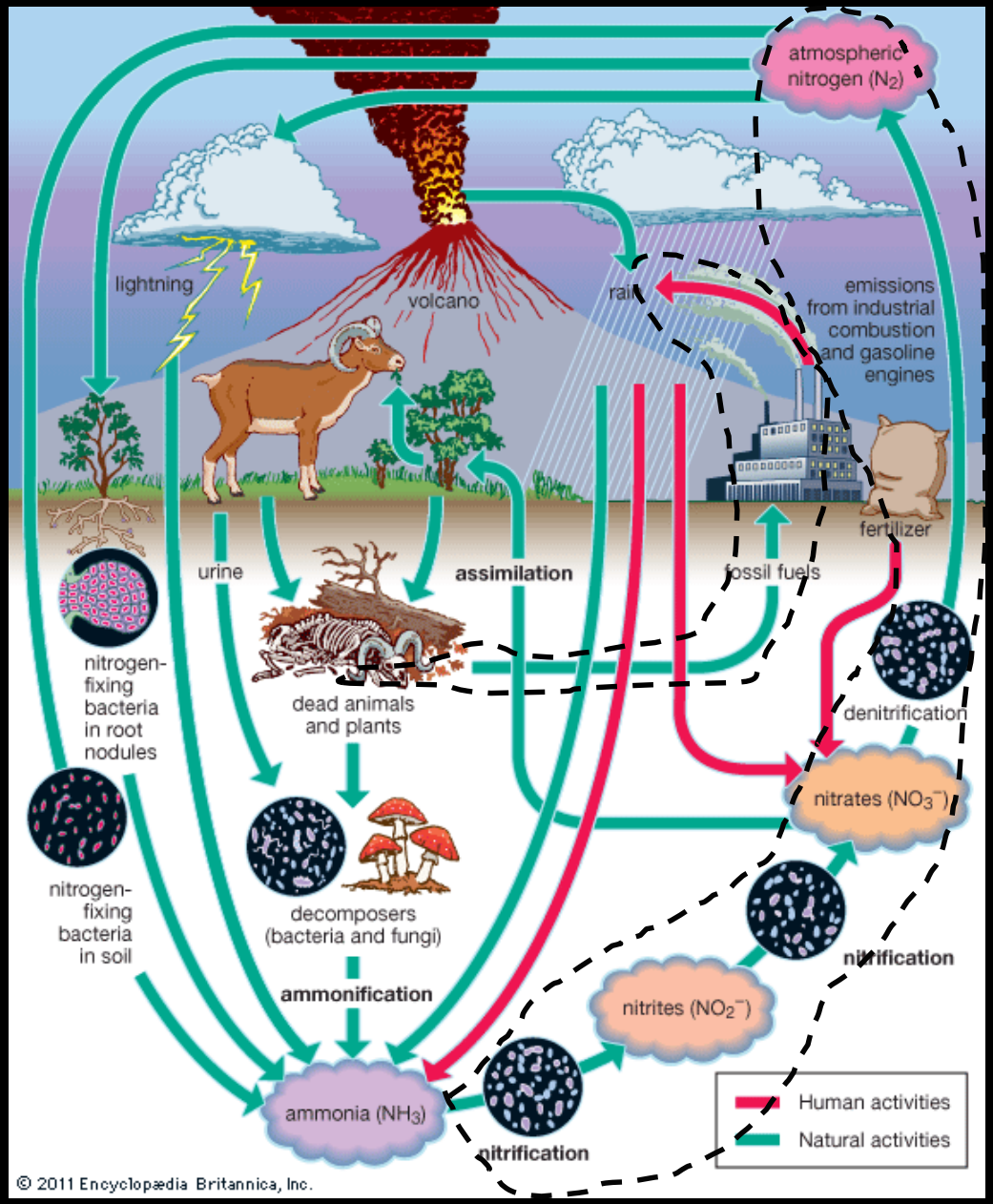
- **Need to convert N-N to N atoms**
- **How?**
- **Nitrogen Fixing Bacteria**

Bio-Availability of N

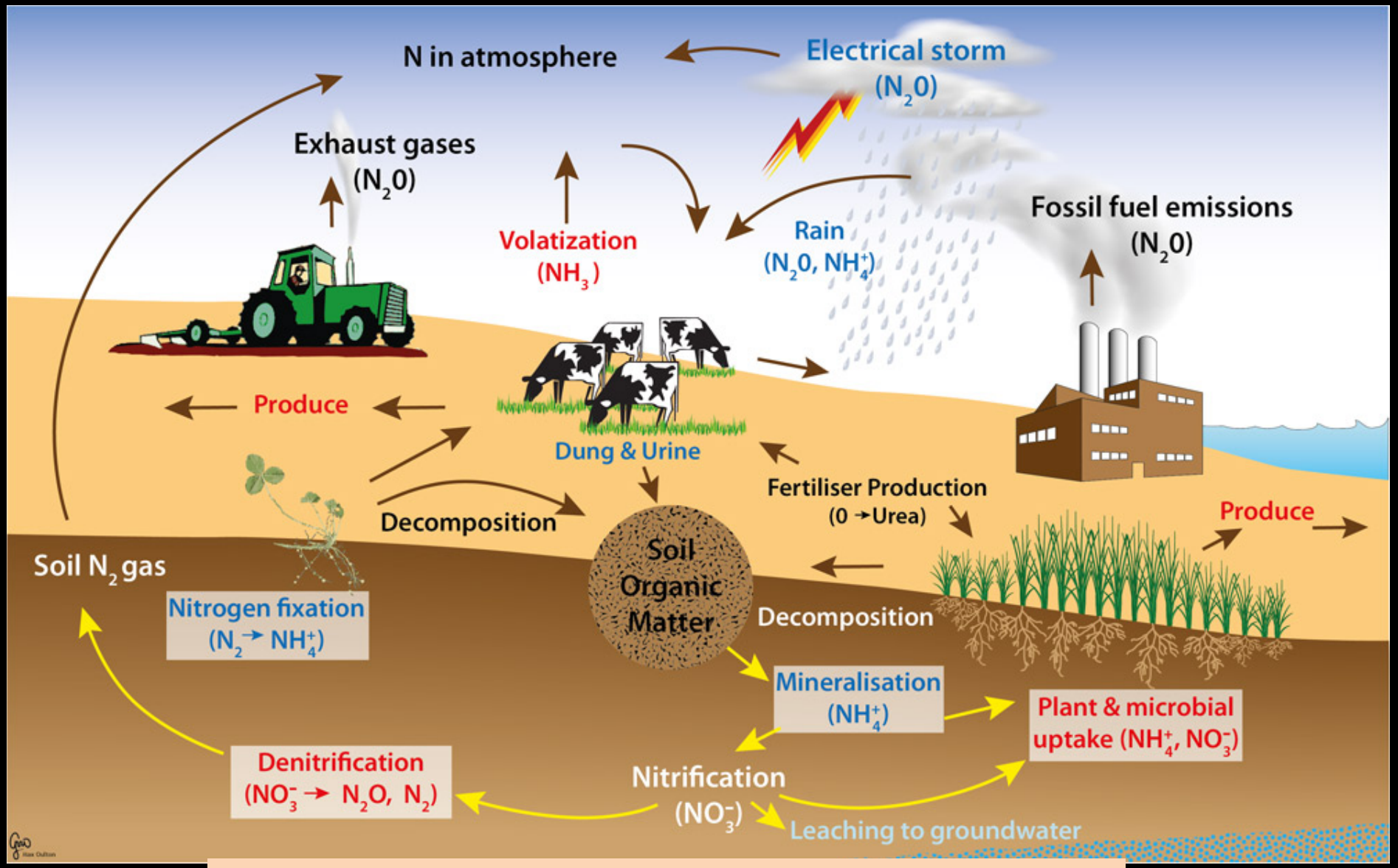
How does atmospheric N get into the Ecosystem?



Nitrogen Cycle



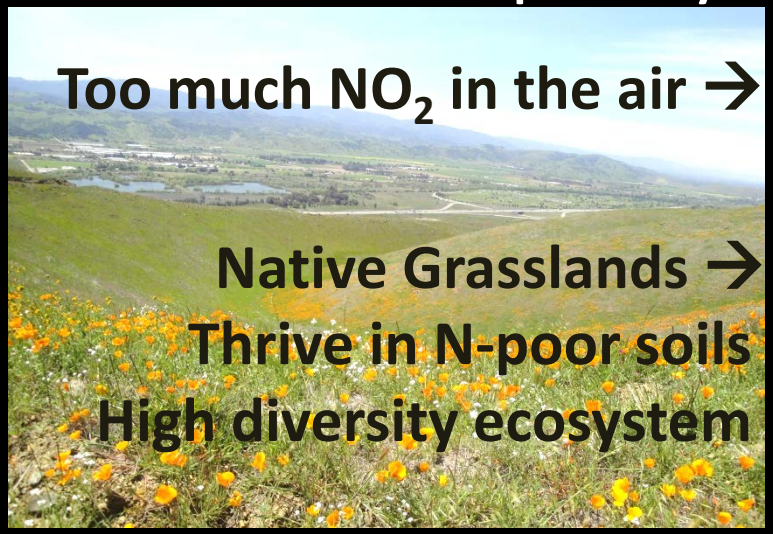
Nitrogen Cycle

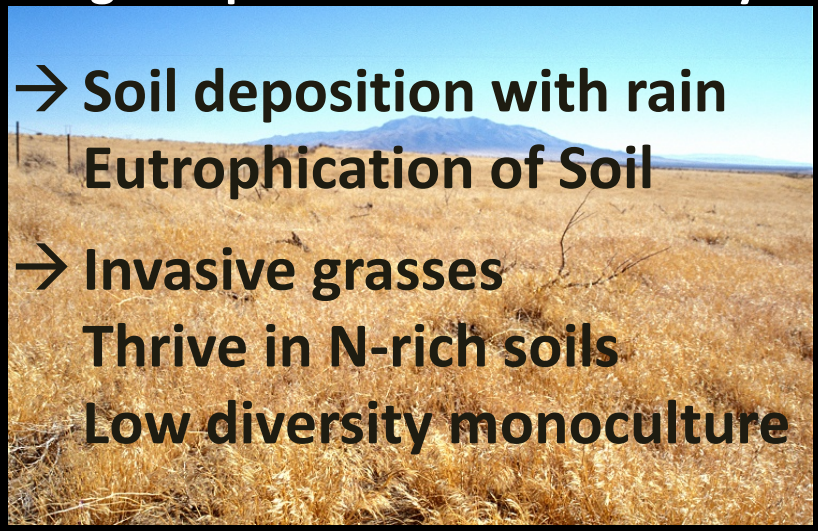


List all the sources and sinks for Nitrogen in the environment

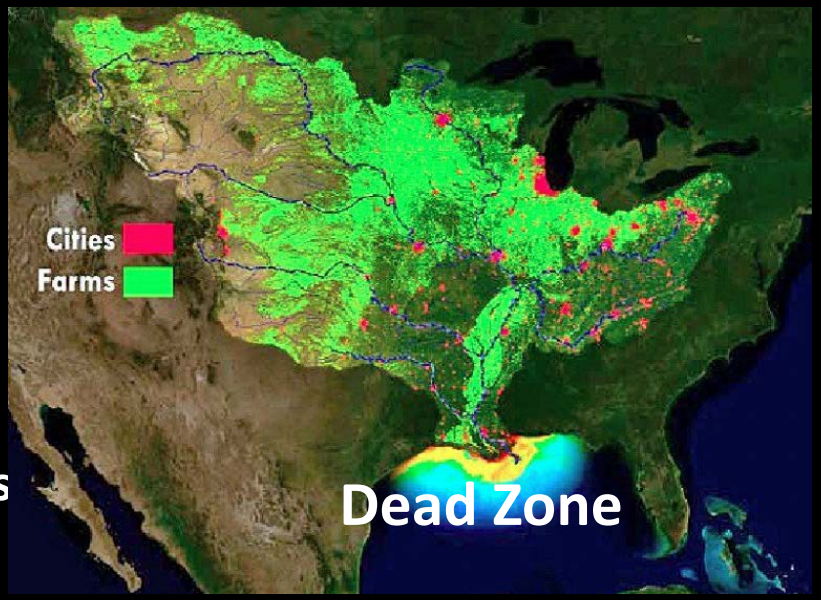
Human Impact – Eutrophication (fertilizing)

Local Environmental Impact: Coyote Ridge Serpentine Grassland Ecosystem

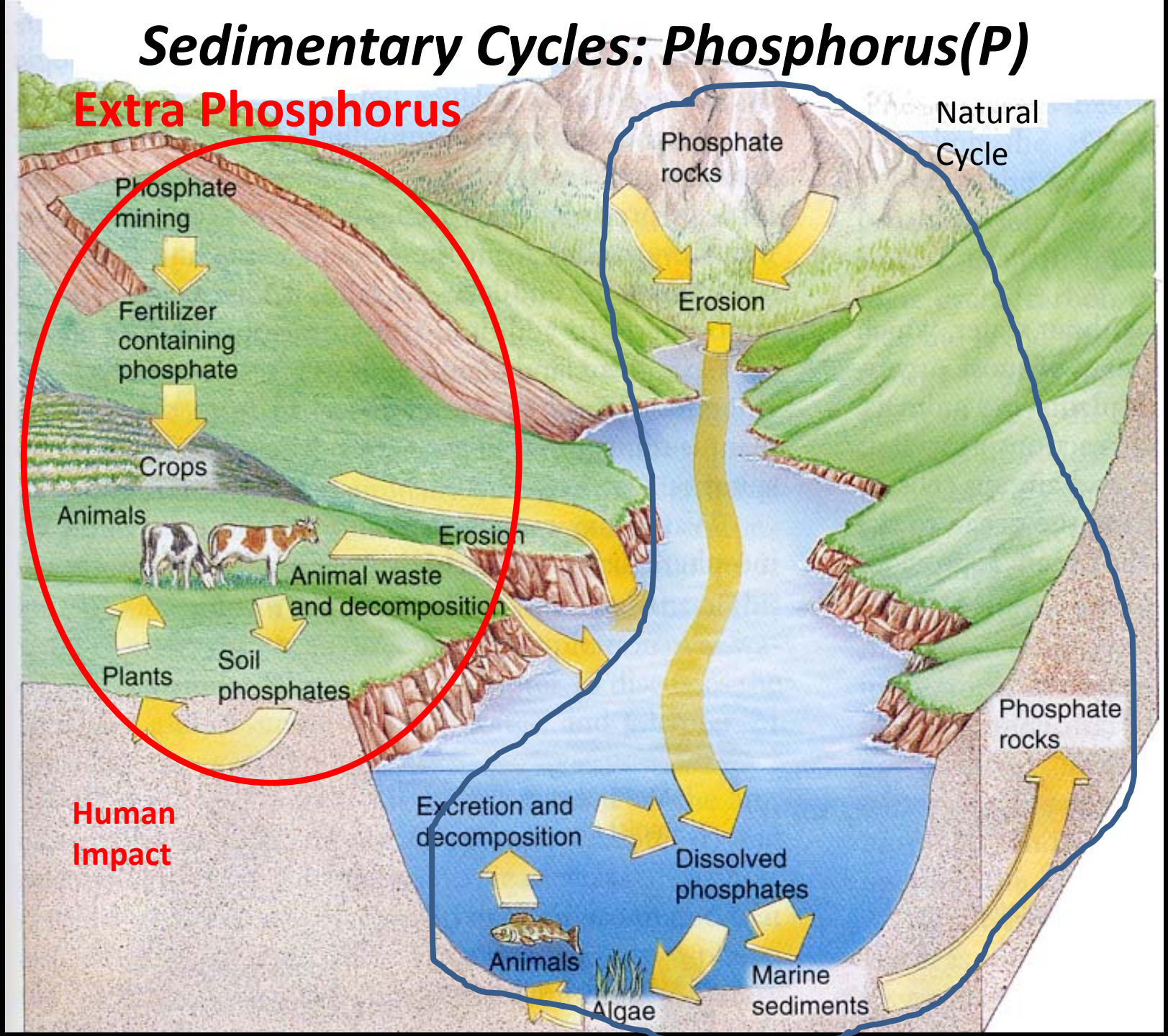




- NO_3 fertilizer leaches to nearby rivers and to major rivers leading to the sea
- Eutrophication of water bodies
- Excessive algal growth sucks the O_2 out of the water (respiration)
- O_2 depletion in ecosystem, killing other organisms
- Coastal Oceans and inland water bodies get Dead Zones



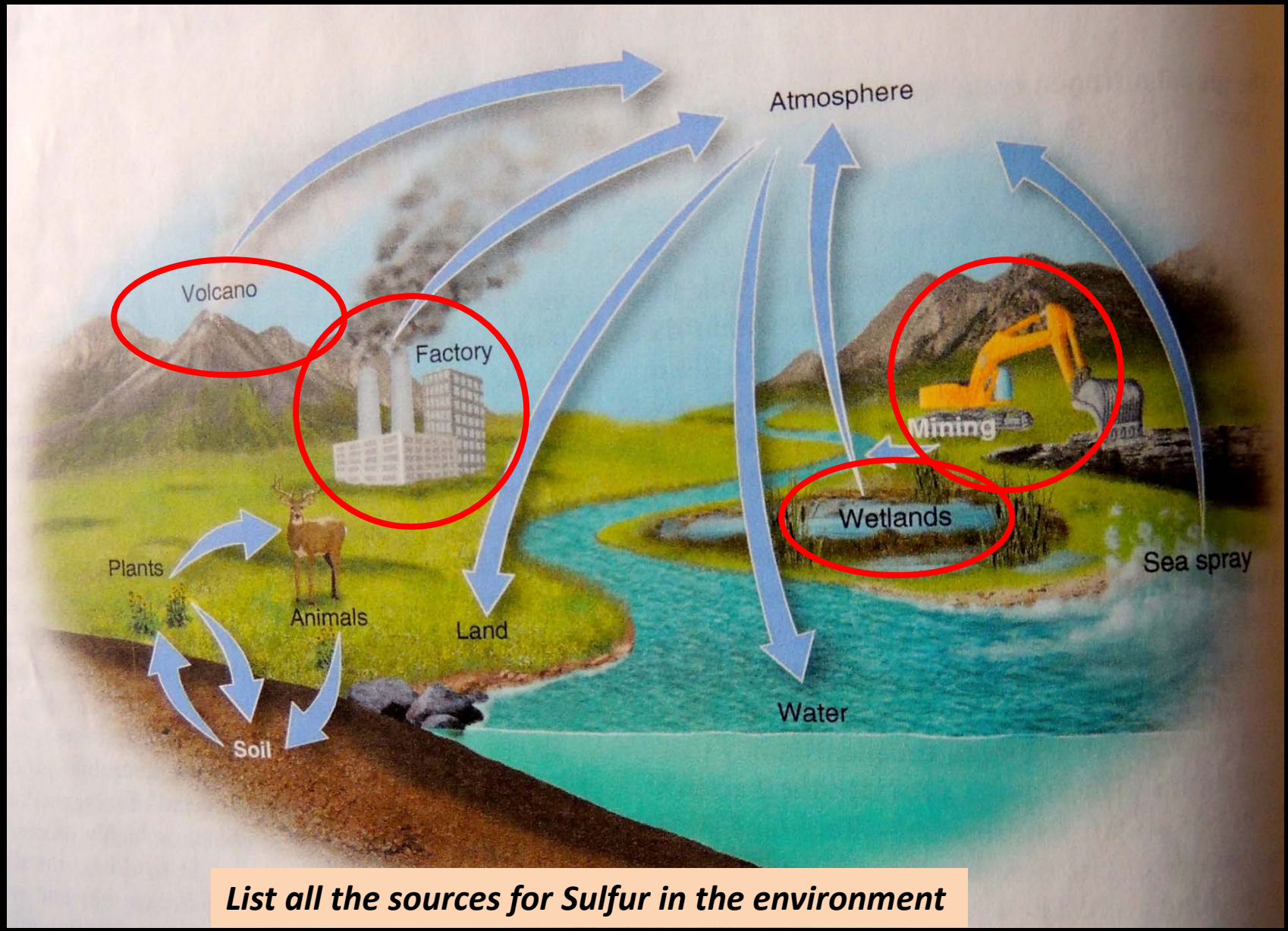
Sedimentary Cycles: Phosphorus(P)



Human Impact – Too Much

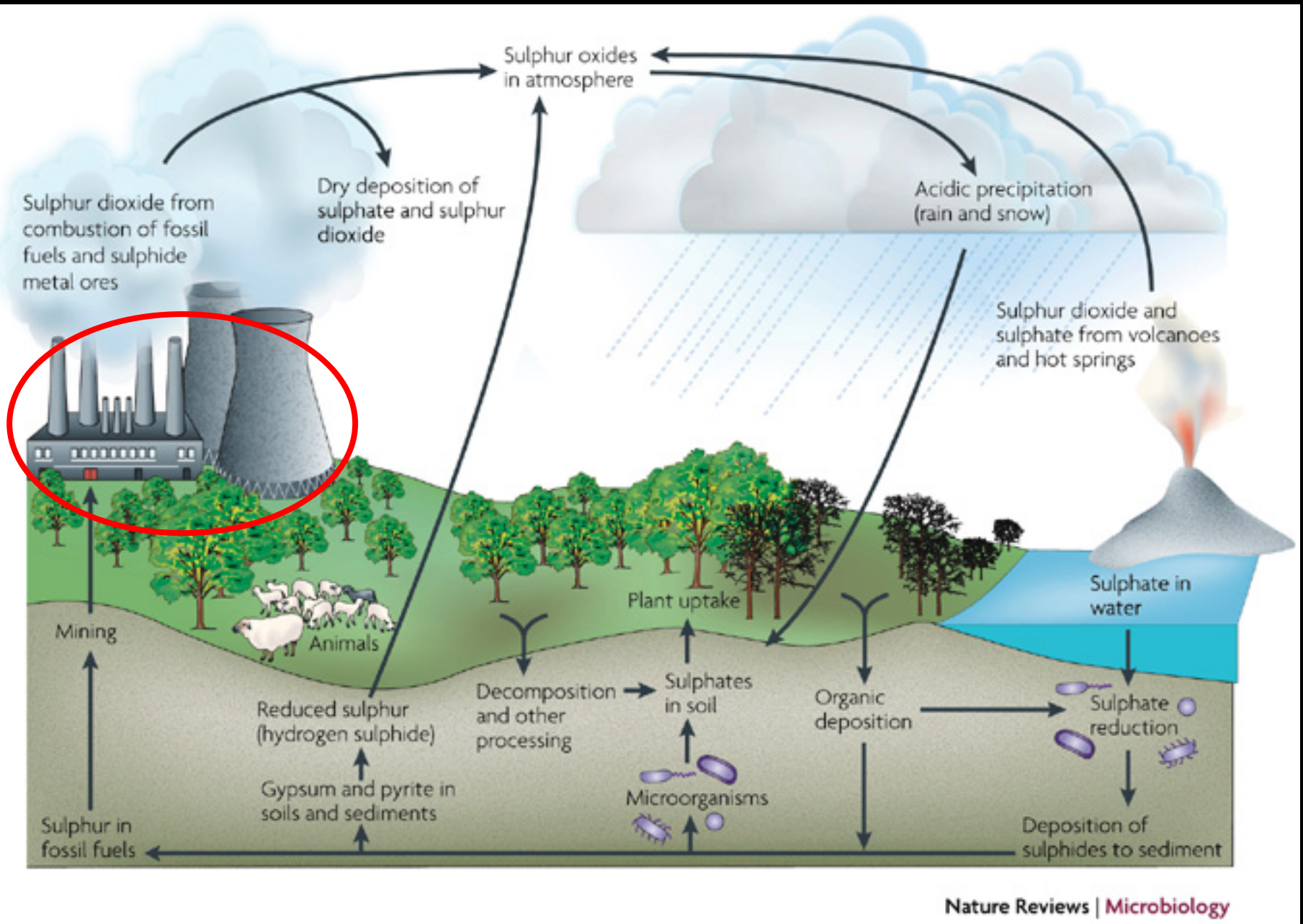
- Biggest source of phosphorus increase
  - From excess fertilizer runoff
- 3x increase in oceans and lakes!
- Leads to ***EUTROPHICATION***

Sulfur Cycle



List all the sources for Sulfur in the environment

Sulfur Cycle



Human Impact – Acid Rain

- Sulfur occurs naturally in the lithosphere
- Gets into atmosphere as Sulfur dioxide (SO_2)
  - Volcanic eruptions
  - Burning fossil fuels
- SO_2 mixes with rain water
  - *ACID RAIN*
  - *Kills off trees*
- 1980, Acid Precipitation Act

Planetary Boundaries

- Nature has Optimal Range & Limits of Tolerance
  - *Time scales of Bio-geochemical cycles and amounts of nutrients in the earth's systems are in balance*
  - *This is the safe operating space for humanity*
  - *Planetary Boundaries*
- When Nature pushed beyond Planetary Boundaries
  - *Nature enters a Zone of Stress*
  - *Cannot recover*
  - *Reaches a Tipping Point*
- How to operate within Planetary Boundaries?
  - *Sustainability is key*
    - *E.g., Limit industrial and agricultural fixation of N*

    Switch towards Organic Agriculture

Video: How Nature Works Grassland

- Attach Activity Sheet to your journal and answer the questions

Class 08 In-class Activity
Matter and Energy Flow in Grasslands

Answer the following questions based on the video "How Nature Works - Grasslands" (Source: De Anza Library web page, *Films on Demand* section. Search for *How Nature Works.)*

1. **Where are grasslands found in the world?**
2. **Why is tall grass less nutritious than new grass? How have the Wildebeest adapted to deal with it?**
3. **How does the White Rhino impact the grassland? List at least 4 species it supports.**
4. **How is the Brazilian grassland different from the Savannah? How does this impact the consumers? Explain with the Maned Wolf as an example.**
5. **Draw the *food chains* involving the Maned Wolf. Specify its *trophic category* in each.**
6. **What was the highlight of the video for you and why?**