6 THE FLOW OF MATTER IN THE ENVIRONMENT

Why Does It Matter?

PowerPoint® Lecture prepared by Gary A. Beluzo

STUDENT LEARNING OUTCOMES

After reading this chapter, students will be able to

- Describe how the availability of matter limits the growth of autotrophs and heterotrophs.
- Compare and contrast food webs and biogeochemical cycles.
- Describe how changes in one cycle affect storages and fluxes in another cycle.
- Explain how biogeochemical cycles can be used to describe many human impacts on the environment.
- Explain how the rate of the nonspontaneous flows and residence times affect the rate at which an atom of carbon, nitrogen, or phosphorus can complete one turn through their respective cycles.

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Animals Eating Plants

- In general, flow of matter is tightly linked to the flow of energy, with some exceptions
- The Venus flytrap derives little or no energy from fly
- Green leaves provide it with food
- Insects are a significant source of nutrients for the plant
- The soil/water is deficient in these nutrients
- **Nutrients (matter in general) can be recycled** whereas energy cannot

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Matter

Building Blocks of Life

Organic Matter

- **Carbohydrates** (sugars and starches- contain CHO)
- **Fats and Oils** (contain CHO)
- **Proteins** (contain N too)

Inorganic Matter

- Macro Nutrients
  - Nitrogen
  - Phosphorus
  - Sulfur
  - Potassium
- Trace Nutrients
  - Calcium
  - Iron
  - Cobalt
  - Selenium
  - molybdenum

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Nutrient Capture by Autotrophs

- Most **autotrophs** get nutrients from environment in an **inorganic** form
- Nitrogen as **nitrate** (NO_3) is available
- Phosphorus as **phosphate** (PO_4) is available
- Nutrient transported in water through transpiration

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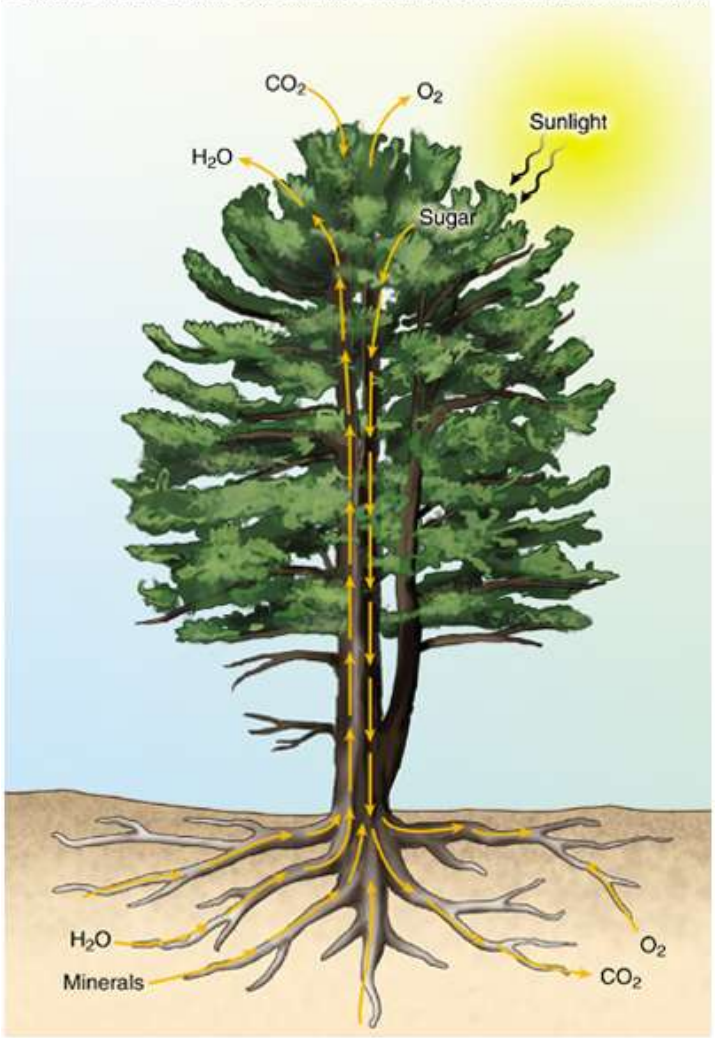

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Liebig's Law of the Minimum

- **Redfield Ratio** in phytoplankton **N:P 16:1**
- **Limiting Nutrient** (nutrient in least supply relative to demand)
- **Liebig's Law of the Minimum**

This law states that the growth rate of plants often is determined by the nutrient that is least abundant or least available relative to the needs of the plant

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TABLE 6.1 The Limiting Nutrient

	Carbon	Nitrogen	Phosphorus
Supply	300	32	5
Redfield Ratio	100	16	1
Units of Biomass Possible	3	2	5

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Nutrient Capture by Heterotroph

- Heterotrophs get nutrients as well as energy from an **organic** form
- Absorption
- Digestion
- Usually the concept of the limiting nutrient does not apply to heterotrophs
- Need balanced diet
- Essential amino acids
- Kwashiorkor

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The Flow of Matter
Biogeochemical Cycles

- Matter is used over and over again
- Biogeochemical Cycles
  - Biological System
  - Geological System
  - Chemical System
- **Storage Pools**
- **Flows**
- Residence Time (flow relative to size of storage)

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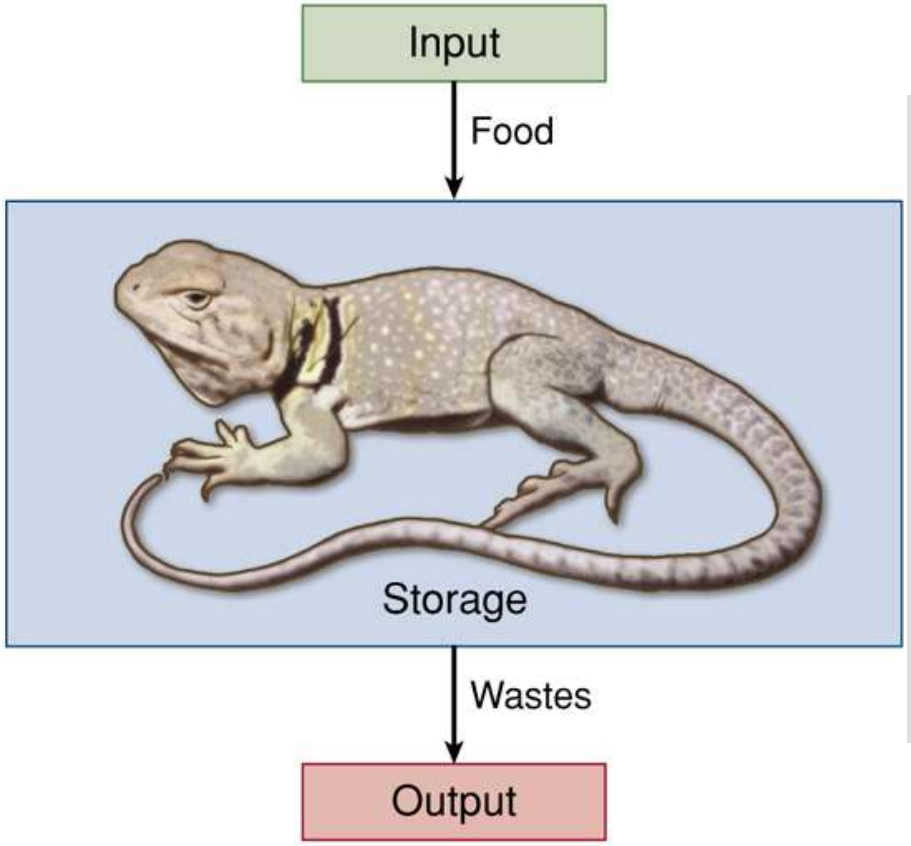

$$\text{Storage}_{t+1} = \text{Storage}_t + \text{Input}_t - \text{Output}_t$$

$$115 = 100 + 40 - 25$$

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How to Read Biogeochemical Cycles

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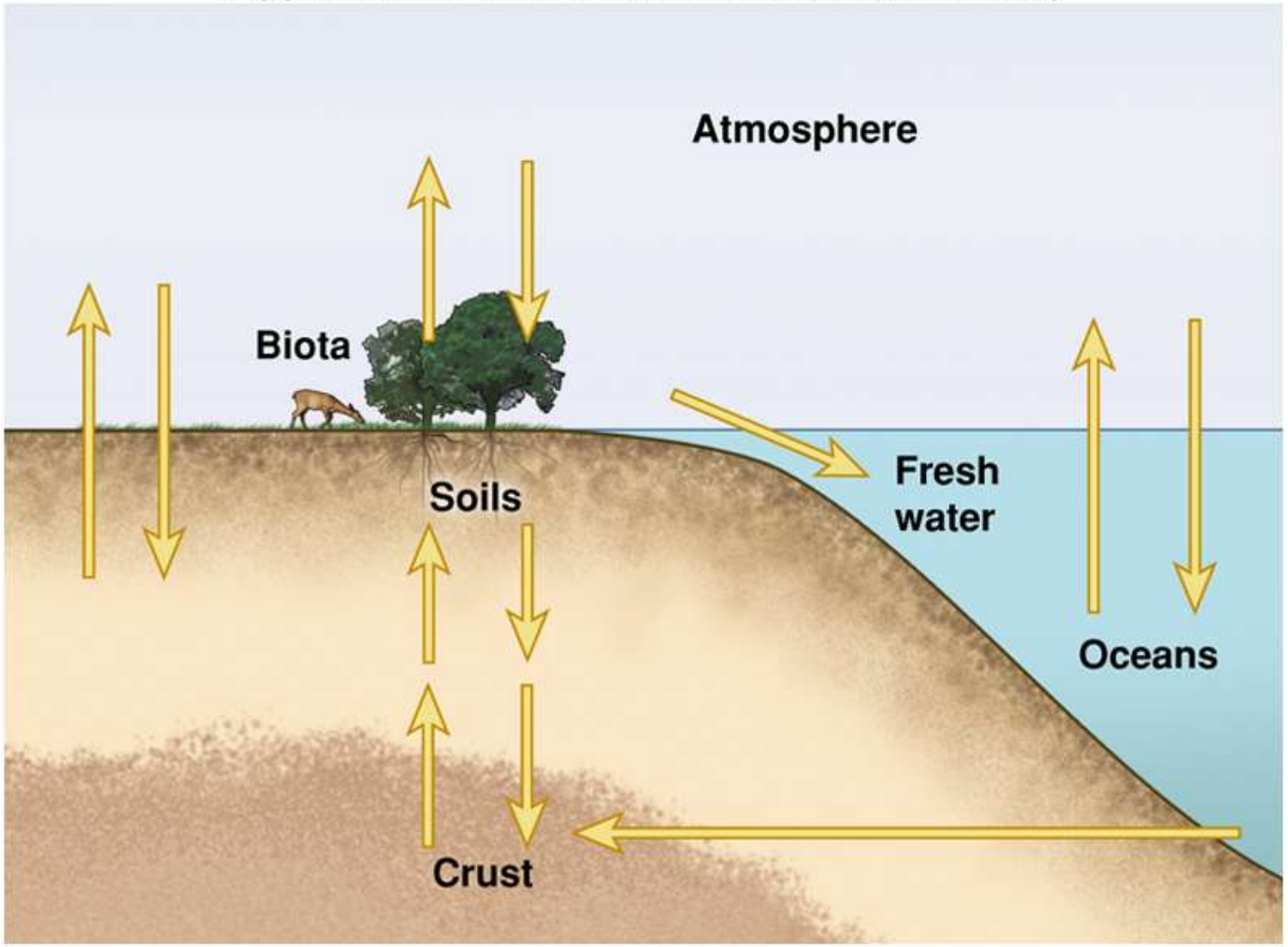

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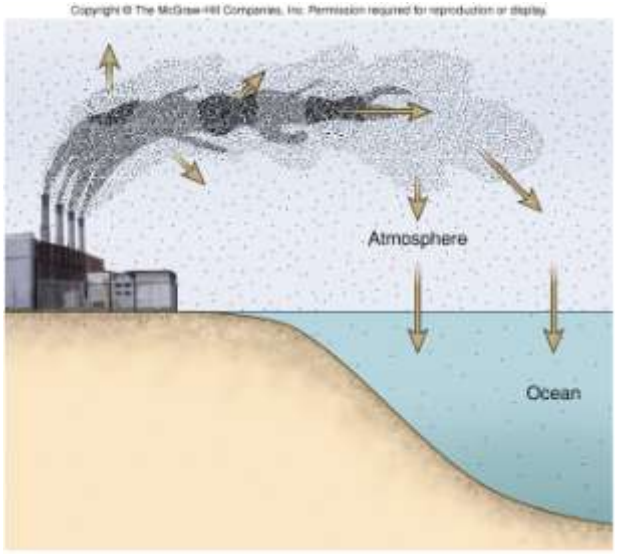
Types of Flow

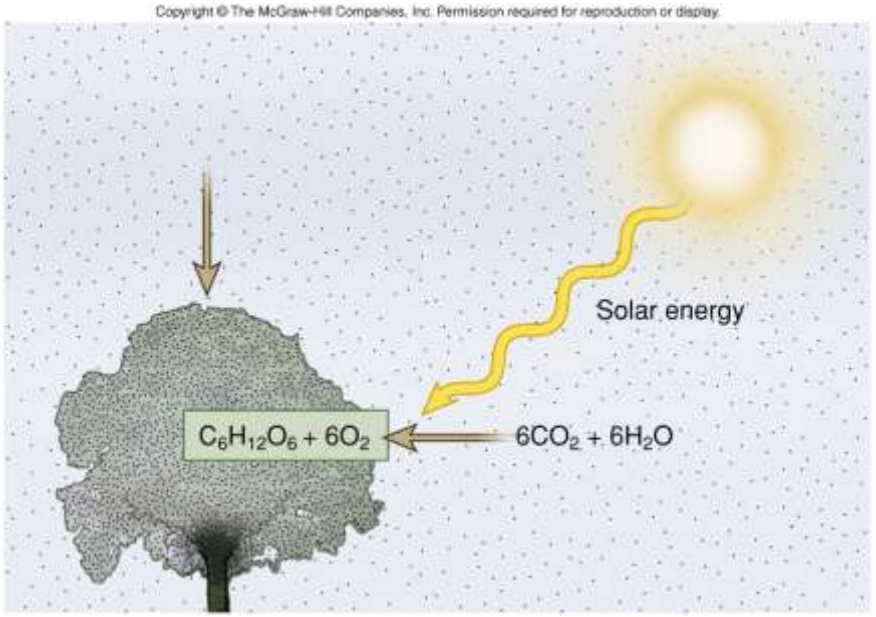
Spontaneous Flows

- Matter flows high to low concentrations
- No energy required to drive these flows between storage pools

Non-Spontaneous Flows

- Matter moves from low to high concentrations
- Energy is needed for this to happen
- Every biogeochemical cycle must have at least one of these





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The Master Cycle: Carbon

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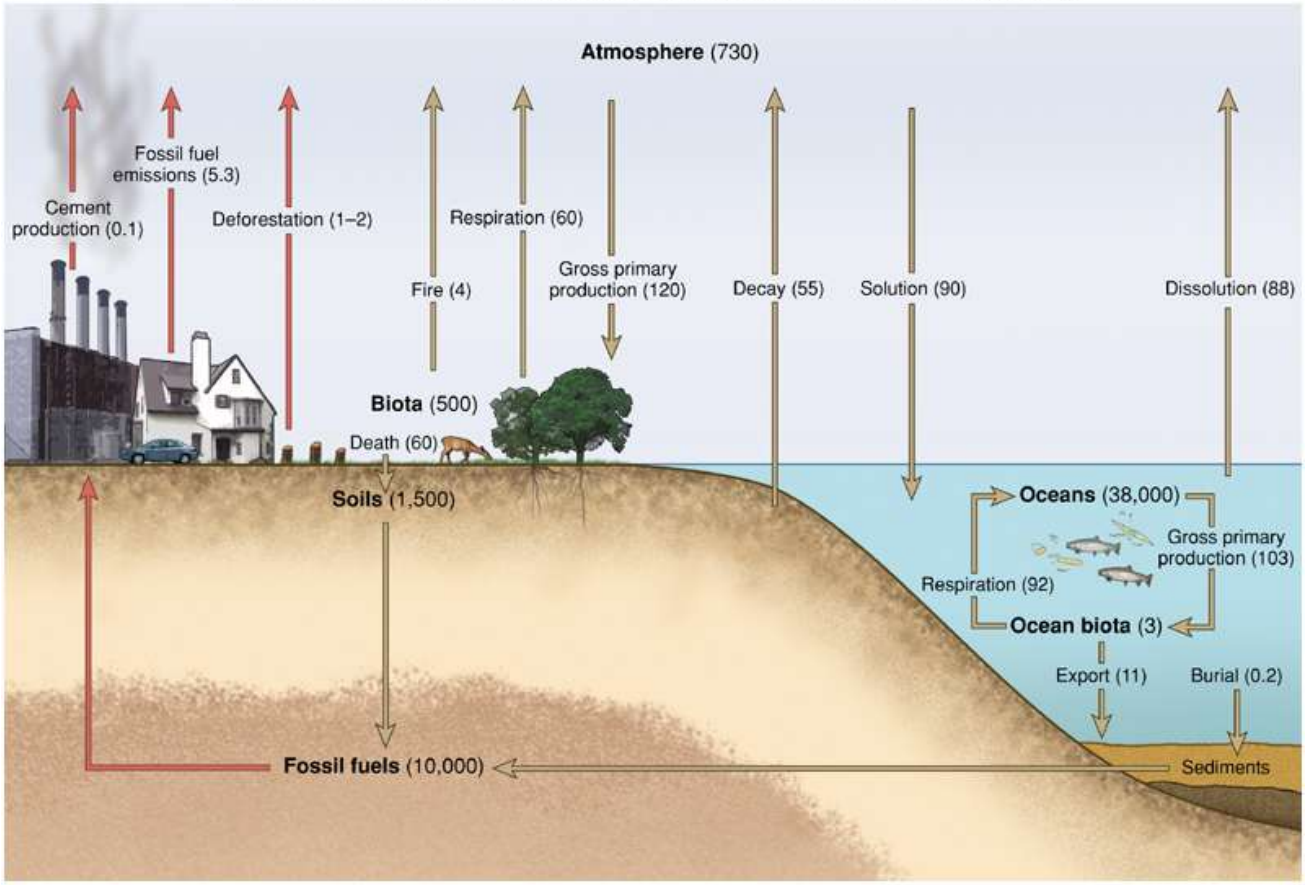

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The Unknown Carbon Sink

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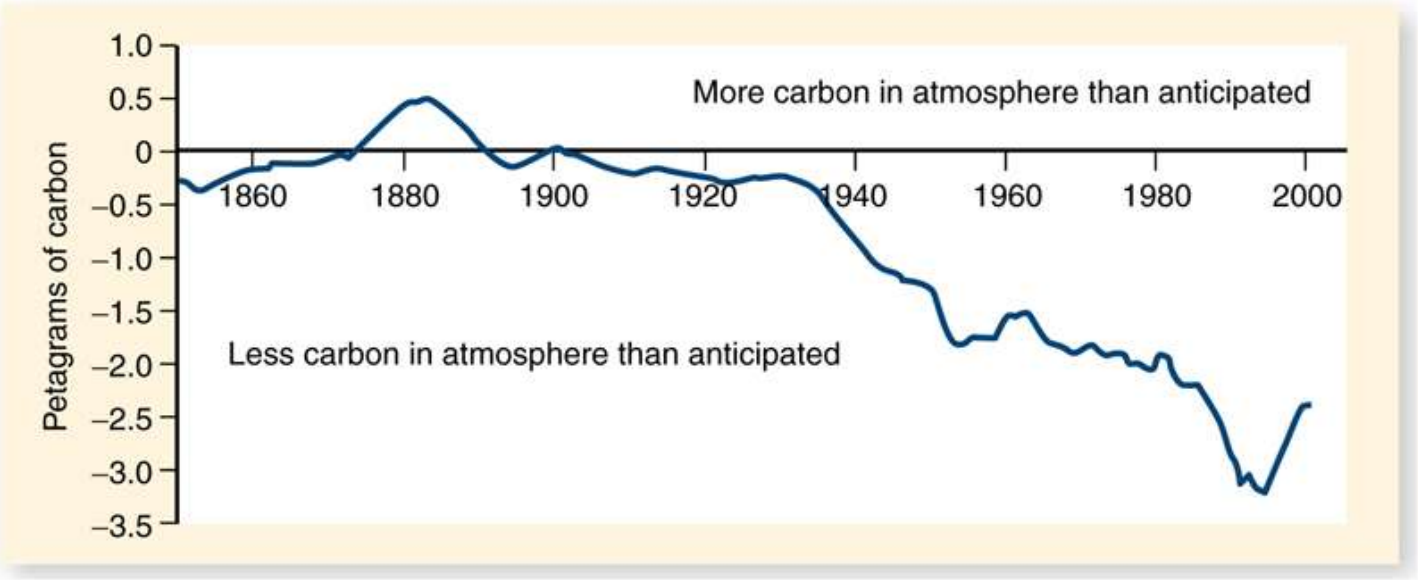

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H1: Increasing CO_2 increases NPP

- Plants grow faster at higher CO_2 but is it significant
- Is growth of plants limited by availability of carbon in the atmosphere?

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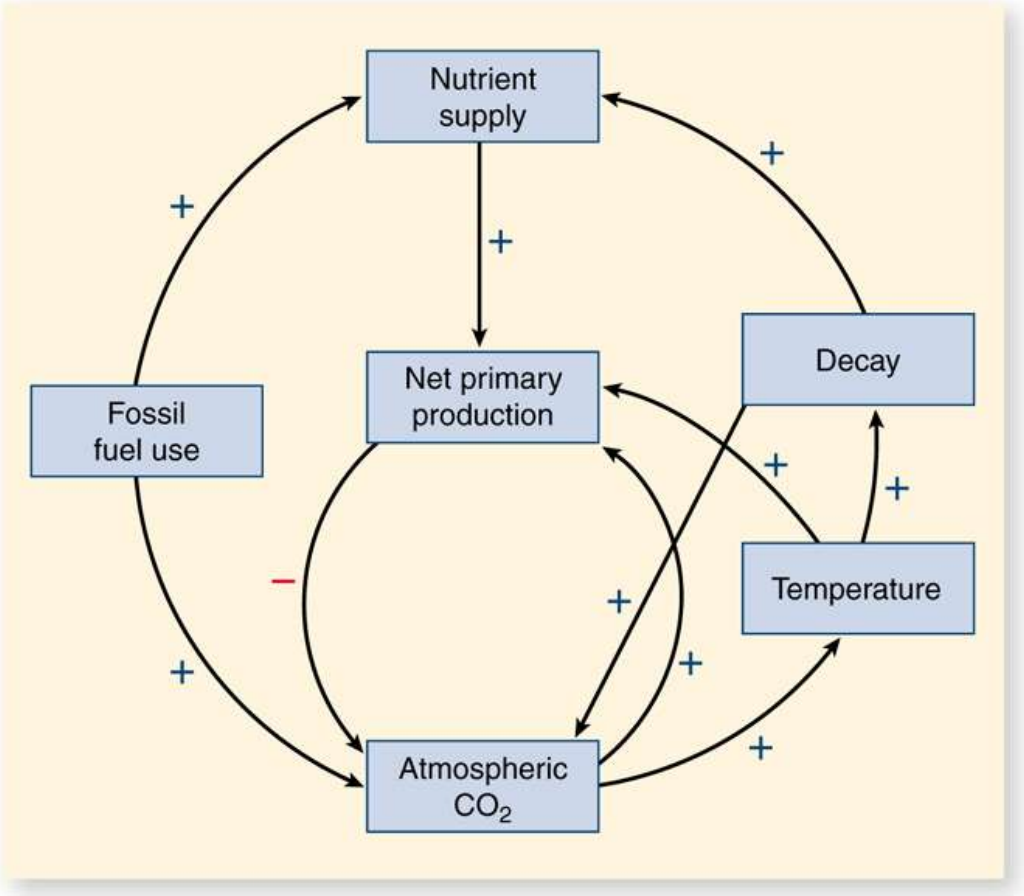

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H2: Increasing CO_2 increases Temp

- As world gets warmer does this enhance plant growth?
- Alternatively, this increase in temperature could accelerate the rate of decay

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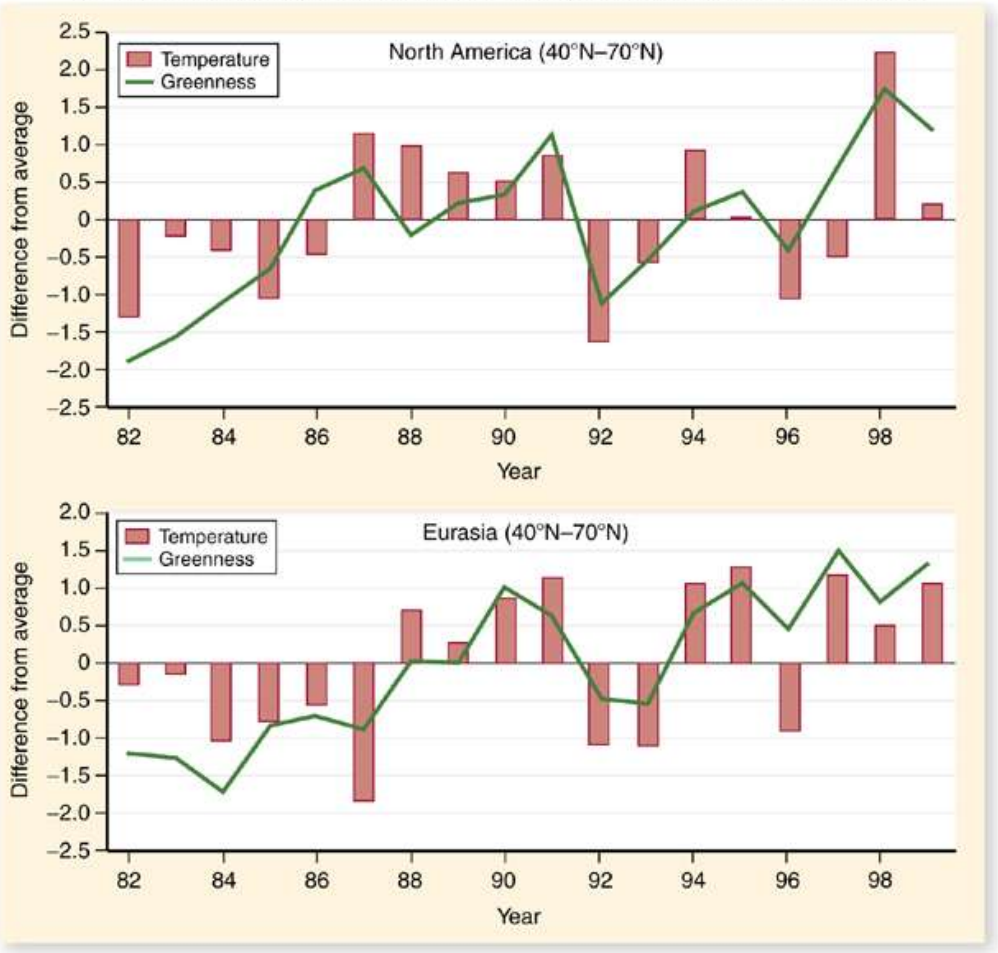

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But the carbon entering the atmosphere is greater

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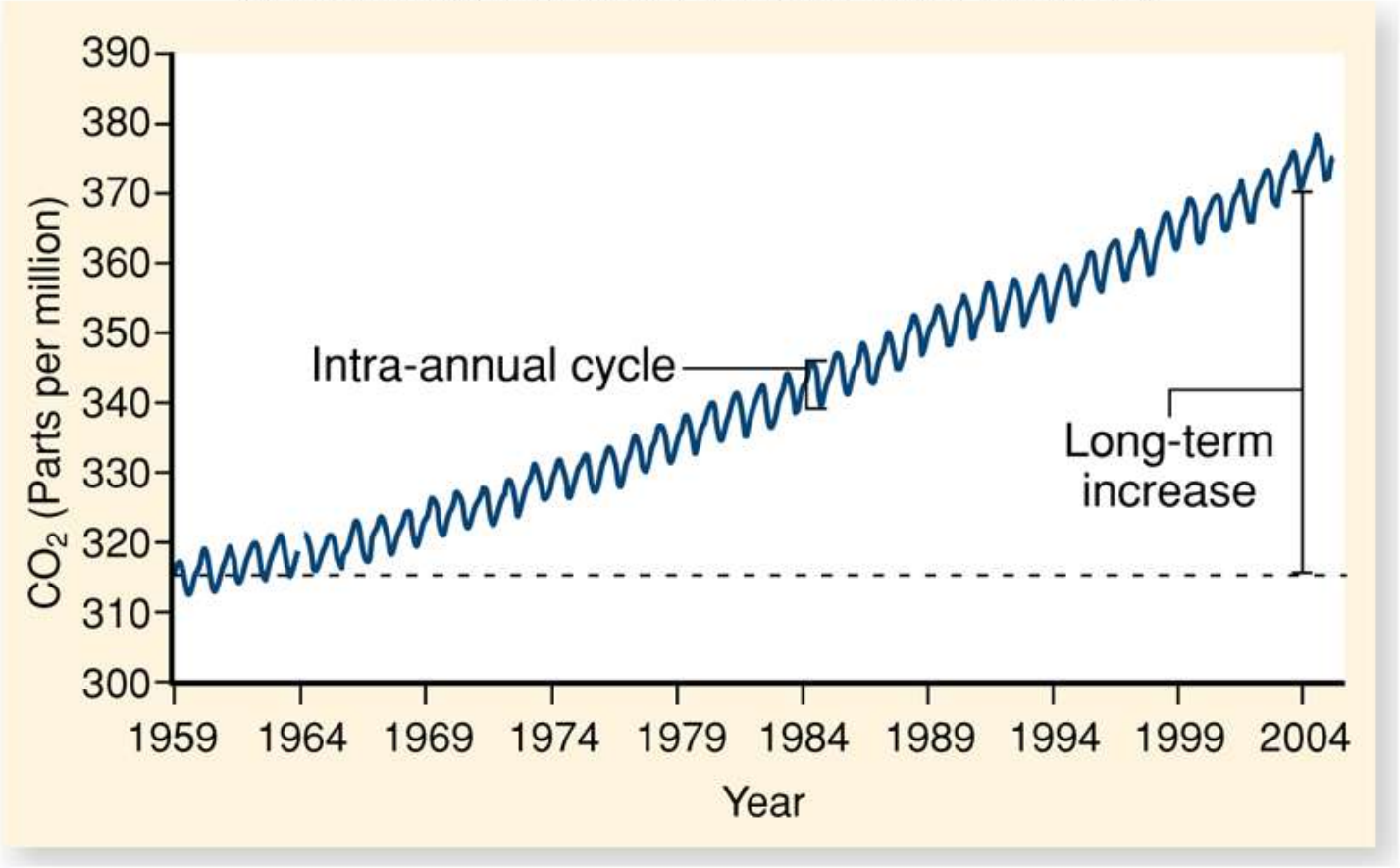

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The Nitrogen Cycle

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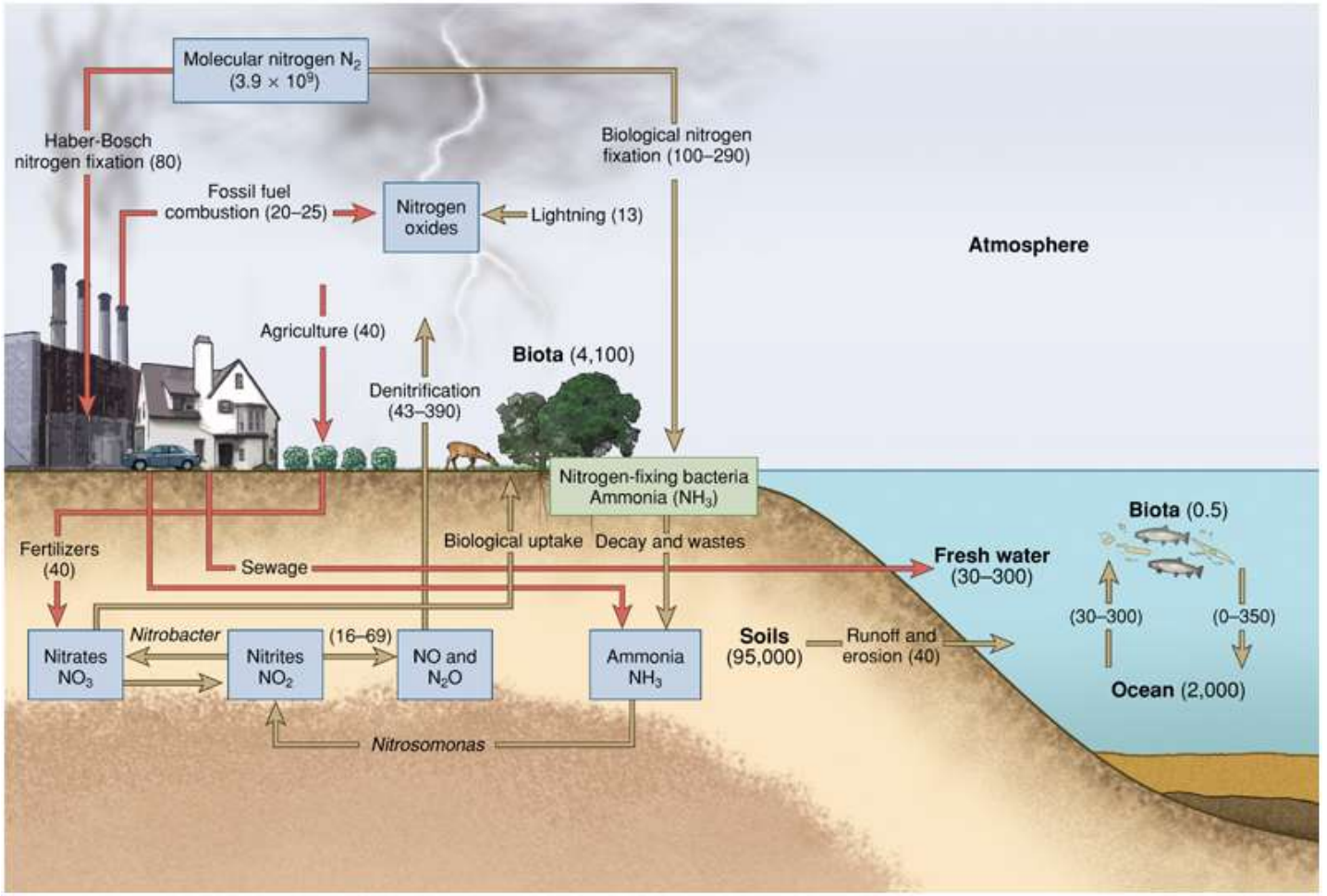

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The Phosphorus Cycle
Running Downhill

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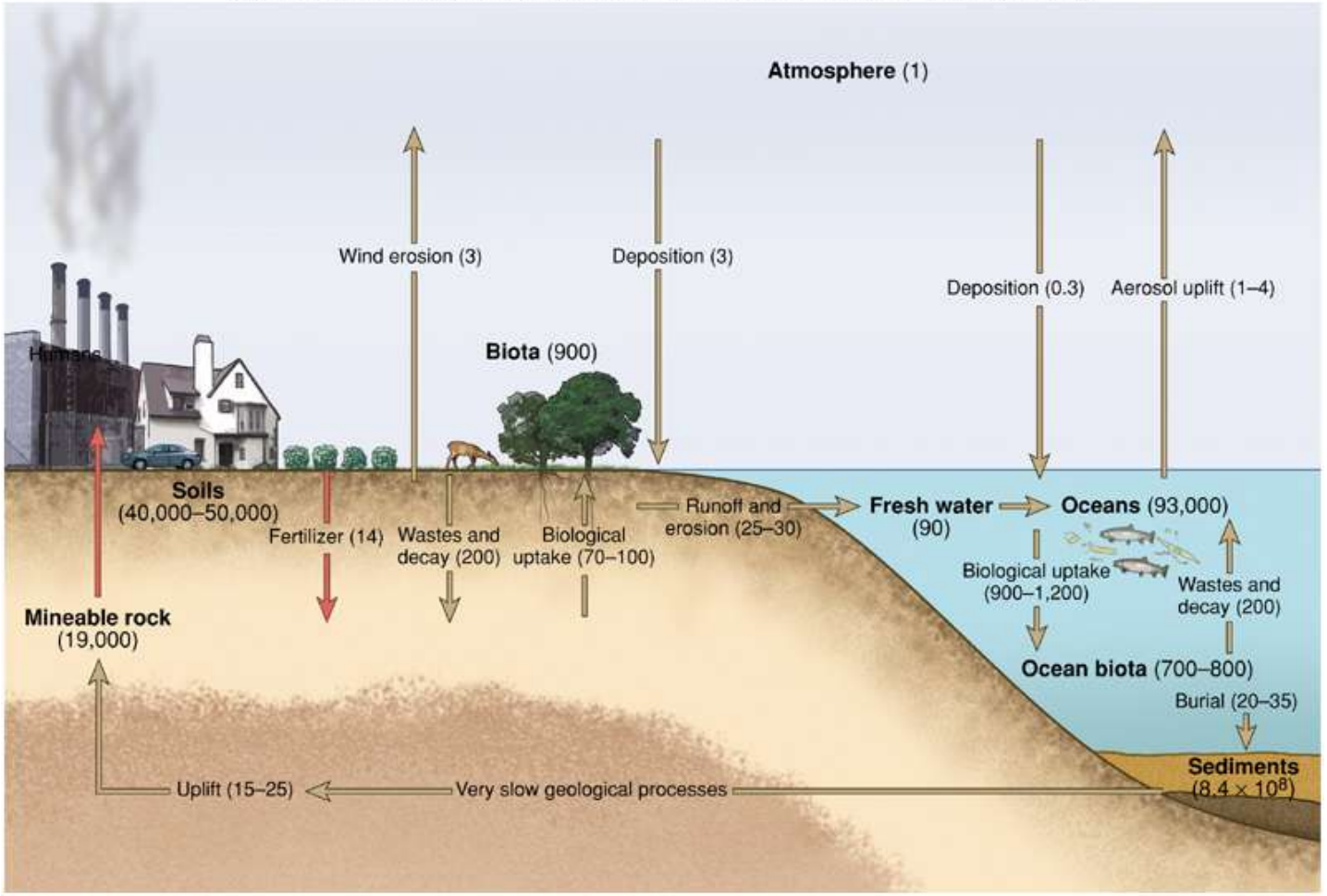

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Phosphorus from Sea Birds

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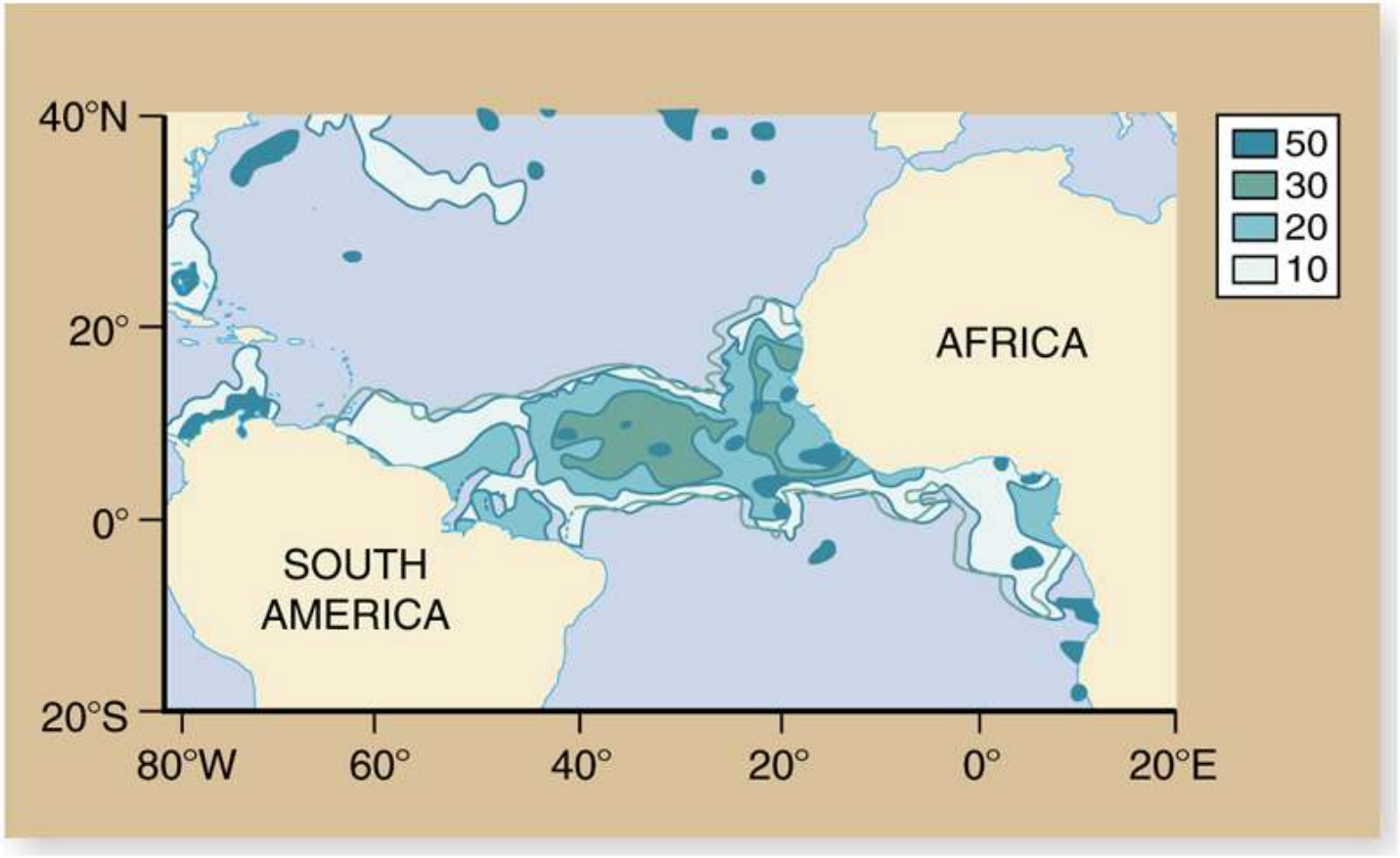

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The Sulfur Cycle

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Interactions Among the Cycles

- Biogeochemical cycles interact in ways that slow or accelerate flows
- Storages can build or deplete
- **C:Nt** (Carbon to Nutrient ratio)
- Limiting factor may change as biomass moves from one storage to the next
- **Trees and detrivores**
- Most tree carbon returns via detrivore food chain
- Detrivores have lower C:Nt than tree materials
- Flow of carbon controlled by nitrogen in forest

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Disrupting Biogeochemical Cycles

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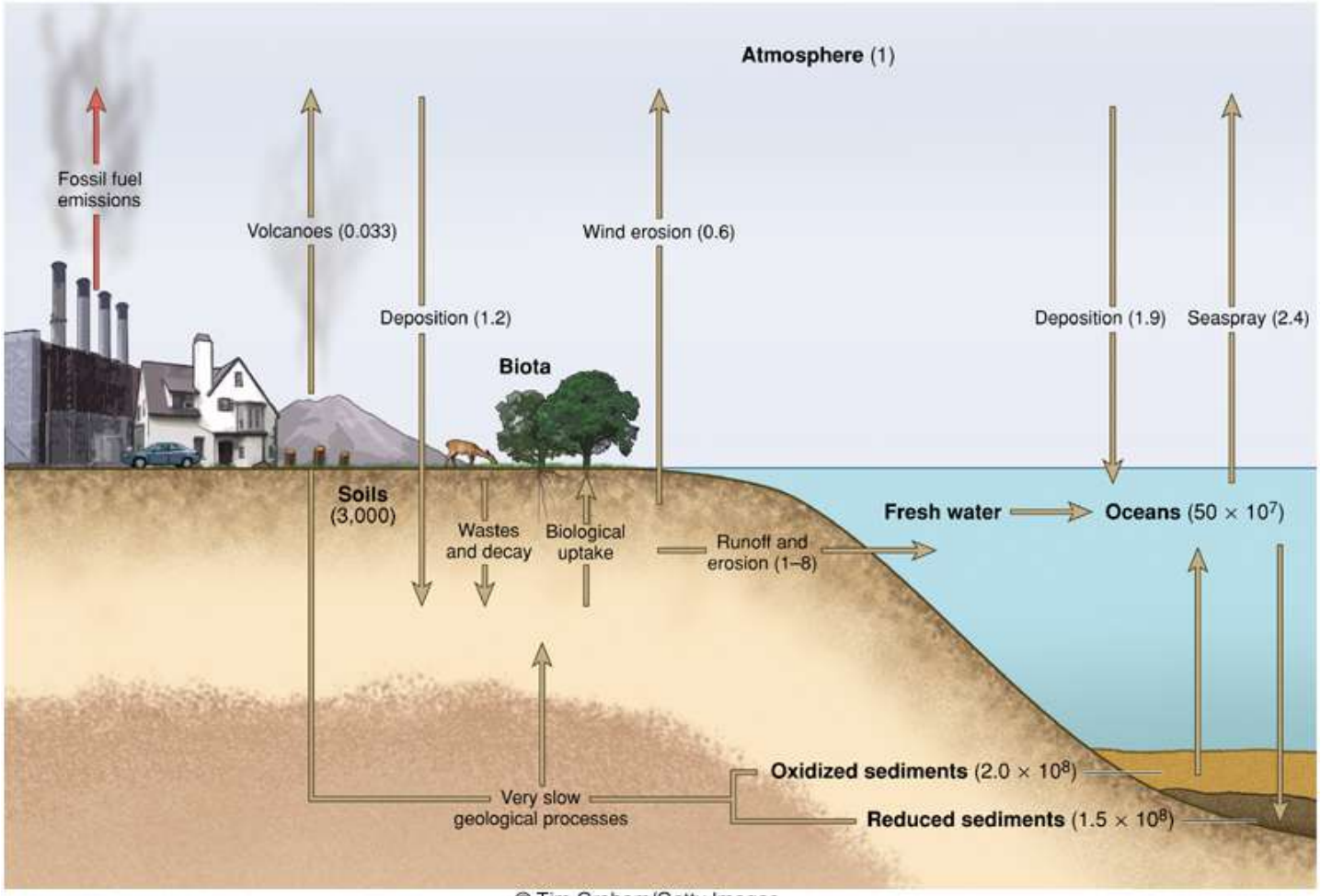

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