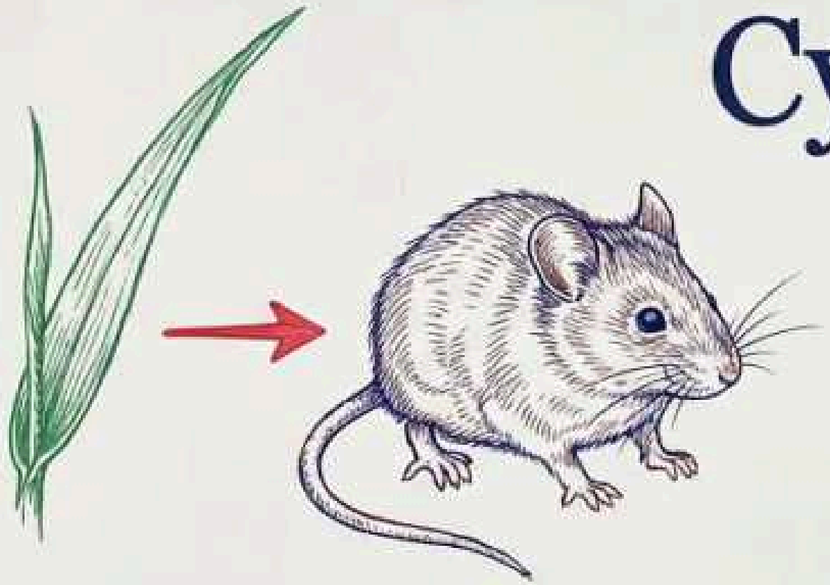
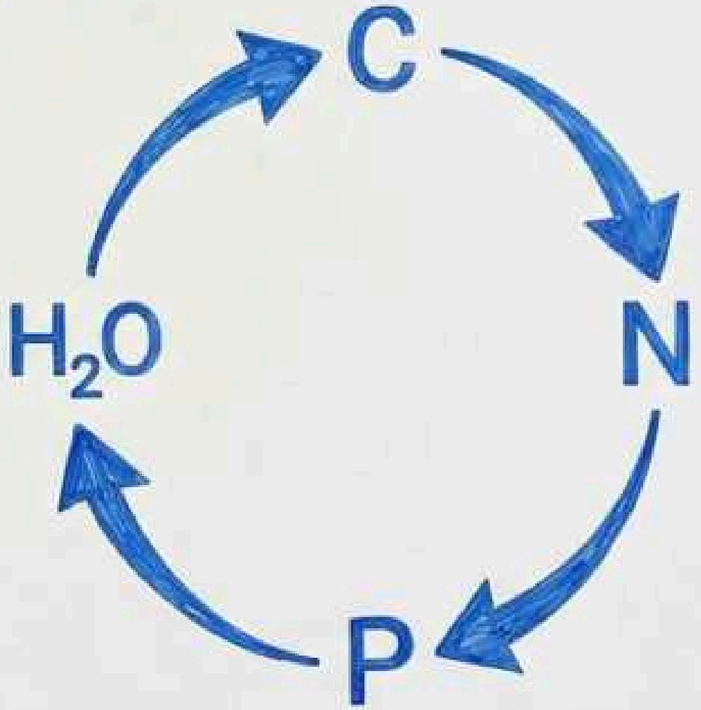
[¶ 2.1]

Ecosystems and the Cycles of Life



10%



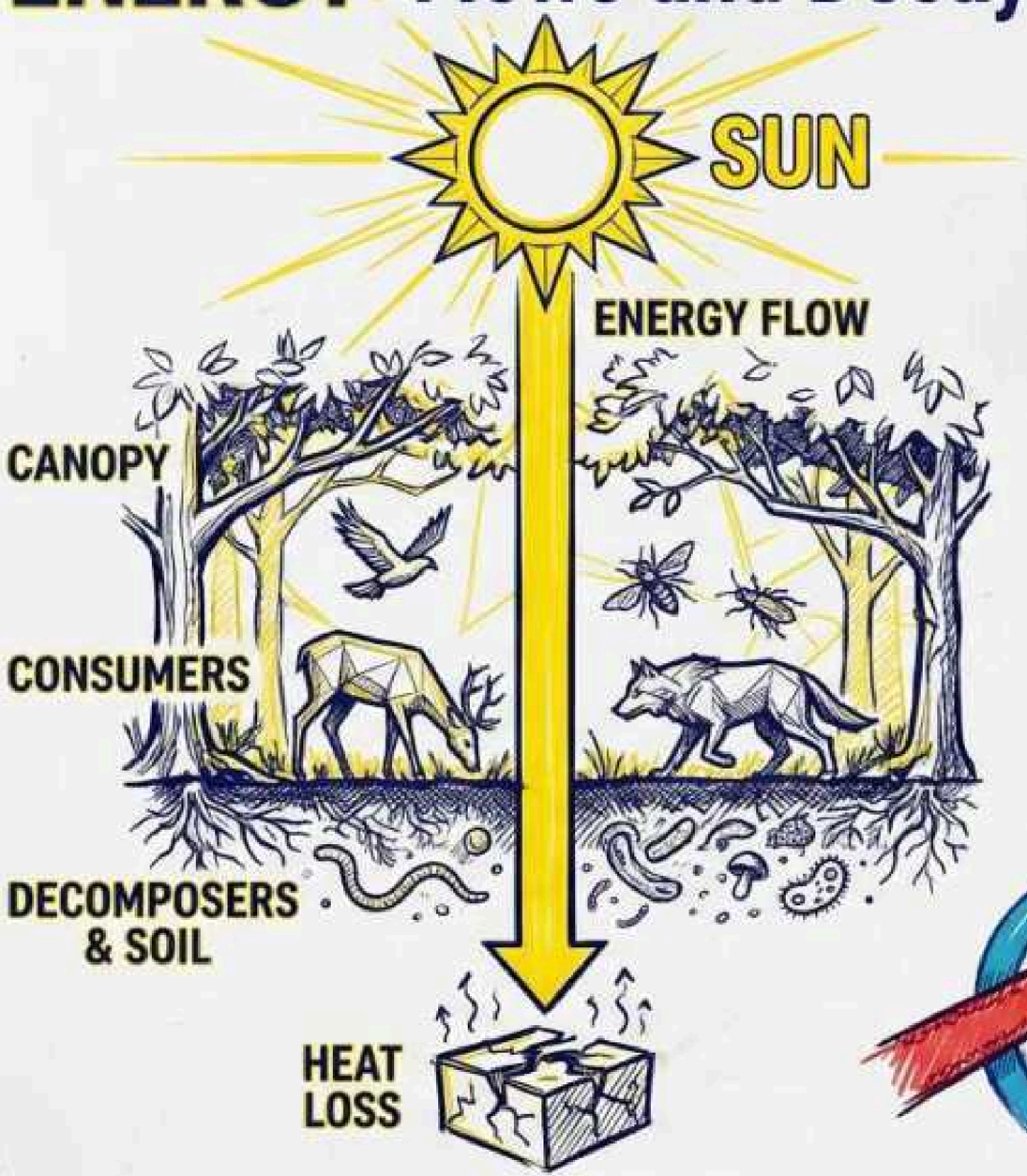
At a Glance

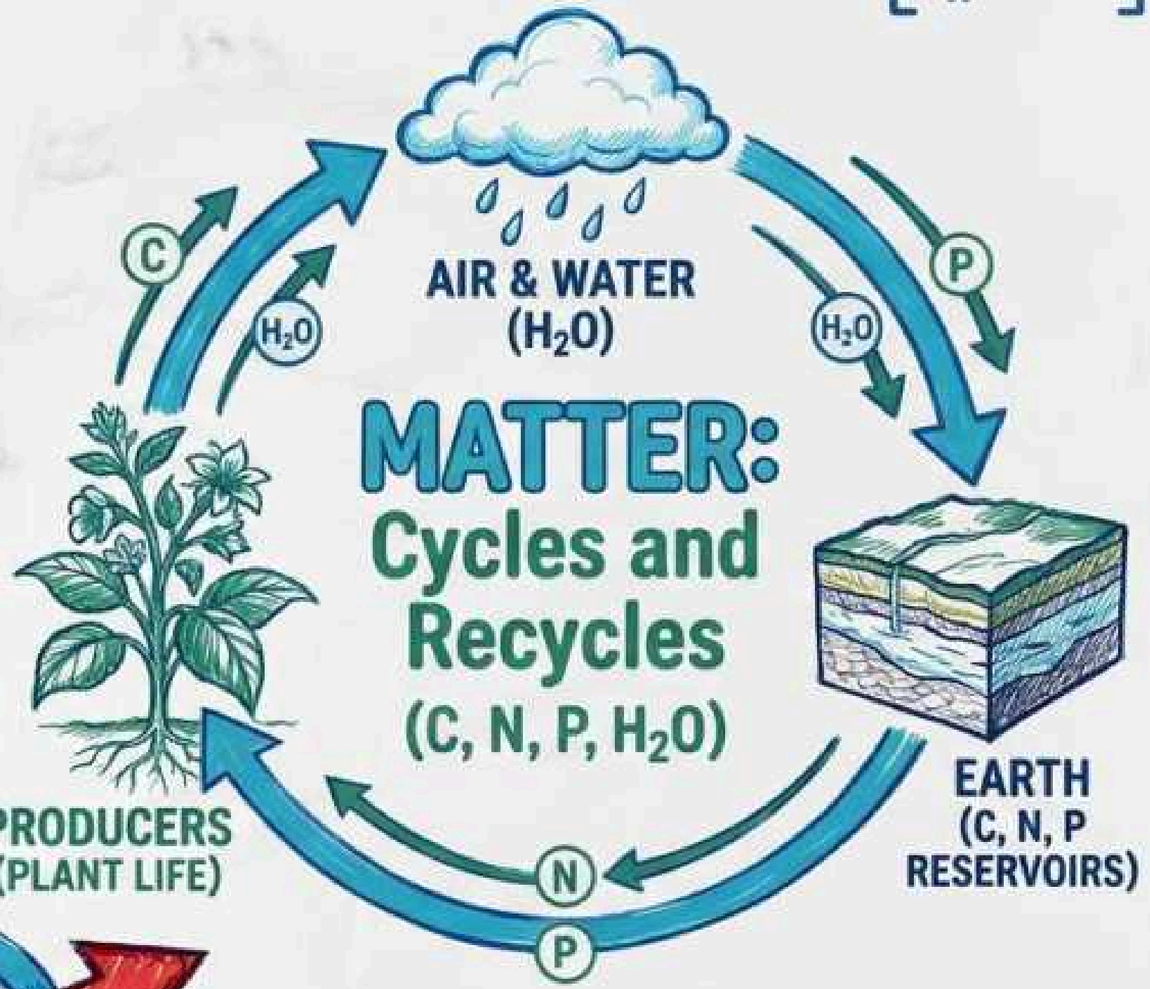
- Food chains, the ten percent rule, and the cycles of carbon, nitrogen, phosphorus, and water.

Gemini Notebook

ENERGY: Flows and Decays

[¶ 2.2]







Human Overload:
When the cycles break.

Gemini Notebook

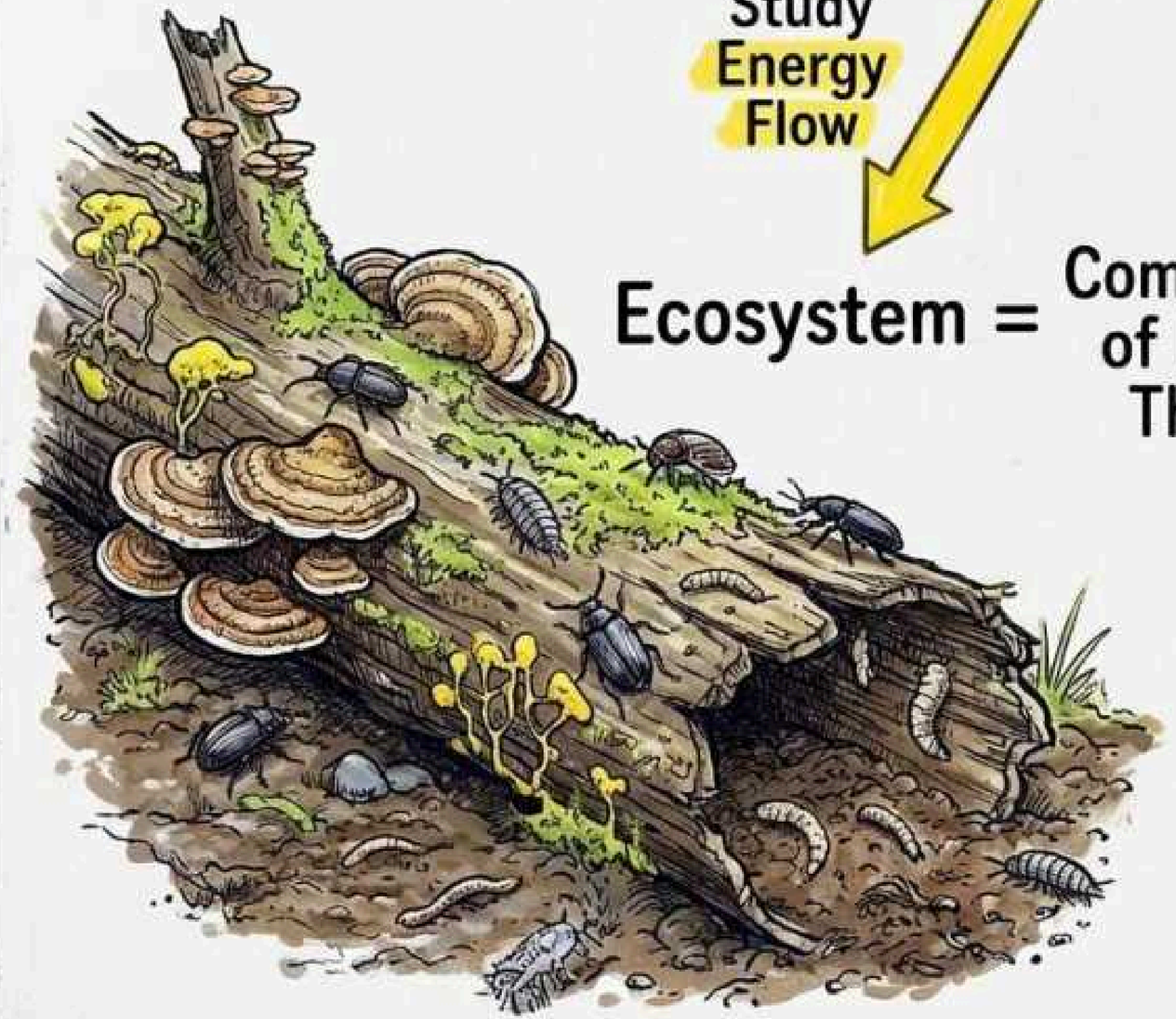
[¶ 2.3]

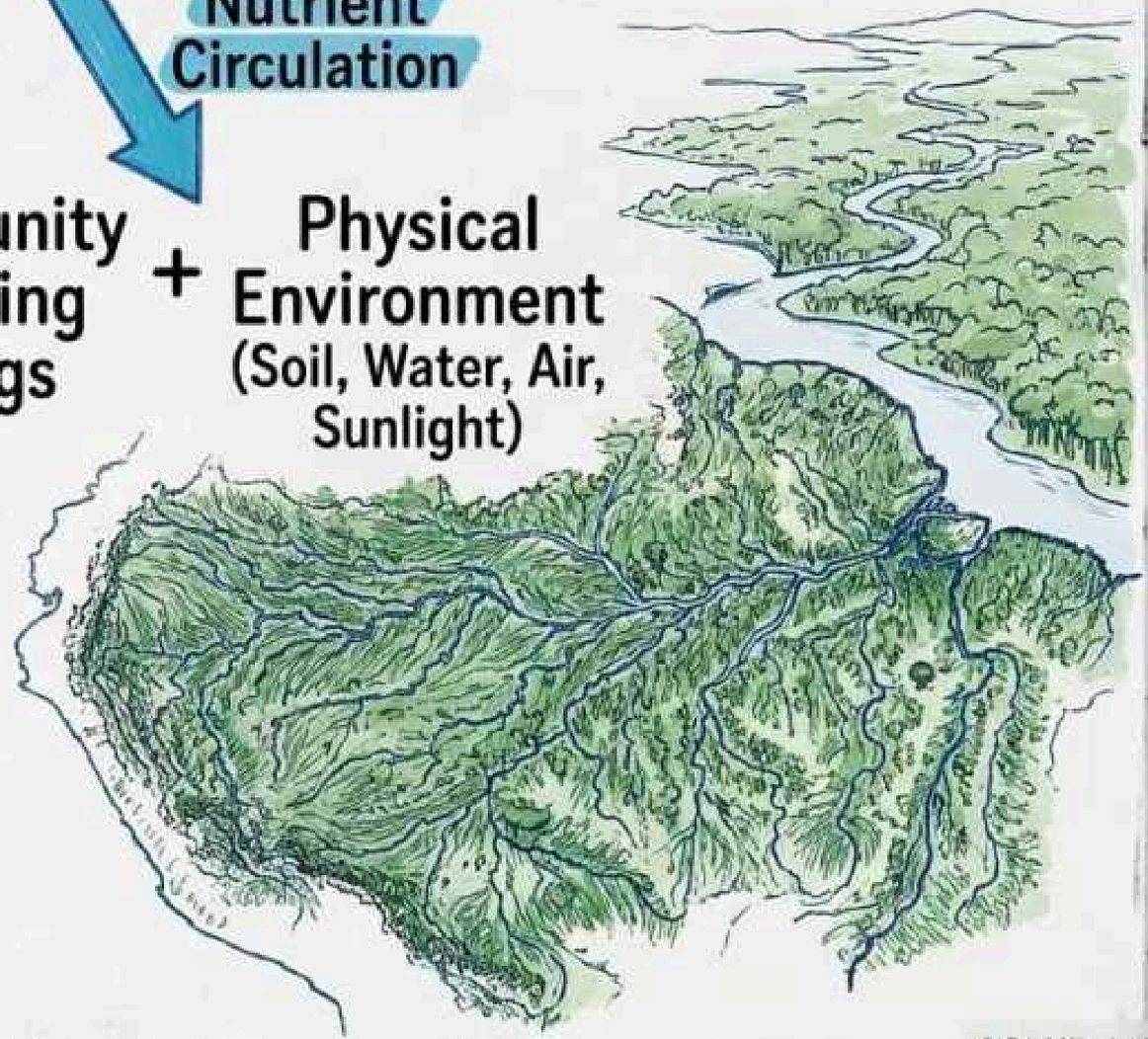
Ecologists

Study **Energy Flow**

Study **Nutrient Circulation**

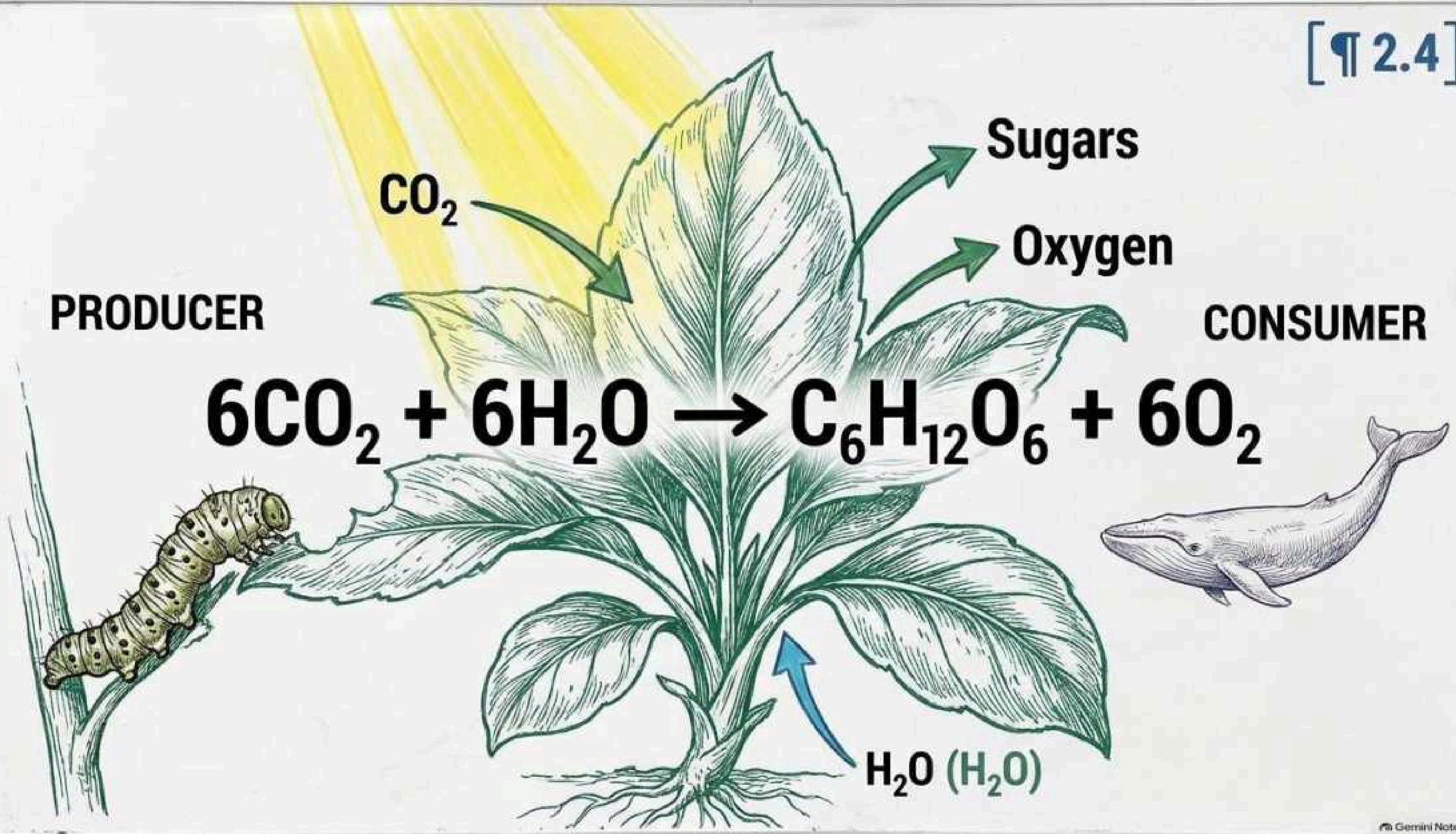
Ecosystem = **Community of Living Things** + **Physical Environment** (Soil, Water, Air, Sunlight)





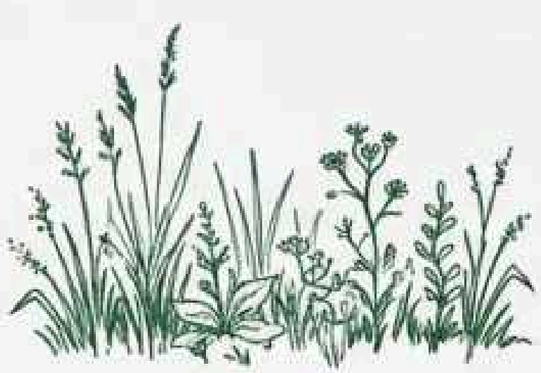
Gemini Notebook

[¶ 2.4]

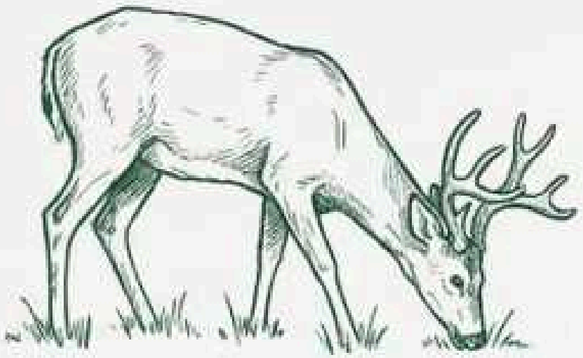


Gemini Notebook

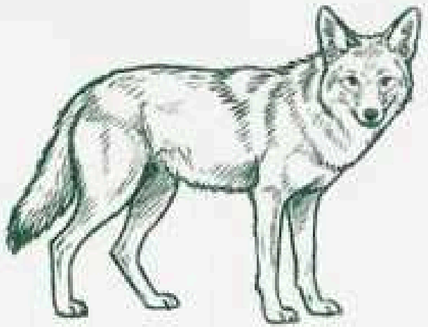
[¶ 2.5]



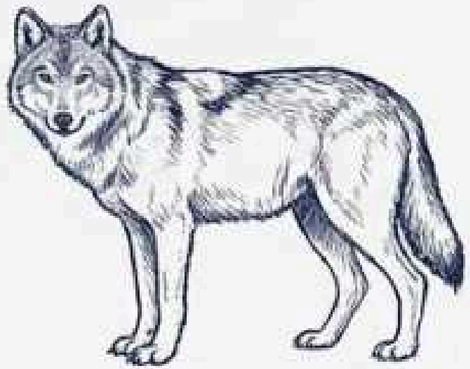
Producers – 1st Level



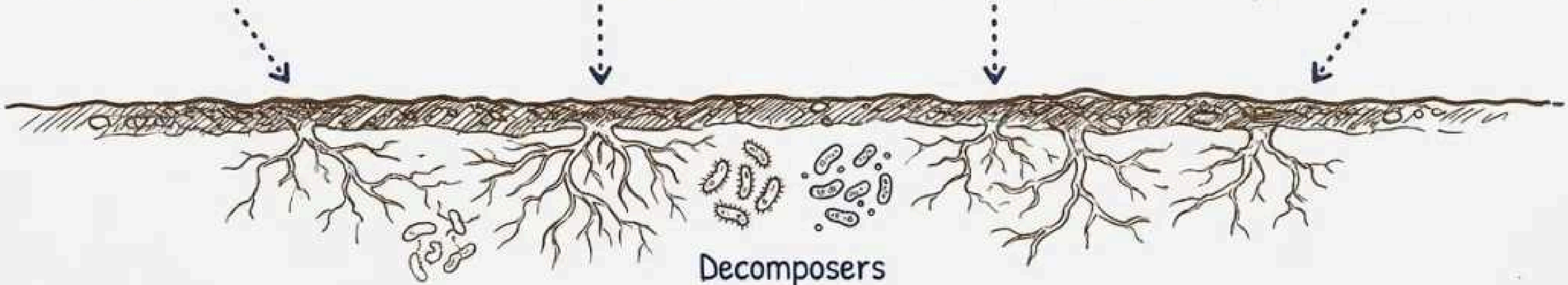
Herbivores - 2nd Level



Carnivores - 3rd Level

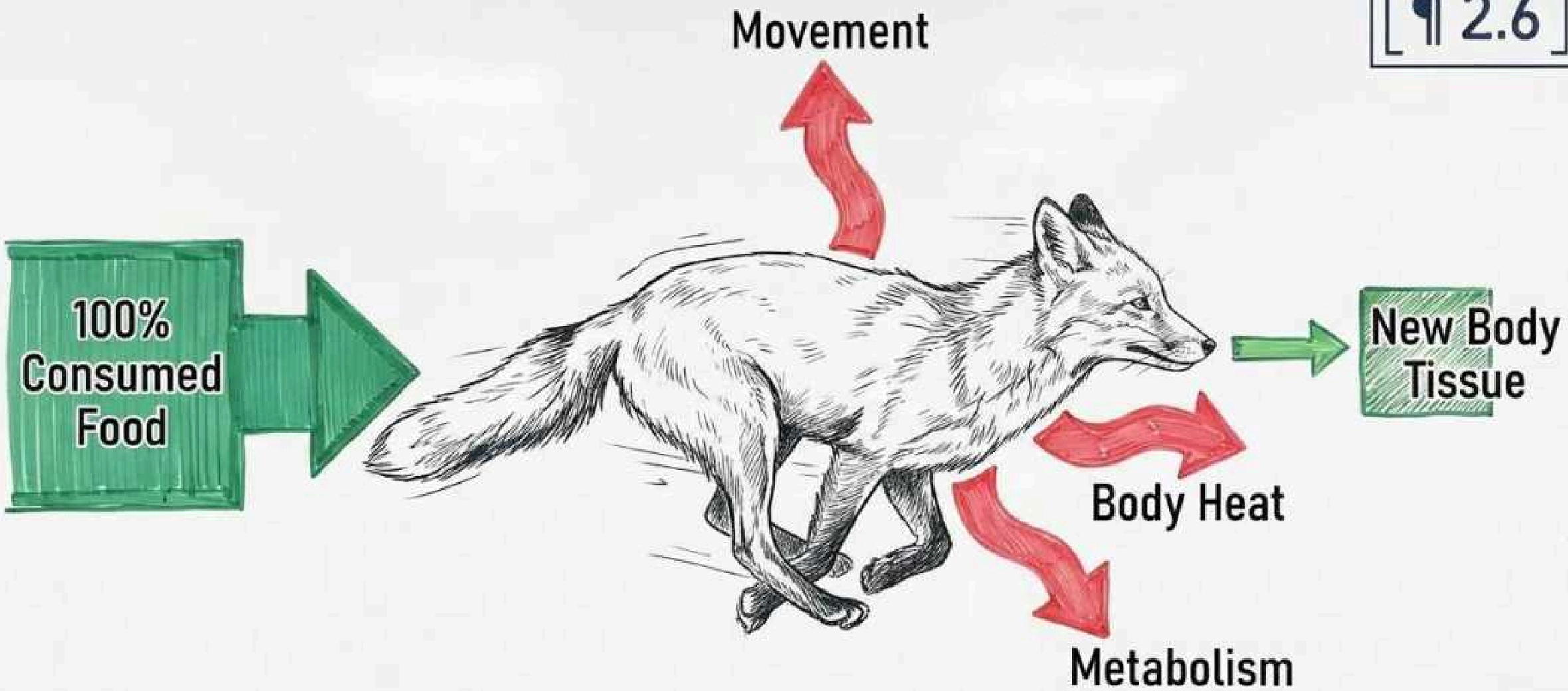


Top Predators - 4th Level



Decomposers

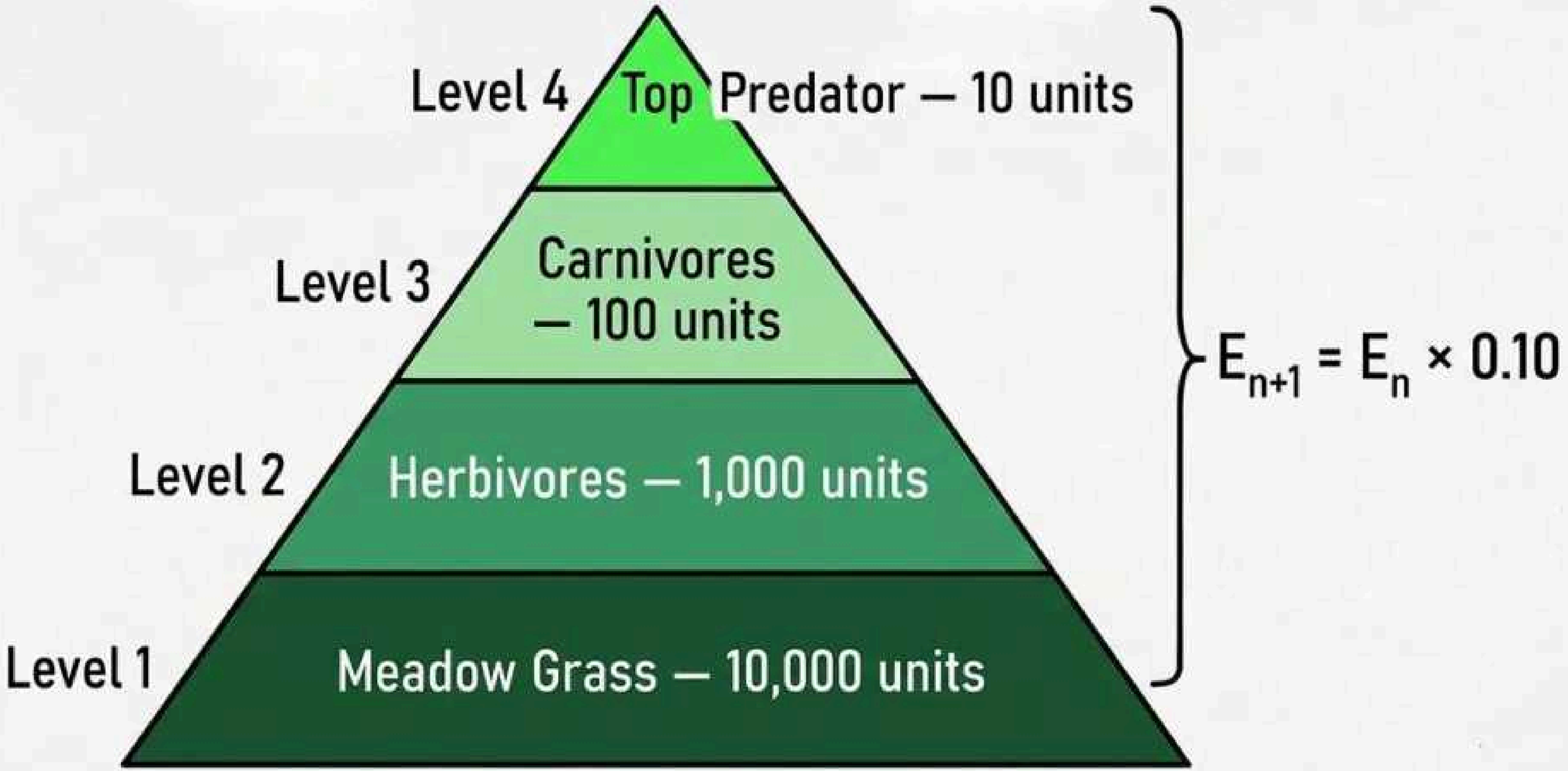
[¶ 2.6]



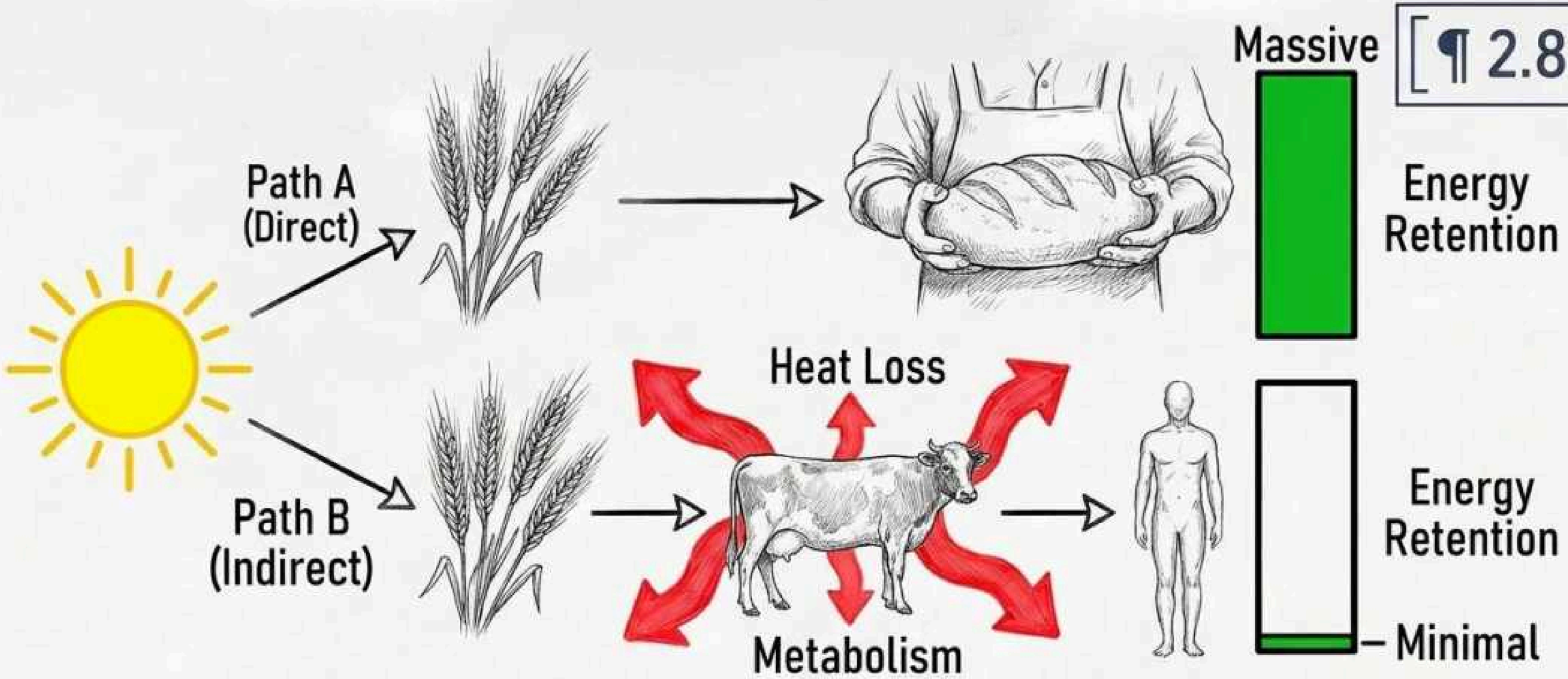
Energy does not recycle, it flows. Only ~10% is passed to the next level.

[¶ 2.7]

Energy Pyramid

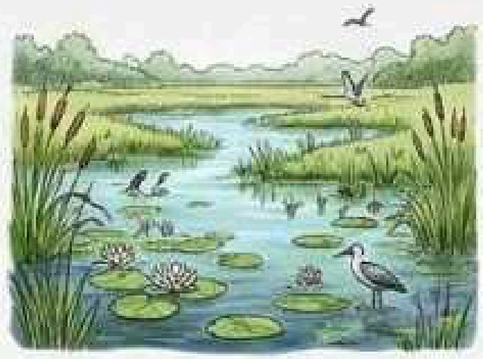
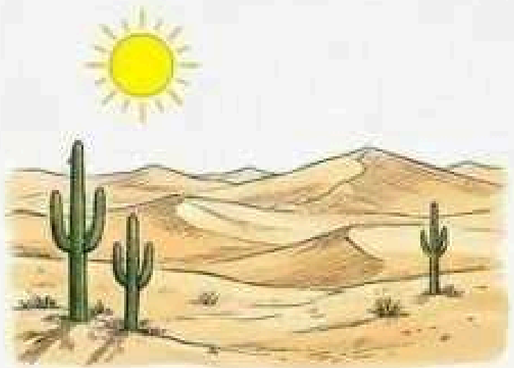
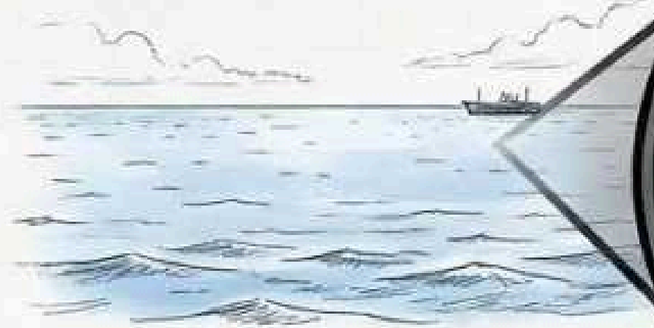


[¶ 2.8]



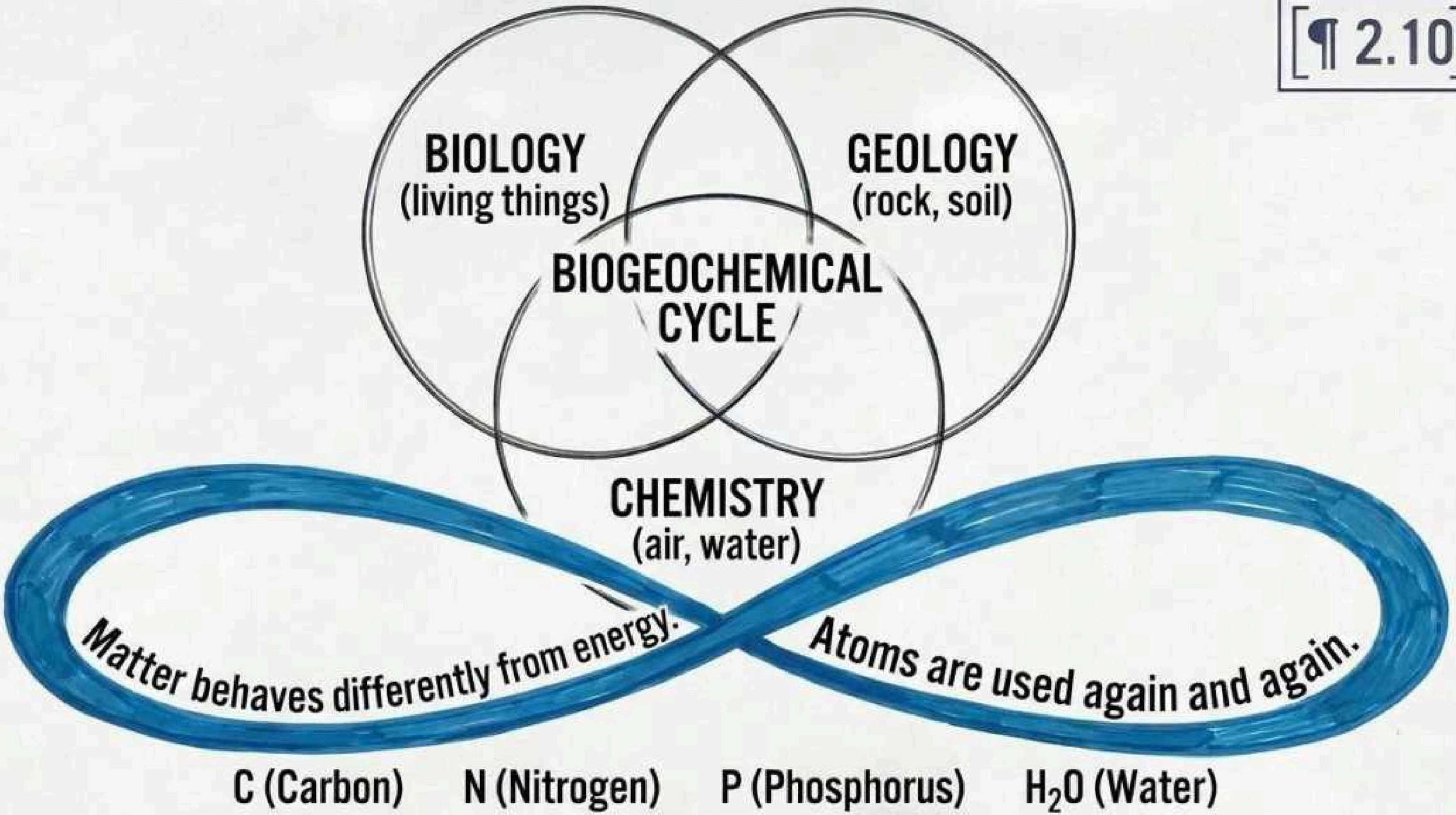
Why food chains are short (3-5 levels) & top predators are rare.
Eating grain directly captures far more solar energy. (See Lecture 4)

[¶ 2.9]

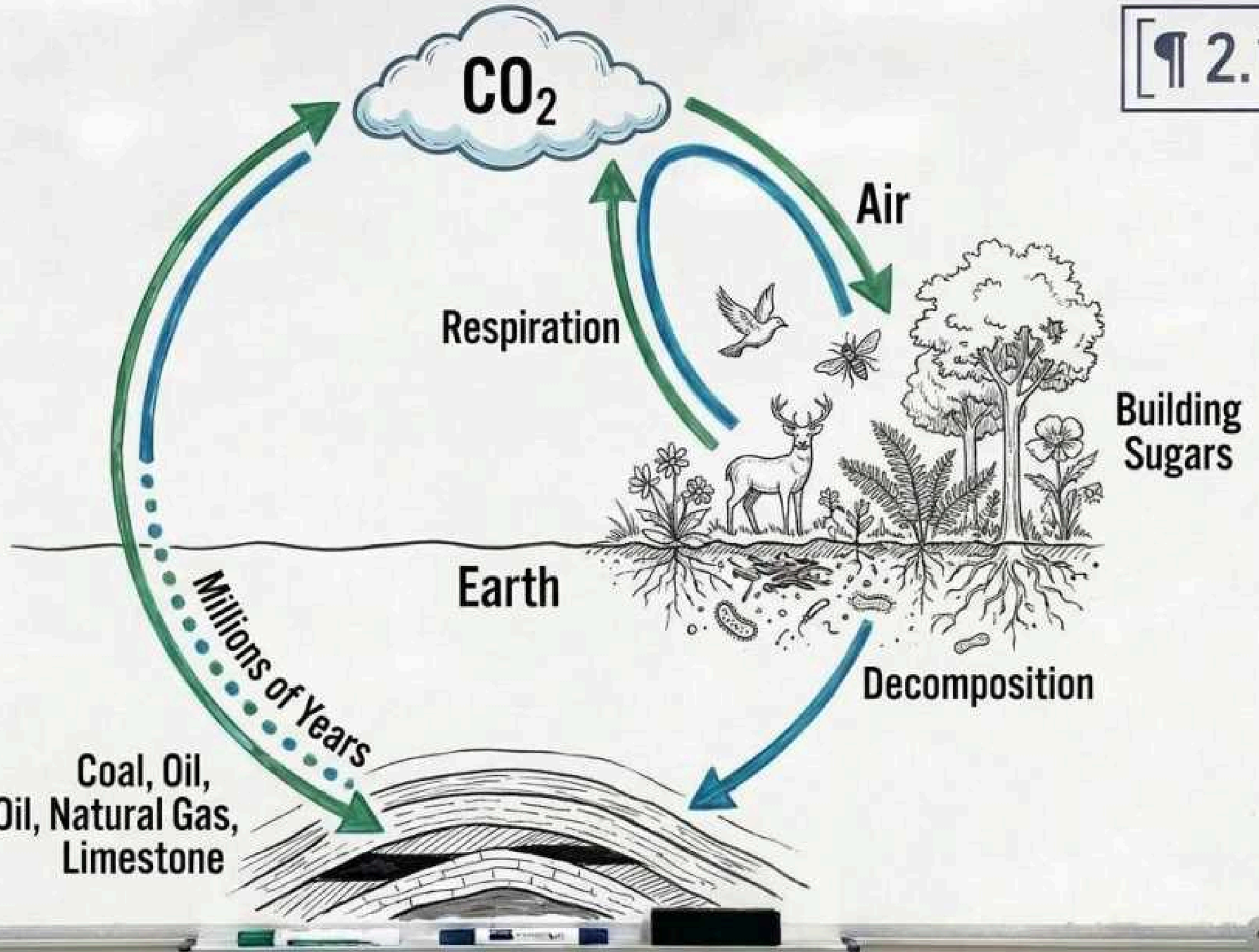
High Production per m^2	 Tropical Rainforest	 Coral Reef  Wetland
Low Production per m^2	 Desert	 Open Ocean 

Massive Ocean Volume × Low m^2 Production = ~50% of Earth's Annual Oxygen.

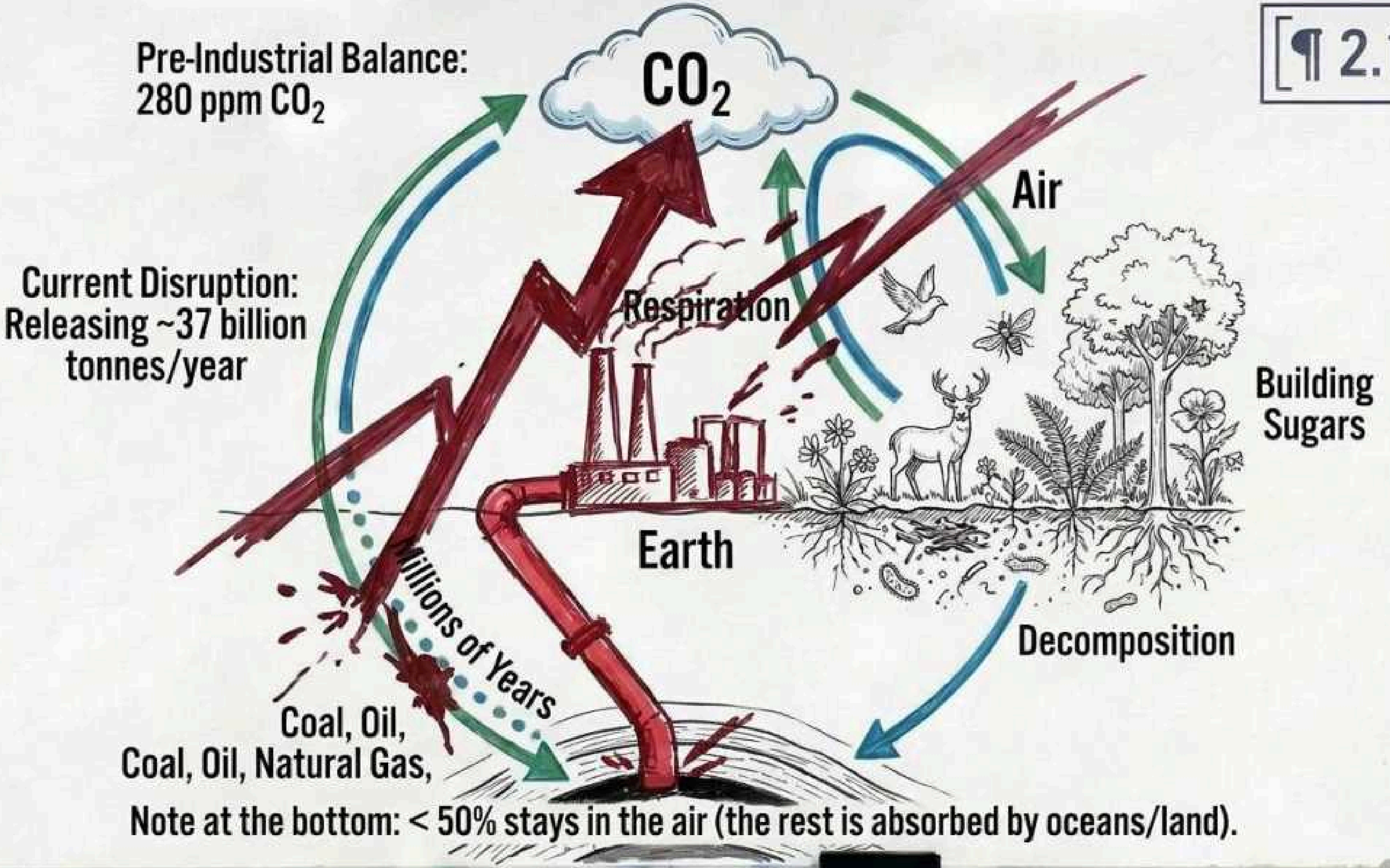
[¶ 2.10]


BIOLOGY
(living things)
GEOLOGY
(rock, soil)
BIOGEOCHEMICAL CYCLE
CHEMISTRY
(air, water)
Matter behaves differently from energy.
Atoms are used again and again.
C (Carbon)
N (Nitrogen)
P (Phosphorus)
H_2O (Water)

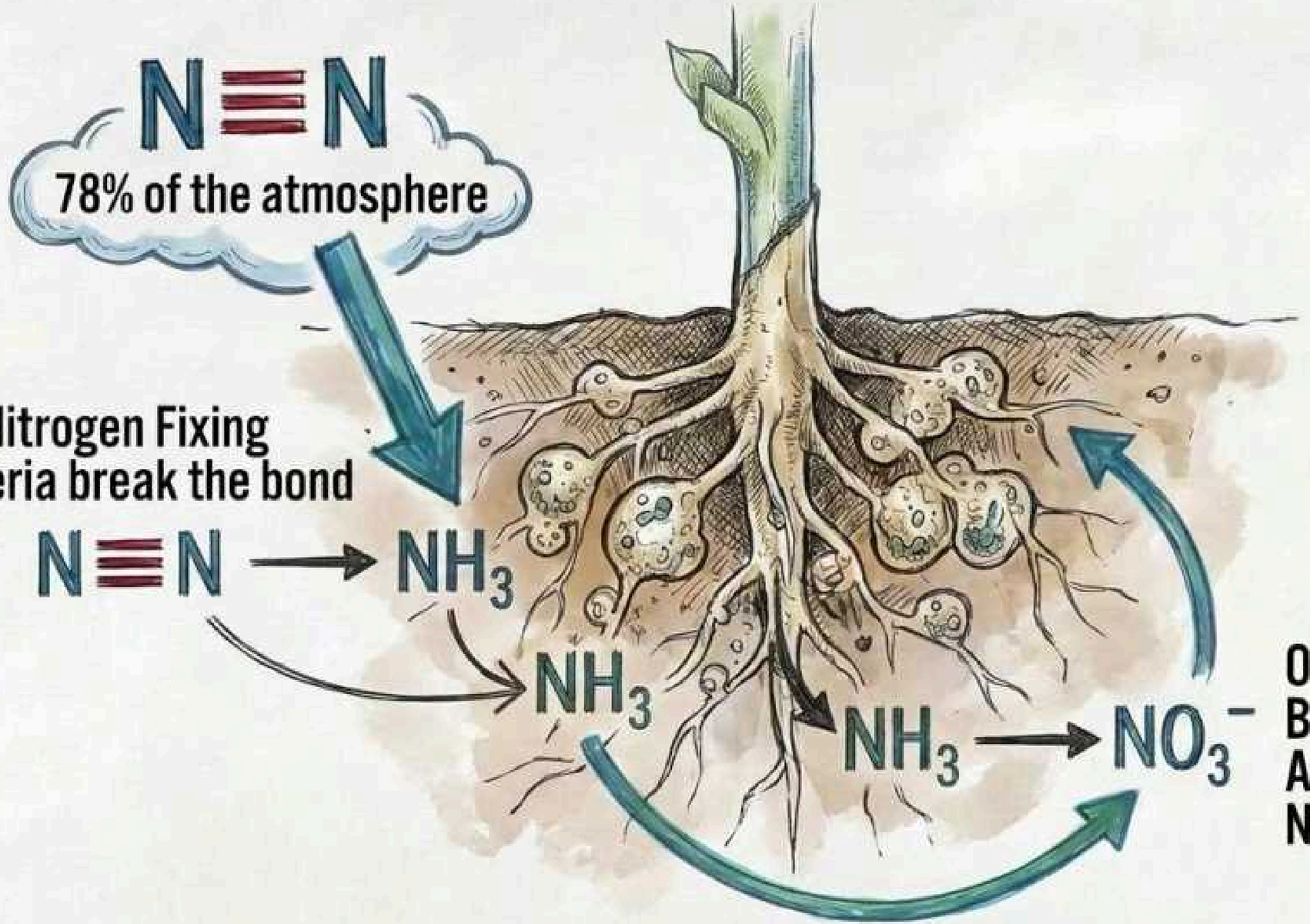
[¶ 2.11]


CO_2
Air
Respiration
Building Sugars
Earth
Millions of Years
Decomposition
Coal, Oil,
Coal, Oil, Natural Gas,
Limestone

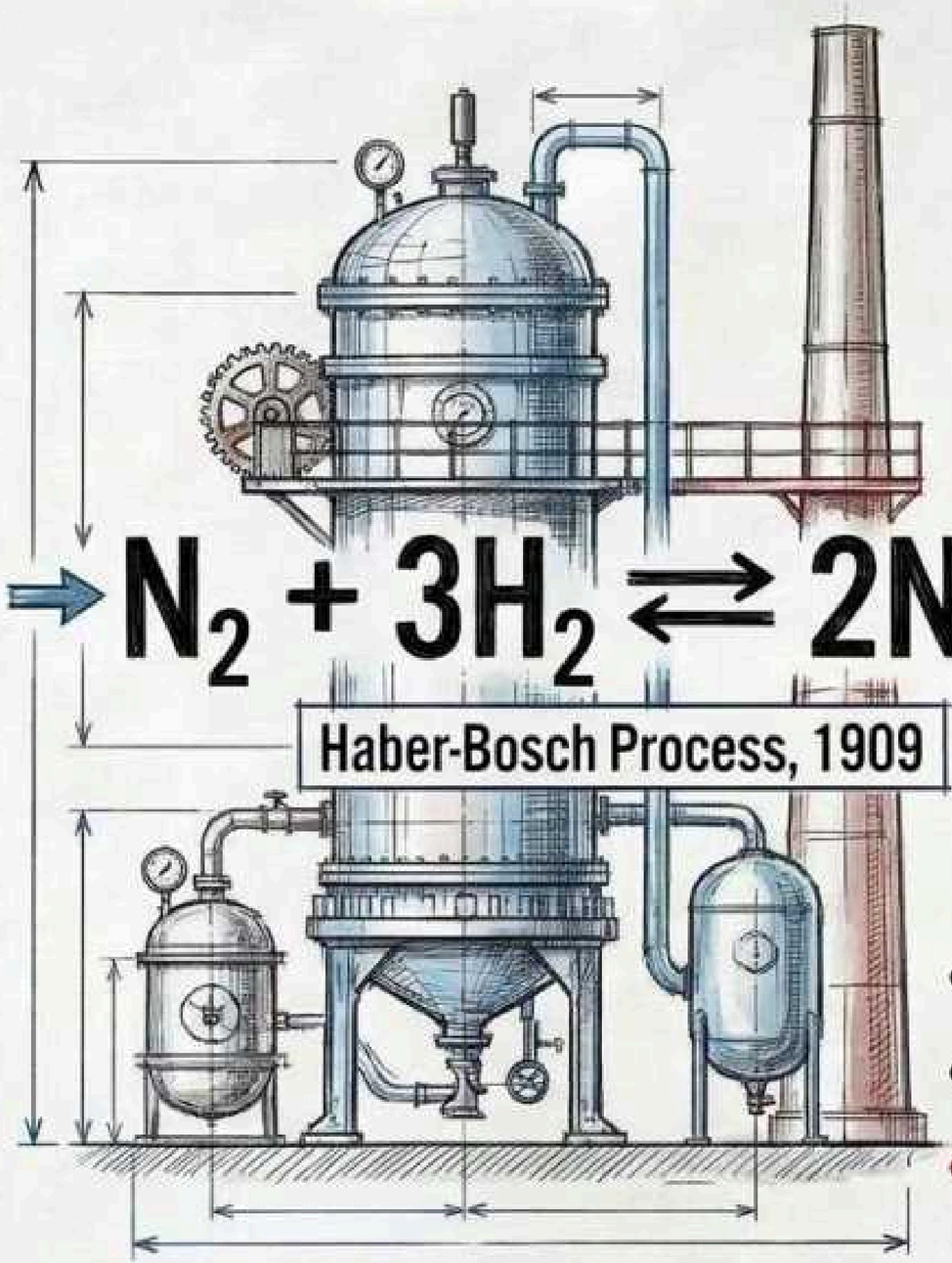
[¶ 2.12]


Pre-Industrial Balance:
280 ppm CO_2
CO_2
Air
Current Disruption:
Releasing ~37 billion
tonnes/year
Respiration
Building
Sugars
Earth
Millions of Years
Decomposition
Coal, Oil,
Coal, Oil, Natural Gas,
Note at the bottom: < 50% stays in the air (the rest is absorbed by oceans/land).

[¶ 2.13]


N≡N
78% of the atmosphere
Nitrogen Fixing Bacteria break the bond
N≡N → NH3
NH3
NH3 → NO3−
Other Soil Bacteria convert Ammonia to Nitrates

[¶ 2.14]



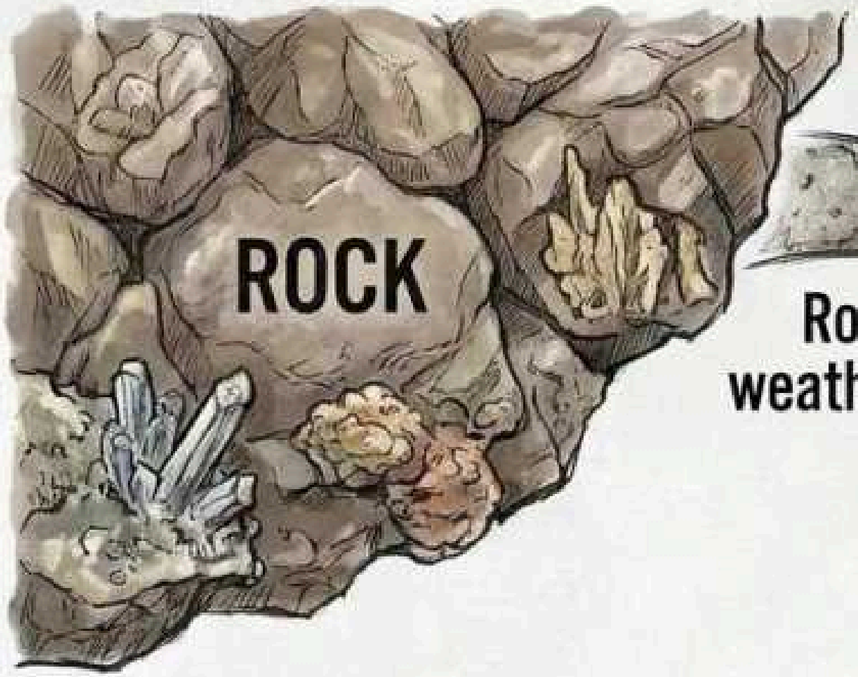
$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Haber-Bosch Process, 1909

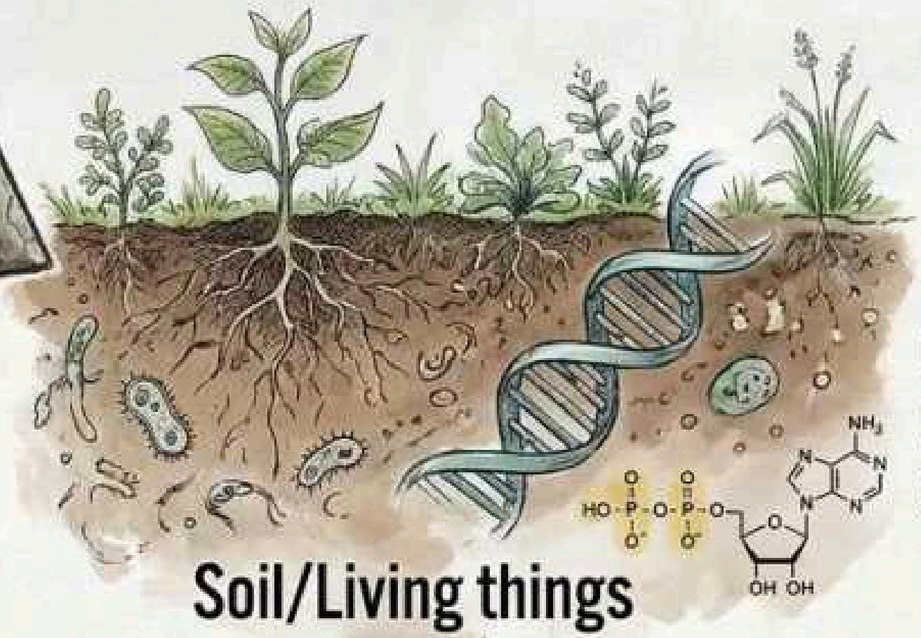


- Inventors: Fritz Haber & Carl Bosch.
- Impact: Supplies artificial fertilizer to feed ~50% of humanity.
- Consequence: The Nitrogen cycle is now critically overloaded.

[¶ 2.15]



Rock weathering



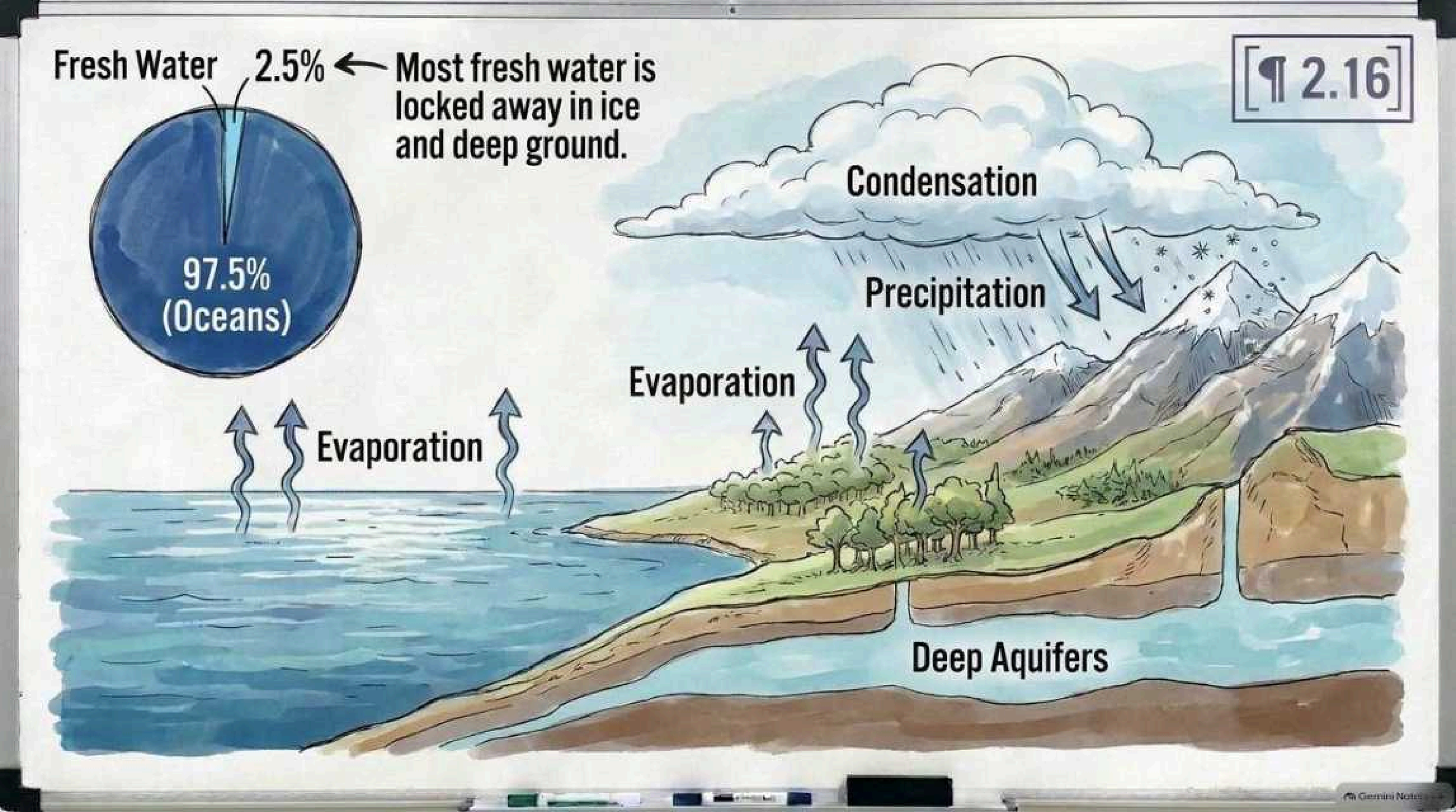
Soil/Living things

Essential for DNA, cell membranes, and ATP.



Finite and unevenly spread reserves mined for fertilizer.

No gas phase = moves very slowly.

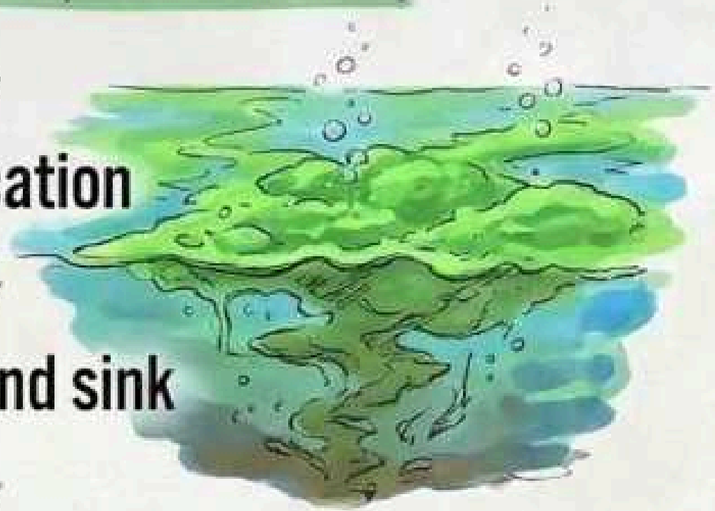

Fresh Water
2.5%
Most fresh water is locked away in ice and deep ground.
97.5% (Oceans)
[¶ 2.16]
Condensation
Precipitation
Evaporation
Evaporation
Deep Aquifers

[¶ 2.17]

Farm & Sewer Runoff (Excess N + P)

↓

Eutrophication



↓

Algae die and sink

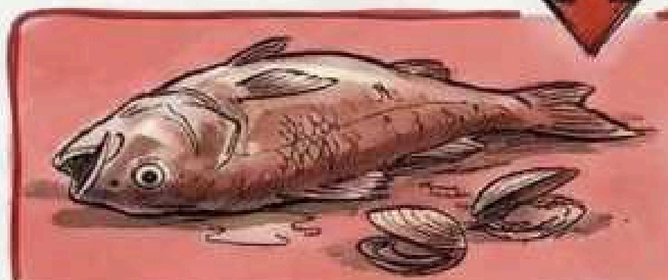
↓

Bacterial Decomposition (Bacteria consume the dead algae, using up massive amounts of oxygen)

↓

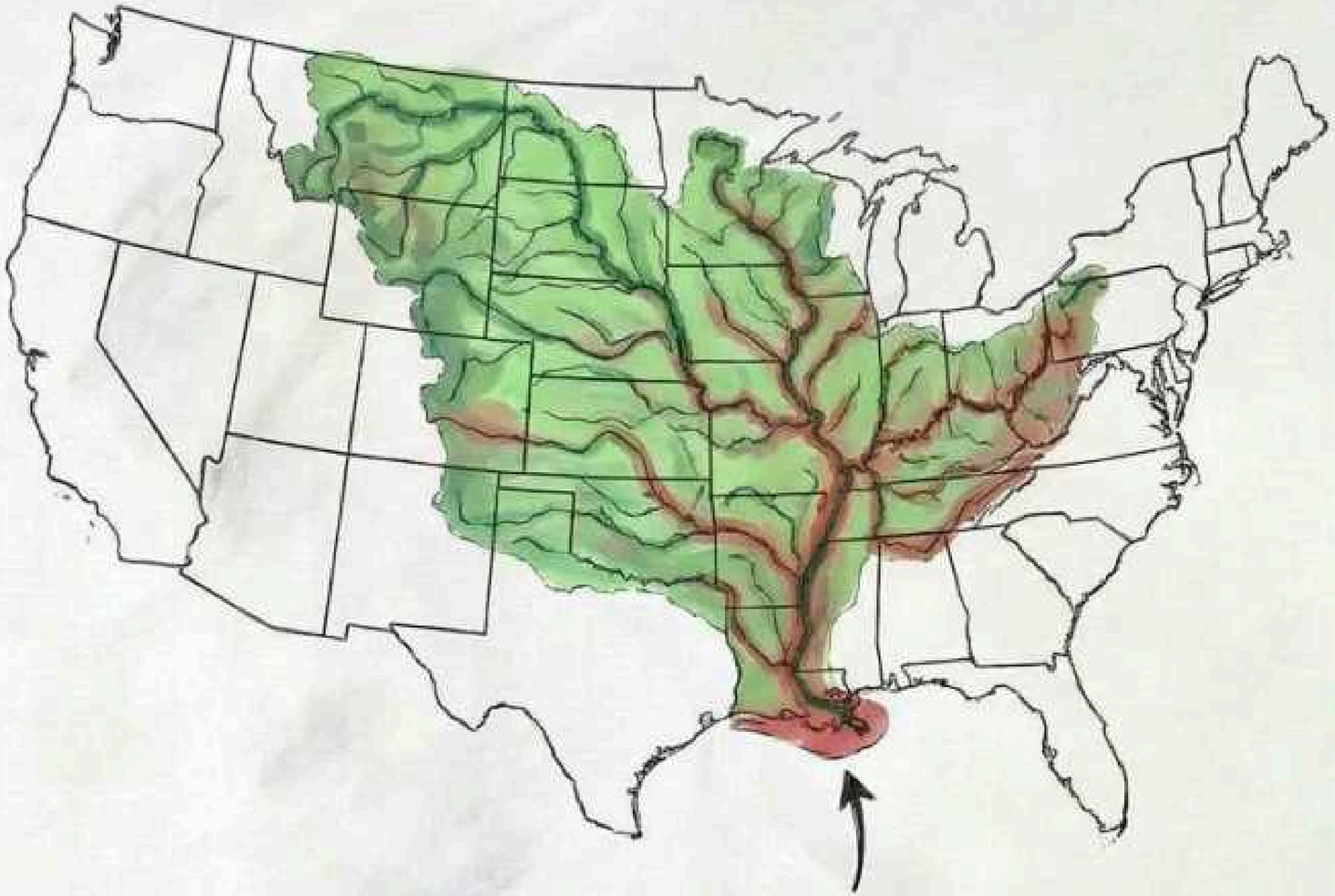
O_2 ↓ (Dissolved Oxygen crashes)

↓



Dead Zone:
Fish and shellfish suffocate or flee.

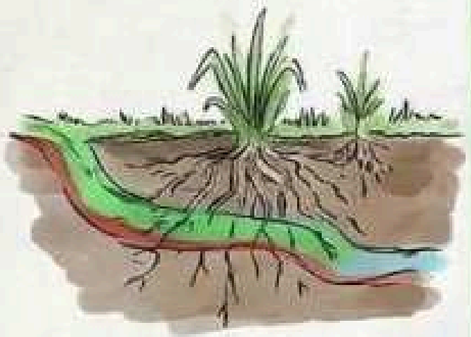
[¶ 2.18]



Gulf of Mexico Dead Zone
(Thousands of square km,
forms every summer).

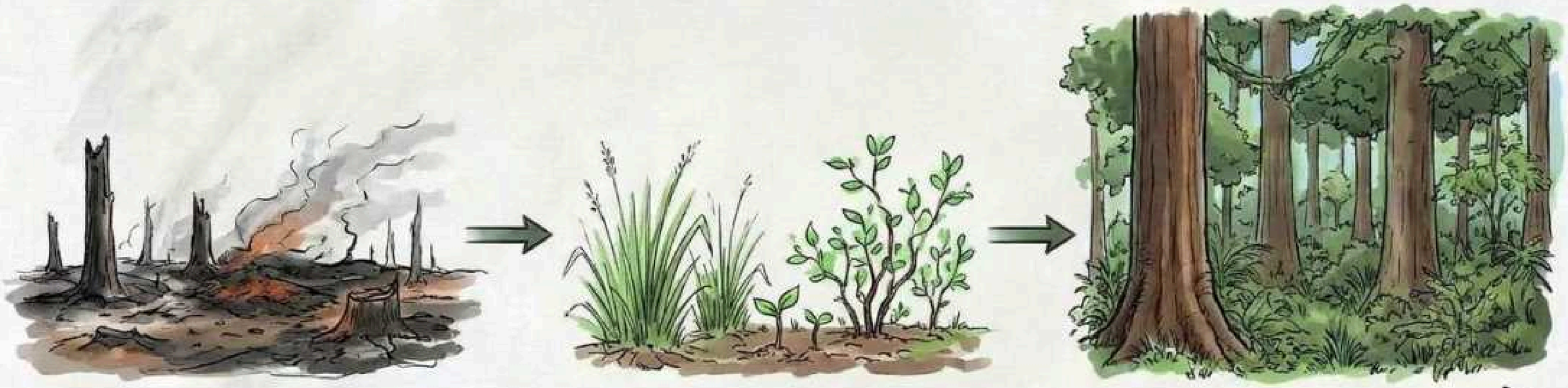
Solutions Panel

1. Better fertilizer timing.
2. Buffer strips of vegetation



3. Improved sewage treatment.

[¶ 2.19]



Natural Disturbance (Fire/Flood)

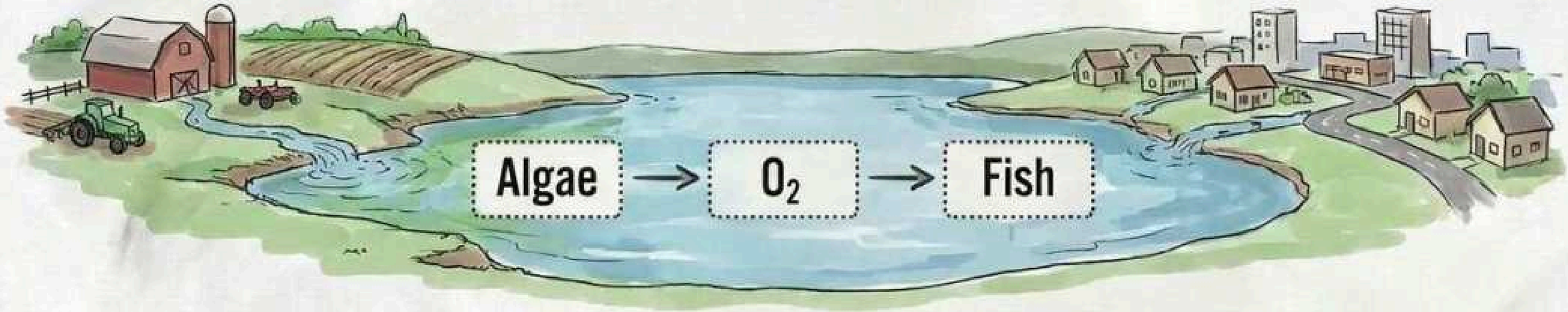
Pioneer Plants

Climax Community

Ecological Succession: Ecosystems change over decades. Disturbance is a natural driver.

The Eutrophication Challenge

[¶ 2.20]



Propose Two Solutions:



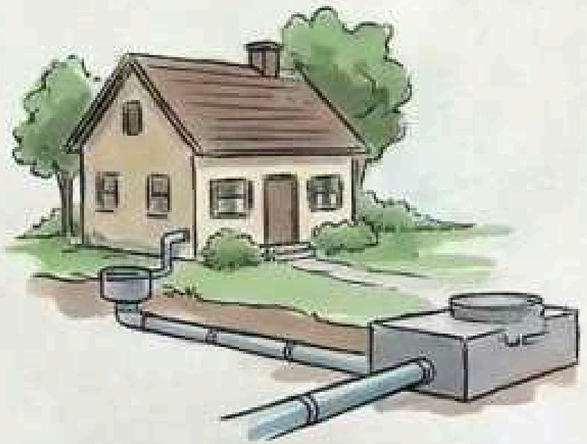
On the Farm

.....

.....

.....

.....



In the Town

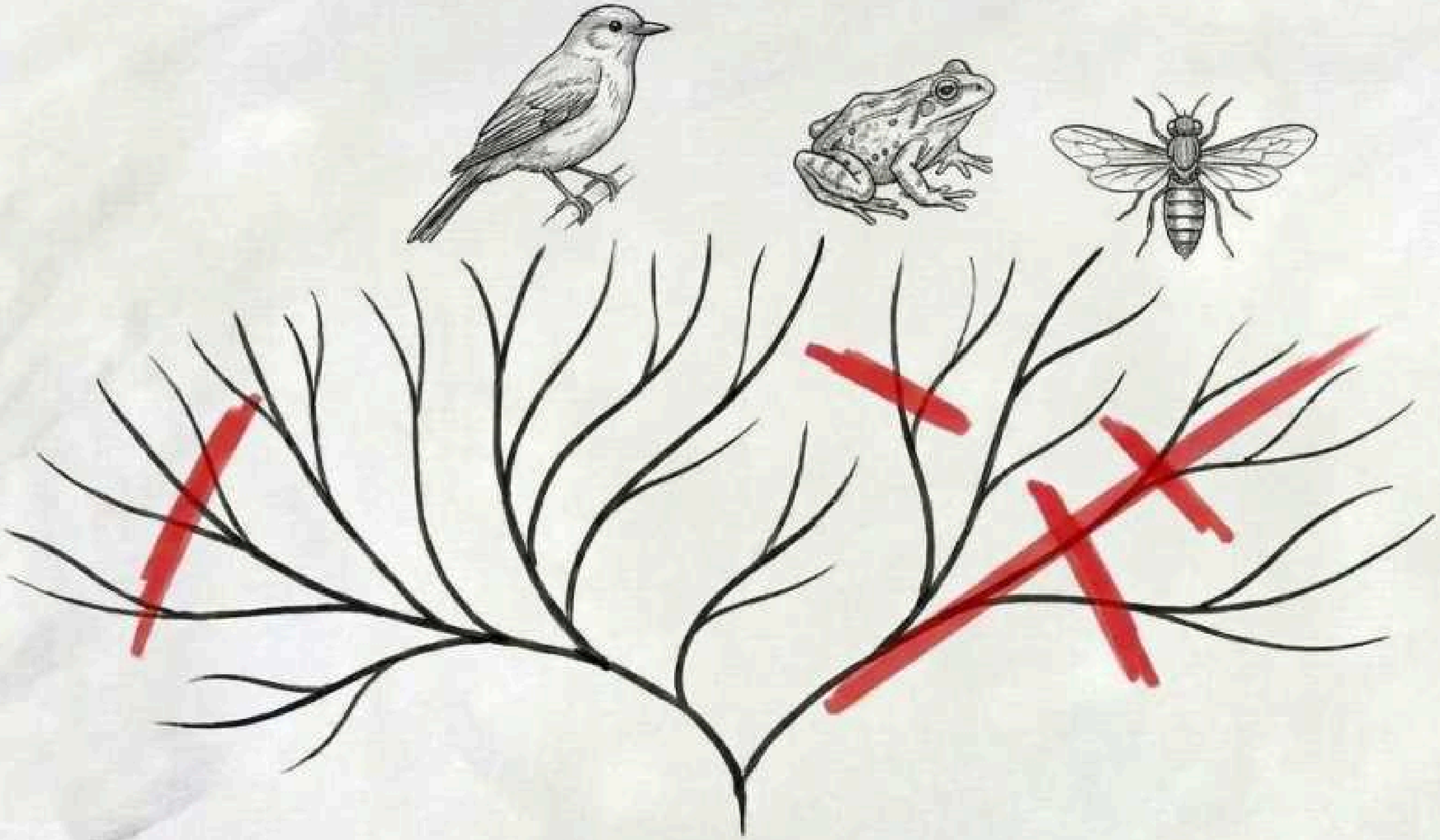
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[¶ 2.21]



Looking ahead to Lecture 3: The Diversity of Life.

How species arise and disappear | What is driving the present wave of extinctions?