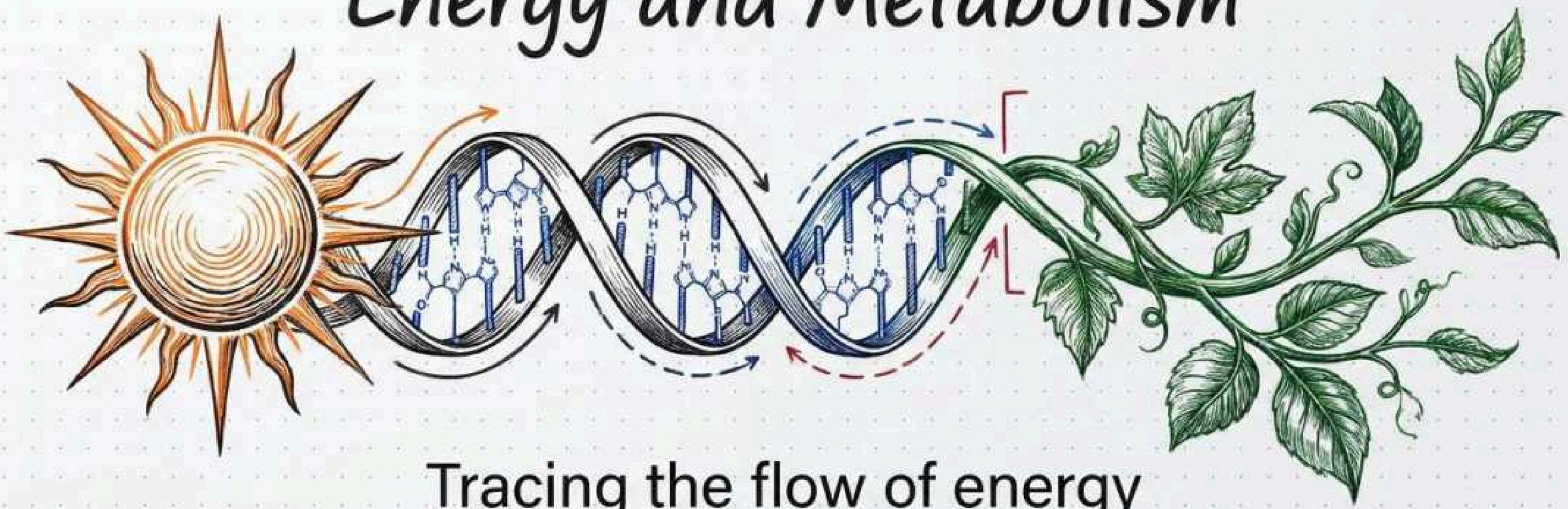
¶ 2.1

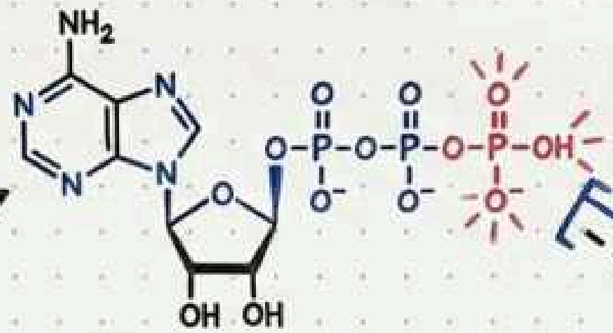
BIO 101 B — Lecture 2: Energy and Metabolism



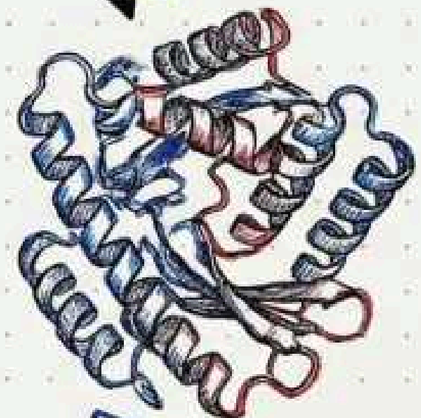
Tracing the flow of energy
and the cycling of matter.

The Busy Cell: A Roadmap

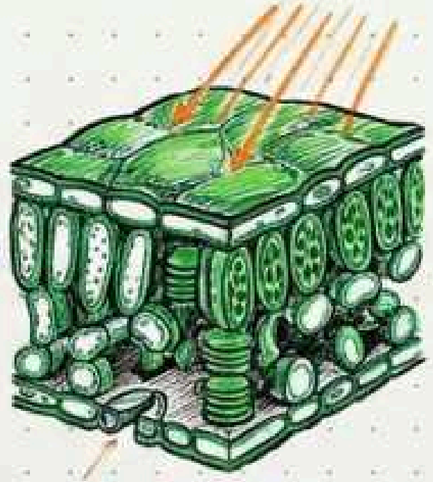
¶2.2



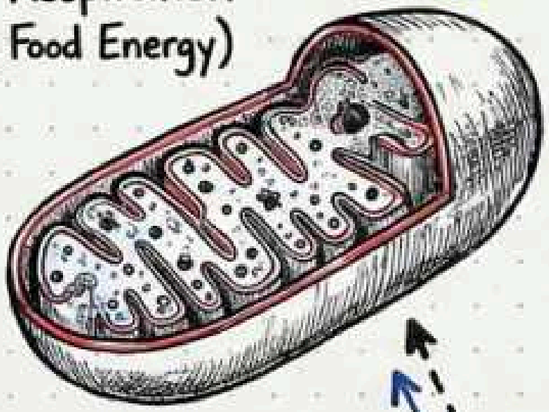
1. ATP
(Energy Currency)



2. Enzymes
(Chemical Speed)



3. Photosynthesis
(Capturing Sunlight)



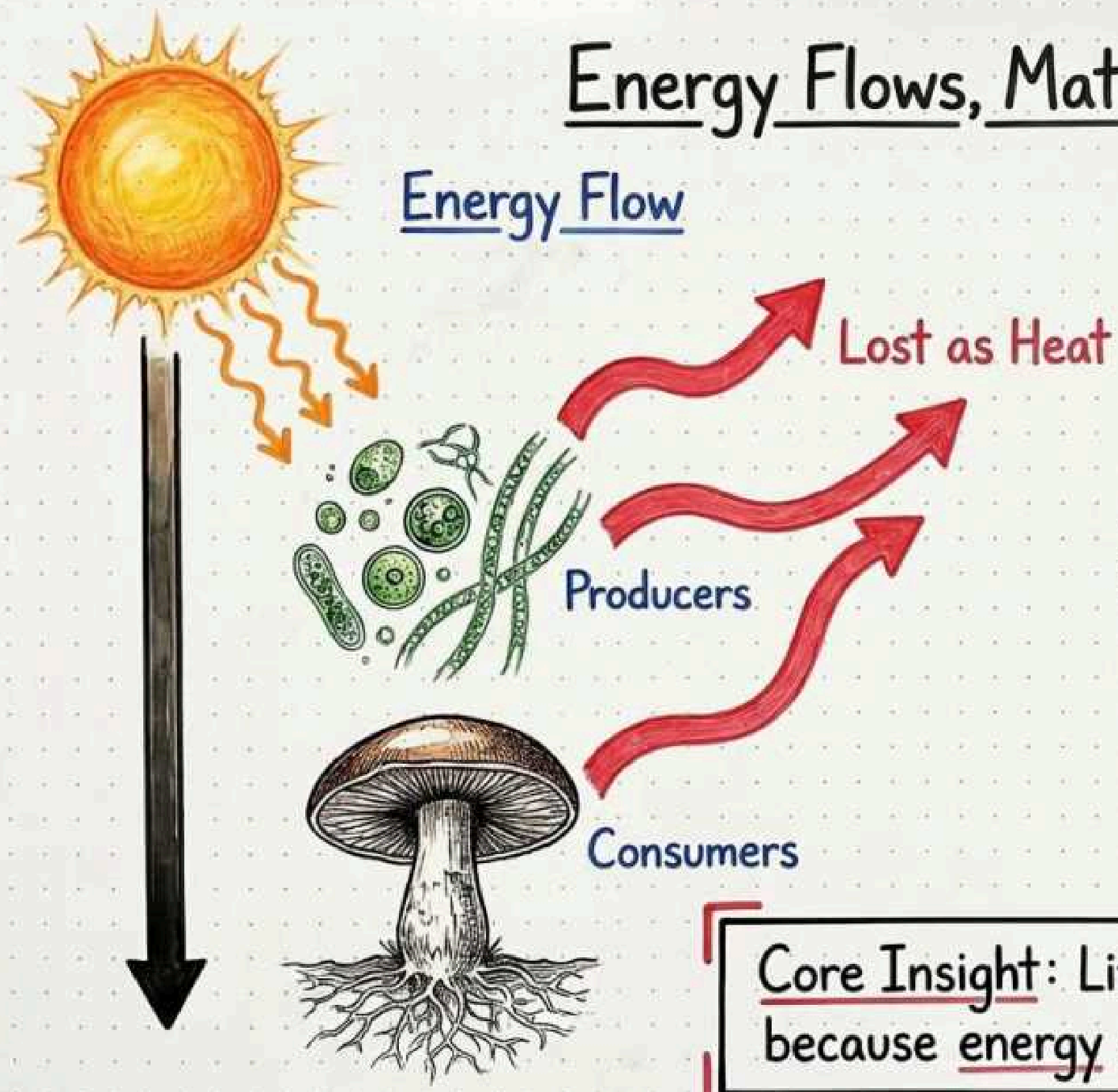
4. Cellular Respiration
(Releasing Food Energy)

Every cell is busy.
This lecture follows
the energy that
powers that work.

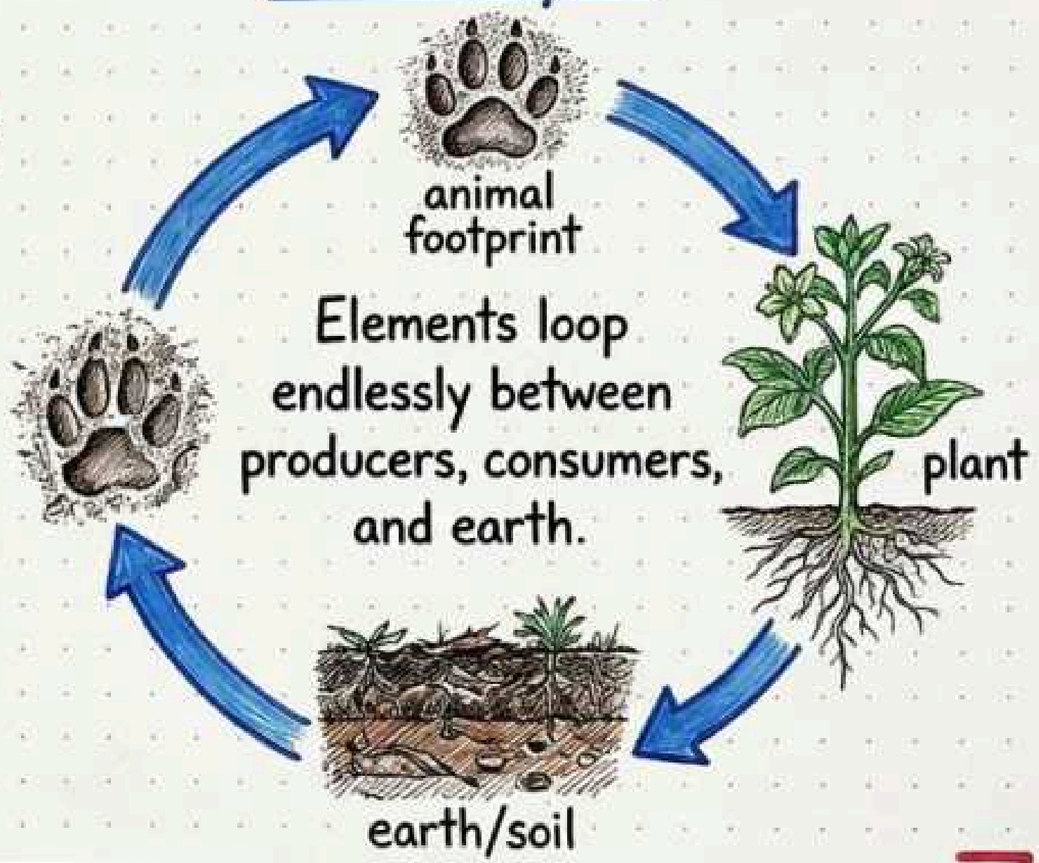
Energy Flows, Matter Cycles

¶2.3

Energy Flow



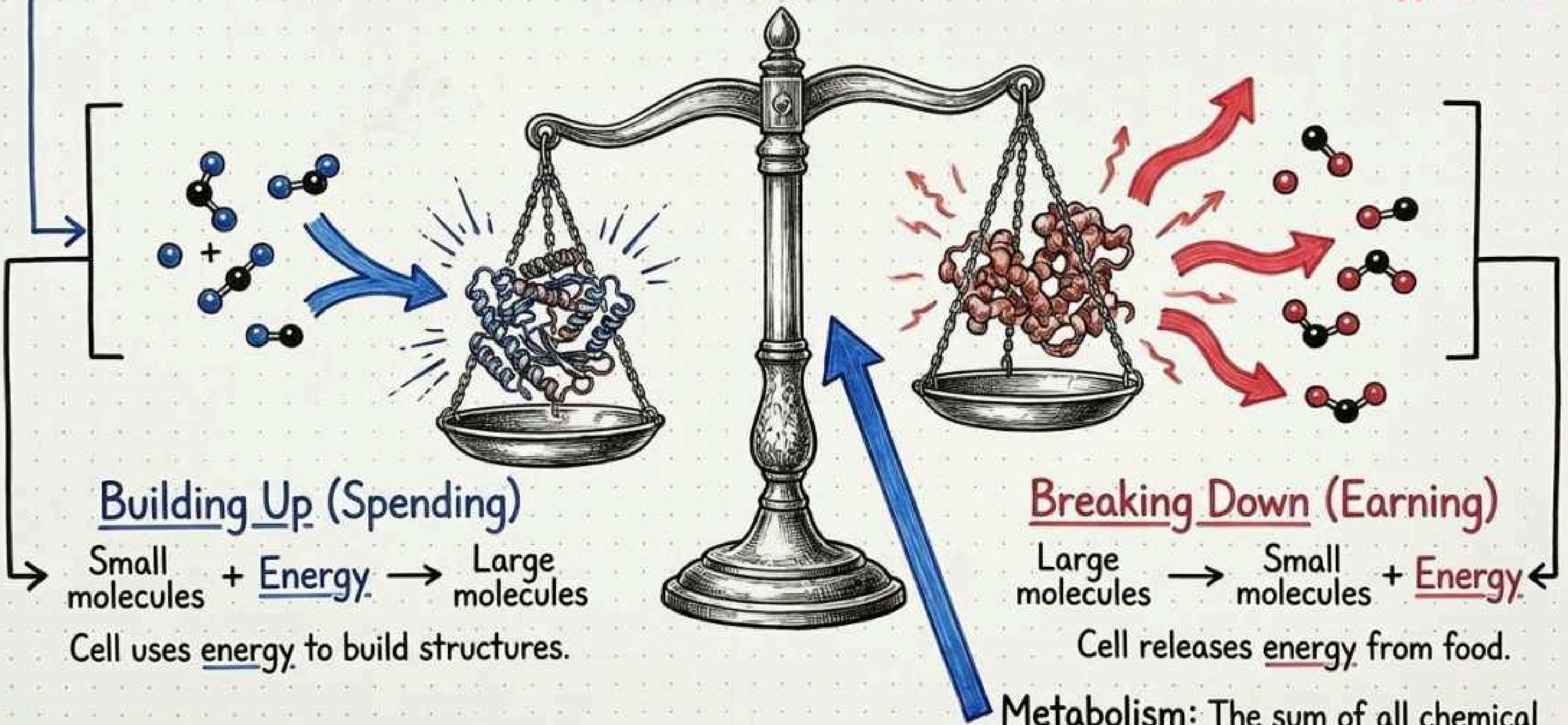
Matter Cycle



Core Insight: Life requires a steady solar supply because energy cannot be recycled—only matter is.

Metabolism: The Cellular Budget

¶2.4



Building Up (Spending)

Small molecules + Energy → Large molecules

Cell uses energy to build structures.

Breaking Down (Earning)

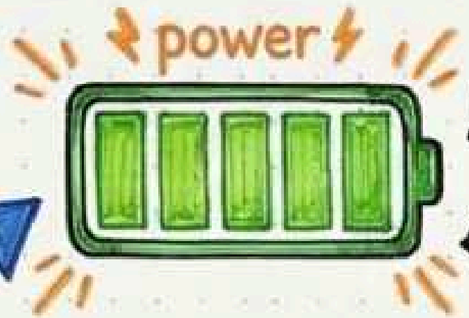
Large molecules → Small molecules + Energy

Cell releases energy from food.

Metabolism: The sum of all chemical reactions keeping this budget balanced.

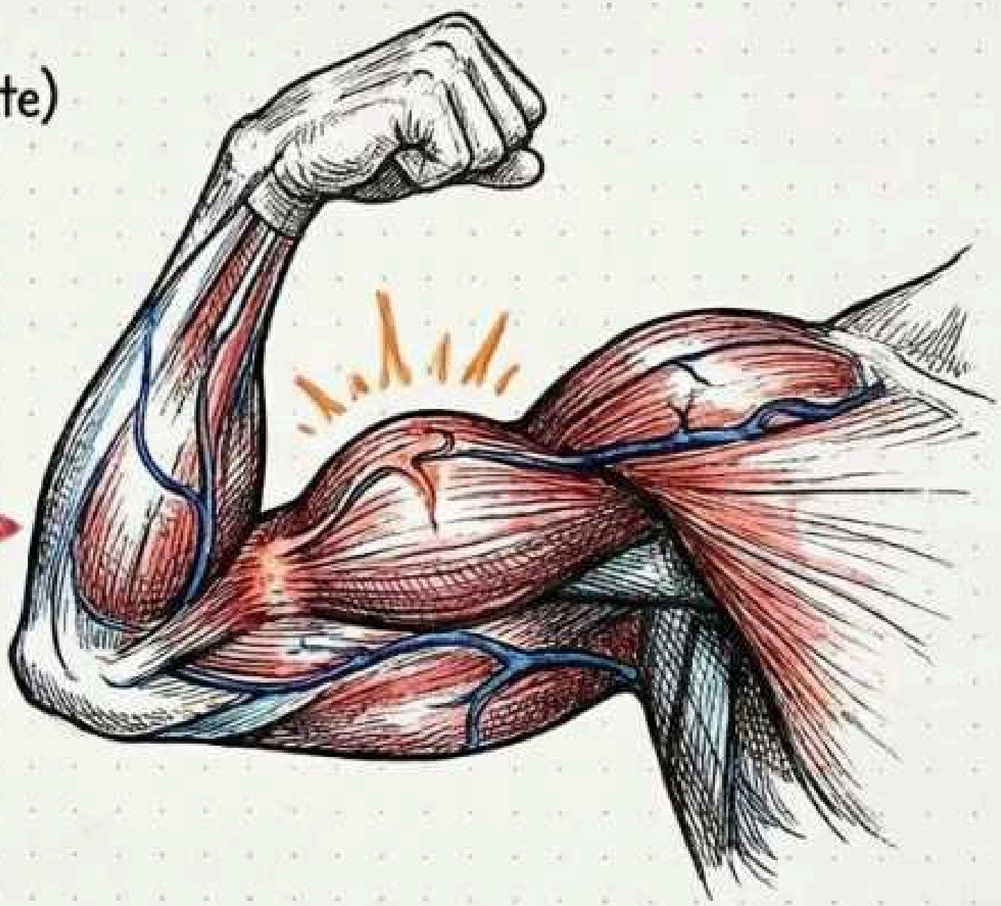
ATP: The Spending Money

¶2.5



ATP (Adenosine Triphosphate)
= Fully Charged

One phosphate group is removed. Energy released for work.



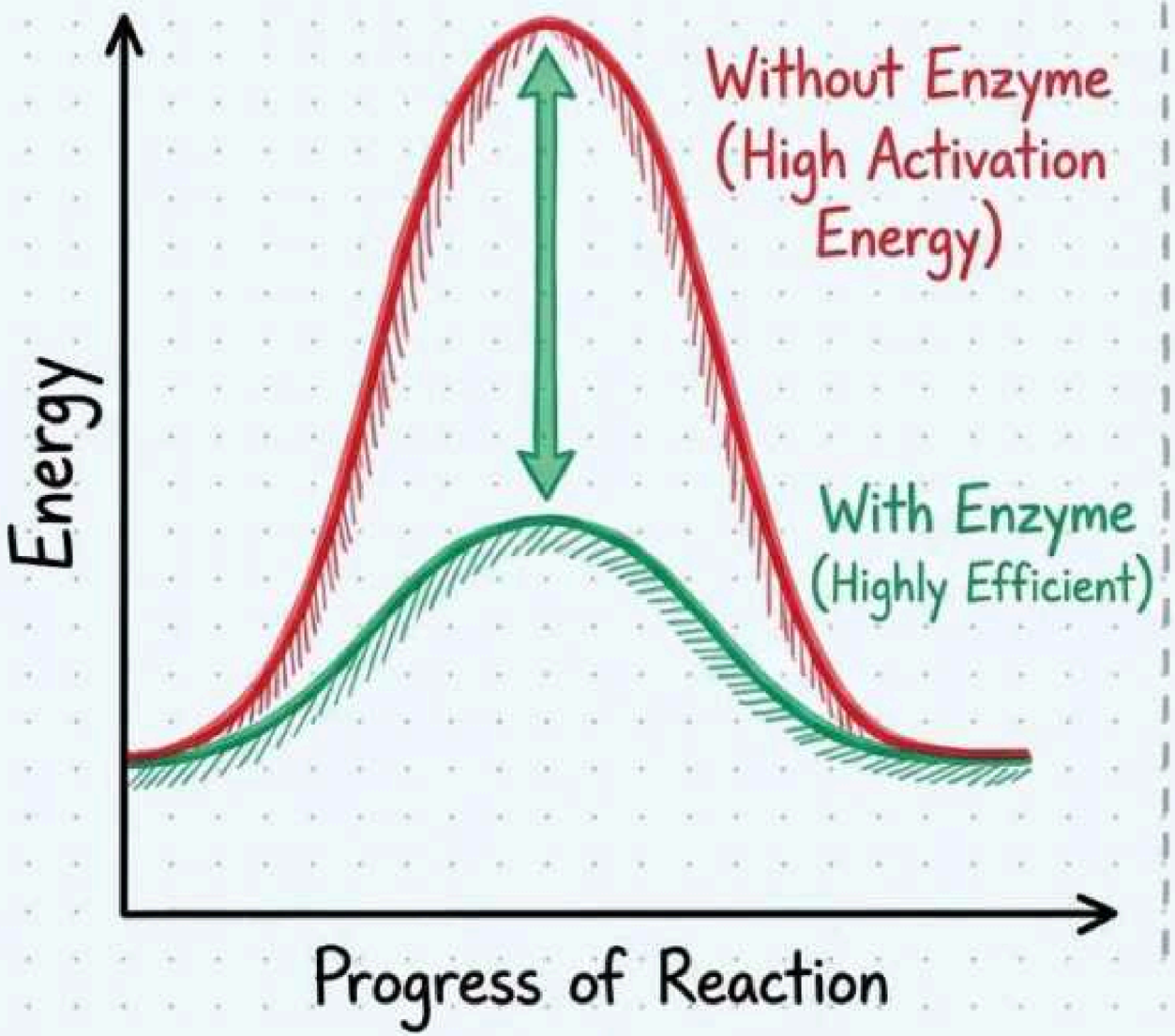
ADP = Needs Charge

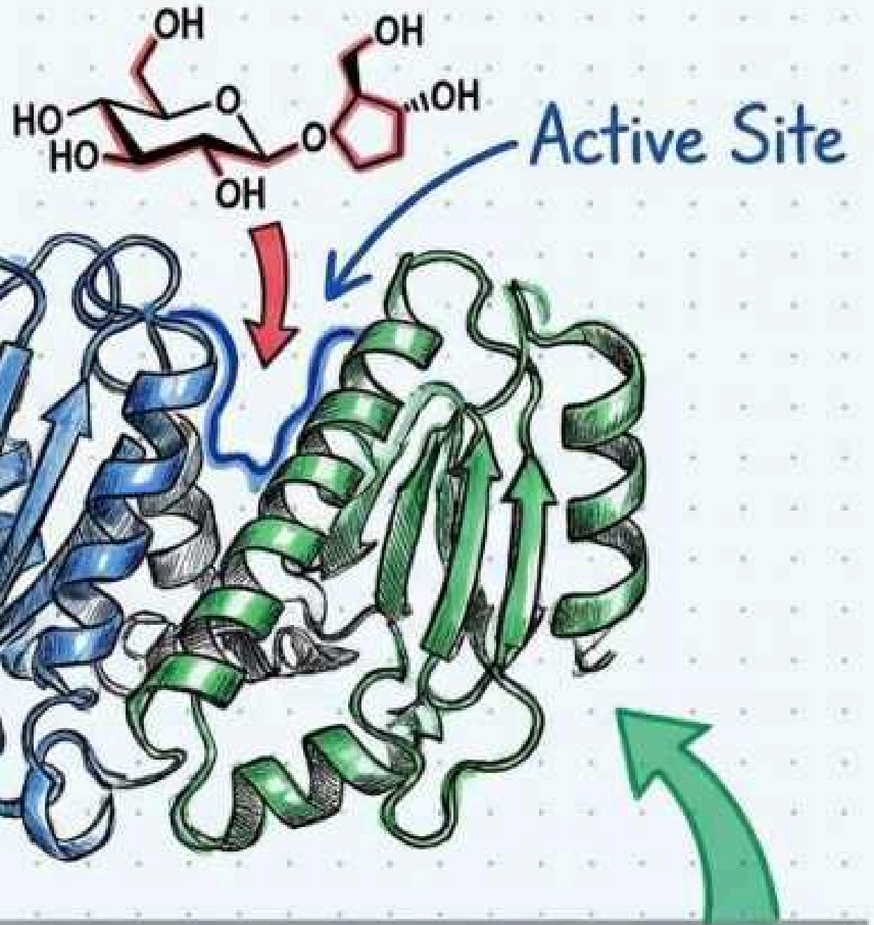
Cell recharges the molecule.

Fact: Over a single day, a human recycles roughly their own body weight in ATP.

Enzymes: Speeding Up Chemistry

¶ 2.6



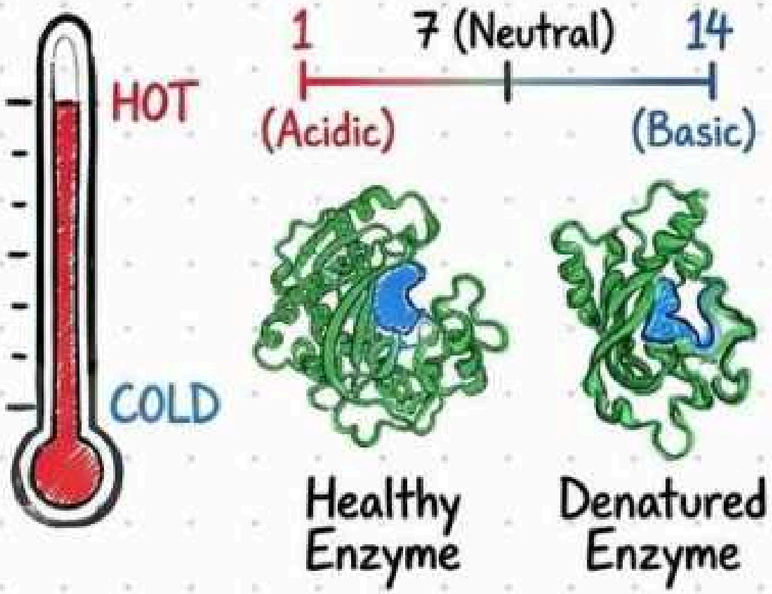


Example: Lactase enzyme fitting perfectly to split lactose (milk sugar).

Enzyme Control & Limitations

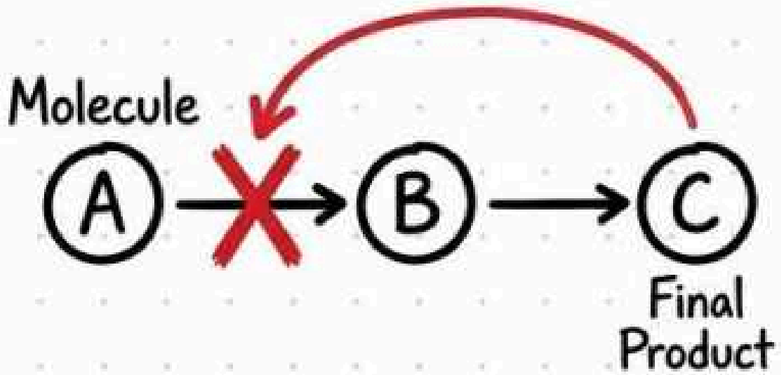
¶ 2.7

Environment



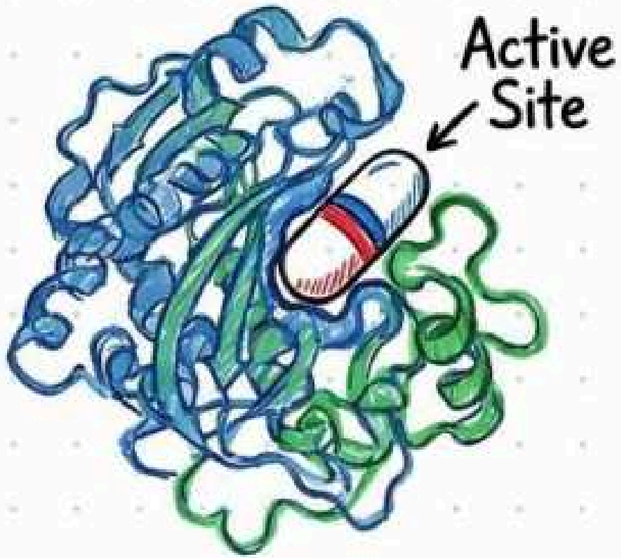
Enzymes have a narrow optimal range. Extreme heat or acid denatures (warps) them.

Feedback Inhibition



Final product blocks the first enzyme. Prevents overproduction.

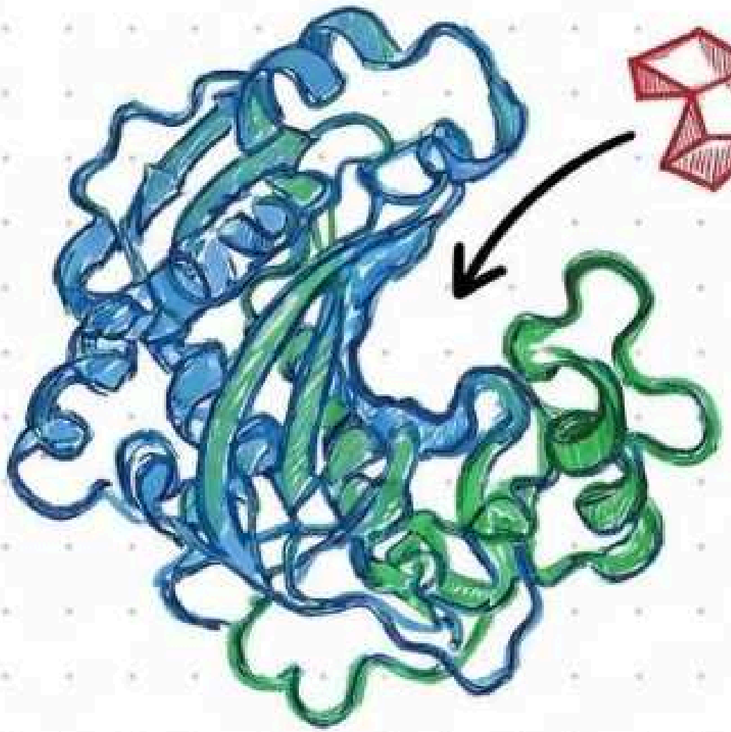
Medicines



Many modern medicines work by blocking a specific enzyme's active site.

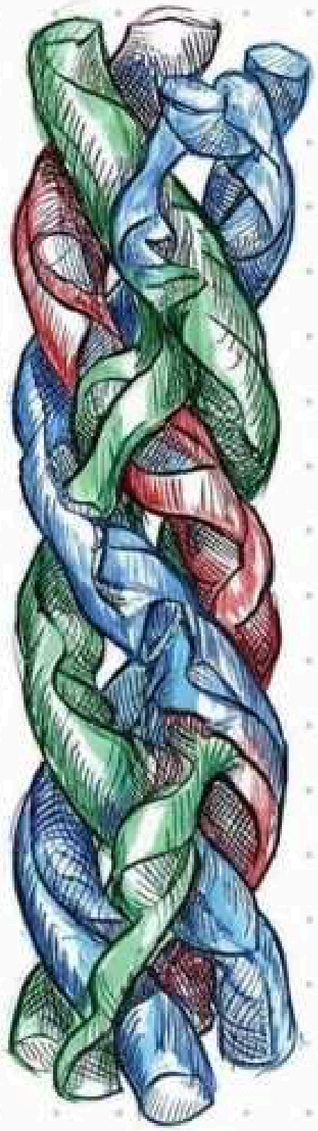
The Role of Vitamins and Minerals

¶ 2.8



Cofactor
(Vitamin/Mineral)

Case Study: Scurvy.
A lack of Vitamin C prevents the body from building the collagen triple-helix.
Small amounts matter greatly.

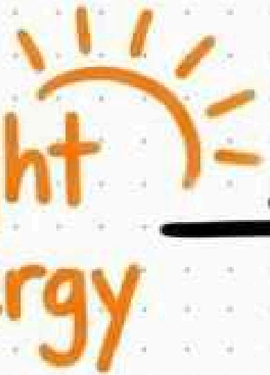


The Mechanism: Enzyme + Cofactor Helper = Active System.

The Consequence: Missing vitamin = Missing helper = Illness.

Photosynthesis: The Equation

¶2.9



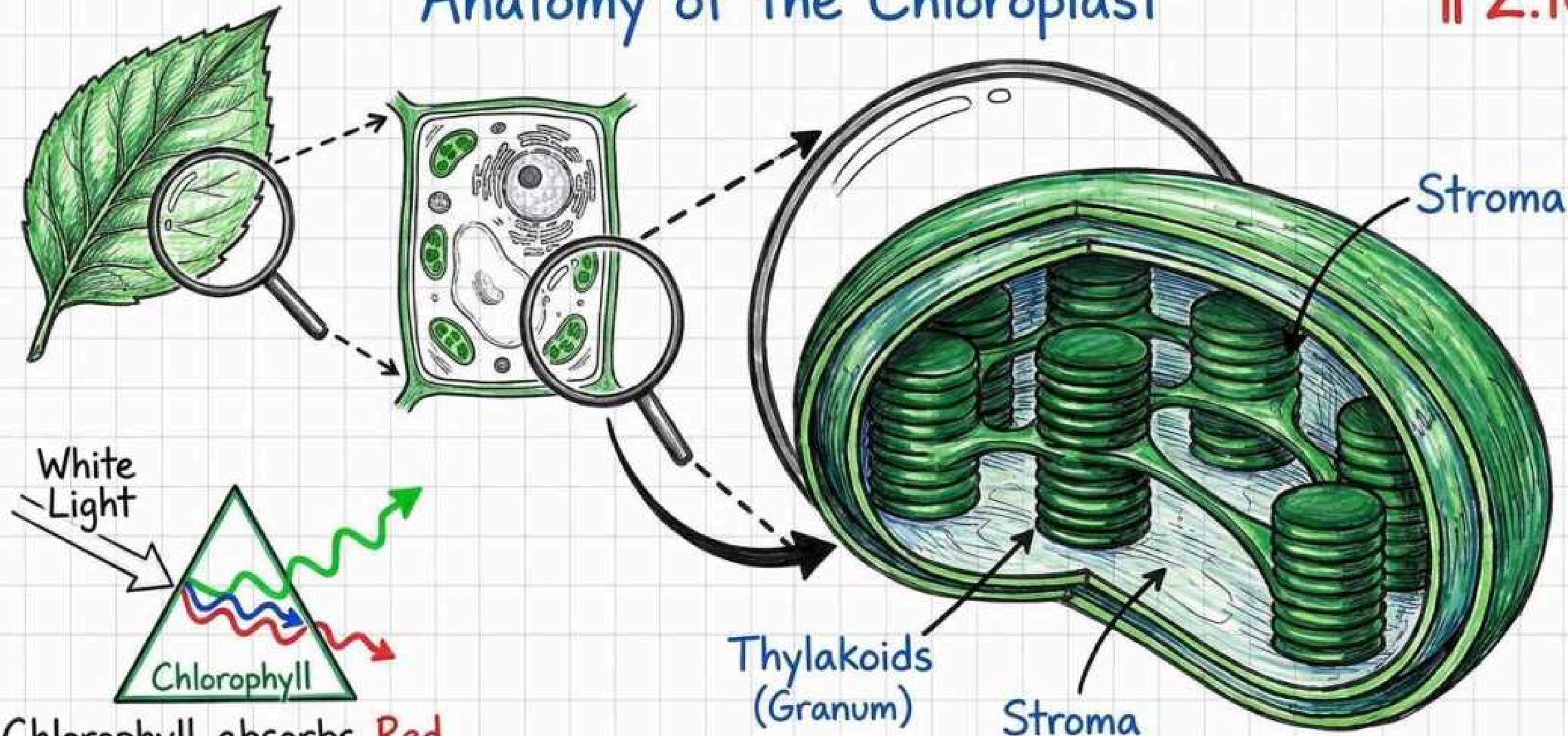
$$6CO_2 + 6H_2O + \text{Light Energy} \rightarrow C_6H_{12}O_6 + 6O_2$$

Carbon Dioxide + Water + Light → Sugar + Oxygen.

{ Performed by plants, algae, and cyanobacteria.
The beginning of almost every food chain on land and sea. }

Anatomy of the Chloroplast

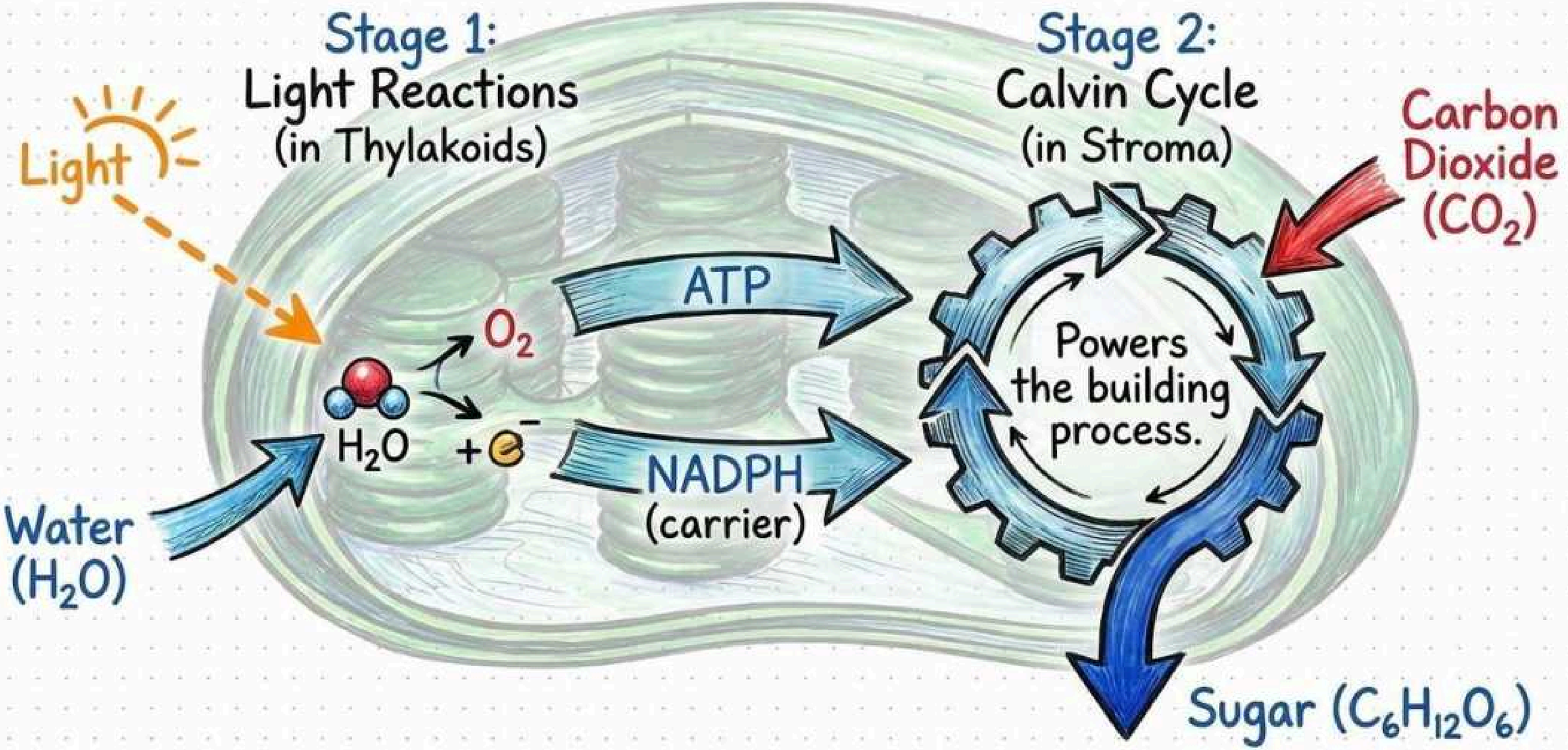
¶ 2.10



Chlorophyll absorbs Red & Blue light, reflects Green.

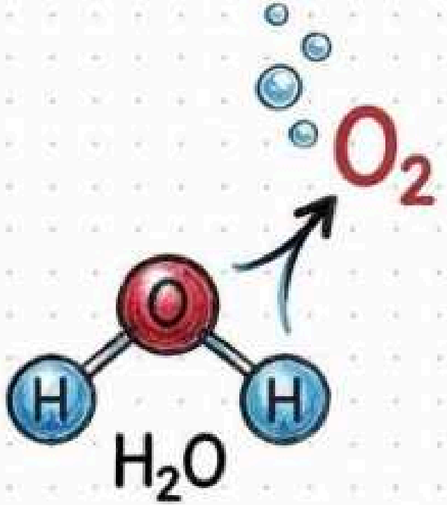
The Two Stages of Photosynthesis

¶ 2.11



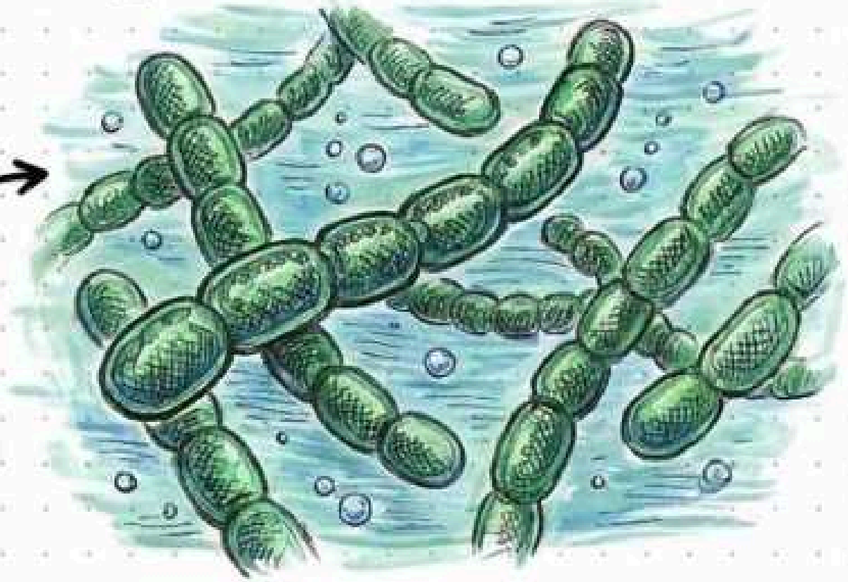
The Great Oxidation Event

¶ 2.12



The Mechanism:
Oxygen is released from splitting water, not CO_2.

The Impact:
Oxygen filled the atmosphere, fundamentally changing Earth and enabling complex life.



The Pioneers:
Cyanobacteria

4.0 Billion Yrs Ago

~2.5 Billion Years Ago

Present Day

Cellular Respiration: The Equation

¶ 2.13

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Energy (ATP)}$$

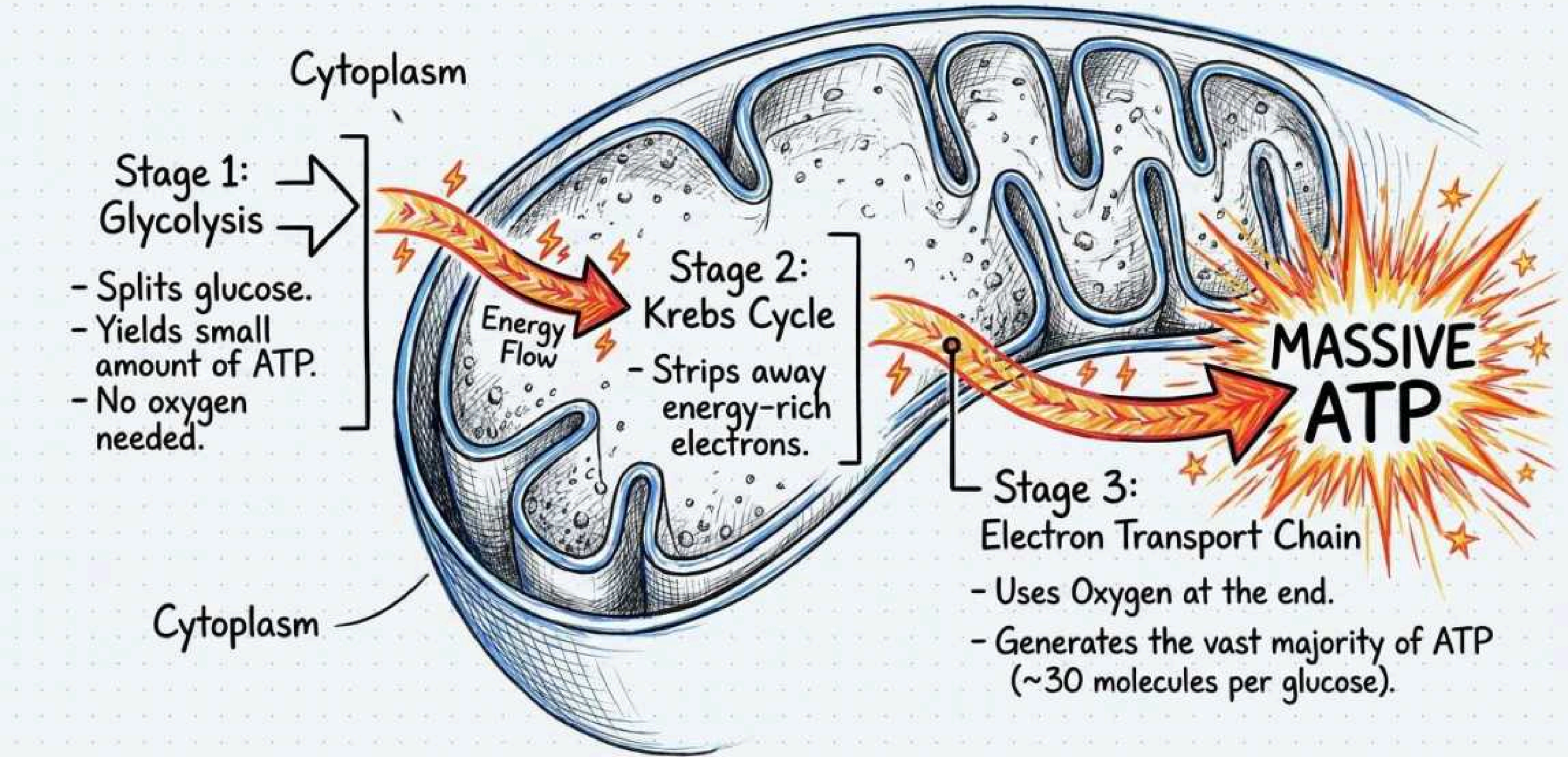
Sugar + Oxygen ⟶ Carbon Dioxide + Water + ATP.

Location: Occurs in the Mitochondria.

Crucial Note: Plants do this too, not just animals.

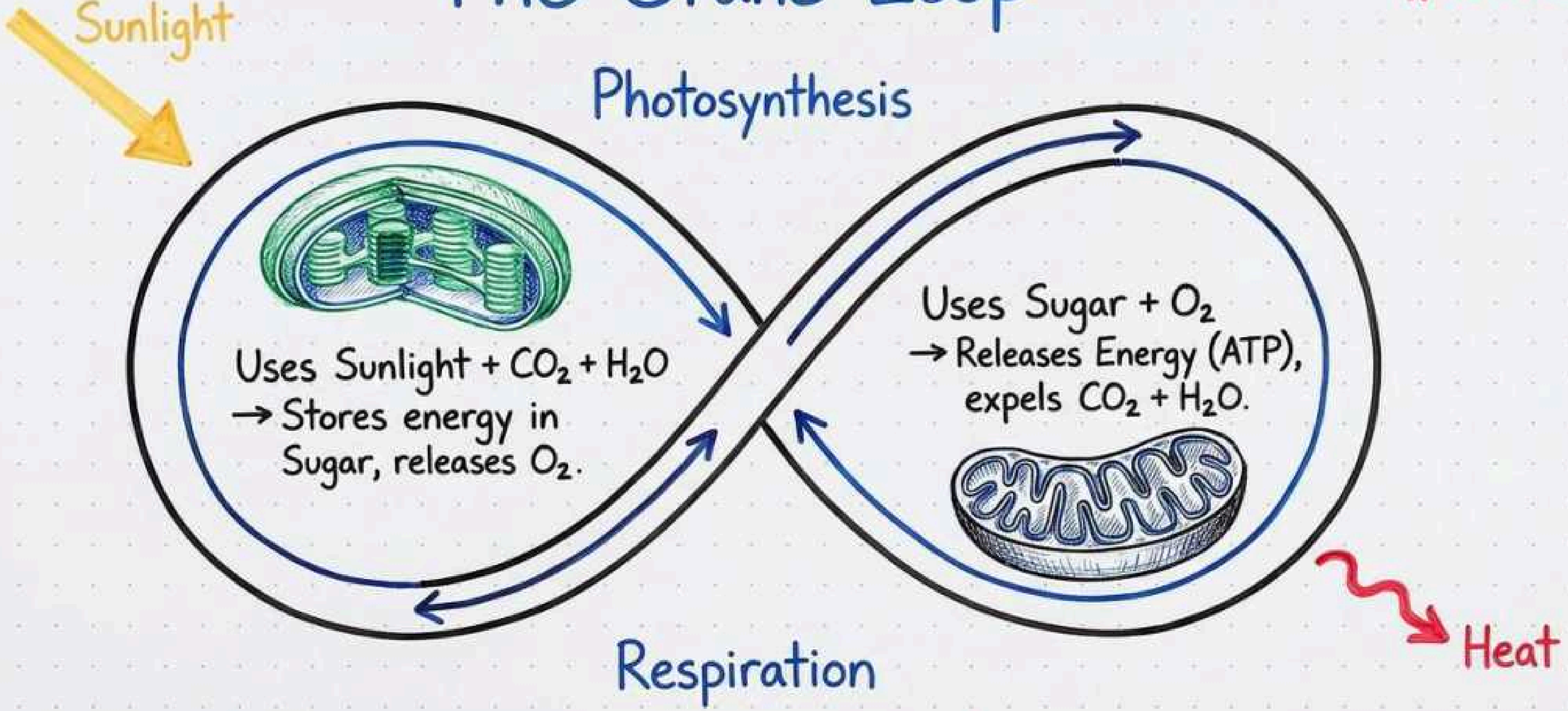
The Three Stages of Respiration

¶ 2.14



The Grand Loop

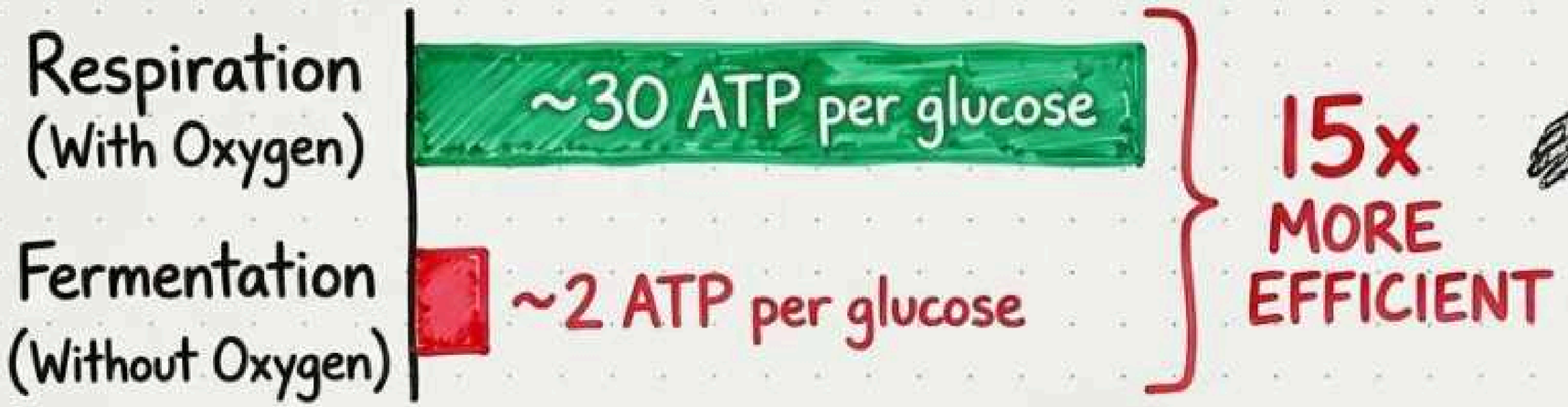
¶ 2.15

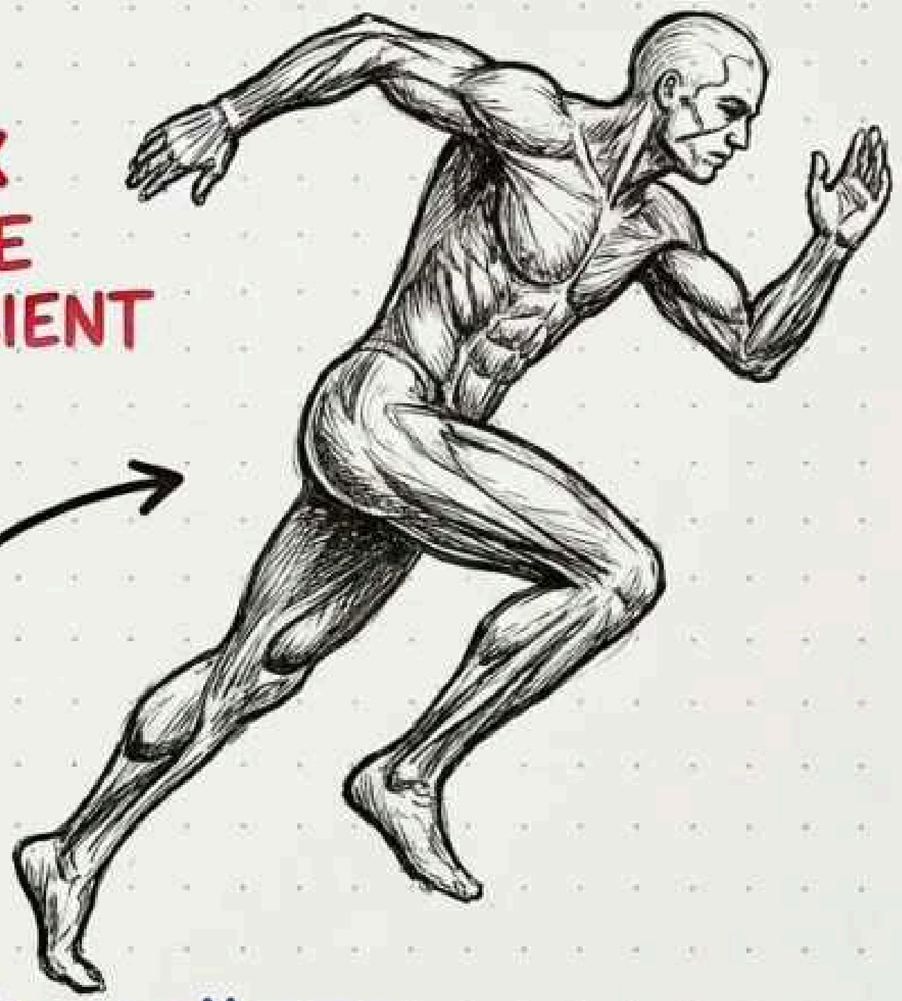


Key Insight: They are near mirror images. Matter (Carbon and Oxygen) cycles in a continuous loop, while energy flows one way from sunlight to heat.

The Numbers: Oxygen's Advantage

¶ 2.16

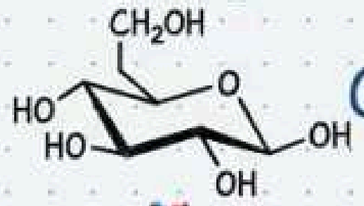




The "Why": Large, active animals depend entirely on this **15x oxygen advantage**. Sprinting at full speed tires muscles quickly because an **oxygen debt** forces the body to temporarily switch to the **low-yield fermentation pathway**. pathway.

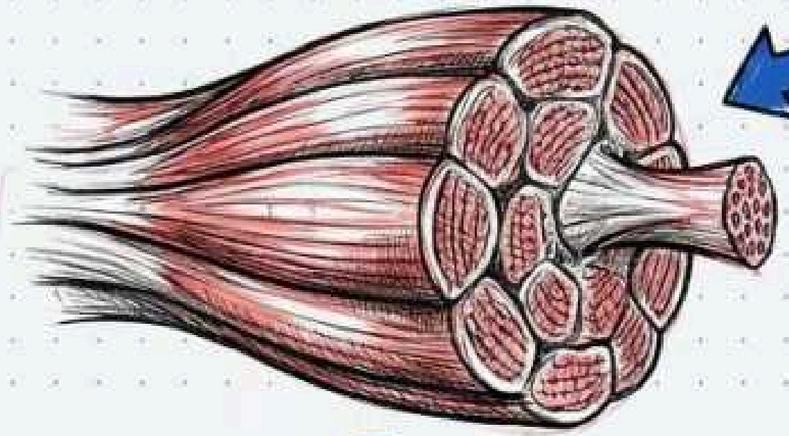
Fermentation: Making Do Without Oxygen

¶ 2.17

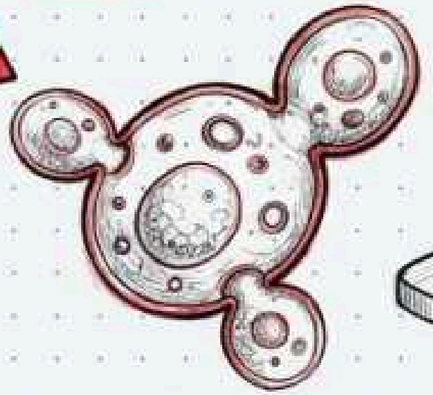


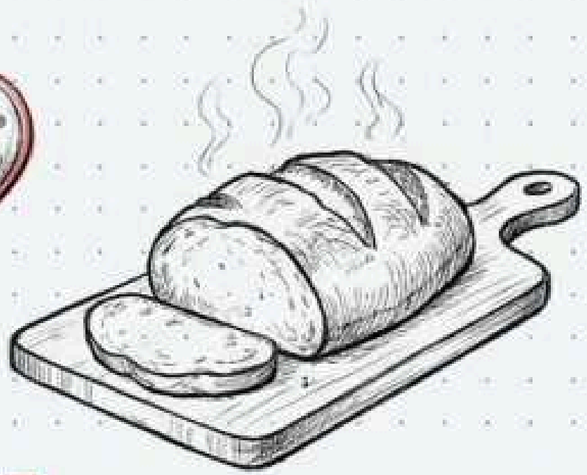
Glucose (Yields only 2 ATP)

Hard-working Muscles



Yeast





Turns into Lactic Acid

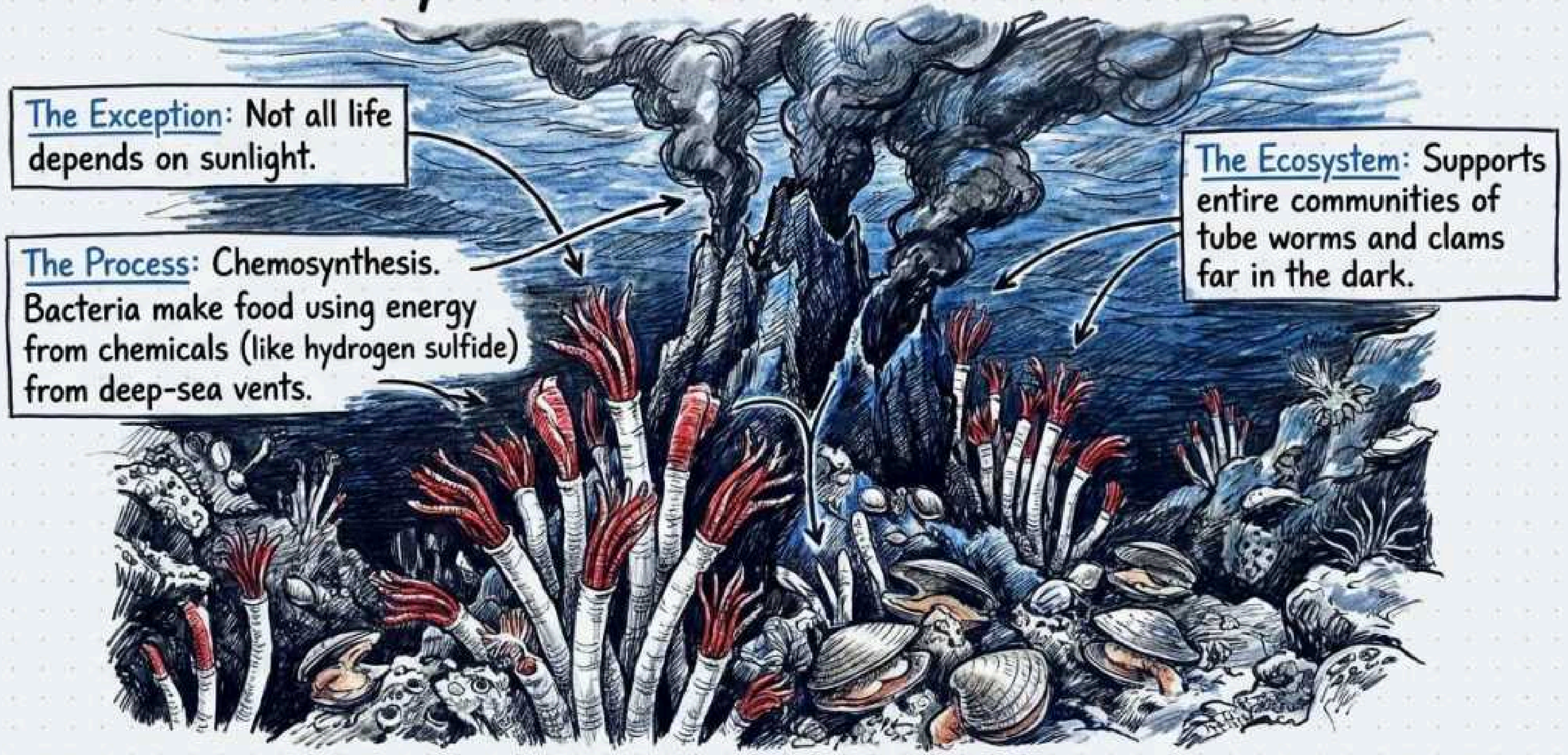
Turns into Alcohol + Carbon Dioxide

(The reason bread rises and beer is made)

When oxygen is scarce, these backup systems keep cells alive, but yield far less energy.

Chemosynthesis: Life Without the Sun

¶ 2.18



The Exception: Not all life depends on sunlight.

The Process: Chemosynthesis. Bacteria make food using energy from chemicals (like hydrogen sulfide) from deep-sea vents.

The Ecosystem: Supports entire communities of tube worms and clams far in the dark.

Core Truth: The essential requirement for life is the FLOW OF ENERGY, not sunlight itself.

The Willow Puzzle

¶ 2.19

Before

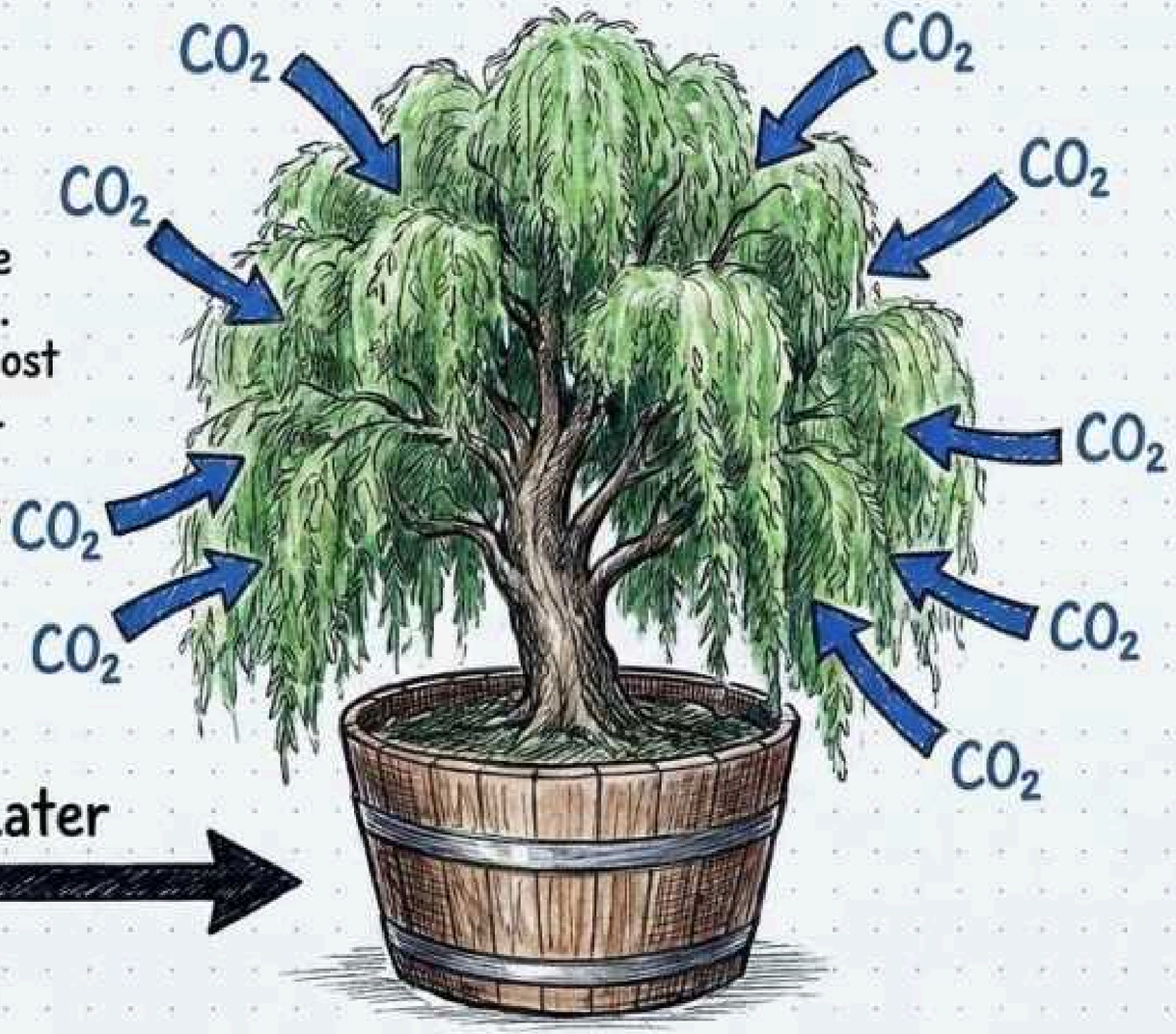
Start:
Small tree +
200 lbs of soil.



5 Years Later

After

Result:
Massive tree
mass gained.
Soil lost almost
zero weight.

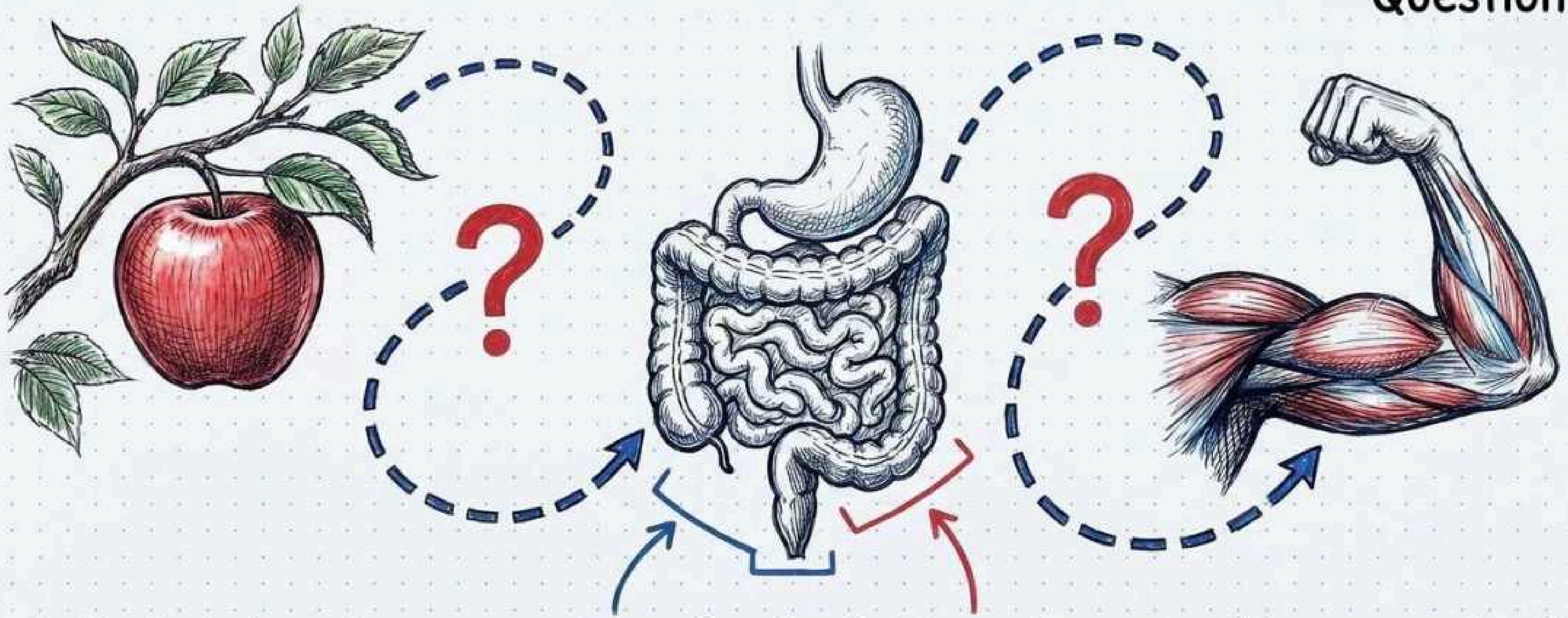


The Solution: Most of a tree's physical mass is built out of thin air—specifically, carbon dioxide gas.

¶ 2.20

Follow a single bite of food from the plant that grew it to the muscle that uses it.

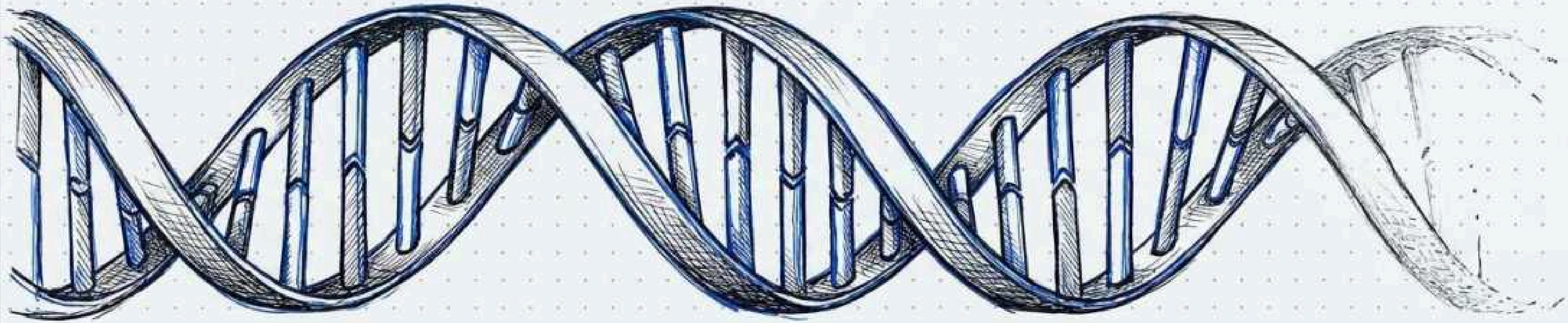
Takeaway Question



1. At which steps does energy change form?

2. Where does some of it escape as heat?

Next Up: The Instructions



Lecture 3 — DNA

The molecule that stores the blueprints and instructions behind all of the chemistry we just covered.