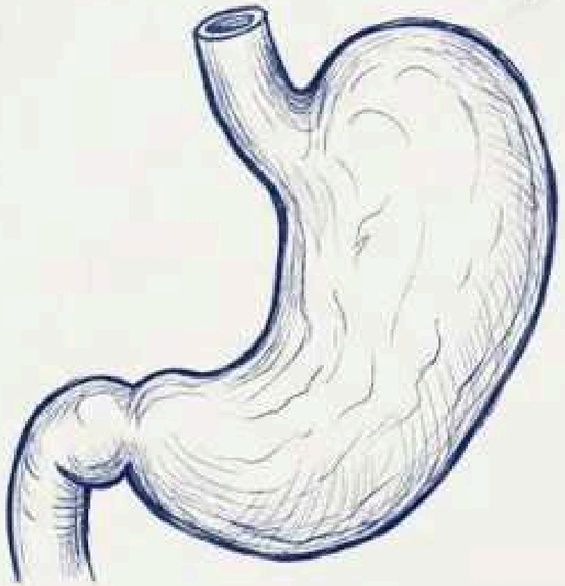
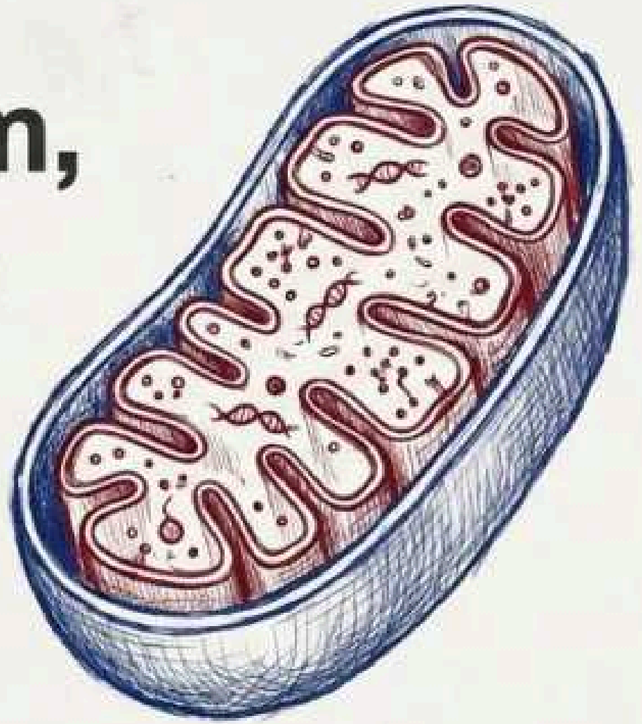
¶ 5.1

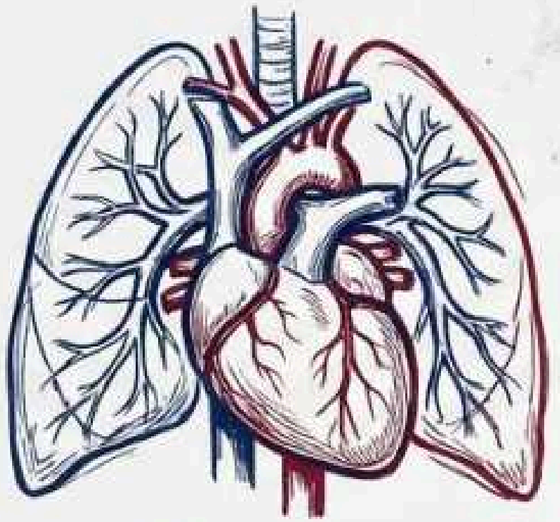


Digestion, Metabolism, and Energy Balance

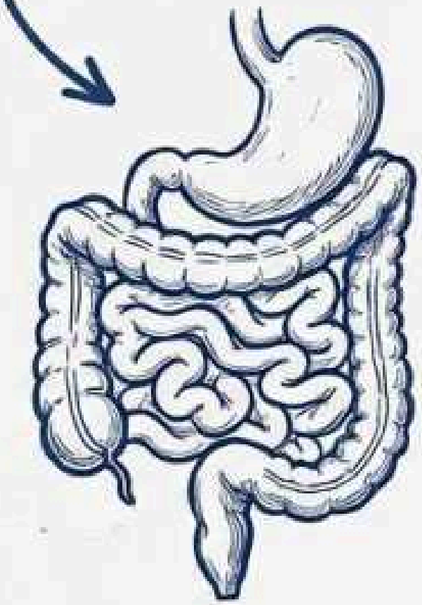
BIO 110B — Lecture 5



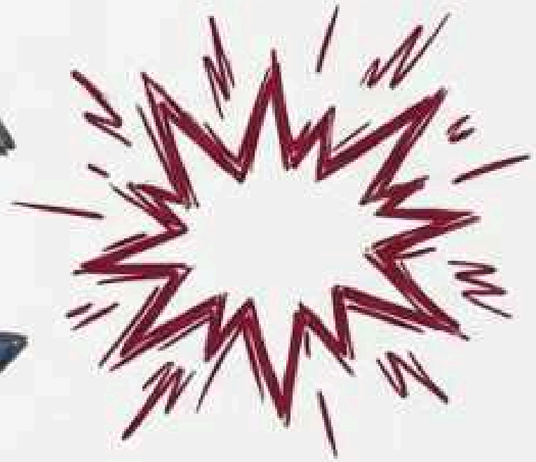
Where does the fuel come from?



Oxygen

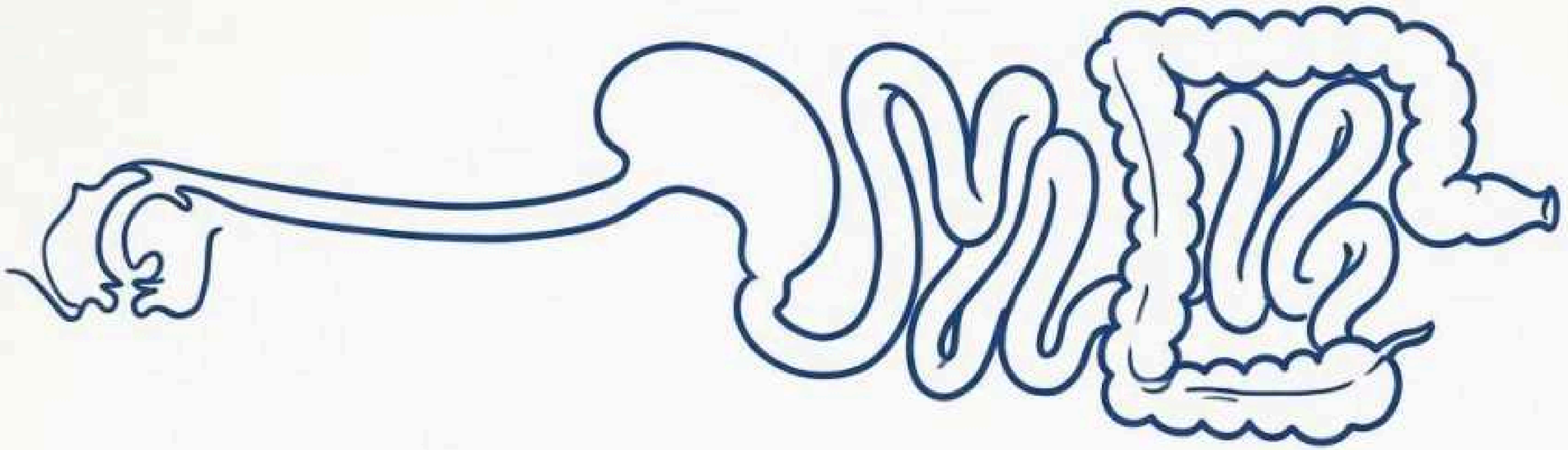


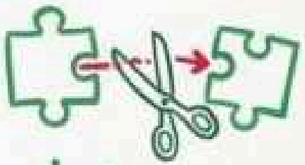
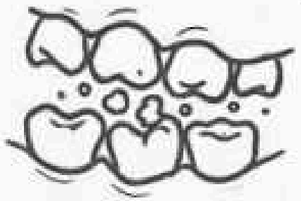
Fuel

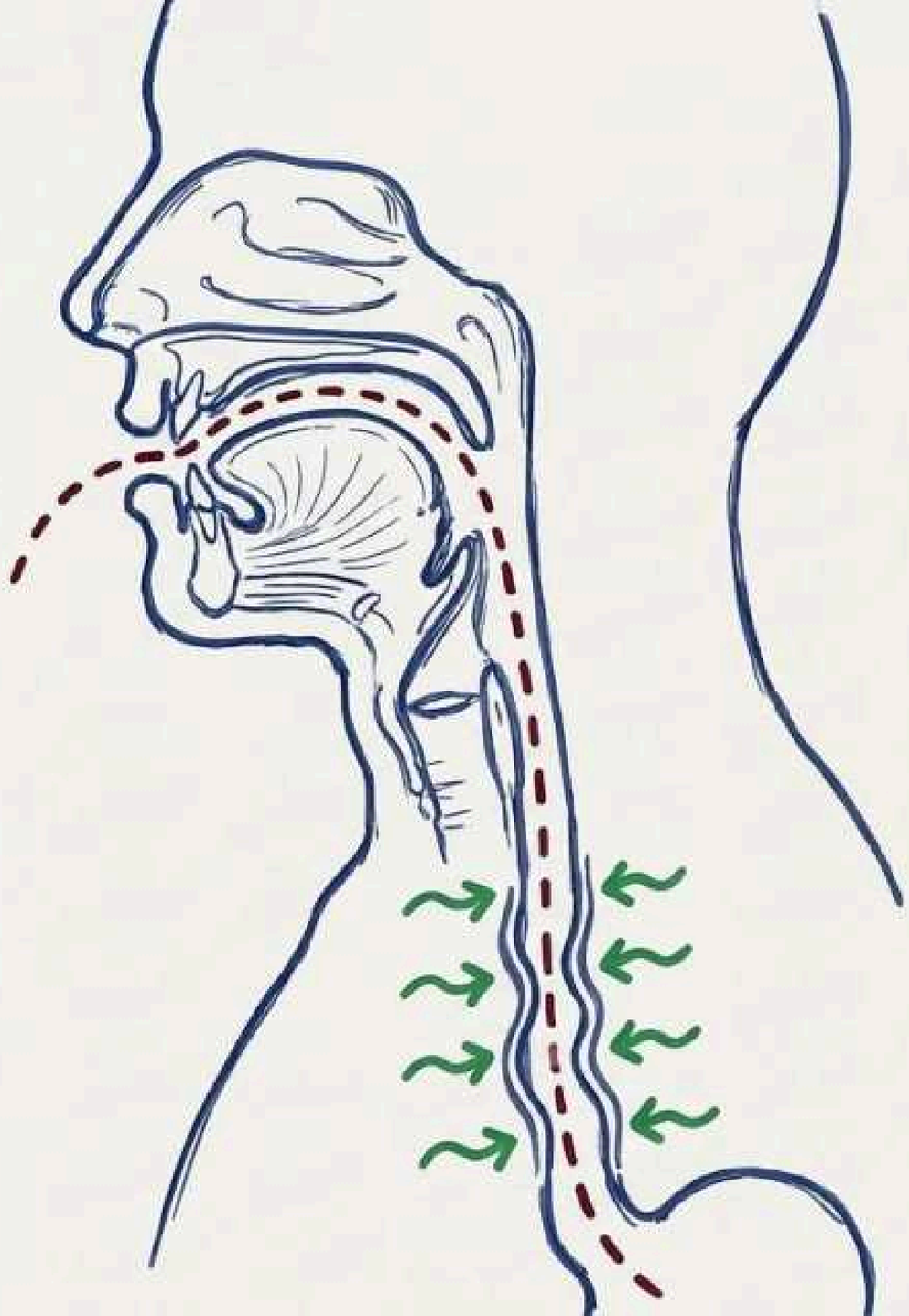


Cellular ATP Energy

1. Digestion & Absorption 〉 2. Cellular Energy 〉 3. Blood Sugar Regulation 〉 4. Energy Balance



Mechanical Digestion	Chemical Digestion
Physical breaking.	Enzymatic breaking. 
Methods: Chewing & Churning. 	Mechanism: Enzymes (proteins that speed up reactions) break large molecules into small ones.

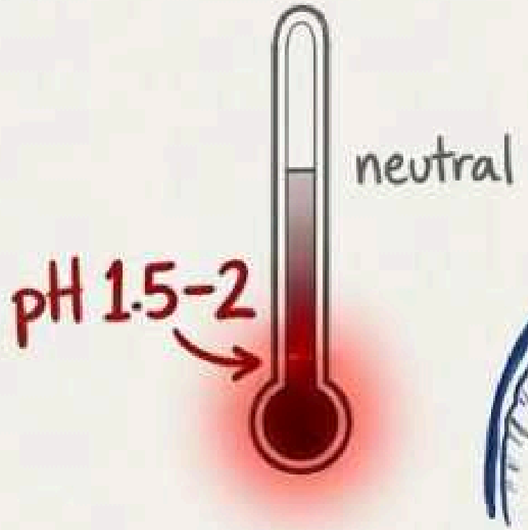


1. **The Mouth:** Chewing grinds; saliva moistens.

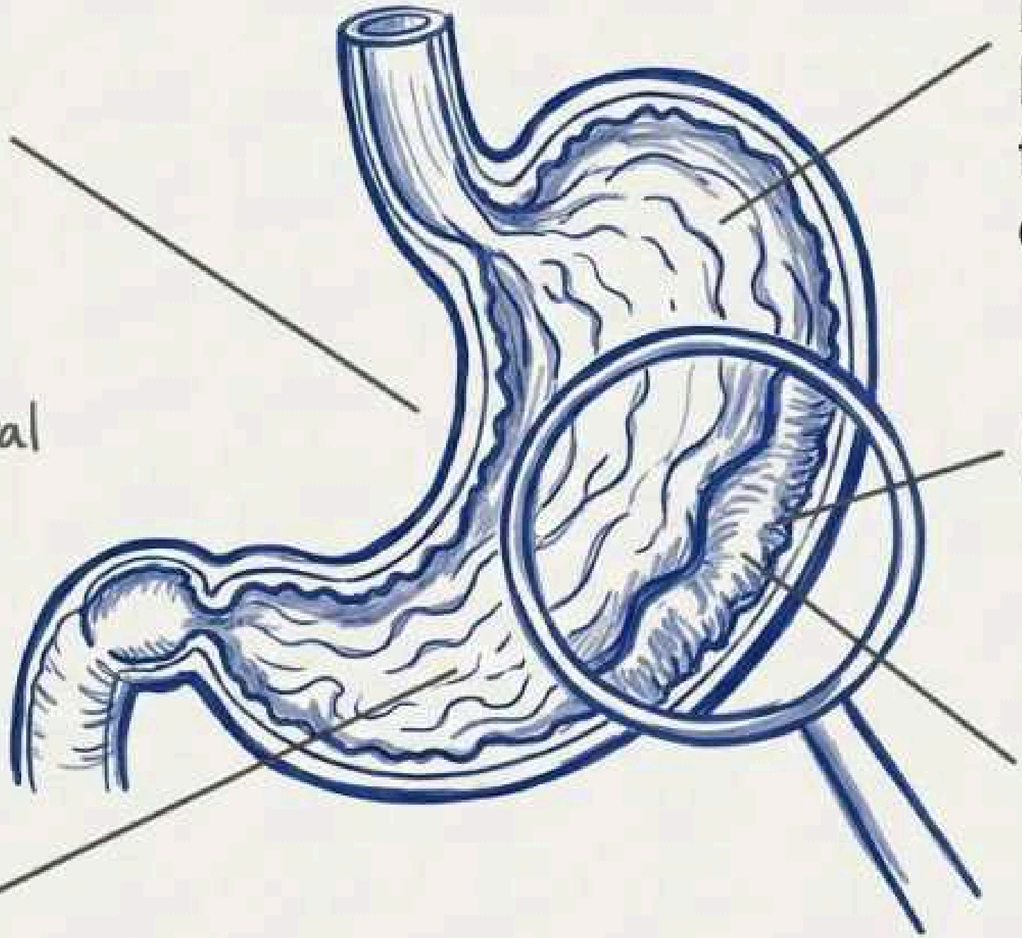
2. **Enzyme Action:** Amylase begins splitting starch into sugars (why a cracker turns sweet after a minute).

3. **The Esophagus:** Peristalsis (waves of muscle contraction) drives food to the stomach.

Environment:
Highly acidic (pH 1.5–2).
Kills microbes, unfolds proteins.



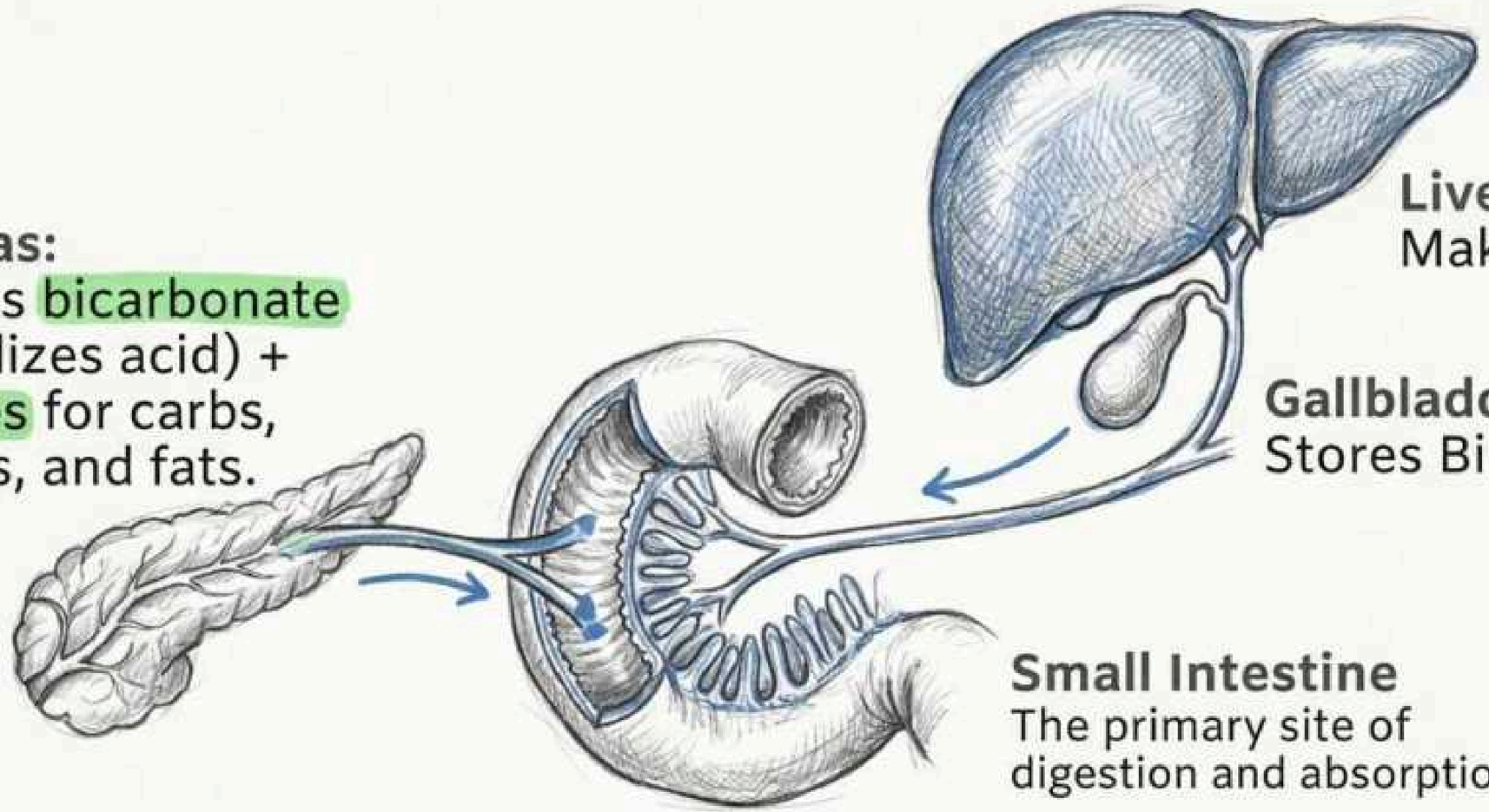
Chemistry: Pepsin begins splitting protein.



Mechanics:
Muscular bag churns food into a soupy liquid over several hours.

Defense: A thick mucus layer protects the stomach wall from its own acid.

Pancreas:
Releases bicarbonate (neutralizes acid) + enzymes for carbs, proteins, and fats.

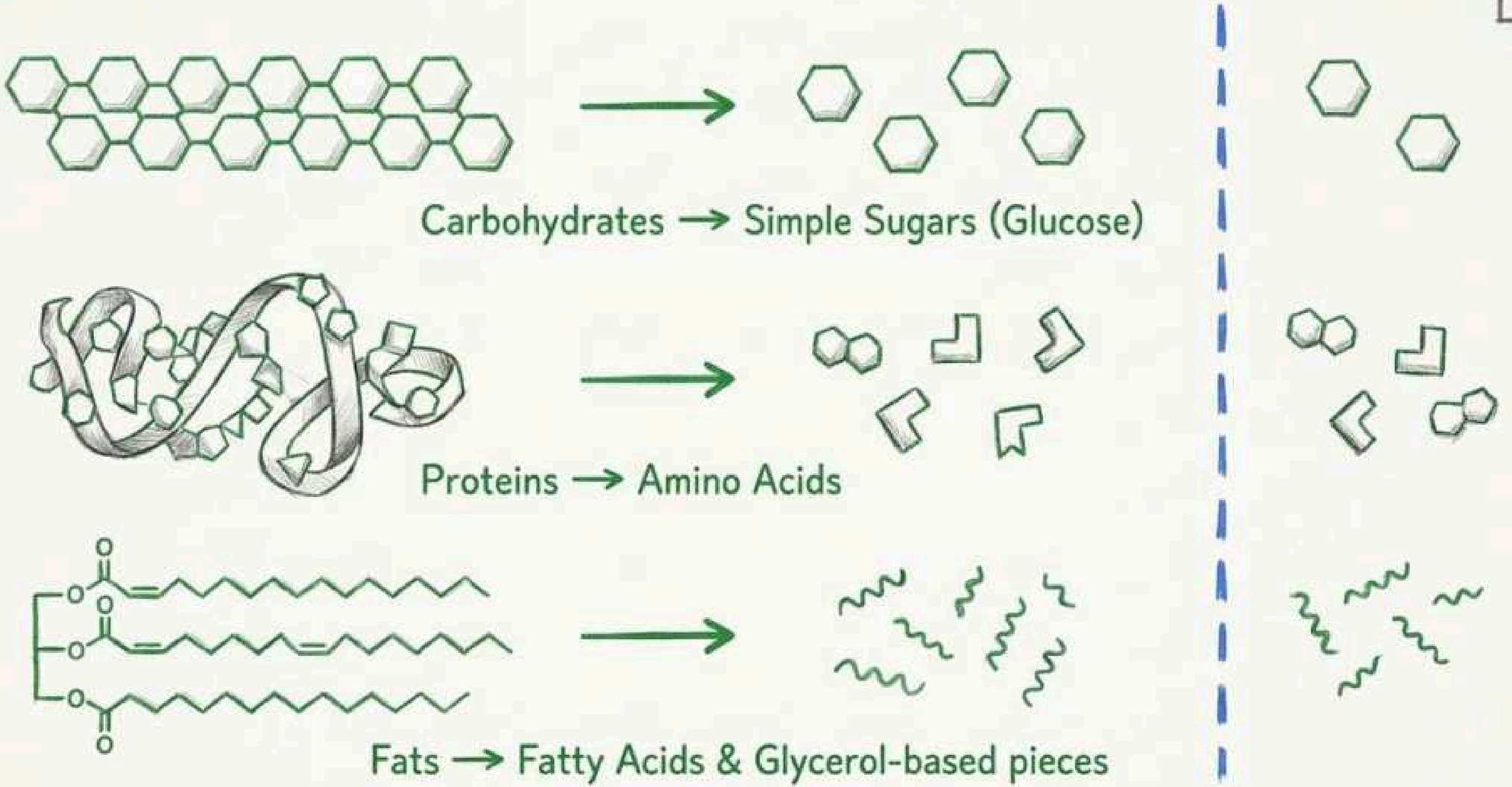


Liver:
Makes Bile.

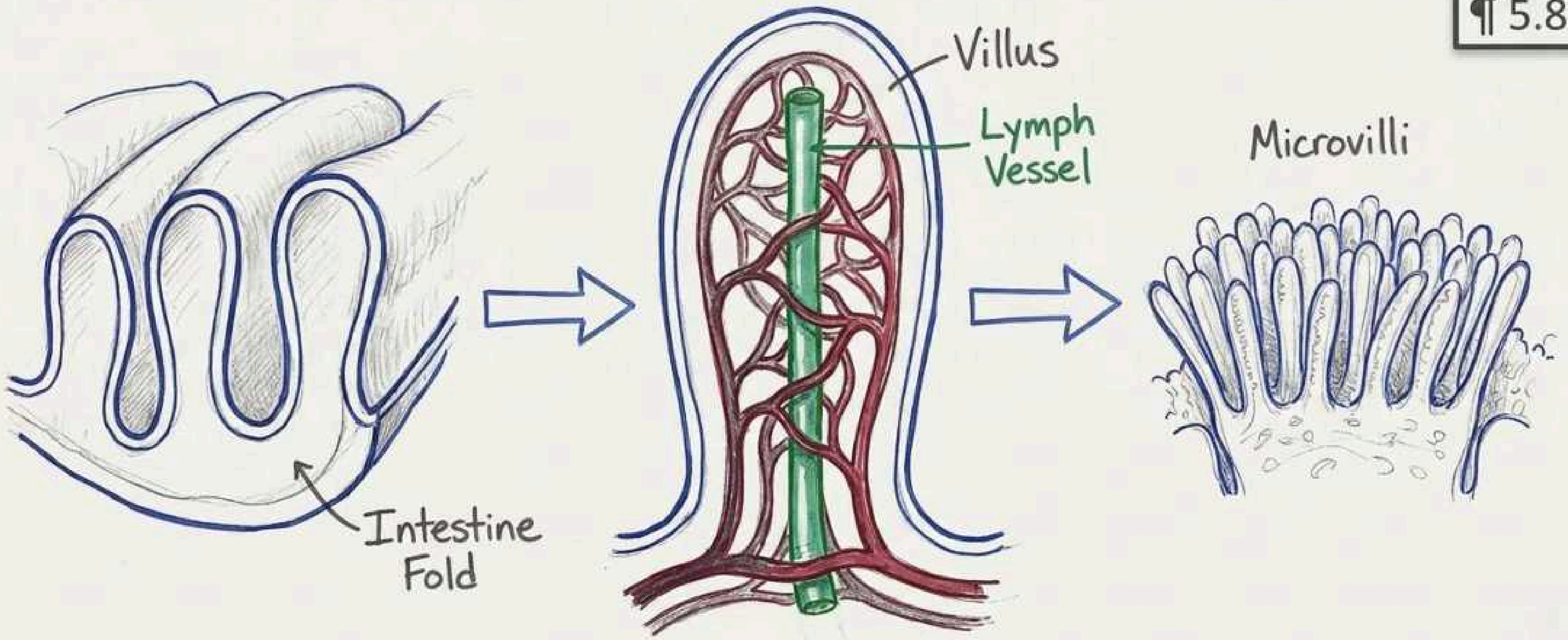
Gallbladder:
Stores Bile.

Small Intestine
The primary site of digestion and absorption

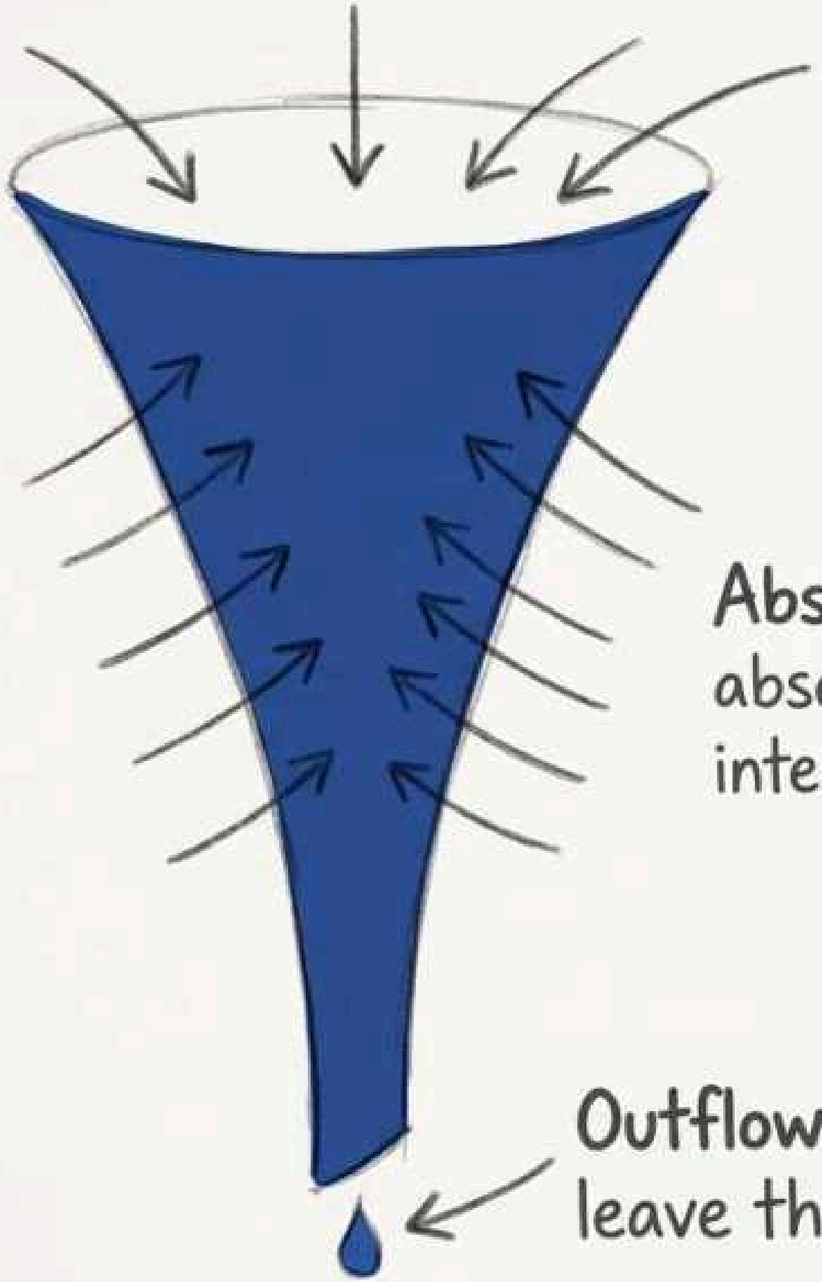
Crucial Distinction: Bile does not digest chemically; it physically breaks fat into droplets so enzymes can reach it.



Takeaway: A meal of bread, beans, and butter is reduced to these same small molecules to cross the intestinal wall alongside vitamins and minerals.



Architecture: Folds + **Villi** + **Microvilli** = Tens of square meters of surface area.
Capillary Network takes up: Sugars & Amino Acids.
Lymph Vessel (green) takes up: Fats.



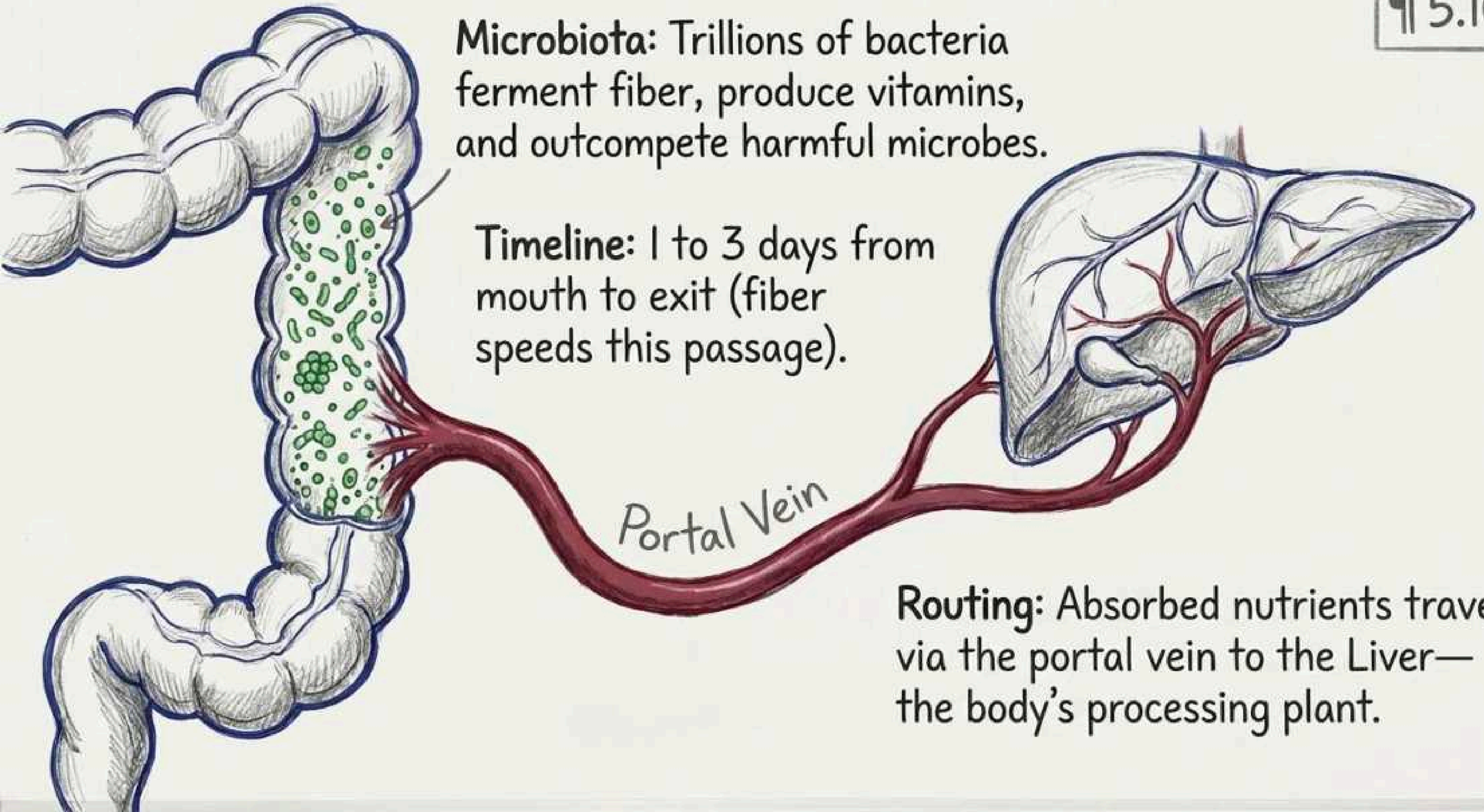
Inflow (9 Liters/day):
2L from drink + 7L from gut/helper organ secretions

Absorption: Small intestine absorbs the vast majority; large intestine absorbs more

Outflow: Only ~100 milliliters leave the body in stool.

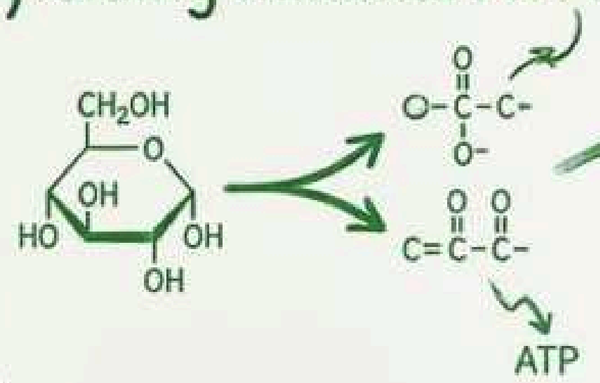
Microbiota: Trillions of bacteria ferment fiber, produce vitamins, and outcompete harmful microbes.

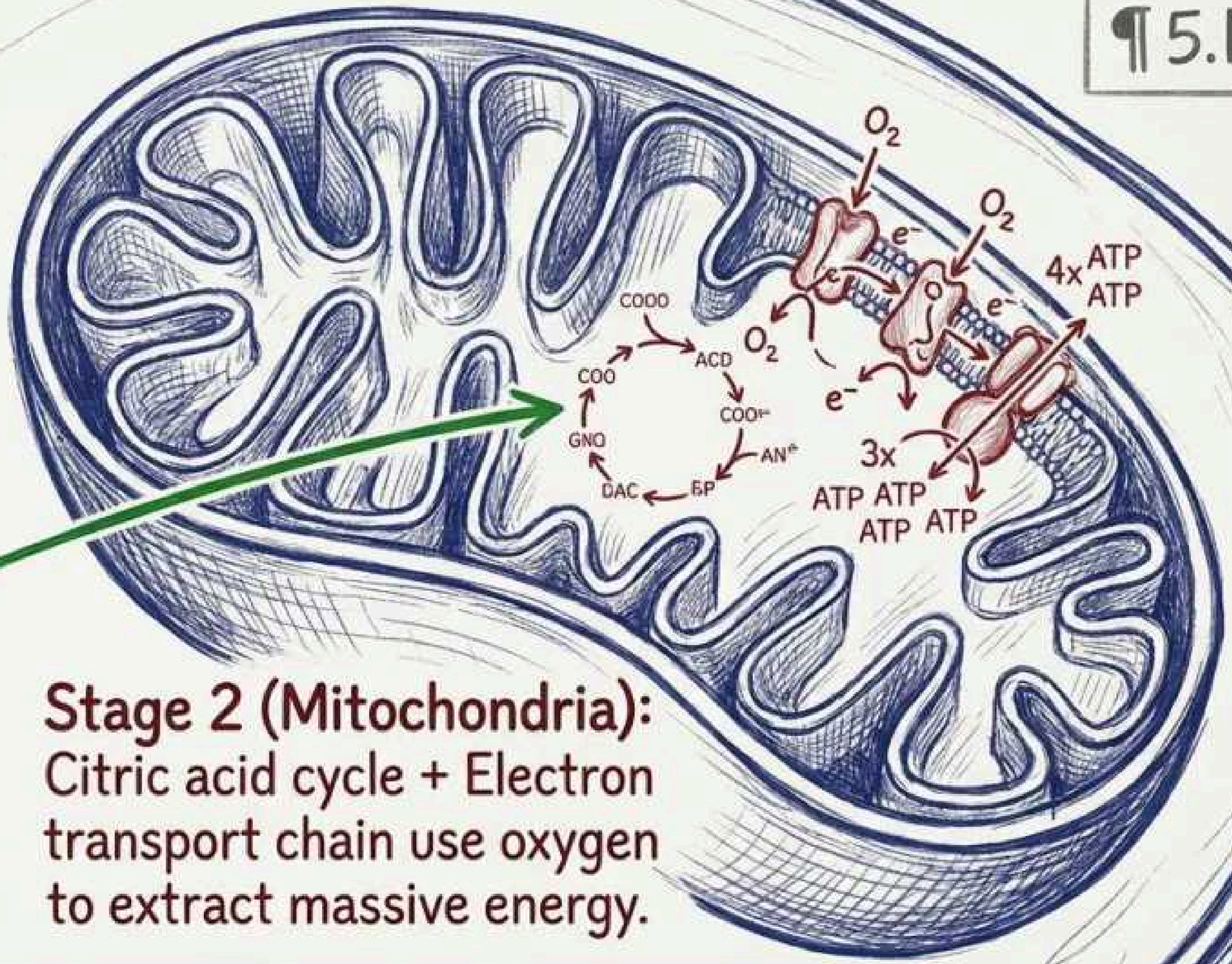
Timeline: 1 to 3 days from mouth to exit (fiber speeds this passage).



Routing: Absorbed nutrients travel via the portal vein to the Liver—the body's processing plant.

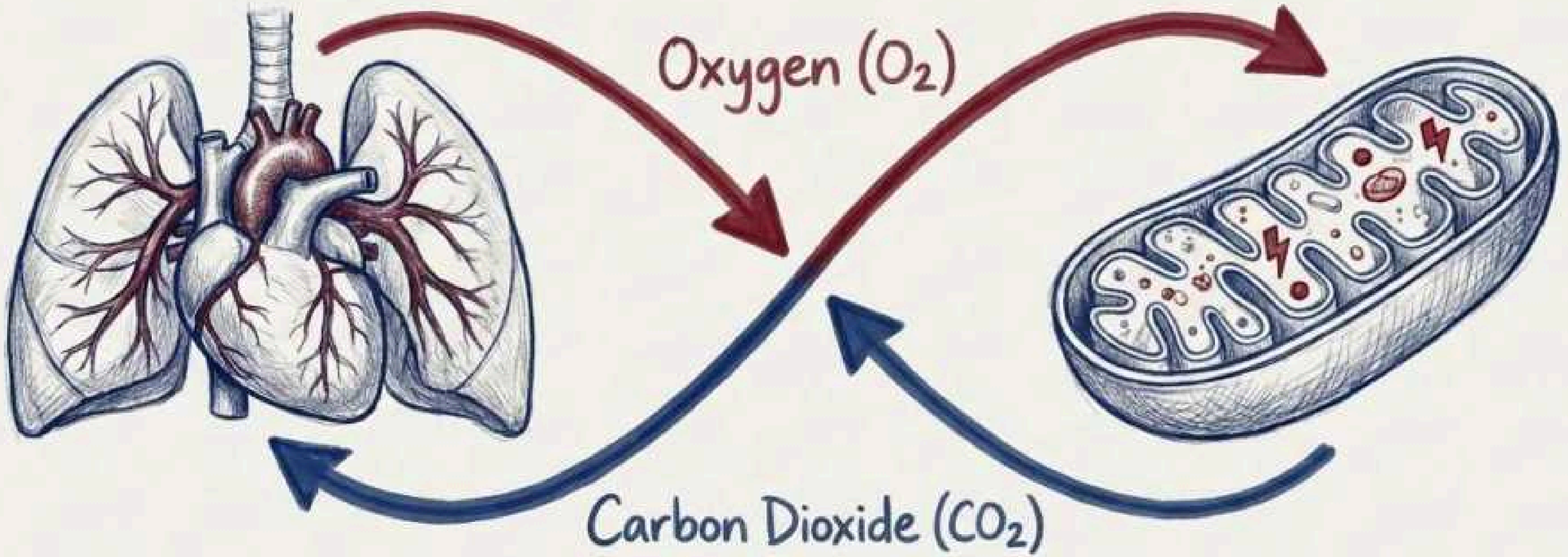
Stage 1 (Cell Fluid):
Glycolysis splits glucose, yielding minimal ATP.





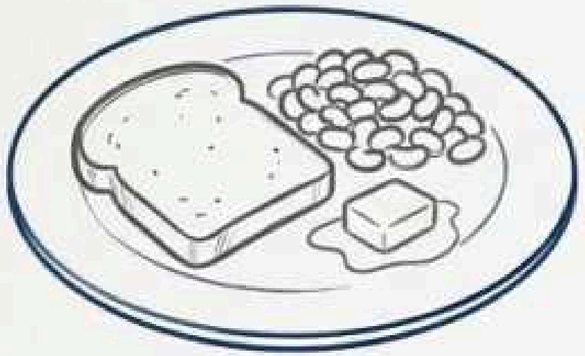
Stage 2 (Mitochondria):
Citric acid cycle + Electron transport chain use oxygen to extract massive energy.

The Yield: 1 Glucose molecule ≈ 30 ATP.



The Systemic Link: Breathing and pumping solely exist to feed mitochondria O2 and remove CO2 waste.

Astonishing Scale: The body makes and uses its own weight in ATP every single day. Each molecule is recycled thousands of times.

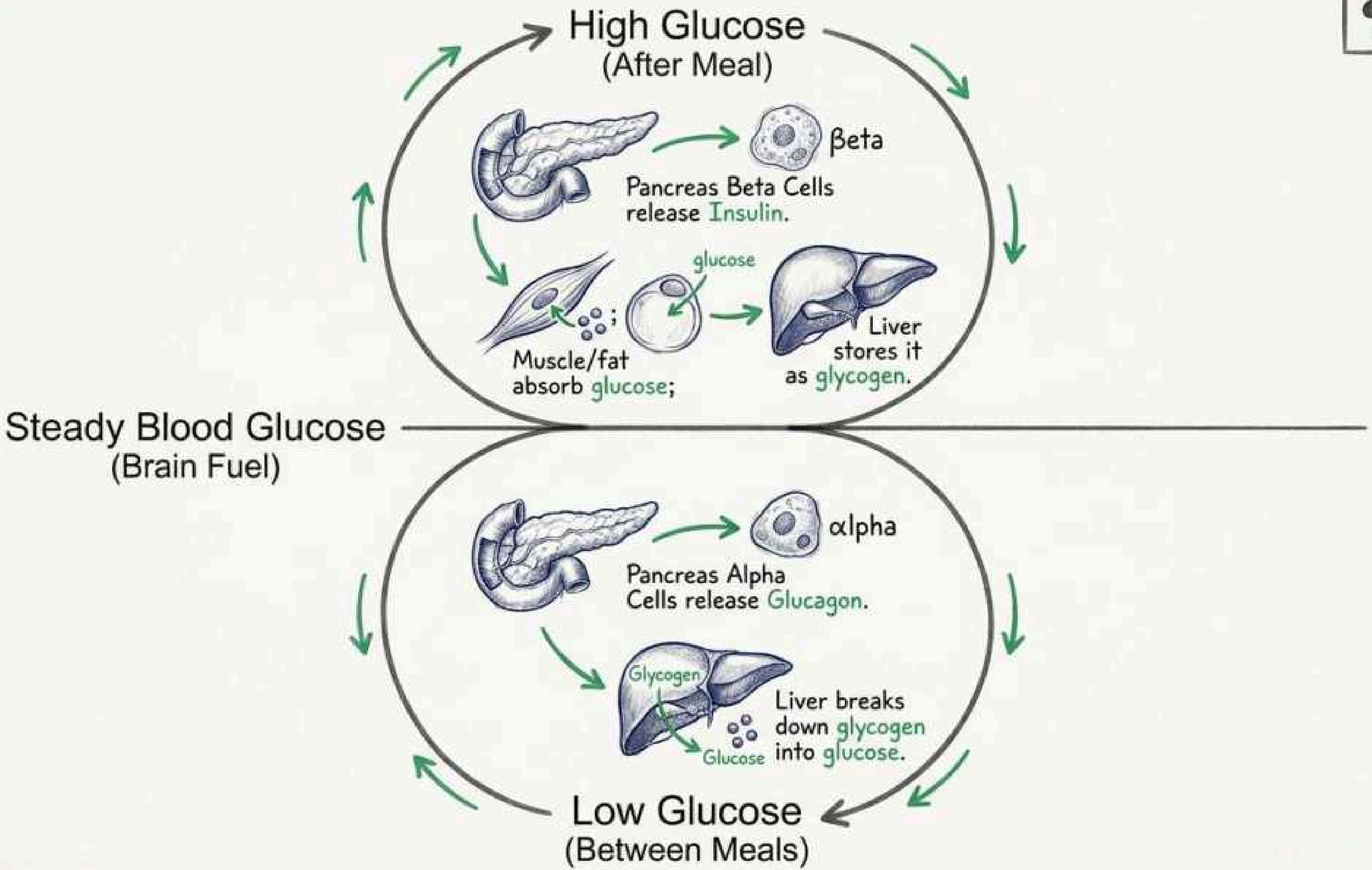


Energy Density Matrix:
Fat = 9 kcal/g | Carb = 4 kcal/g | Protein = 4 kcal/g.
(Fat is the most energy-dense).

Meal Calculation:

60g	Carb	× 4	=	240
20g	Protein	× 4	=	80
15g	Fat	× 9	=	135

Total Energy = 455 kilocalories.


High Glucose
(After Meal)
βeta
Pancreas Beta Cells
release Insulin.
glucose
Muscle/fat
absorb glucose;
Liver
stores it
as glycogen.
Steady Blood Glucose
(Brain Fuel)
αlpha
Pancreas Alpha
Cells release Glucagon.
Glycogen
Liver breaks
down glycogen
into glucose.
Glucose
Low Glucose
(Between Meals)

Liver Glycogen



~100 grams.
Secures systemic normal needs for a few hours.

Muscle Glycogen



~400 grams.
Locked in for local muscle use only.

Body Fat



Many kilograms.
The primary reserve, sufficient for weeks without food.

(Protein is guarded as a last resort).

System Failure — Diabetes

Type 1 Diabetes



Immune system destroys beta cells. Insulin is completely absent.

- Treatment: Injected insulin.

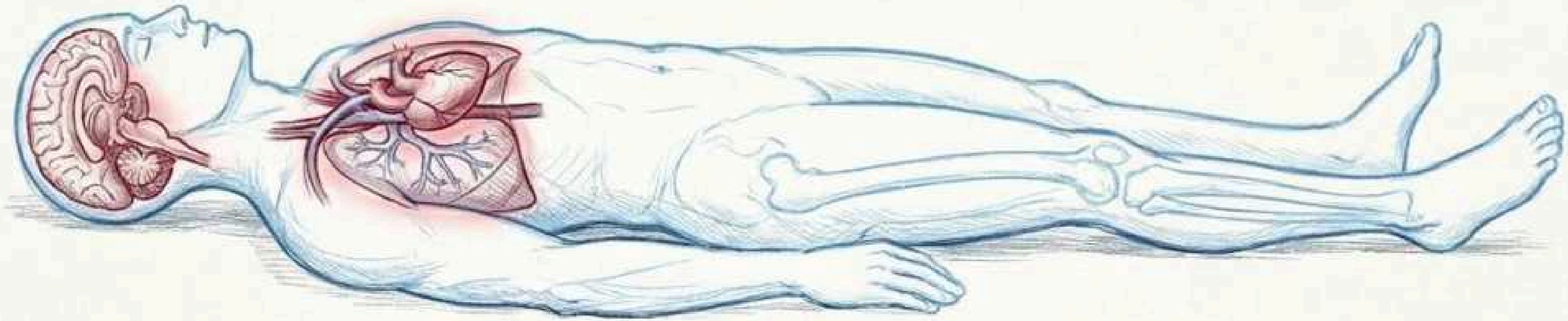
Type 2 Diabetes



Cells respond poorly to insulin (resistance); pancreas eventually tires out.

- Treatment: Drugs for sensitivity, diet, and activity changes.

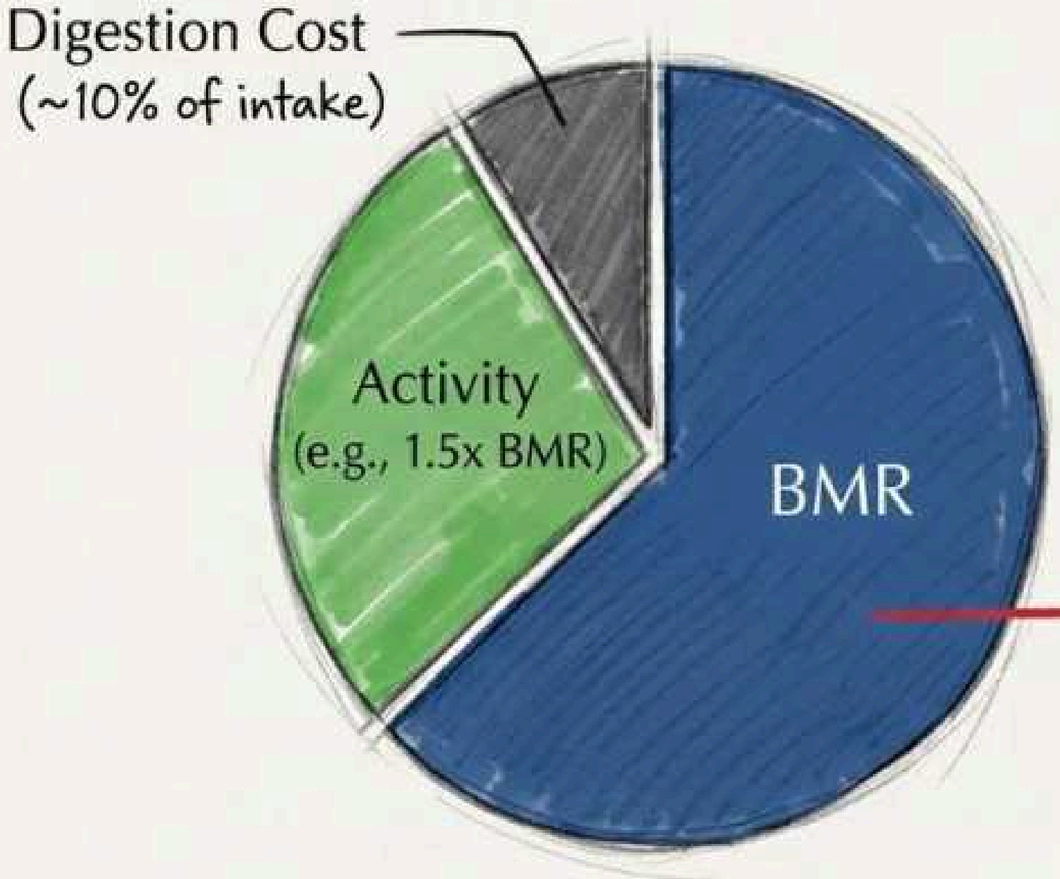
The Golden Rule:
~1 kilocalorie / kilogram of body weight / hour.

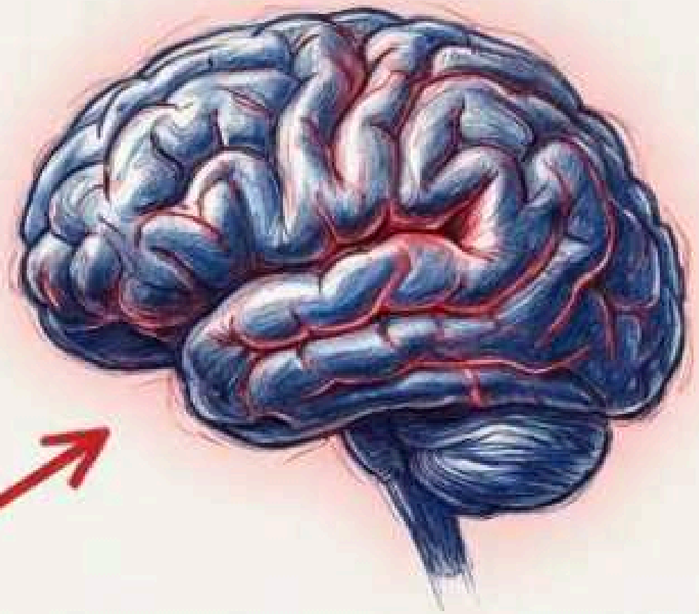


Basal Metabolic Rate (BMR): Energy used at complete rest to run heart, lungs, brain, and organs.

Calculation (70kg adult): 70 kg × 24 hrs = 1,680 kcal/day.

Total Expenditure





Organ Inefficiency (The Brain):

Accounts for only 2% of body weight, but consumes ~20% of resting energy.

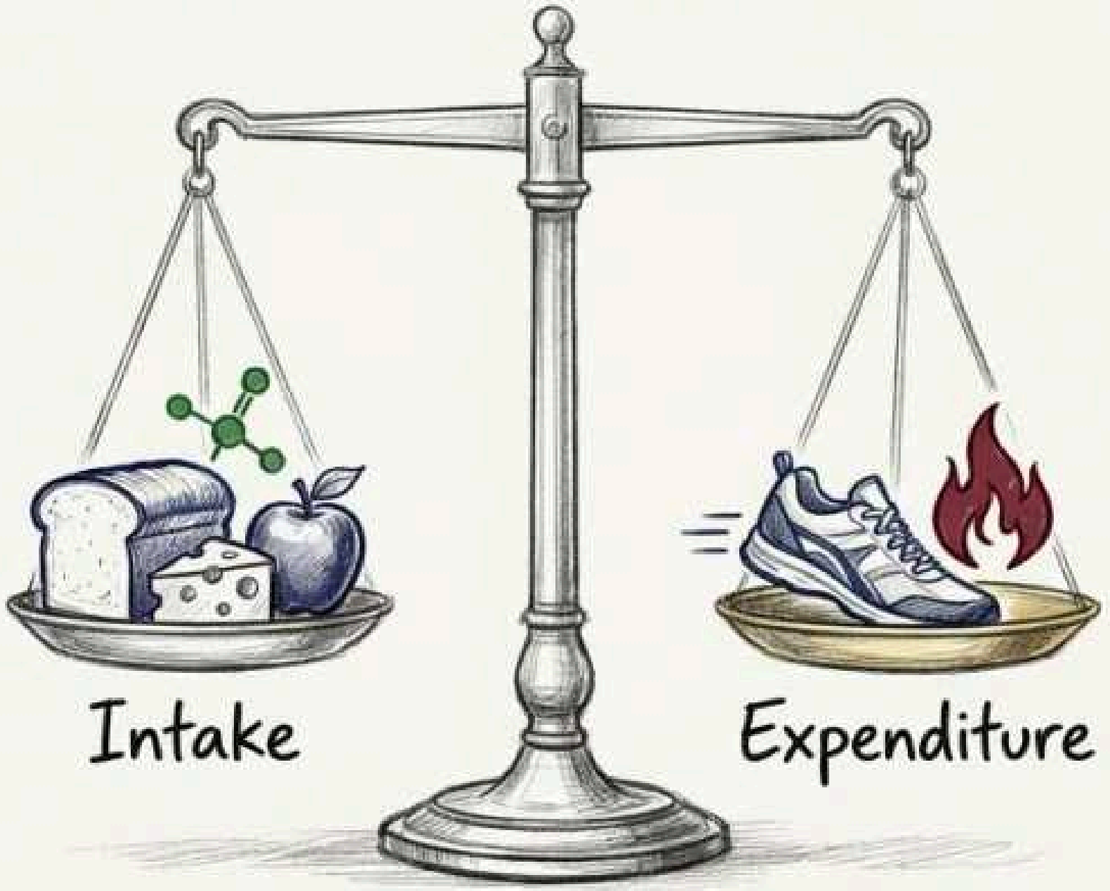
Example: 1,680 BMR × 1.5 = 2,520 kcal total.

The Principle:

Intake = Expenditure → **Stable Weight.**

Surplus:

Excess is stored mostly as fat. (1 kg of body fat ≈ 7,700 kcal).

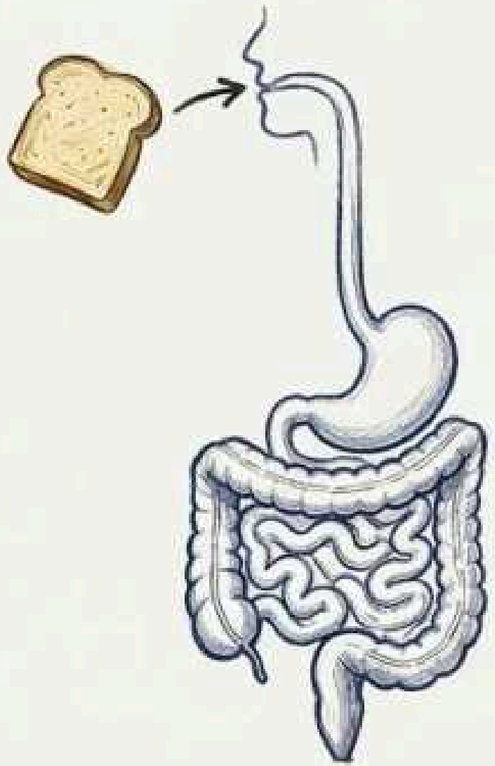


The Reality Check:

The body adapts.

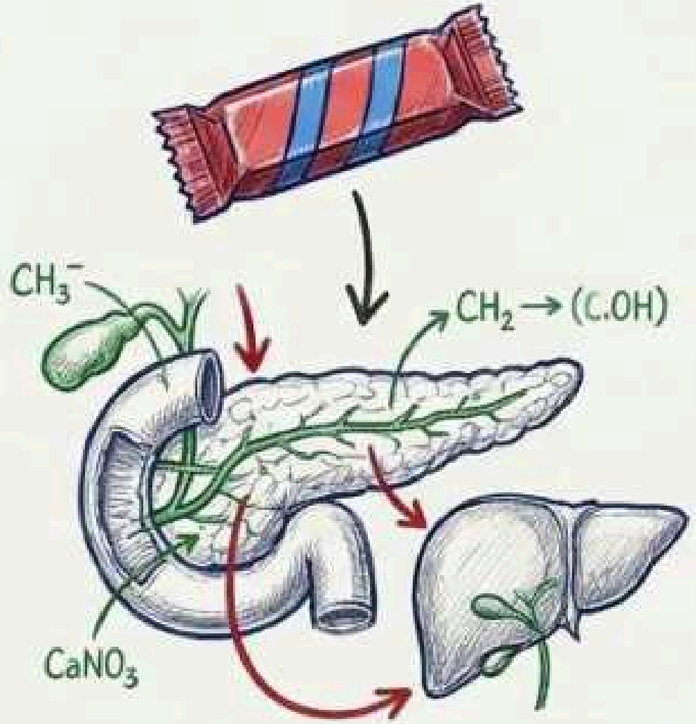
Real weight change is much more complex than simple arithmetic suggests.

Challenge 1 (Trace the Bread):



From mouth to cell, name where starch is split, where glucose is absorbed, and where it is burned for ATP.

Challenge 2 (Trace the Sugar):



After a sugary snack, which hormone rises? What exactly does it tell the liver to do?

Next in Lecture 6:

The Kidneys: Understanding how the body balances water and salts.

The Hormonal System: The chemical messengers that tie the entire body together.

