D.PHARM • SECOND YEAR

Biochemistry & Clinical Pathology

CHAPTER 8

Metabolism

ENGLISH CHAPTER NOTES



DIPLOMA IN PHARMACY

METABOLISM: AN OVERVIEW

DEFINITION

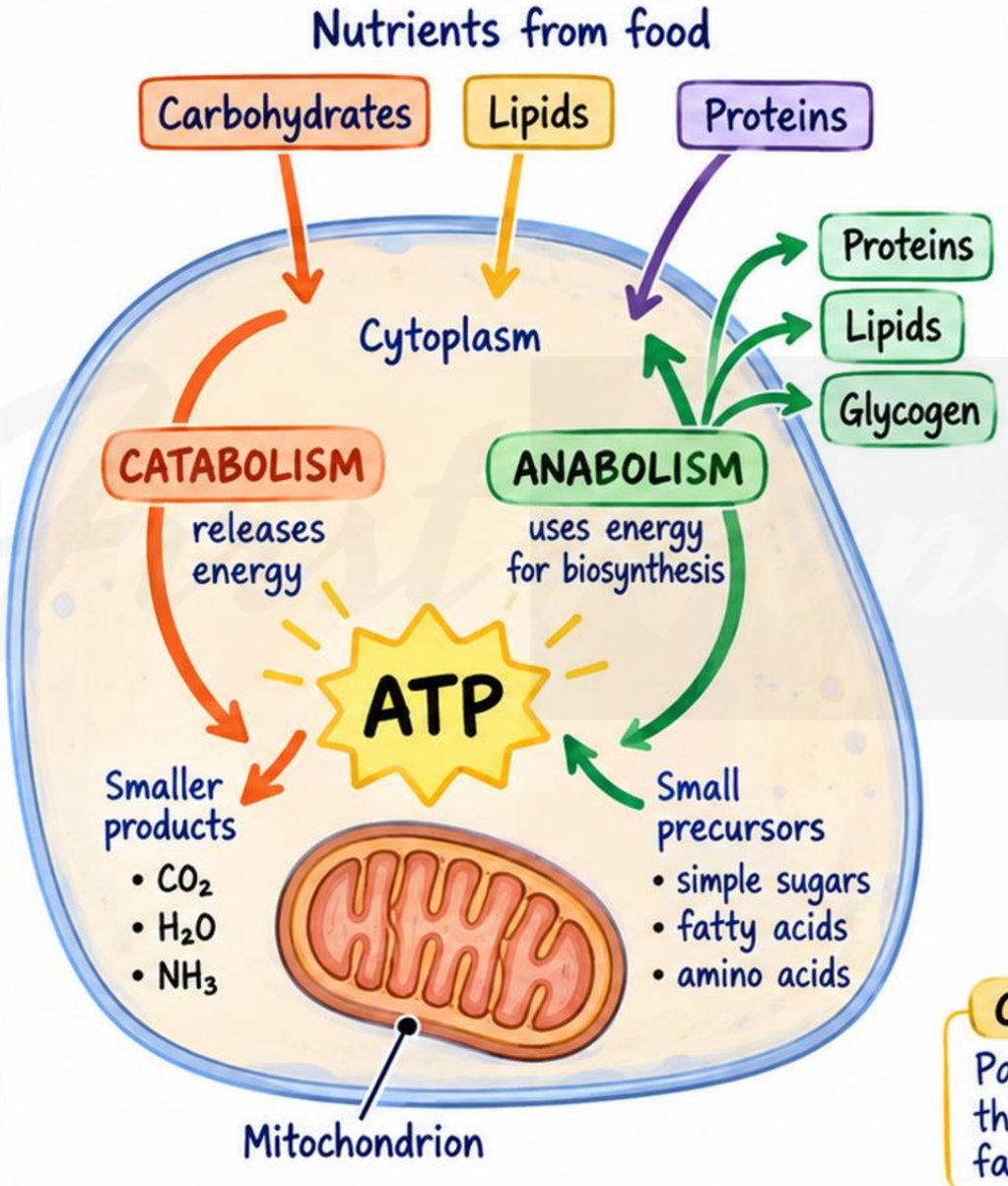
Metabolism is the complete set of chemical reactions that keeps a living cell and the body functioning.

TWO CONNECTED PARTS

- **CATABOLISM** — breaks complex molecules into simpler products and releases usable energy.
- **ANABOLISM** — uses energy to build complex molecules needed for growth, repair and storage.

ENERGY COUPLING

Energy released by catabolism is captured mainly as ATP and reduced coenzymes such as NADH and $FADH_2$. ATP then supplies energy for biosynthesis, transport, movement and other cell work.



MAJOR NUTRIENT ROUTES

Carbohydrates → glucose → pyruvate → acetyl-CoA

Lipids → fatty acids → acetyl-CoA

Proteins → amino acids → carbon skeletons + nitrogen

Acetyl-CoA and other intermediates connect many pathways.

IMPORTANT LOCATIONS

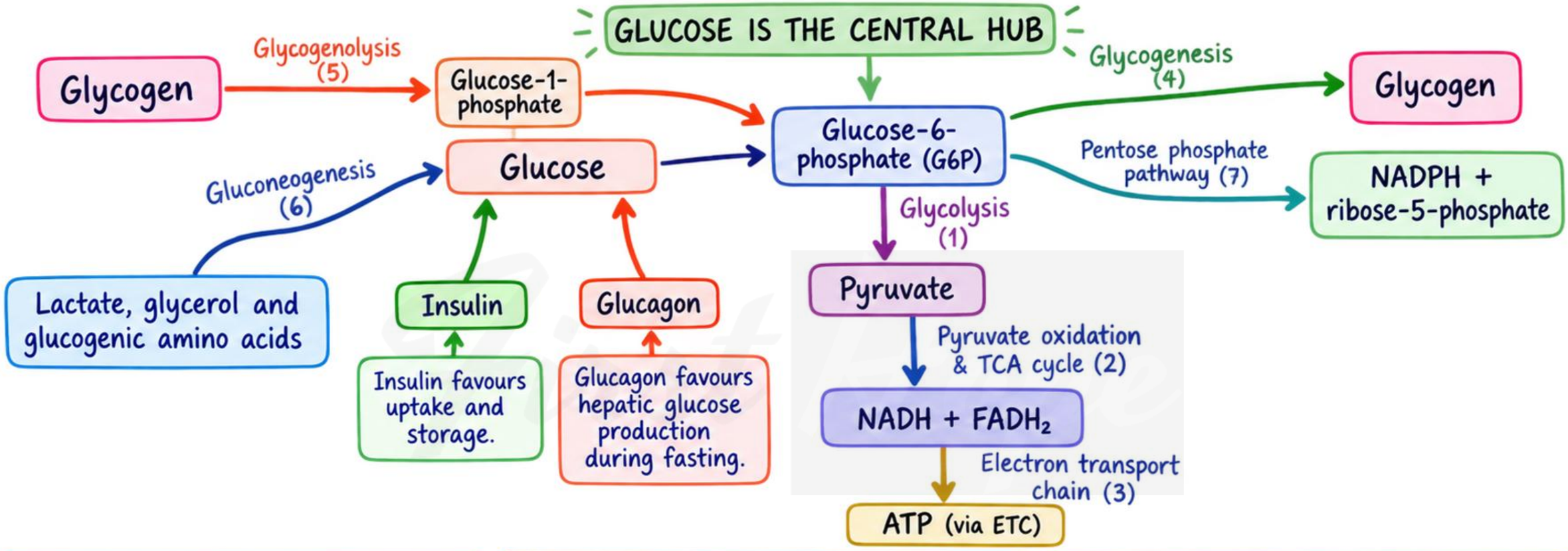
- **Cytoplasm** — glycolysis, glycogenesis and pentose phosphate pathway.
- **Mitochondria** — pyruvate oxidation, TCA cycle, β-oxidation and oxidative phosphorylation.
- **Liver** — coordinates blood glucose, lipid, amino-acid and ammonia metabolism.



CORE IDEA

Pathways are regulated and integrated; the direction changes with feeding, fasting, exercise and hormonal signals.

CARBOHYDRATE METABOLISM MAP



1 GLYCOLYSIS — cytoplasm

Glucose → 2 pyruvate + net 2 ATP + 2 NADH. It can proceed without oxygen.

2 PYRUVATE OXIDATION & TCA CYCLE — mitochondria

Pyruvate → acetyl-CoA. The TCA cycle oxidises acetyl-CoA and produces NADH, $FADH_2$, GTP and CO_2.

3 ELECTRON TRANSPORT CHAIN — inner mitochondriad membrane

NADH and $FADH_2$ donate electrons. Oxygen is the final electron acceptor; the proton gradient drives ATP synthesis.

4 GLYCOGENESIS

Glucose → glycogen for storage, mainly in liver and skeletal muscle.

5 GLYCOGENOLYSIS

Glycogen → glucose-1-phosphate. Liver supports blood glucose; muscle uses its glycogen locally.

6 GLUCONEOGENESIS — mainly liver, also kidney

Lactate, glycerol and glucogenic amino acids → glucose during fasting.

7 PENTOSE PHOSPHATE PATHWAY — cytoplasm

Produces NADPH and ribose-5-phosphate for antioxidant defence and biosynthesis.

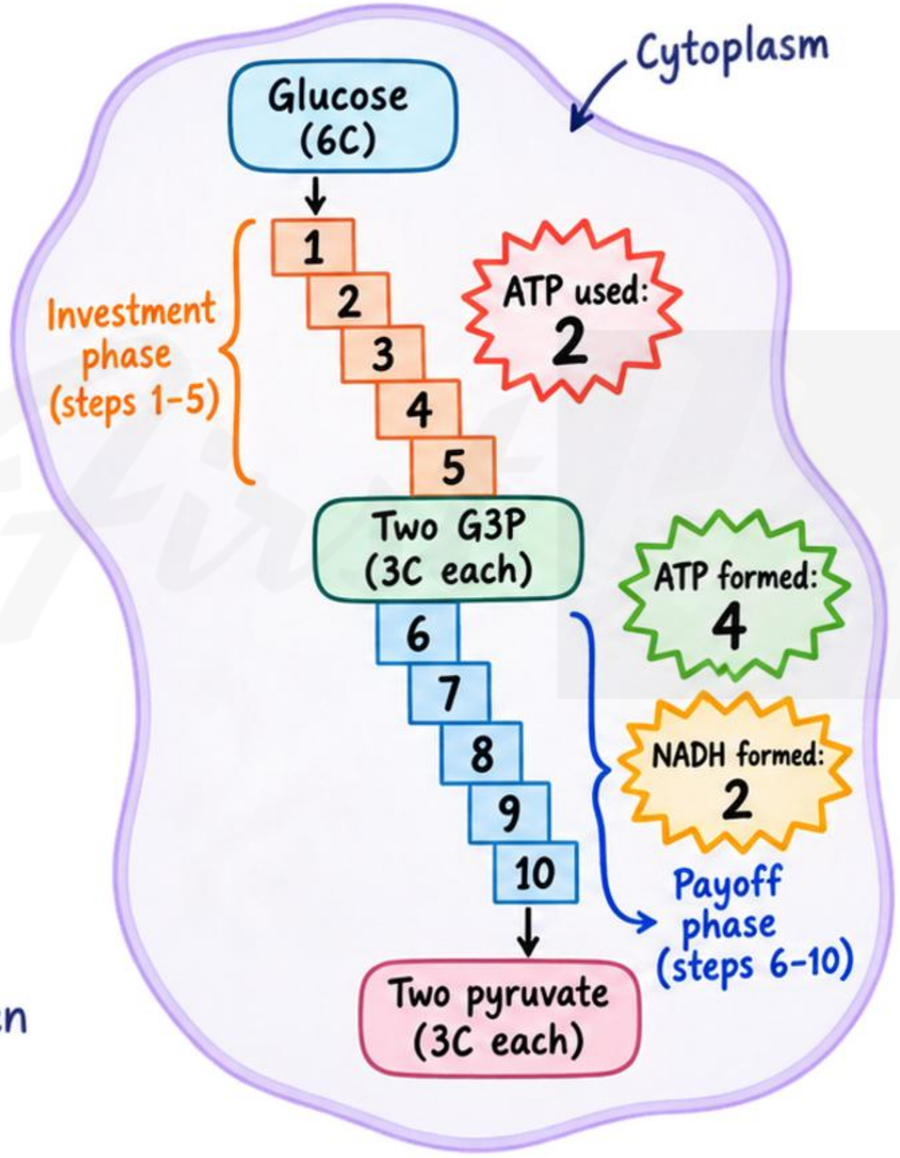
GLYCOLYSIS: PURPOSE & PHASES

DEFINITION

Glycolysis is a ten-reaction pathway that converts one glucose into two pyruvate molecules. It occurs in the cytoplasm of every cell.

WHY IT MATTERS

- gives rapid ATP
- supplies pyruvate for aerobic oxidation
- supplies metabolic intermediates for other pathways
- can continue without oxygen if NAD^+ is regenerated



PHASE 1: ENERGY INVESTMENT — STEPS 1–5

Glucose is phosphorylated, rearranged and split.

ATP used: **2**

One 6-carbon glucose ⟶ two 3-carbon glyceraldehyde-3-phosphate, G3P.

PHASE 2: ENERGY PAYOFF — STEPS 6–10

Each G3P is oxidised and converted to pyruvate. Because two G3P molecules are processed, each payoff reaction occurs twice per glucose.

ATP formed: **4**

NADH formed: **2**

Pyruvate formed: **2**

NET RESULT PER GLUCOSE

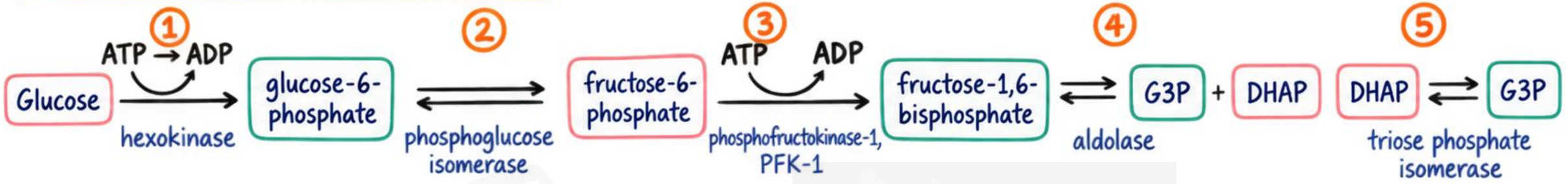
2 ATP + **2** NADH + **2** pyruvate

OXYGEN LINK

Glycolysis itself does not directly use O_2. With oxygen, pyruvate usually enters mitochondria. When oxygen supply or mitochondrial oxidation is limited, pyruvate can form lactate to regenerate NAD^+.

GLYCOLYSIS: STEPS 1–5

ENERGY INVESTMENT PHASE



1. PHOSPHORYLATION

Glucose + ATP → glucose-6-phosphate + ADP

Enzyme: hexokinase; glucokinase performs this role in liver cells.

Purpose: traps glucose inside the cell.

2. ISOMERISATION

Glucose-6-phosphate ⇌ fructose-6-phosphate

Enzyme: phosphoglucose isomerase.

3. SECOND PHOSPHORYLATION

Fructose-6-phosphate + ATP → fructose-1,6-bisphosphate + ADP

Enzyme: phosphofructokinase-1, PFK-1.

This is the committed and major regulated step of glycolysis.

4. CLEAVAGE

Fructose-1,6-bisphosphate ⇌ G3P + DHAP

Enzyme: aldolase.

One 6-carbon compound becomes two 3-carbon triose phosphates.

5. TRIOSE ISOMERISATION

DHAP ⇌ G3P

Enzyme: triose phosphate isomerase.

END OF PHASE

- Two G3P molecules continue to the payoff phase.
- ATP invested per glucose = 2.
- No ATP has yet been produced.

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