Carbohydrate Metabolism

Learning goals

- Follow glucose from uptake to ATP: glycolysis, pyruvate dehydrogenase and the TCA cycle.
- Name the three irreversible steps of glycolysis: hexokinase, PFK-1 and pyruvate kinase.
- Explain how insulin and glucagon switch the liver between glycolysis and gluconeogenesis.

Glucose transporters

- GLUT-1: red blood cells and brain; steady basal uptake.
- GLUT-2: liver and pancreatic beta cells; high Km, works as a glucose sensor.
- GLUT-4: skeletal muscle and fat; insulin moves it to the cell membrane.
- SGLT-1: small intestine; takes up glucose and galactose together with Na+.
- GLUT-5: small intestine; fructose uptake.

Glycolysis: control points

- Hexokinase: inhibited by its product, glucose-6-phosphate.
- PFK-1: the rate-limiting enzyme; activated by fructose-2,6-bisphosphate and AMP, inhibited by ATP and citrate.
- Pyruvate kinase: activated by fructose-1,6-bisphosphate; inhibited by ATP and alanine.
- Net yield per glucose: 2 ATP and 2 NADH.

Gluconeogenesis

- Runs mainly in the liver, and in the kidney, during fasting.
- Pyruvate carboxylase (mitochondria) makes oxaloacetate; it needs biotin and is activated by acetyl-CoA.
- PEPCK turns oxaloacetate into phosphoenolpyruvate.
- Fructose-1,6-bisphosphatase and glucose-6-phosphatase bypass the other two irreversible steps.
- Muscle lacks glucose-6-phosphatase, so it cannot release free glucose into the blood.

Practice quiz

1. Which transporter moves to the cell membrane when insulin rises?

A) GLUT-1
B) GLUT-2
C) GLUT-4
D) SGLT-1

2. Which enzyme catalyses the rate-limiting step of glycolysis?

A) Hexokinase
B) PFK-1
C) Pyruvate kinase
D) Aldolase

3. Which tissue cannot release free glucose into the blood?

A) Liver
B) Kidney
C) Skeletal muscle
D) None of these

Answer key: 1-C 2-B 3-C