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Glucose Transport & Phosphorylation

Study Guide — Metabolism

Pre-med style questions on glucose entry into cells, GLUT transporters, SGLTs, facilitated diffusion, and phosphorylation by hexokinase and glucokinase.

30 items — Study Guide with Answers

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1 **Which statement best describes HOW GLUT transporters move glucose across the plasma membrane?**

A Primary active transport directly using ATP

B Secondary active transport using a Na^+ gradient

C **Facilitated diffusion down a concentration gradient** ✓

D Endocytosis of glucose-containing vesicles

E Simple diffusion through the lipid bilayer

▶ **Explanation:** GLUTs are carrier proteins that mediate facilitated diffusion of glucose down its concentration gradient without direct energy use.

2 **Which statement correctly compares GLUT transporters with SGLT transporters?**

A Both are Na^+-dependent cotransporters

B **GLUT uses facilitated diffusion; SGLT uses Na^+-coupled secondary active transport** ✓

C GLUT requires ATP; SGLT does not

D SGLT is only found in red blood cells

E GLUT moves glucose against its gradient; SGLT moves it down its gradient

▶ **Explanation:** GLUTs mediate passive, Na^+-independent transport. SGLTs (e.g., SGLT1, SGLT2) use the Na^+ gradient created by the Na^+/K^+ ATPase (secondary active transport).

3 **Why does phosphorylation of glucose to glucose-6-phosphate (G6P) help maintain glucose uptake into cells?**

A It increases the number of GLUT transporters

B It converts glucose into a lipid

C **It prevents glucose from leaving the cell and keeps intracellular free glucose low** ✓

D It directly opens voltage-gated Na^+ channels

E It raises intracellular glucose concentration, reversing the gradient

▶ **Explanation:** Once inside, glucose is rapidly phosphorylated to G6P, which cannot pass through GLUT. This 'traps' glucose and maintains a steep gradient for continued uptake.

4 Hexokinase and glucokinase both phosphorylate glucose to G6P. Which statement correctly contrasts their affinities (Km) for glucose?

A Hexokinase has a higher Km (lower affinity) than glucokinase

B Both have identical Km values

C **Hexokinase has a lower Km (higher affinity); glucokinase has a higher Km (lower affinity)** ✓

D Hexokinase does not bind glucose at all

E Glucokinase has zero affinity for glucose

▶ **Explanation:** Hexokinase saturates at low glucose concentrations (high affinity). Glucokinase only becomes active at higher glucose levels, acting as a 'glucose sensor' in liver and pancreatic -cells.

5 Which tissues primarily express GLUCOKINASE (hexokinase IV)?

A Skeletal muscle and adipose tissue

B **Liver and pancreatic -cells** ✓

C Red blood cells only

D All tissues at equal levels

E Brain neurons only

▶ **Explanation:** Glucokinase is found mainly in hepatocytes and pancreatic -cells, enabling liver glucose storage and -cell glucose sensing.

6 Hexokinase, but not glucokinase, is strongly inhibited by its product G6P. What is the functional consequence of this difference?

A Peripheral tissues can keep phosphorylating glucose indefinitely

B Liver cells stop glycolysis at low glucose concentrations

C Peripheral tissues self-limit glucose phosphorylation when G6P accumulates, while the liver can continue storing excess glucose as glycogen ✓

D Glucokinase cannot phosphorylate glucose at all

E Hexokinase does not function in low-energy states

▶ **Explanation:** Product inhibition of hexokinase prevents excessive trapping of glucose in most tissues. Glucokinase's lack of inhibition allows liver to keep converting glucose to G6P for storage when blood glucose is high.

7 Which GLUT isoform is INSULIN-DEPENDENT and found mainly in skeletal muscle, cardiac muscle and adipose tissue?

A GLUT1

B GLUT2

C GLUT3

D GLUT4 ✓

E GLUT5

▶ **Explanation:** GLUT4 is stored in intracellular vesicles and translocates to the plasma membrane in response to insulin, increasing glucose uptake in muscle and adipose tissue.

8 **Which GLUT isoform is a HIGH AFFINITY transporter that supplies glucose to neurons and is largely insulin-independent?**

A GLUT1

B GLUT2

C **GLUT3** ✓

D GLUT4

E GLUT5

▶ **Explanation:** GLUT3 has a low Km (high affinity) and is abundantly expressed in neurons, ensuring adequate glucose uptake even when blood glucose is relatively low.

9 **Which GLUT isoform is mainly responsible for BASAL glucose uptake in many tissues and is highly expressed in red blood cells and the blood–brain barrier?**

A **GLUT1** ✓

B GLUT2

C GLUT3

D GLUT4

E GLUT5

▶ **Explanation:** GLUT1 provides basal glucose uptake and is key in tissues such as RBCs and endothelial cells of the BBB.

10 **GLUT2 has a relatively HIGH Km (low affinity) for glucose. What is a major physiological consequence of this property?**

A It is saturated at very low blood glucose levels

B It transports glucose at a constant rate regardless of glucose concentration

C It acts as a glucose sensor in liver and pancreatic -cells, increasing transport only when glucose is high ✓

D It prevents any glucose uptake in the liver

E It requires insulin to function

▶ **Explanation:** Because GLUT2 has a high Km, its activity increases as blood glucose rises post-prandially, contributing to liver uptake and -cell glucose sensing.

11 **Which GLUT isoform primarily transports FRUCTOSE, especially in the small intestine?**

A GLUT1

B GLUT2

C GLUT3

D GLUT4

E GLUT5 ✓

▶ **Explanation:** GLUT5 is a fructose transporter found in the apical membrane of intestinal cells and in other tissues involved in fructose handling.

12 **Which statement about GLUT transporters is TRUE?**

A They are ion channels that allow uncontrolled glucose flux

B **They are carrier proteins that show saturation at high glucose concentrations** ✓

C They require ATP binding and hydrolysis at the transporter

D They move glucose only in one direction

E They transport glucose against its concentration gradient

▶ **Explanation:** GLUTs are saturable carriers that undergo conformational changes to move glucose down its gradient; they are not channels and do not directly use ATP.

13 **In a hepatocyte, what is the CORRECT order of events for handling glucose shortly AFTER a carbohydrate-rich meal?**

A SGLT1 uptake → hexokinase phosphorylation → export via GLUT4

B **GLUT2 uptake → phosphorylation by glucokinase → storage as glycogen** ✓

C GLUT1 uptake → phosphorylation by hexokinase → conversion to ketone bodies

D GLUT4 uptake → immediate release back to blood

E Endocytosis of intact glycogen → breakdown to glucose

▶ **Explanation:** Liver uses insulin-independent GLUT2 for glucose uptake. Glucokinase phosphorylates glucose to G6P, which is directed into glycogen synthesis or glycolysis.

14 **Which statement best explains why liver can BOTH take up AND release glucose efficiently?**

A Liver lacks glucose transporters and therefore traps glucose

B **Liver expresses GLUT2 plus enzymes that can both phosphorylate and dephosphorylate glucose** ✓

C Liver uses only SGLT and never releases glucose

D Liver has only hexokinase, which cannot be reversed

E Liver cells are impermeable to glucose

▶ **Explanation:** Liver expresses GLUT2 (bidirectional transport), glucokinase (phosphorylation) and glucose-6-phosphatase (dephosphorylation), allowing uptake in the fed state and release in fasting.

15 Which of the following is TRUE regarding hexokinase in most peripheral tissues (e.g. muscle, brain)?

A It has LOW affinity for glucose and functions only when glucose is very high

B It has HIGH affinity for glucose and allows tissues to phosphorylate glucose even at low concentrations ✓

C It is present only in liver

D It cannot use ATP

E It is inactive in the presence of insulin

▶ **Explanation:** Hexokinase has a low Km (high affinity), so it efficiently phosphorylates glucose in most tissues to support metabolism at normal or low blood glucose.

16 In INSULIN DEFICIENCY (untreated type 1 diabetes), which glucose transporter's activity in peripheral tissues is most directly reduced?

A GLUT1 in red blood cells

B GLUT2 in liver

C GLUT3 in neurons

D GLUT4 in skeletal muscle and adipose tissue ✓

E GLUT5 in intestine

▶ **Explanation:** GLUT4 translocation to the plasma membrane is insulin-dependent; in insulin deficiency, GLUT4 remains largely intracellular, reducing glucose uptake in muscle and fat.

17 **Which transport process is MOST directly impaired by a drug that inhibits the Na^+/K^+ ATPase in intestinal epithelial cells?**

A GLUT2-mediated glucose efflux into blood

B GLUT4-mediated glucose uptake into muscle

C **SGLT1-mediated glucose uptake from the intestinal lumen** ✓

D Simple diffusion of CO_2

E GLUT1-mediated uptake in red blood cells

▶ **Explanation:** SGLT1 relies on the Na^+ gradient established by the Na^+/K^+ ATPase. Inhibition of the pump collapses the gradient and impairs Na^+-coupled glucose uptake.

18 **Which transporter reabsorbs MOST of the filtered glucose in the early proximal convoluted tubule of the kidney?**

A GLUT4

B **SGLT2** ✓

C SGLT1

D GLUT5

E GLUT3

▶ **Explanation:** SGLT2 is a high-capacity Na^+-glucose cotransporter in the early proximal tubule, reabsorbing most filtered glucose. SGLT1 contributes in the later proximal tubule.

19 **A new drug blocks SGLT2 in the kidney. Which effect on glucose handling is expected?**

A Increased renal reabsorption of glucose, lowering urine glucose

B **Decreased renal reabsorption of glucose, increasing urinary glucose loss** ✓

C No change in urinary glucose

D Complete block of intestinal glucose absorption

E Inhibition of GLUT4 in muscle

▶ **Explanation:** SGLT2 inhibitors reduce glucose reabsorption, causing glucosuria and lowering blood glucose—this is the basis of SGLT2 inhibitor drugs for diabetes.

20 **Which statement about the FIRST step of glycolysis (glucose → G6P) is CORRECT?**

A It is catalysed only by glucokinase in all tissues

B **It traps glucose inside the cell and commits it to metabolic pathways** ✓

C It converts glucose into a lipid

D It does not require ATP

E It produces glucose that can easily leave via GLUT

▶ **Explanation:** Phosphorylation to G6P uses ATP and prevents glucose from leaving the cell, committing it to further metabolism (glycolysis, glycogenesis, or pentose phosphate pathway).

21 **In most cells, what would be the effect of acutely inhibiting hexokinase activity while GLUT function remains normal?**

A Glucose uptake would stop because GLUT needs hexokinase

B **Glucose would accumulate inside the cell as free glucose and more easily diffuse back out** ✓

C More G6P would be formed

D The Na^+ gradient would collapse

E GLUT would start active transport

▶ **Explanation:** GLUT can still bring glucose in, but without phosphorylation it is not 'trapped', so intracellular glucose rises and the net gradient for entry decreases.

22 **Which of the following correctly describes FACILITATED DIFFUSION of glucose via GLUT?**

A **Saturable, specific, and energy-independent transport down a concentration gradient** ✓

B Non-specific, non-saturable, energy-independent

C Requires ATP at the transporter site for each glucose

D Moves glucose against its concentration gradient

E Continuous regardless of concentration differences

▶ **Explanation:** Facilitated diffusion is carrier-mediated, specific and saturable. It does not require ATP and moves solutes down their gradients.

23 **Which of the following BEST explains why the brain's glucose uptake is relatively unaffected in early insulin deficiency?**

A Brain uses only GLUT4, which is insulin-independent

B **Brain uses mainly GLUT3 and GLUT1, which are insulin-independent, high-affinity transporters** ✓

C Brain does not require glucose

D Insulin cannot cross the blood–brain barrier

E Brain has large glycogen stores to replace glucose

▶ **Explanation:** Neuronal uptake is mediated primarily by GLUT3 (and BBB GLUT1), which are not insulin-regulated, so brain remains supplied with glucose despite low insulin.

24 Which GLUT isoform is mainly responsible for glucose exit from hepatocytes into the blood during fasting?

A GLUT1

B **GLUT2** ✓

C GLUT3

D GLUT4

E SGLT1

▶ **Explanation:** GLUT2 is bidirectional; during fasting, glucose produced from glycogen or gluconeogenesis leaves the liver via GLUT2 into the bloodstream.

25 Which statement correctly links INSULIN, GLUT4 and HEXOKINASE in skeletal muscle after a meal?

A Insulin decreases GLUT4 and hexokinase activity, limiting glucose uptake

B **Insulin increases GLUT4 translocation and hexokinase activity, enhancing glucose uptake and phosphorylation** ✓

C Insulin acts only on hexokinase and not on GLUT4

D Insulin blocks glucose phosphorylation, preventing glycolysis

E Insulin causes glucose to leave muscle cells via GLUT4

▶ **Explanation:** Insulin stimulates both GLUT4 insertion into the membrane and the activity of enzymes like hexokinase, promoting rapid uptake and trapping of glucose as G6P.

26 Which of the following is MOST responsible for the fact that glucose can reach a transport MAXIMUM (Tm) in renal tubules at high plasma glucose levels?

A Non-saturable simple diffusion

B **Limited number of SGLT transporters that can become saturated** ✓

C Unlimited capacity of SGLT transporters

D Insulin-dependent GLUT4 in the kidney

E Direct ATP binding to GLUT1

▶ **Explanation:** SGLT transporters in the proximal tubule are saturable. Above a certain filtered load of glucose, reabsorption reaches Tm and additional glucose appears in the urine.

27 Which of the following would MOST DIRECTLY REDUCE the gradient driving GLUT-mediated glucose entry into a cell?

A Increased hexokinase activity

B **Decreased hexokinase activity so intracellular free glucose rises** ✓

C Increased expression of GLUT

D Decreased blood glucose concentration

E Increased Na^+/K^+ pump activity

▶ **Explanation:** If phosphorylation slows, free intracellular glucose accumulates, reducing the extracellular–intracellular gradient, so net entry by GLUT is reduced.

28 **Which of the following pairs is CORRECTLY matched with its MAIN substrate?**

A **SGLT1 – Na^+ and glucose cotransport** ✓

B GLUT5 – Na^+ and fructose cotransport

C GLUT4 – ATP-driven glucose pump

D Hexokinase – phosphorylation of fructose only

E Glucokinase – phosphorylation of amino acids only

▶ **Explanation:** SGLT1 cotransports Na^+ and glucose (and galactose). GLUT5 transports fructose by facilitated diffusion; GLUT4 is not an ATP pump.

29 **Which of the following best describes the ROLE of glucokinase in pancreatic -cells?**

A It blocks insulin secretion at high glucose

B **It serves as a glucose sensor by phosphorylating glucose in proportion to blood levels, helping regulate insulin release** ✓

C It is inhibited by G6P, switching off insulin at high glucose

D It converts glucose directly to glycogen in -cells

E It has no role in -cells, only in hepatocytes

▶ **Explanation:** Glucokinase's high Km means -cell glucose phosphorylation increases as glucose rises, linking blood glucose to ATP production and insulin secretion.

30 **Which concise statement correctly summarises the division of labour between GLUTs and hexokinase/glucokinase in cellular glucose handling?**

A GLUTs trap glucose inside the cell; kinases move it across membranes

B **GLUTs move glucose across membranes; hexokinase/glucokinase trap it by phosphorylation** ✓

C Both GLUTs and kinases are required for glucose to leave the cell

D Kinases transport glucose, GLUTs phosphorylate it

E Neither GLUTs nor kinases are involved in glucose uptake

▶ **Explanation:** First, GLUTs mediate entry by facilitated diffusion. Then hexokinase or glucokinase phosphorylate glucose to G6P, trapping it and routing it into metabolic pathways.