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Glycolysis in Human Cells & Tissues

Exam — Metabolism

Comprehensive Pre-med/IB-style practice on glycolysis fundamentals, regulation, and how different human cell types depend on glycolysis (RBCs, muscle, liver, brain, kidney medulla, lens/cornea, immune cells, cancer). Includes common traps: insulin dependence, NAD^+ regeneration, ATP accounting, glycogen vs blood glucose, lactate handling, and lab/clinical-style scenarios.

50 items — Printable Exam

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1 **Which human cell type relies on glycolysis as its only source of ATP under normal conditions?**

A Red blood cell (erythrocyte)

B Hepatocyte (liver cell)

C Cardiac muscle cell

D Neuron

E Adipocyte

2 **A well-oxygenated red blood cell takes up glucose. What is the most likely fate of pyruvate produced by glycolysis?**

A Converted to acetyl-CoA in mitochondria

B Reduced to lactate in the cytosol

C Converted to ethanol and CO2

D Converted to glucose via gluconeogenesis inside the same cell

E Stored as glycogen inside the nucleus

3 **A patient has absolute insulin deficiency. Which cell type can still take up glucose efficiently via predominantly GLUT1-mediated transport and keep glycolysis relatively normal?**

A Red blood cell

B Skeletal muscle cell

C Adipocyte

D Intestinal epithelial cell (apical membrane)

E Pancreatic acinar cell

4 **Glucokinase (rather than hexokinase) is the major glucose-phosphorylating enzyme in which pair of tissues?**

A Red blood cells and skeletal muscle

B Liver and pancreatic cells

C Brain and heart muscle

D Lens and cornea

E Renal medulla and adipose tissue

5 **Compared with hexokinase, glucokinase generally has which property profile?**

A Lower Km (higher affinity) and strong inhibition by glucose-6-phosphate

B Higher Km (lower affinity) and higher Vmax, enabling glucose handling when levels are high

C Located in the mitochondrial inner membrane

D Uses oxygen directly to phosphorylate glucose

E Produces lactate directly from glucose

6 **Why does phosphorylation of glucose to glucose-6-phosphate (G6P) effectively trap glucose inside most cells?**

A G6P is nonpolar and diffuses freely out of the membrane

B GLUT transporters export G6P rapidly

C G6P is charged and is not transported by GLUTs, so it cannot easily cross the membrane

D G6P is immediately converted into oxygen

E Phosphorylation destroys the glucose carbon skeleton

7 Which cell type is especially adapted to store glycogen to rapidly fuel glycolysis during brief, intense activity?

A Red blood cell

B Fast-twitch skeletal muscle fiber

C Neuron

D Lens epithelial cell

E Alveolar epithelial cell

8 During a sprint, glycolysis in a skeletal muscle cell starts from glycogen-derived glucose units (entering as glucose-6-phosphate). Compared with starting from free blood glucose, the net ATP yield per glucose unit is:

A One ATP lower

B The same

C One ATP higher

D Two ATP higher

E It becomes zero

9 Why can liver cells release free glucose into the bloodstream after glycogen breakdown, but skeletal muscle cells generally cannot?

A Muscle cells lack mitochondria

B Muscle cells lack GLUT transporters

C Muscle cells lack glucose-6-phosphatase to dephosphorylate glucose-6-phosphate

D Liver cells cannot perform glycolysis

E Liver cells store glycogen only in the nucleus

10 **High ATP and citrate levels in a cell most directly inhibit which key regulatory step of glycolysis?**

A Hexokinase/glucokinase

B Phosphofructokinase-1 (PFK-1)

C Phosphoglycerate kinase

D Pyruvate kinase

E Lactate dehydrogenase

11 **In hepatocytes, fructose-2,6-bisphosphate (F2,6BP) most directly causes which effect?**

A Strong activation of PFK-1, increasing glycolysis

B Strong inhibition of PFK-1, decreasing glycolysis

C Direct conversion of pyruvate into lactate

D Direct activation of ATP synthase in mitochondria

E Splitting water to form oxygen

12 **During fasting, glucagon signaling in liver cells tends to change fructose-2,6-bisphosphate (F2,6BP) levels in which direction?**

A Increase

B Decrease

C No change

D Oscillate randomly with no net effect

E Convert into NADPH

13 **After a carbohydrate-rich meal, insulin signaling in liver cells tends to cause which change that promotes glycolysis?**

A Decrease F2,6BP, inhibiting PFK-1

B Increase F2,6BP, activating PFK-1

C Block glucose entry by closing GLUT2

D Convert NAD^+ into oxygen

E Stop glycolysis to preserve glucose for the brain

14 **A toxin severely reduces ATP production from glycolysis in red blood cells. Which immediate problem is most likely to occur first?**

A Failure of Na^+/K^+ pumps leading to ionic imbalance, swelling, and possible hemolysis

B Complete loss of DNA replication in the nucleus

C Shutdown of mitochondrial electron transport chain

D Inability to make ATP via photosynthesis

E Failure of myosin cross-bridge cycling

15 **During a 200 m sprint, oxygen delivery to fast-twitch muscle becomes limiting. To keep glycolysis producing ATP at a high rate, the muscle cell must primarily:**

- **A** Regenerate NAD^+ by reducing pyruvate to lactate
- **B** Import oxygen through GLUT4 transporters
- **C** Convert pyruvate into acetyl-CoA in the cytosol
- **D** Use the Calvin cycle to fix CO2
- **E** Hydrolyze ATP to produce more ATP

16 **Lactate produced by active muscle can be transported to the liver and converted back into glucose. This pathway is called:**

- **A** Krebs cycle
- **B** Cori cycle
- **C** Calvin cycle
- **D** Urea cycle
- **E** Pentose phosphate pathway

17 **After intense exercise, which tissue can significantly help lower blood lactate by taking up lactate and oxidizing it as a fuel?**

- **A** Red blood cells
- **B** Heart muscle
- **C** Lens of the eye
- **D** Epidermis (outer skin) only

E Bone matrix

18 **Cells in which region are most likely to rely more on anaerobic glycolysis because oxygen tension is relatively low?**

A Renal cortex

B Renal medulla

C Left ventricular myocardium at rest

D Hepatic artery endothelium

E Cerebral cortex

19 **The eye lens is avascular and has limited oxygen diffusion. It generates much of its ATP primarily by:**

A Anaerobic glycolysis

B Oxidative phosphorylation from fatty acids

C Photosynthesis

D Krebs cycle only, without glycolysis

E Gluconeogenesis from amino acids

20 **Why are neurons especially sensitive to interruption of oxygen supply (seconds to minutes)?**

A Glycolysis requires oxygen directly

B Neurons depend heavily on oxidative phosphorylation for ATP and have limited energy stores

C Neurons lack glucose transporters

D Neurons cannot use ATP for ion pumps

E Neurons perform photosynthesis in mitochondria

21 **During acute systemic hypoxia, which cell type maintains ATP production most effectively (initially) because its ATP generation does not depend on oxygen?**

A Neuron

B Cardiac muscle cell

C Red blood cell

D Hepatocyte

E Kidney proximal tubule cell

22 **Many cancer cells show high rates of glucose uptake and lactate production even when oxygen is available. This phenomenon is called:**

A Photorespiration

B Warburg effect

C Cori cycle

D Calvin cycle

E Oxidative burst

23 **Why might a rapidly dividing cell benefit from running glycolysis at a high rate even when oxygen is present?**

- A It produces more ATP per glucose than oxidative phosphorylation
- B It supplies metabolic intermediates for biosynthesis (e.g., amino acids, nucleotides, lipids)
- C It eliminates the need for glucose transporters
- D It converts CO2 into O2
- E It prevents any need for NAD^+ recycling

24 **If oxygen delivery to tissues improves (e.g., after supplemental oxygen), which cell type's lactate production is expected to change the least?**

- A Fast-twitch skeletal muscle during recovery
- B Cardiac muscle
- C Red blood cell
- D Kidney cortex cell
- E Hepatocyte

25 **During prolonged fasting, some tissues can switch partly to fatty acids or ketone bodies. Which cell type cannot use fatty acids or ketones for ATP and therefore must continue glycolysis using glucose?**

- A Hepatocyte
- B Cardiac muscle cell
- C Skeletal muscle cell
- D Neuron
- E Red blood cell

26 **Which set of net products best matches anaerobic glycolysis in human muscle (glucose → lactate)?**

A 2 pyruvate + 2 NADH + net 2 ATP

B 2 lactate + net 2 ATP (with NAD^+ regenerated; no net NADH output)

C 2 acetyl-CoA + 2 CO2 + net 2 ATP

D 6 CO2 + ~30 ATP

E 2 lactate + net 4 ATP

27 **A drug inhibits lactate dehydrogenase in muscle during severe hypoxia. The most immediate metabolic consequence is:**

A NAD^+ regeneration falls, slowing glycolysis and decreasing ATP production

B Glycolysis speeds up because lactate is toxic

C Oxygen consumption increases because the ETC speeds up

D More ATP is produced because lactate dehydrogenase normally wastes energy

E CO2 production rises sharply in the cytosol

28 **A mutation reduces PFK-1 activity in skeletal muscle. Which symptom is most directly expected during intense exercise?**

A Enhanced sprint performance due to faster glycolysis

B Reduced ability to generate ATP quickly and reduced lactate production

C Increased oxygen production in muscle

D Increased glucose release from muscle into blood

E No effect because PFK-1 is not in glycolysis

29 **During heavy exercise, intracellular pH in muscle may drop. A key reason this slows glycolysis is that low pH:**

A Activates PFK-1 to speed up glycolysis

B Inhibits PFK-1, reducing glycolytic rate (a protective negative feedback)

C Forces glucose to leave the cell through GLUT4

D Converts NAD^+ directly into NADPH

E Turns pyruvate into acetyl-CoA without mitochondria

30 **At high altitude, red blood cells often increase 2,3-BPG. The most direct effect on oxygen transport is:**

A Increased hemoglobin O2 affinity (left shift)

B Decreased hemoglobin O2 affinity, promoting O2 unloading to tissues (right shift)

C Complete blockage of O2 binding to hemoglobin

D Conversion of hemoglobin into myoglobin

E O2 production from CO2 in the blood

31 **When red blood cells produce 2,3-BPG from 1,3-BPG, which ATP-producing glycolysis step is effectively bypassed?**

A Hexokinase (glucose → glucose-6-phosphate)

B PFK-1 (fructose-6-phosphate → fructose-1,6-bisphosphate)

C Phosphoglycerate kinase (1,3-BPG → 3-phosphoglycerate)

D Pyruvate kinase (PEP → pyruvate)

E Lactate dehydrogenase (pyruvate → lactate)

32 **Red blood cells need NADPH to maintain reduced glutathione and protect against oxidative damage. NADPH is produced mainly by the:**

A Krebs cycle

B Electron transport chain

C Pentose phosphate pathway

D Lactate dehydrogenase reaction

E Pyruvate kinase step

33 **During recovery after exercise, lactate is converted back to pyruvate in a well-oxygenated muscle cell. This conversion requires and produces which pair?**

A Requires NADH and produces NAD^+

B Requires NAD^+ and produces NADH

C Requires ATP and produces glucose

D Requires FADH2 and produces FAD

E Requires O2 directly and produces CO2 in the cytosol

34 **In adipocytes, which glycolysis intermediate is a major source of glycerol-3-phosphate needed to build triglycerides?**

A Glucose-6-phosphate

B Fructose-1,6-bisphosphate

C Dihydroxyacetone phosphate (DHAP)

D Pyruvate

E Acetyl-CoA in the mitochondrial matrix

35 **In uncontrolled type 1 diabetes (very low insulin), why is triglyceride synthesis in adipose tissue often impaired even when fatty acids are available?**

A Adipocytes cannot take up fatty acids without insulin

B Low glucose uptake reduces glycolysis-derived glycerol-3-phosphate needed to esterify fatty acids

C Adipocytes lack the enzymes of glycolysis

D Fatty acids are converted directly into glucose in adipose tissue

E ATP synthase in adipocytes stops because oxygen becomes unavailable

36 **Neutrophils often function in low-oxygen (inflamed) environments. Which metabolic strategy best supports their ATP needs in such conditions?**

A Rely mainly on oxidative phosphorylation

B Rely heavily on glycolysis for ATP

C Rely on photosynthesis

D Rely on CO2 fixation via RuBisCO

E Rely on ketone body oxidation exclusively

37 **Which cell type most increases glucose uptake for glycolysis in response to insulin by translocating GLUT4 to the cell membrane?**

A Red blood cell

B Skeletal muscle cell

C Neuron

D Hepatocyte

E Renal proximal tubule (apical surface)

38 **During prolonged fasting, the brain can partially switch to ketone bodies. Which cell type cannot switch to ketone bodies and remains fully dependent on glucose-driven glycolysis?**

A Neuron

B Cardiac muscle cell

C Skeletal muscle cell

D Red blood cell

E Hepatocyte

39 **Which glycolysis step directly requires NAD^+ and produces NADH?**

A Glucose → glucose-6-phosphate

B Fructose-6-phosphate → fructose-1,6-bisphosphate

C Glyceraldehyde-3-phosphate → 1,3-bisphosphoglycerate

D Phosphoenolpyruvate → pyruvate

E Pyruvate → lactate

40 Why is sodium fluoride sometimes added to a blood sample tube when measuring plasma glucose?

A It increases glucose production in the sample

B It inhibits glycolysis in blood cells, preventing them from consuming glucose after collection

C It converts lactate back into glucose directly

D It binds oxygen to prevent oxidative phosphorylation

E It forces insulin release from red blood cells

41 A blood sample sits unprocessed at room temperature for an hour before glucose is measured. The measured glucose is likely to be lower than the true in-vivo value mainly because:

A Hemoglobin converts glucose into oxygen

B Blood cells continue glycolysis and consume glucose

C CO_2 in the tube reacts with glucose to form starch

D GLUT transporters stop working outside the body

E Glucose evaporates from the sample

42 Placing a blood sample on ice slows the drop in glucose concentration mainly because:

A Cold temperature increases glycolysis enzyme activity

B Cold temperature reduces enzyme activity, slowing glycolysis in blood cells

C Cold temperature forces glucose to leave red blood cells through GLUT1

D Cold temperature converts lactate into glucose automatically

E Cold temperature creates mitochondria inside red blood cells

43 A muscle cell transitions from intense exercise (low O2) to recovery (adequate O2). Which change best supports shifting from lactate production back toward pyruvate oxidation in mitochondria?

A Increased availability of NAD^+ and restored ETC activity to reoxidize NADH

B Permanent closure of GLUT4 channels

C Inhibition of pyruvate dehydrogenase by oxygen

D Stopping all ATP production so lactate cannot form

E Converting lactate into glucose inside the muscle cytosol as the main pathway

44 In a working muscle cell, an increase in AMP/ADP levels most directly tends to:

A Inhibit PFK-1 and slow glycolysis

B Activate PFK-1 and speed glycolysis

C Stop glucose uptake by internalizing GLUT4

D Convert pyruvate into acetyl-CoA without mitochondria

E Prevent NAD^+ regeneration

45 **If pyruvate kinase is inhibited in a cell, which immediate effect is most expected in glycolysis?**

- A More ATP is produced because the pathway is less wasteful
- B Phosphoenolpyruvate (PEP) accumulates and ATP production decreases
- C NADH production stops at the glyceraldehyde-3-phosphate step
- D Glucose is converted directly into acetyl-CoA in the cytosol
- E Oxygen becomes the final electron acceptor in glycolysis

46 **Compared with slow-twitch (type I) muscle fibers, fast-twitch (type II) muscle fibers typically:**

- A Have more mitochondria and rely mainly on oxidative phosphorylation
- B Rely more on glycolysis and produce more lactate during intense activity
- C Cannot perform glycolysis
- D Do not store glycogen
- E Perform photosynthesis to generate ATP

47 **During ischemia (reduced blood flow) in cardiac tissue, which metabolic shift is most likely?**

- A Increased reliance on anaerobic glycolysis with increased lactate production
- B Increased reliance on photosynthesis
- C Increased oxygen consumption by mitochondria
- D Complete shutdown of glycolysis because it requires oxygen
- E Conversion of glucose directly into CO_2 in the cytosol

48 **In the Cori cycle, which organ is the primary site that converts lactate into glucose for release into the bloodstream?**

A Liver

B Lung

C Spleen

D Pancreas

E Skin

49 **Which reduced electron carrier is produced directly in glycolysis but cannot be reoxidized by an electron transport chain in a red blood cell?**

A NADH

B FADH2

C NADPH

D Ubiquinol (CoQH2)

E Cytochrome c (reduced form)

50 **In red blood cells, suppose every 1,3-bisphosphoglycerate molecule is diverted into the 2,3-BPG shunt (bypassing phosphoglycerate kinase) and later re-enters glycolysis as 3-phosphoglycerate without producing ATP. What is the net ATP yield per glucose from glycolysis under this assumption?**

A 0

B 1

C 2

D 3

E 4

#	Ans	Answer Text
1	A	Red blood cell (erythrocyte)
2	B	Reduced to lactate in the cytosol
3	A	Red blood cell
4	B	Liver and pancreatic cells
5	B	Higher Km (lower affinity) and higher Vmax, enabling glucose handling wh...
6	C	G6P is charged and is not transported by GLUTs, so it cannot easily cros...
7	B	Fast-twitch skeletal muscle fiber
8	C	One ATP higher
9	C	Muscle cells lack glucose-6-phosphatase to dephosphorylate glucose-6-pho...
10	B	Phosphofructokinase-1 (PFK-1)
11	A	Strong activation of PFK-1, increasing glycolysis
12	B	Decrease
13	B	Increase F2,6BP, activating PFK-1
14	A	Failure of Na^+/K^+ pumps leading to ionic imbalance, swelling, and possib...
15	A	Regenerate NAD^+ by reducing pyruvate to lactate
16	B	Cori cycle
17	B	Heart muscle
18	B	Renal medulla
19	A	Anaerobic glycolysis
20	B	Neurons depend heavily on oxidative phosphorylation for ATP and have lim...
21	C	Red blood cell
22	B	Warburg effect
23	B	It supplies metabolic intermediates for biosynthesis (e.g., amino acids,...
24	C	Red blood cell
25	E	Red blood cell
26	B	2 lactate + net 2 ATP (with NAD^+ regenerated; no net NADH output)
27	A	NAD^+ regeneration falls, slowing glycolysis and decreasing ATP productio...
28	B	Reduced ability to generate ATP quickly and reduced lactate production
29	B	Inhibits PFK-1, reducing glycolytic rate (a protective negative feedback...
30	B	Decreased hemoglobin O2 affinity, promoting O2 unloading to tissues (rig...
31	C	Phosphoglycerate kinase (1,3-BPG $\rightarrow$ 3-phosphoglycerate)
32	C	Pentose phosphate pathway
33	B	Requires NAD^+ and produces NADH
34	C	Dihydroxyacetone phosphate (DHAP)
35	B	Low glucose uptake reduces glycolysis-derived glycerol-3-phosphate neede...
36	B	Rely heavily on glycolysis for ATP
37	B	Skeletal muscle cell
38		Red blood cell