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Glycolysis in Human Cells & Tissues

Study Guide — 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 — Study Guide with Answers

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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

▶ **Explanation:** Mature red blood cells lack mitochondria, so they cannot run the link reaction, Krebs cycle, or oxidative phosphorylation; ATP must come from glycolysis. The other listed cells contain mitochondria and can generate ATP aerobically.

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

▶ **Explanation:** Red blood cells have no mitochondria, so pyruvate cannot be oxidized to acetyl-CoA; instead, lactate dehydrogenase converts pyruvate to lactate to regenerate NAD^+. Ethanol production is typical of yeast, not human cells.

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

▶ **Explanation:** Red blood cells use insulin-independent GLUT1 for glucose uptake. Skeletal muscle and adipose rely heavily on insulin-stimulated GLUT4; intestinal apical uptake uses SGLT1 rather than GLUT1.

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

▶ **Explanation:** Glucokinase is characteristic of hepatocytes and pancreatic cells, where it helps handle high glucose loads and acts as a glucose sensor. Most other tissues mainly use hexokinase.

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

▶ **Explanation:** Glucokinase has a higher Km (works best when glucose is high) and high capacity (higher Vmax), fitting liver/ -cell roles. Hexokinase has higher affinity and is often inhibited by glucose-6-phosphate; neither enzyme uses oxygen directly.

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

▶ **Explanation:** Adding a phosphate makes the molecule more polar/charged, preventing passive diffusion and preventing export via GLUT transporters (which move unphosphorylated glucose). This helps maintain an inward gradient for glucose uptake.

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

▶ **Explanation:** Fast-twitch muscle fibers rely heavily on rapid ATP generation from glycolysis and therefore store glycogen to supply glucose units quickly. Neurons store little glycogen and rely mainly on aerobic metabolism.

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

▶ **Explanation:** Glycogen breakdown provides glucose-6-phosphate, bypassing the hexokinase step that consumes 1 ATP. So glycolysis from glycogen yields net 3 ATP per glucose unit (vs net 2 from free glucose).

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

▶ **Explanation:** To export glucose, cells must convert glucose-6-phosphate back to free glucose. Liver has glucose-6-phosphatase; skeletal muscle generally does not, so muscle uses its glycogen locally for ATP production.

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

▶ **Explanation:** PFK-1 is a major "commitment" and rate-controlling step; ATP and citrate signal high energy/abundant building blocks and inhibit PFK-1 to slow glycolytic flux. The other enzymes are not the main target of citrate regulation.

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

▶ **Explanation:** F2,6BP is a powerful allosteric activator of PFK-1 (and it inhibits fructose-1,6-bisphosphatase), pushing metabolism toward glycolysis. It does not directly act on mitochondria or make lactate by itself.

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

▶ **Explanation:** Glucagon (via cAMP/PKA) lowers F2,6BP in liver, reducing PFK-1 stimulation and favoring gluconeogenesis over glycolysis. This helps maintain blood glucose during fasting.

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

▶ **Explanation:** Insulin promotes glycolysis in the fed state, in part by increasing F2,6BP, which strongly activates PFK-1. GLUT2 is not "closed" by insulin; it is largely insulin-independent.

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

▶ **Explanation:** RBCs depend on glycolytic ATP to run membrane ion pumps; without ATP, ion gradients fail and the cell can swell/rupture. RBCs lack nuclei and mitochondria, so those options do not apply.

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

▶ **Explanation:** Without sufficient oxygen, the ETC can't reoxidize NADH efficiently; reducing pyruvate to lactate regenerates NAD^+ so glycolysis can continue. GLUT4 transports glucose (not oxygen).

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

▶ **Explanation:** The Cori cycle describes lactate export from tissues (like muscle) to the liver, where it is converted to glucose (via gluconeogenesis). The other cycles/pathways have different roles.

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

▶ **Explanation:** Cardiac muscle has abundant mitochondria and can oxidize lactate back to pyruvate and into the TCA cycle. RBCs and lens rely heavily on glycolysis and do not oxidize lactate via mitochondria.

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

▶ **Explanation:** The renal medulla has lower oxygen availability (relative hypoxia) and often depends more on anaerobic metabolism than the cortex. The heart and brain are highly oxidative under normal conditions.

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

▶ **Explanation:** Because the lens lacks blood vessels, it relies heavily on glycolysis (often anaerobic) for ATP. Photosynthesis is absent in animals, and Krebs/oxidative phosphorylation require mitochondria and oxygen.

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

▶ **Explanation:** Most neuronal ATP supports ion gradients for electrical activity and comes mainly from oxidative phosphorylation; ATP falls rapidly when oxygen is absent. Glycolysis does not use oxygen directly, but it often cannot meet neuronal ATP demand alone.

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

▶ **Explanation:** RBCs rely on glycolysis and do not use oxygen to make ATP because they lack mitochondria. Highly oxidative tissues (heart, brain, proximal tubule) are much more affected by hypoxia.

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

▶ **Explanation:** The Warburg effect refers to aerobic glycolysis: cancer cells often favor glycolysis and lactate production even with oxygen, supporting rapid growth and biosynthesis. Cori cycle is lactate recycling via liver.

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

▶ **Explanation:** High glycolytic flux provides carbon skeletons for building macromolecules (growth), not just ATP. Oxidative phosphorylation is more ATP-efficient per glucose, and NAD^+ recycling is still required.

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

▶ **Explanation:** RBCs produce lactate regardless of oxygen availability because they lack mitochondria. In contrast, improved oxygen allows many tissues to oxidize pyruvate/lactate and reduce lactate production.

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** ✓

▶ **Explanation:** RBCs have no mitochondria, so they cannot oxidize fatty acids or ketone bodies and must use glucose via glycolysis. Neurons can use ketones during prolonged fasting; heart and muscle can use fatty acids and ketones.

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

▶ **Explanation:** Anaerobic conditions convert pyruvate to lactate to regenerate NAD^+, allowing glycolysis to yield net 2 ATP per glucose. Extra ATP is not generated by lactate formation; CO2 and large ATP yield require aerobic mitochondrial metabolism.

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

▶ **Explanation:** Under hypoxia, the ETC cannot reoxidize NADH effectively. Blocking lactate dehydrogenase prevents NAD^+ regeneration, so glycolysis stalls at the NAD^+-requiring step and ATP production drops.

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

▶ **Explanation:** PFK-1 is a key rate-controlling step of glycolysis. Lower PFK-1 activity reduces glycolytic flux, decreasing rapid ATP generation and lowering pyruvate/lactate output during high-intensity exercise.

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

▶ **Explanation:** A fall in pH (more H^+) inhibits PFK-1, slowing glycolysis. This helps limit excessive acidification during intense anaerobic metabolism.

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

▶ **Explanation:** 2,3-BPG binds deoxygenated hemoglobin and stabilizes it, lowering O2 affinity and shifting the dissociation curve right—helping unloading in tissues. Making 2,3-BPG also comes with an ATP tradeoff (a common trap).

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)

▶ **Explanation:** The 2,3-BPG shunt diverts 1,3-BPG away from phosphoglycerate kinase, so the ATP that would be generated at that step is not produced. This is why increased 2,3-BPG can reduce RBC ATP yield.

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

▶ **Explanation:** RBCs do not have mitochondria for ETC/Krebs. NADPH mainly comes from the pentose phosphate pathway (HMP shunt), not from glycolysis itself.

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

▶ **Explanation:** Lactate → pyruvate is an oxidation reaction: NAD^+ accepts electrons and becomes NADH. Oxygen is used later in mitochondria (ETC) but is not directly a cytosolic reactant in the lactate dehydrogenase step.

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

▶ **Explanation:** DHAP can be reduced to glycerol-3-phosphate, providing the glycerol backbone for triglyceride synthesis. This links glucose metabolism to fat storage in adipose tissue.

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

▶ **Explanation:** With low insulin, adipose glucose uptake (GLUT4) falls, lowering glycolysis and reducing glycerol-3-phosphate availability for triglyceride assembly. This contributes to increased free fatty acids in the blood.

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 CO_2 fixation via RuBisCO
- E Rely on ketone body oxidation exclusively

▶ **Explanation:** Many immune cells (including neutrophils) can rely strongly on glycolysis, which can function without oxygen directly. This supports activity in hypoxic tissues where oxidative phosphorylation is limited.

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)

▶ **Explanation:** Skeletal muscle (and adipose tissue) uses insulin-responsive GLUT4. RBCs use GLUT1, neurons mostly use GLUT3, hepatocytes use GLUT2, and renal apical uptake is mainly via SGLT transporters.

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

▶ **Explanation:** RBCs lack mitochondria, so they cannot oxidize ketone bodies or fatty acids; they must use glucose via glycolysis. Many other tissues can oxidize fats/ketones when fasting is prolonged.

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

▶ **Explanation:** Glyceraldehyde-3-phosphate dehydrogenase reduces NAD^+ to NADH while oxidizing glyceraldehyde-3-phosphate. The lactate step consumes NADH to regenerate NAD^+ (the opposite direction).

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

▶ **Explanation:** Blood cells (especially RBCs) continue glycolysis after blood is drawn, lowering measured glucose if not stopped. Fluoride inhibits a glycolysis enzyme (commonly taught as enolase), helping preserve the true glucose concentration.

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 CO2 in the tube reacts with glucose to form starch

D GLUT transporters stop working outside the body

E Glucose evaporates from the sample

▶ **Explanation:** Cells in the sample remain metabolically active for a while and keep using glucose via glycolysis, causing glucose concentration to fall unless glycolysis is inhibited or the sample is processed quickly.

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

▶ **Explanation:** Lower temperature reduces the rate of enzyme-catalyzed reactions, including glycolysis. This slows glucose consumption by cells in the sample.

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

▶ **Explanation:** When oxygen returns, the ETC can run again, reoxidizing NADH to NAD^+ and supporting pyruvate entry into mitochondria for oxidation (via pyruvate dehydrogenase and the TCA cycle). Muscle does not primarily do gluconeogenesis from lactate.

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

▶ **Explanation:** AMP/ADP signal low energy status and stimulate glycolysis (notably by activating PFK-1), helping restore ATP. High ATP tends to inhibit glycolysis instead.

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

▶ **Explanation:** Pyruvate kinase catalyzes PEP $\rightarrow$ pyruvate and generates ATP by substrate-level phosphorylation. Inhibiting it reduces ATP output and causes upstream buildup of PEP and related intermediates.

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

▶ **Explanation:** Fast-twitch fibers are adapted for rapid, powerful contractions and often depend more on glycolysis (and glycogen) during high intensity, producing more lactate. Slow-twitch fibers are more oxidative with higher mitochondrial density.

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 CO2 in the cytosol

▶ **Explanation:** Reduced oxygen delivery limits oxidative phosphorylation, so cells increase anaerobic glycolysis to maintain ATP, producing lactate. Glycolysis does not require oxygen directly; mitochondria do.

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

▶ **Explanation:** The liver is the main organ performing gluconeogenesis from lactate (Cori cycle), helping recycle lactate produced by muscle and RBCs. The other organs are not primary gluconeogenic hubs at this level.

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)

▶ **Explanation:** Glycolysis produces NADH in the cytosol. RBCs have no mitochondria (and therefore no ETC), so NADH must be reoxidized to NAD^+ via lactate dehydrogenase instead of oxidative phosphorylation.

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

▶ **Explanation:** Normal glycolysis nets 2 ATP per glucose (4 made − 2 used). Bypassing phosphoglycerate kinase removes the 2 ATP normally produced at that step (one per triose), leaving only 2 ATP made at pyruvate kinase, which is canceled by the 2 ATP invested earlier → net 0.