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Glucose Metabolism: Glycolysis, Link Reaction, Krebs Cycle & ETC

Exam — Metabolism

Pre-med/IB-level practice on cellular respiration from glycolysis (cytosol) to pyruvate oxidation (link reaction), citric acid cycle (Krebs), anaerobic vs aerobic ATP yield, mitochondrial structure, electron transport chain, chemiosmosis, and ATP synthase—focused on concept traps and multi-step reasoning.

50 items — Printable Exam

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1 **Where does glycolysis occur in a typical human cell?**

- A Mitochondrial matrix
- B Inner mitochondrial membrane
- C Cytosol
- D Nucleus
- E Endoplasmic reticulum lumen

2 **What is the net ATP yield from glycolysis per molecule of glucose (assuming it proceeds to pyruvate)?**

- A 0 ATP
- B 1 ATP
- C 2 ATP
- D 4 ATP
- E 36 ATP

3 **Which set of products is generated by glycolysis per glucose molecule (before fermentation or mitochondrial oxidation)?**

- A 2 pyruvate, 2 NADH, net 2 ATP
- B 2 acetyl-CoA, 2 NADH, net 2 ATP
- C 2 pyruvate, 2 FADH2, net 2 ATP
- D 6 CO2, 2 NADH, net 2 ATP
- E 2 lactate, 0 NADH, net 4 ATP

4 **Glycolysis can continue without oxygen only if the cell can regenerate which molecule?**

A FAD

B Coenzyme A

C NAD^+

D O2

E ATP synthase

5 **Which step of glycolysis directly requires NAD^+ as a reactant?**

A Glucose → glucose-6-phosphate

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

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

D 2-phosphoglycerate → phosphoenolpyruvate

E Phosphoenolpyruvate → pyruvate

6 **Which statement best defines substrate-level phosphorylation?**

A ATP formation using energy from a proton gradient across a membrane

B ATP formation by direct transfer of a phosphate group from a high-energy substrate to ADP

C ATP formation only in the presence of oxygen

D ATP formation by splitting glucose in half

E ATP formation by attaching phosphate to glucose

7 **Which pair of glycolysis steps produces ATP directly by substrate-level phosphorylation?**

A Hexokinase and phosphofructokinase-1

B Glyceraldehyde-3-phosphate dehydrogenase and enolase

C Phosphoglycerate kinase and pyruvate kinase

D Aldolase and triose phosphate isomerase

E Pyruvate dehydrogenase and citrate synthase

8 **Which glycolysis enzyme catalyzes the committed, rate-limiting step in many cells?**

A Hexokinase

B Phosphofructokinase-1 (PFK-1)

C Pyruvate kinase

D Lactate dehydrogenase

E ATP synthase

9 **High ATP levels in a cell would most directly tend to:**

A Activate PFK-1 to speed up glycolysis

B Inhibit PFK-1 to slow down glycolysis

C Force pyruvate to become lactate

D Increase oxygen binding to hemoglobin

E Block glucose entry into the cell in all tissues

10 **A high AMP (or ADP) level in a cell generally indicates low energy. Which effect is most expected?**

A Inhibition of PFK-1, slowing glycolysis

B Activation of PFK-1, speeding glycolysis

C Immediate stop of electron transport chain

D Conversion of acetyl-CoA into glucose in humans

E Direct synthesis of ATP without substrates

11 **What is the main purpose of fermentation in human muscle during intense exercise?**

A To produce large amounts of ATP directly from lactate

B To regenerate NAD^+ so glycolysis can continue producing ATP

C To produce acetyl-CoA for the Krebs cycle

D To transport oxygen into mitochondria

E To convert glucose into CO2 in the cytosol

12 **In lactic acid fermentation, pyruvate is converted to lactate. What happens to NADH in this reaction?**

A NADH is produced from NAD^+

B NADH is oxidized to NAD^+

C NADH is converted into FADH2

D NADH is pumped across the mitochondrial membrane

E NADH becomes acetyl-CoA

13 Which statement about ATP yield is correct?

A Fermentation produces additional ATP beyond glycolysis

B Anaerobic metabolism yields the same ATP per glucose as aerobic metabolism

C Without oxygen, the net ATP per glucose from glycolysis is still 2

D Without oxygen, glycolysis yields 0 ATP because NADH cannot form

E Without oxygen, the Krebs cycle speeds up to compensate

14 Which process directly produces CO2 from pyruvate before the Krebs cycle begins?

A Glycolysis

B Link reaction (pyruvate oxidation by pyruvate dehydrogenase)

C ATP synthase activity

D Lactic acid fermentation

E Phosphorylation of glucose by hexokinase

15 **During the link reaction, one pyruvate molecule (3 carbons) becomes:**

- A One acetyl-CoA (2C) + one CO_2 (1C) + NADH
- B One acetyl-CoA (3C) + one CO_2 (0C) + $FADH_2$
- C Two acetyl-CoA (2C each) + one CO_2
- D One lactate (3C) + NADH
- E One citrate (6C) directly

16 **Where do the link reaction and Krebs cycle occur in eukaryotic cells?**

- A Cytosol
- B Mitochondrial matrix
- C Outer mitochondrial membrane
- D Inner mitochondrial membrane
- E Nucleus

17 **Per acetyl-CoA entering the Krebs cycle, which set of reduced electron carriers is produced?**

- A 2 NADH and 2 $FADH_2$
- B 3 NADH and 1 $FADH_2$
- C 1 NADH and 3 $FADH_2$
- D 4 NADH and 0 $FADH_2$
- E 0 NADH and 0 $FADH_2$

18 **How many CO2 molecules are released per acetyl-CoA during the Krebs cycle itself (not counting the link reaction)?**

A 0

B 1

C 2

D 3

E 6

19 **Which step produces GTP (or ATP equivalent) directly in the Krebs cycle?**

A Citrate synthase step

B Isocitrate $\rightarrow$ -ketoglutarate

C Succinyl-CoA $\rightarrow$ succinate

D Succinate $\rightarrow$ fumarate

E Malate $\rightarrow$ oxaloacetate

20 **Which statement best explains why the Krebs cycle is considered 'aerobic' even though O2 is not used directly in the cycle?**

A O2 is a substrate in the citrate synthase reaction

B The cycle requires NAD^+ and FAD, which are regenerated mainly by the electron transport chain that depends on O2

C The cycle occurs in the lungs, where O2 is abundant

D O2 is produced by the cycle, so it must be aerobic

E The cycle only occurs during exercise

21 **Where is the electron transport chain (ETC) located in eukaryotic cells?**

A Cytosol

B Mitochondrial matrix

C Outer mitochondrial membrane

D Inner mitochondrial membrane

E Nuclear envelope

22 **The final electron acceptor in aerobic respiration is:**

A NAD^+

B FAD

C Oxygen (O_2)

D Carbon dioxide (CO_2)

E Glucose

23 **Which complexes pump protons across the inner mitochondrial membrane in the ETC?**

A I, II, and III

B II, III, and IV

C I, III, and IV

D I and II only

E All complexes I–IV pump protons equally

24 **In mitochondria, protons are pumped by the ETC from the:**

A Intermembrane space into the matrix

B Matrix into the intermembrane space

C Cytosol into the nucleus

D Outer membrane into the cytosol

E ER lumen into the cytosol

25 **ATP synthase makes ATP primarily by:**

A Using oxygen to directly phosphorylate ADP

B Using light energy absorbed by chlorophyll

C Allowing protons to flow down their electrochemical gradient through the enzyme, driving conformational changes that synthesize ATP

D Breaking ATP to release energy and build more ATP

E Transferring phosphate directly from glucose to ADP

26 **In mitochondria, the catalytic 'head' (F1) of ATP synthase faces the:**

A Intermembrane space

B Mitochondrial matrix

C Cytosol

D Outer mitochondrial membrane

E Nucleus

27 **Which statement best distinguishes oxidative phosphorylation from substrate-level phosphorylation?**

A Oxidative phosphorylation happens in the cytosol; substrate-level phosphorylation happens in mitochondria only

B Oxidative phosphorylation requires a proton gradient and ATP synthase; substrate-level phosphorylation uses direct phosphate transfer from a metabolic intermediate

C Substrate-level phosphorylation requires oxygen; oxidative phosphorylation does not

D Oxidative phosphorylation produces lactate; substrate-level phosphorylation produces CO2

E They are different names for the same process

28 **Which molecule donates electrons to Complex I of the ETC?**

A NADH

B FADH2

C ATP

D CO2

E O2

29 **Complex II is unique among ETC complexes because it:**

A Is located in the mitochondrial matrix and never touches the membrane

B Pumps the most protons

C Transfers electrons from NADH to oxygen

D Is the same enzyme as succinate dehydrogenase from the Krebs cycle and does not pump

protons

E Directly makes ATP from ADP

30 Why does NADH typically produce more ATP than FADH2 in oxidative phosphorylation?

A FADH2 cannot donate electrons to the ETC

B NADH enters at Complex I, which pumps protons; FADH2 enters at Complex II, which does not pump protons

C FADH2 is used only in glycolysis

D NADH is produced only in the nucleus

E FADH2 directly turns into lactate

31 A student claims: "Oxygen is needed for glycolysis." Which is the best correction?

A True—glycolysis uses oxygen directly to split glucose

B True—without oxygen, glycolysis cannot make any ATP

C False—glycolysis does not use oxygen directly, but it requires NAD^+ regeneration, which can be supported by fermentation when oxygen is absent

D False—glycolysis occurs in mitochondria where oxygen binds ATP synthase

E False—glycolysis occurs only in plants

32 Red blood cells (RBCs) rely heavily on anaerobic glycolysis mainly because they:

A Have no mitochondria for Krebs cycle and oxidative phosphorylation

B Have no cytosol for glycolysis

C Use photosynthesis for ATP

D Cannot take up glucose

E Contain chloroplasts instead of mitochondria

33 If oxygen suddenly becomes unavailable, which immediate change is most likely inside mitochondria?

A Electron transport accelerates because there is less competition

B NADH levels rise and NAD^+ levels fall because electrons cannot be passed to oxygen

C CO2 production increases sharply because Krebs cycle speeds up

D ATP synthase produces more ATP because the proton gradient increases forever

E Glycolysis stops because it requires oxygen directly

34 Cyanide poisoning inhibits Complex IV. Which outcome is most expected?

A Oxygen consumption increases and ATP production increases

B Electron flow stops, oxygen cannot be reduced to water, and ATP production by oxidative phosphorylation falls dramatically

C Glycolysis stops instantly in all tissues because Complex IV is in the cytosol

D CO2 production from glycolysis increases

E Fermentation becomes impossible because NAD^+ becomes too abundant

35 **Oligomycin blocks the proton channel of ATP synthase. What is the best prediction for oxygen consumption?**

A Oxygen consumption increases because electrons flow faster

B Oxygen consumption decreases because the proton gradient cannot be used and electron transport slows due to backpressure

C Oxygen consumption is unchanged because ATP synthase is unrelated to the ETC

D Oxygen consumption becomes negative (oxygen is produced)

E Oxygen consumption increases only if glycolysis is blocked

36 **A chemical uncoupler makes the inner mitochondrial membrane more permeable to protons. Which combination is most expected?**

A Decreased oxygen consumption, increased ATP production, decreased heat

B Increased oxygen consumption, decreased ATP production, increased heat

C No change in oxygen consumption or ATP, because uncouplers act only on glycolysis

D Increased ATP production because the gradient is larger

E Stopped electron transport but increased ATP production

37 **Which stage(s) of glucose metabolism produce(s) ATP directly by substrate-level phosphorylation?**

A Electron transport chain only

B Glycolysis and one step of the Krebs cycle

C Link reaction only

D ATP synthase only

E Krebs cycle only at every step

38 **Which statement correctly tracks carbon atoms during complete oxidation of one glucose molecule in aerobic respiration?**

A Glucose (6C) becomes 6 CO_2 (1C each) overall

B Glucose (6C) becomes 2 CO_2 overall

C Glucose (6C) becomes 4 CO_2 overall

D Glucose (6C) becomes 6 lactate (3C each) overall

E Glucose carbons are conserved as water in aerobic respiration

39 **How many molecules of CO_2 are produced from one glucose molecule by the link reaction (pyruvate oxidation) alone?**

A 0

B 1

C 2

D 4

E 6

40 **Which of the following is the most direct reason mitochondria have highly folded cristae?**

A To increase the surface area of the inner membrane for ETC complexes and ATP synthase

B To increase DNA replication speed in the nucleus

C To allow glycolysis enzymes to attach to the membrane

D To increase the thickness of the outer membrane to prevent diffusion of CO_2

E To store glucose as glycogen inside mitochondria

41 Which process directly produces the proton gradient that ATP synthase uses?

A Glycolysis enzymes in the cytosol

B Pyruvate dehydrogenase reaction in the matrix

C Electron transport chain proton pumping across the inner mitochondrial membrane

D Lactate dehydrogenase converting pyruvate to lactate

E Citrate synthase condensing acetyl-CoA with oxaloacetate

42 If the inner mitochondrial membrane suddenly became freely permeable to H^+, what would happen to ATP production by oxidative phosphorylation?

A It would increase because protons can reach ATP synthase faster

B It would decrease sharply because the proton gradient would collapse

C It would be unaffected because ATP synthase does not use protons

D It would stop glycolysis in the cytosol

E It would increase CO2 production in glycolysis

43 Which description best matches the link reaction?

A Glucose is split into two 3-carbon molecules and 2 ATP are produced

B A 3-carbon pyruvate is oxidized to a 2-carbon acetyl group attached to CoA, producing NADH and releasing CO2

C Acetyl-CoA combines with oxygen to make water

D Protons flow down a gradient to phosphorylate ADP

E Pyruvate is reduced to lactate to produce ATP

44 Which statement about NADH is correct in cellular respiration?

A NADH is the final electron acceptor in the ETC

B NADH carries high-energy electrons to the ETC where their energy helps pump protons to build a gradient

C NADH is produced only during oxidative phosphorylation

D NADH is used to directly phosphorylate ADP by transferring phosphate groups

E NADH is a structural protein of the mitochondrial membrane

45 Which statement is most accurate about anaerobic vs aerobic conditions in human cells?

A Anaerobic conditions allow Krebs cycle and ETC to run normally

B Anaerobic conditions prevent glycolysis from producing ATP

C Aerobic conditions allow NADH to be oxidized by the ETC, supporting continued Krebs cycle activity

D Oxygen is used directly in glycolysis to split glucose

E Fermentation occurs in mitochondria to make CO2 and water

46 **Which step is the main reason glycolysis is considered to have an 'investment phase'?**

A NAD^+ is reduced to NADH

B ATP is used to phosphorylate intermediates before ATP is produced later

C CO2 is produced early

D FADH2 is consumed to start the pathway

E Oxygen is used to activate glucose

47 **A student says: "The mitochondrion is where glucose is broken into two pyruvates." Which correction is best?**

A Correct—glycolysis occurs in the mitochondrial matrix

B Correct—glycolysis occurs on the inner mitochondrial membrane

C Incorrect—glycolysis occurs in the cytosol; mitochondria oxidize pyruvate and run the Krebs cycle and ETC

D Incorrect—glucose is broken into CO2 directly in the nucleus

E Incorrect—glucose is broken into lactate only inside mitochondria

48 **Which of the following happens directly at Complex IV of the ETC?**

A NADH donates electrons to ubiquinone

B Succinate is oxidized to fumarate

C Electrons are transferred to oxygen to form water

D ATP is made by direct phosphate transfer from PEP

E Glucose is phosphorylated to glucose-6-phosphate

49 **Which statement best captures why ATP synthase is not considered a 'pump' in the same way as ETC complexes I, III, and IV?**

A ATP synthase actively pumps protons from matrix to intermembrane space using ATP

B ATP synthase mainly allows protons to flow down their gradient and uses that energy to synthesize ATP

C ATP synthase is located in the cytosol and uses glucose directly

D ATP synthase transfers electrons to oxygen

E ATP synthase converts CO_2 into glucose

50 **Cytosolic NADH produced by glycolysis cannot cross the inner mitochondrial membrane directly. In many cells, it is shuttled into mitochondria. Why does this matter for ATP yield?**

A Because cytosolic NADH is always wasted and produces 0 ATP

B Because different shuttles can transfer the electrons in ways that enter the ETC at different points, affecting how many protons are pumped and thus ATP yield

C Because cytosolic NADH is converted into glucose in the shuttle

D Because shuttles are only used during fermentation

E Because shuttles move oxygen into mitochondria

#	Ans	Answer Text
	C	
2	C	2 ATP
	A	
4	C	NAD^+
	C	
6	B	ATP formation by direct transfer of a phosphate group from a high-energy...
	C	
8	B	Phosphofructokinase-1 (PFK-1)
	B	
10	B	Activation of PFK-1, speeding glycolysis
	B	
12	B	NADH is oxidized to NAD^+
	C	
14	B	Link reaction (pyruvate oxidation by pyruvate dehydrogenase)
	A	
16	B	Mitochondrial matrix
	B	
18	C	2
	C	
20	B	The cycle requires NAD^+ and FAD, which are regenerated mainly by the ele...
	D	
22	C	Oxygen (O_2)
	C	
24	B	Matrix into the intermembrane space
	C	
26	B	Mitochondrial matrix
	B	
28	A	NADH
	D	
30	B	NADH enters at Complex I, which pumps protons; $FADH_2$ enters at Complex I...
	C	
32	A	Have no mitochondria for Krebs cycle and oxidative phosphorylation
	B	
34	B	Electron flow stops, oxygen cannot be reduced to water, and ATP producti...
	B	
36	B	Increased oxygen consumption, decreased ATP production, increased heat
	B	
38	A	Glucose (6C) becomes 6 CO_2 (1C each) overall