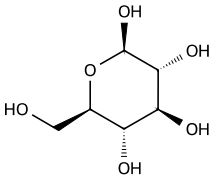
# Glycolysis ANSWER KEY

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Name _____ Date _____

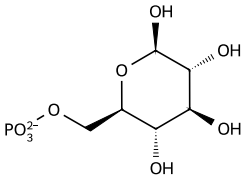
## PHASE 1 · INVESTMENT

**Glucose**



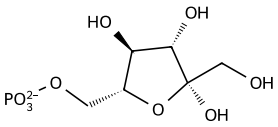
**1 Hexokinase** (glucokinase in liver)
in **ATP**
out **ADP**

**Glucose 6-phosphate**



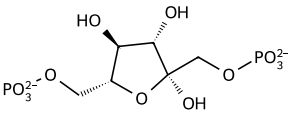
**2 Phosphoglucose isomerase**
in **none**
out **none**

**Fructose 6-phosphate**



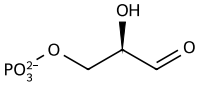
**3 Phosphofructokinase-1 (PFK-1)**
in **ATP**
out **ADP**

**Fructose 1,6-bisphosphate**



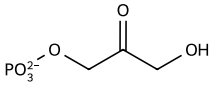
**4 Aldolase**
in **none**
out **DHAP + G3P**

**Glyceraldehyde 3-phosphate (G3P)**



**5 Triose phosphate isomerase**
in **none**
out **none**

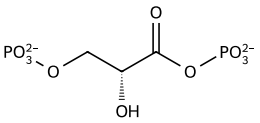
**Dihydroxyacetone phosphate (DHAP)**



**6 Glyceraldehyde-3-phosphate dehydrogenase**
in **$NAD^+$, $P_i$**
out **NADH, $H^+$**

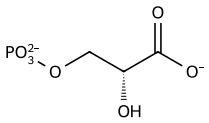
## PHASE 2 · PAYOFF (×2)

**1,3-Bisphosphoglycerate**



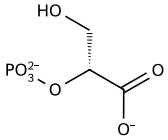
**7 Phosphoglycerate kinase**
in **ADP**
out **ATP**

**3-Phosphoglycerate**



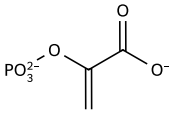
**8 Phosphoglycerate mutase**
in **none**
out **none**

**2-Phosphoglycerate**



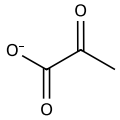
**9 Enolase**
in **none**
out **$H_2O$**

**Phosphoenolpyruvate (PEP)**



**10 Pyruvate kinase**
in **ADP**
out **ATP**

**Pyruvate**



### Glycolysis by the numbers

- Location **cytosol**
- Net ATP / glucose **2 (4 made, 2 spent)**
- NADH / glucose **2**
- Pyruvate / glucose **2**
- Irreversible steps **1, 3, 10**
- Rate-limiting enzyme **PFK-1**
- Pyruvate fate, $O_2$ present **acetyl-CoA**
- Pyruvate fate, no $O_2$ **lactate**

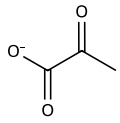

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# Citric Acid Cycle ANSWER KEY

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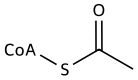
Name _____ Date _____

**Pyruvate**



**P** Pyruvate dehydrogenase complex
in **NAD$^+$, CoA-SH**
out **NADH, $CO_2$**

**Acetyl-CoA**



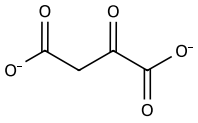
**Where and how often**

PDH + cycle location **mito. matrix**

Turns per glucose **2**

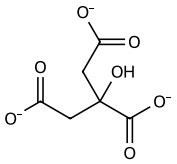
Cycle enzyme that is ETC complex II **succinate DH**

**Oxaloacetate**



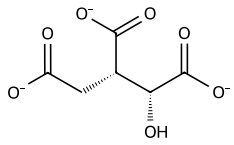
**1** Citrate synthase
in **Acetyl-CoA, $H_2O$**
out **CoA-SH**

**Citrate**



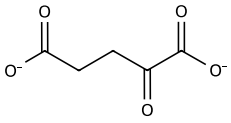
**2** Aconitase
in **none**
out **none**

**Isocitrate**



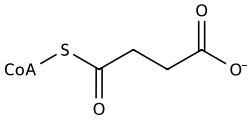
**3** Isocitrate dehydrogenase
in **NAD$^+$**
out **NADH, $CO_2$**

**α-Ketoglutarate**



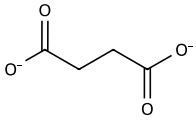
**4** α-Ketoglutarate dehydrogenase complex
in **NAD$^+$, CoA-SH**
out **NADH, $CO_2$**

**Succinyl-CoA**



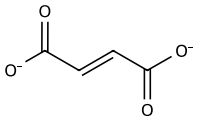
**5** Succinyl-CoA synthetase
in **GDP, $P_i$**
out **GTP, CoA-SH**

**Succinate**



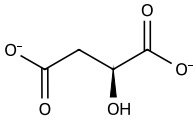
**6** Succinate dehydrogenase
in **FAD**
out **$FADH_2$**

**Fumarate**



**7** Fumarase
in **$H_2O$**
out **none**

**Malate**



**8** Malate dehydrogenase
in **NAD$^+$**
out **NADH**

**Per acetyl-CoA**

NADH **3** $FADH_2$ **1**

GTP **1** $CO_2$ **2**

Rate-limiting **isocitrate DH**


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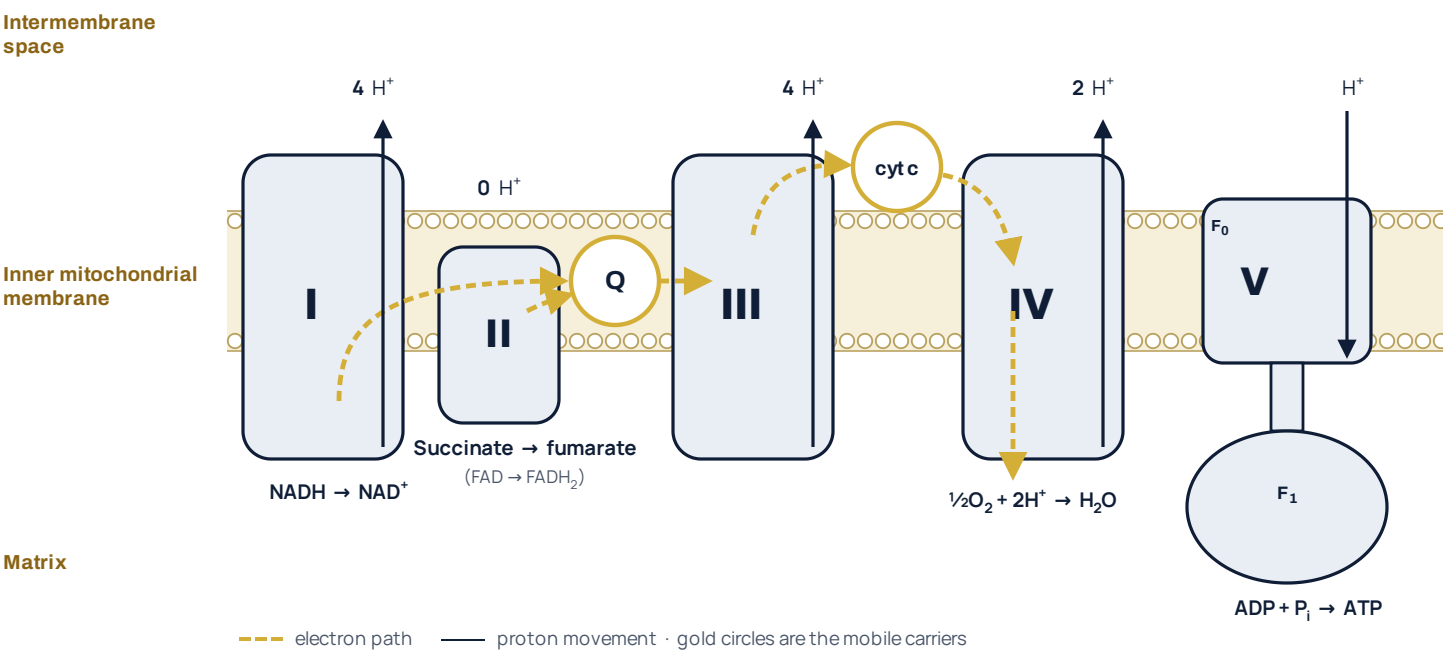
# Electron Transport Chain

**ANSWER KEY**

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Name _____ Date _____

## LABEL THE COMPARTMENTS




| Complex | Name | Electrons from → to | H+ pumped | Inhibitor |
|---|---|---|---|---|
| I | NADH dehydrogenase | NADH → CoQ | 4 | Rotenone |
| II | Succinate dehydrogenase | $FADH_2$ (succinate) → CoQ | 0 | Malonate |
| III | Cytochrome $bc_1$ (cytochrome reductase) | $CoQH_2$ → cytochrome c | 4 | Antimycin A |
| IV | Cytochrome c oxidase | Cytochrome c → $O_2$ | 2 | Cyanide, CO, azide |
| V | ATP synthase | None. $H^+$ flows back in and drives ATP synthesis | — | Oligomycin |

### The ETC by the numbers

Final electron acceptor **$O_2$**

How the gradient makes ATP **chemiosmosis**

ATP per NADH **~2.5**

ATP per $FADH_2$ **~1.5**

Total ATP per glucose (aerobic) **~30–32**

Example uncouplers **DNP, thermogenin (UCP1)**

Uncoupler effect on ATP output **decreases**

Uncoupler effect on $O_2$ use and heat **both increase**


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