

Chapter 7: Cellular Respiration



Part 1: Aerobic Respiration (4 Steps of Glucose Metabolism)

I. Step 1: Glycolysis (Fig. 7.4)

- A. Performed by almost all organisms
- B. Doesn't require O_2
- C. Occurs in cytosol
- D. Breaks glucose in half ($C_6 \rightarrow 2 C_3$)
 - 1. (1 glucose \rightarrow 2 pyruvate)
- E. Net gain of 2 ATP & 2 (NADH + H^+)
- F. 10 steps in 3 phases:
 - 1. Energy Investment Phase
 - a. Glucose + Enzyme + 2ATP \rightarrow 6-Carbon compound + 2 ADP
 - 2. Cleavage Phase
 - a. 6-Carbon compound \rightarrow 2 G3P
 - 3. Energy Liberation Phase
 - a. 2 G3P \rightarrow 2 molecules of pyruvate + 4 ATP + 2 NADH:

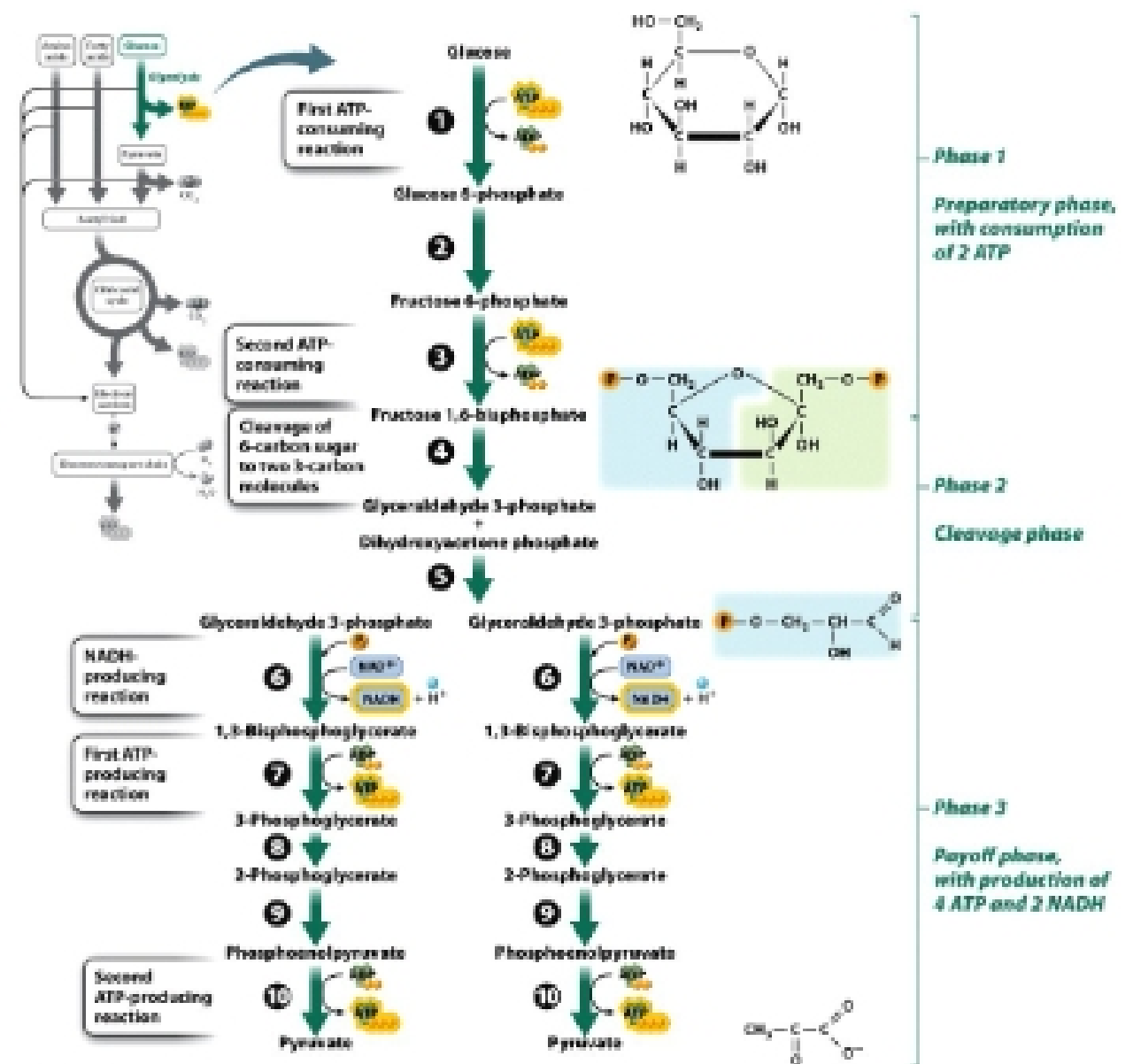


Figure 7.4
Biology: How Life Works
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G. NADH & Redox Reactions

- 1. $NAD^+ + 2e^- + H^+ \rightarrow NADH$ (redox rxn.)
 - a. NAD^+ reduced (gains energy); Pyruvate oxidized (loses energy)
 - b. NADH is an "energy intermediate"
- 2. Redox Reactions
 - a. Oxidized molecules tend to lose H
 - i. Tend to have C-O bonds, not C-H bonds
 - ii. Follow H to follow electrons

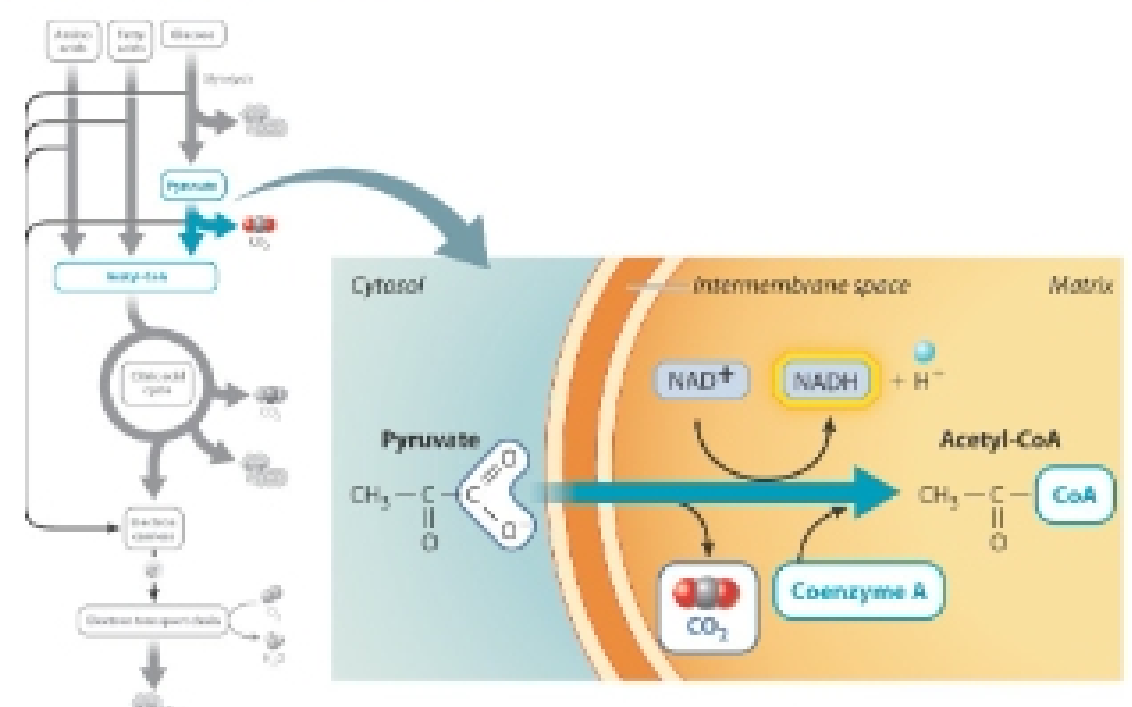
H. ATP in glycolysis is generated by an enzyme (substrate level phosphorylation)

- 1. Phosphoenolpyruvate (1 phosphorous) and ADP combine on an enzyme to form ATP + pyruvate

I. Pyruvate is transported into mitochondria & breakdown continues—

II. Step 2: Pyruvate Breakdown (Acetyl Co-A Synthesis) (Fig. 7.6)

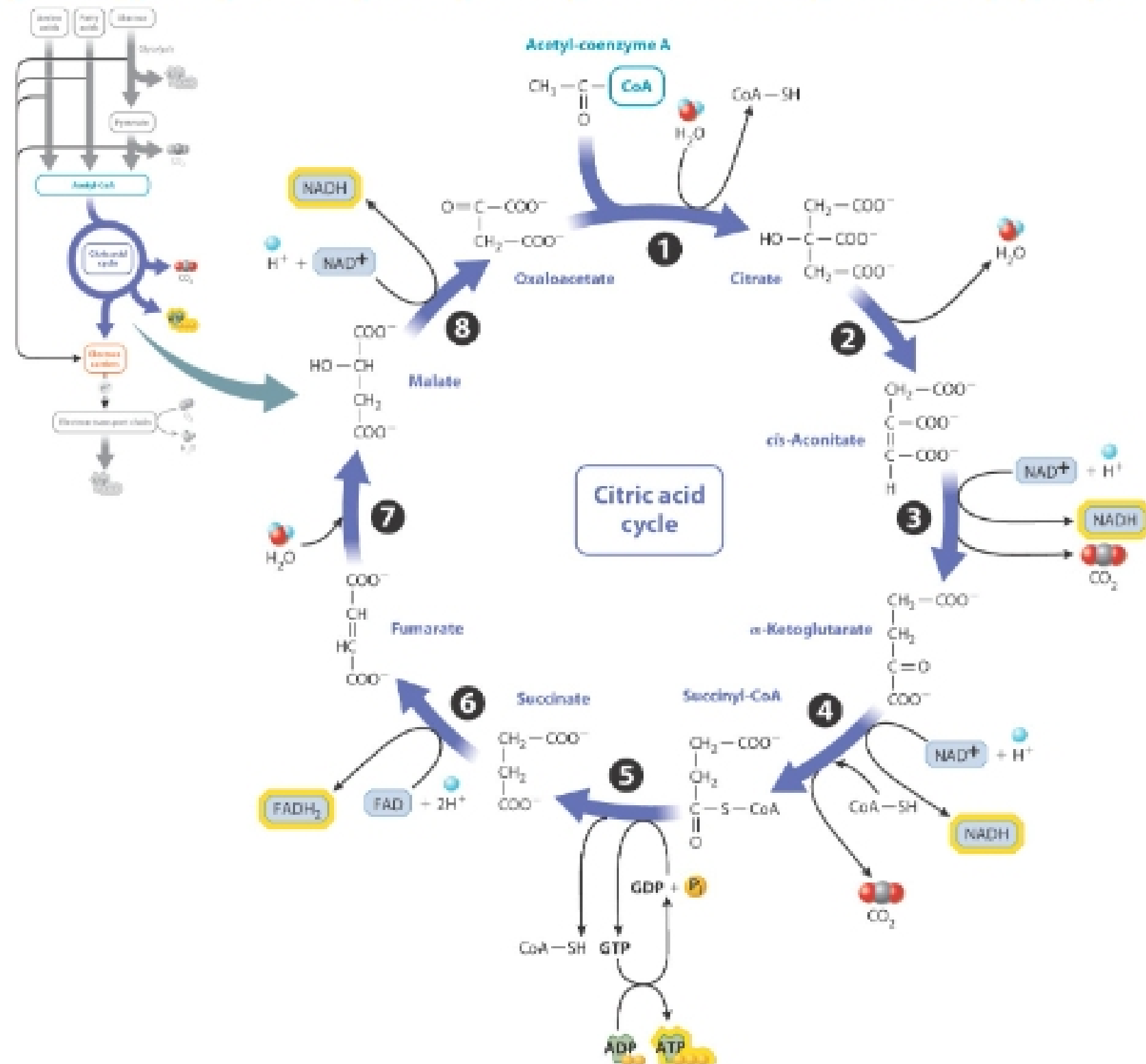
- A. Pyruvate dehydrogenase removes CO_2 from 3-C pyruvate
- B. 2-C acetyl combines with CoA
- C. Per pyruvate: 1 acetyl CoA, 1 NADH, 1 CO_2



III. Step 3: Citric Acid Cycle (Krebs Cycle) (Fig. 7.7)

- A. Each acetyl group is oxidized to 2 CO₂
- B. Acetyl (2-C) removed & attached to oxaloacetate (4-C → Citrate (6-C)
- C. Cycle releases 2 CO₂, 1 ATP, 3NADH, 1 FADH₂
- D. Oxaloacetate is regenerated
- E. Regenrates high energy compounds by incorporating & then breaking down acetyl group

(see Fig. 7.7)



Breakdown of 1 glucose (so far):

Process	ATP	NADH	FADH ₂	CO ₂	Other
Glycolysis	2	2	--	--	2 Pyruvate
Pyruvate breakdown	--	2	--	2	2 Acetyl-CoA
Krebs	2	6	2	4	--
Total	4	10	2	6	--

IV. Oxidative Phosphorylation (Electron Transport Chain + ATP Synthesis)

A. Uses NADH & FADH₂ to make ATP

B. "Oxidative Phosphorylation" includes the ETC & phosphorylation of ADP via ATP Synthase

1. Electron Transport Chain

- a. Composed proteins or small organic molecules
- b. Accept & release electrons in a series of redox reactions
- c. Electrons lose energy as they move through ETC
- d. Electron movement generates H⁺ electrochemical gradient (proton-motive force)

C. Process of Oxidative Phosphorylation

1. NADH donates electrons to complex I; complex I accepts them & pumps H⁺ across membrane
2. FADH₂ transfers electrons to complex II
3. Electrons move to CoQ (Or U, for ubiquinone), forming CoQH₂
4. Electrons donated from CoQH₂ to complex III; H⁺ pumped across membrane
 - a. H⁺ accumulating on bottom of diagram (inside) – making acidic environment
 - b. Protons (H⁺) being pumped across membrane at complex I & complex III so far
5. Electrons transferred to Cc
6. Electron transferred to IV. IV pumps H⁺ across the membrane and transfers electrons to the final electron acceptor, an oxygen atom, resulting in H₂O formation – **electron transport chain ends**
 - a. Products of electron transport chain – H₂O & the H⁺ gradient
7. H⁺ gradient used by ATP synthase to make ATP

