

# AP BIOLOGY

- *Cellular Respiration:  
Harvesting Chemical Energy*



CYCLES ATTACHED  
TO THESE RAILINGS  
WILL BE REMOVED



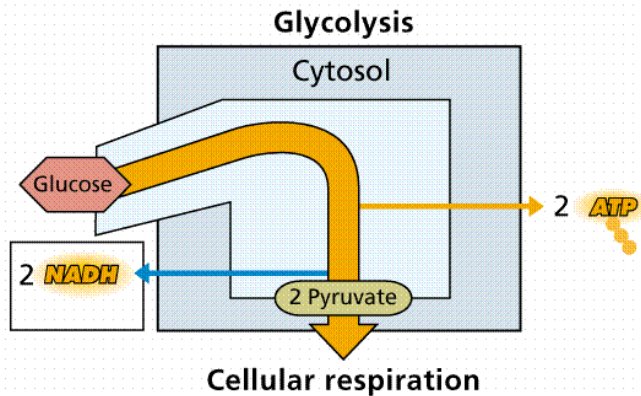
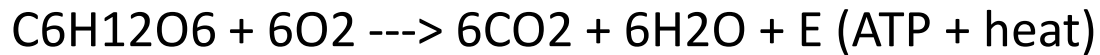
QOD

- Classify each of the following as heterotroph or autotroph:
- Grass
- Deer
- Lichen
- mushroom



# Principles of Energy Harvest

- Catabolic pathway
  - Fermentation
  - Cellular Respiration

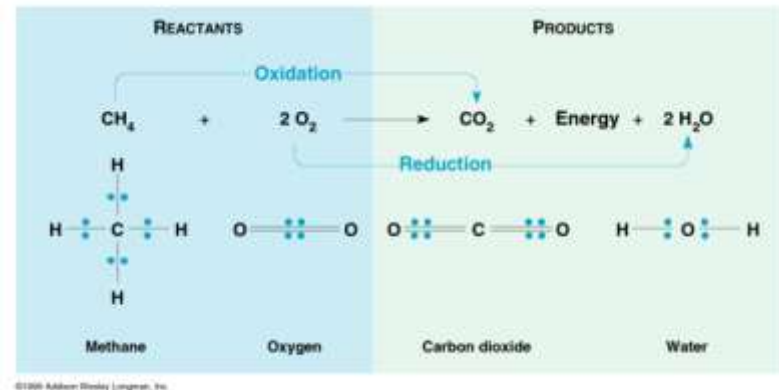


# Redox reactions

- Oxidation-reduction
- OIL RIG

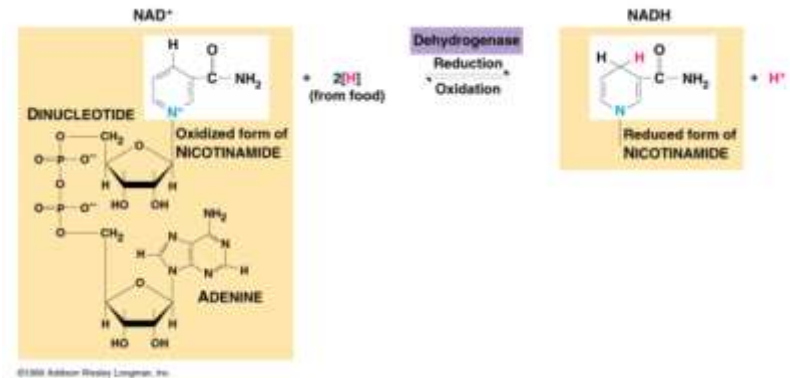
(adding e<sup>-</sup> reduces + charge)

- Oxidation is e<sup>-</sup> loss;  
reduction is e<sup>-</sup> gain
- Reducing agent:  
e<sup>-</sup> donor
- Oxidizing agent:  
e<sup>-</sup> acceptor



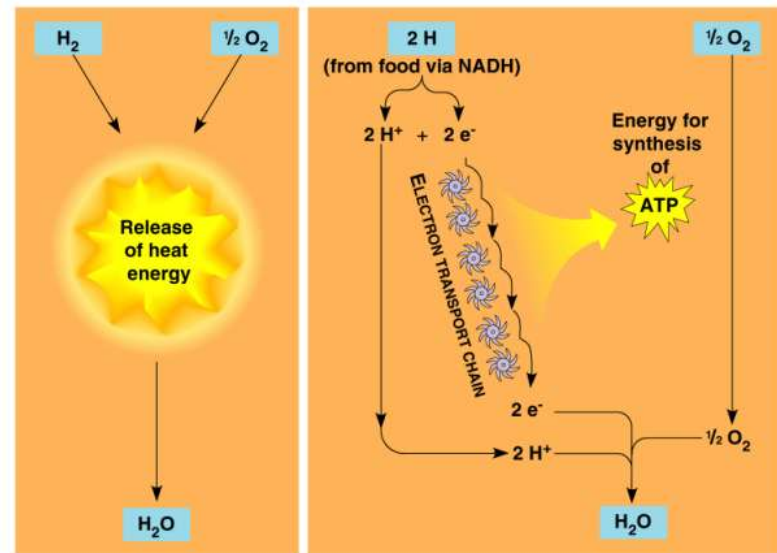
# Oxidizing agent in respiration

- NAD<sup>+</sup> (nicotinamide adenine dinucleotide)
- Removes electrons from food (series of reactions)
- NAD<sup>+</sup> is reduced to NADH
- Enzyme action: dehydrogenase
- Oxygen is the eventual e-acceptor



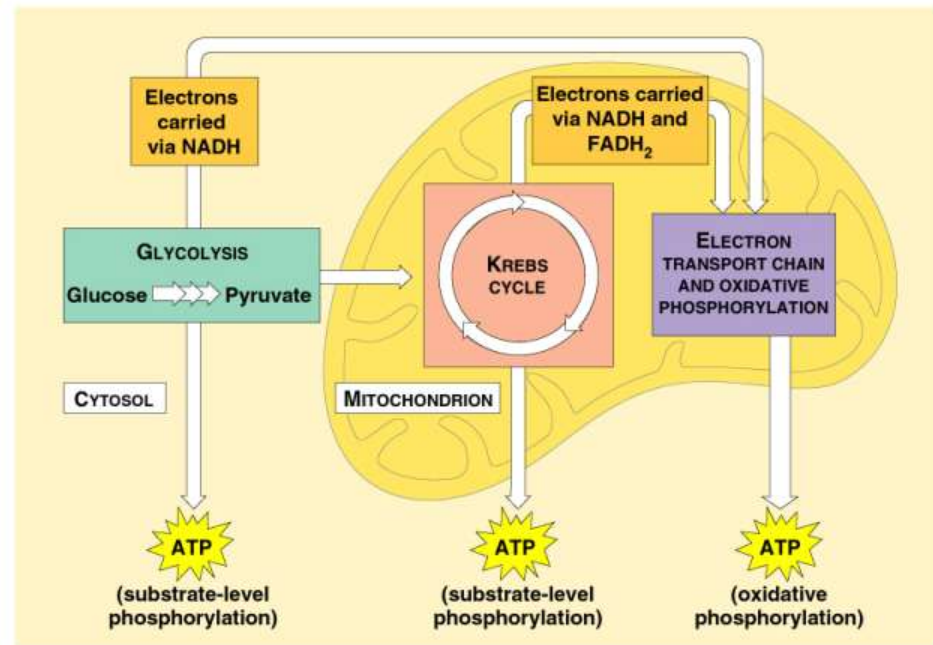
# Electron transport chains

- Electron carrier molecules (membrane proteins)
- Shuttles electrons that release energy used to make ATP
- Sequence of reactions that prevents energy release in 1 explosive step
- Electron route: food ---> NADH ---> electron transport chain ---> oxygen



# Cellular respiration

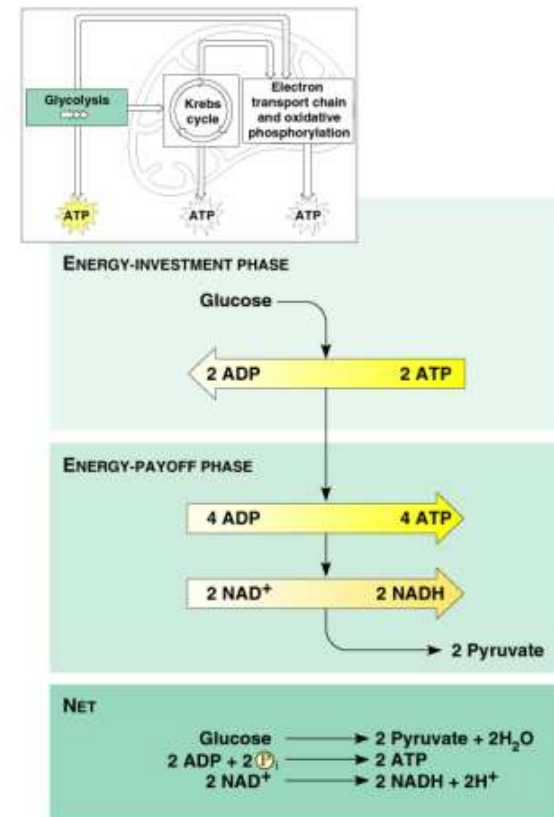
- Glycolysis: cytosol; degrades glucose into pyruvate
- Kreb's Cycle: mitochondrial matrix; pyruvate into carbon dioxide
- Electron Transport Chain: inner membrane of mitochondrion; electrons passed to oxygen





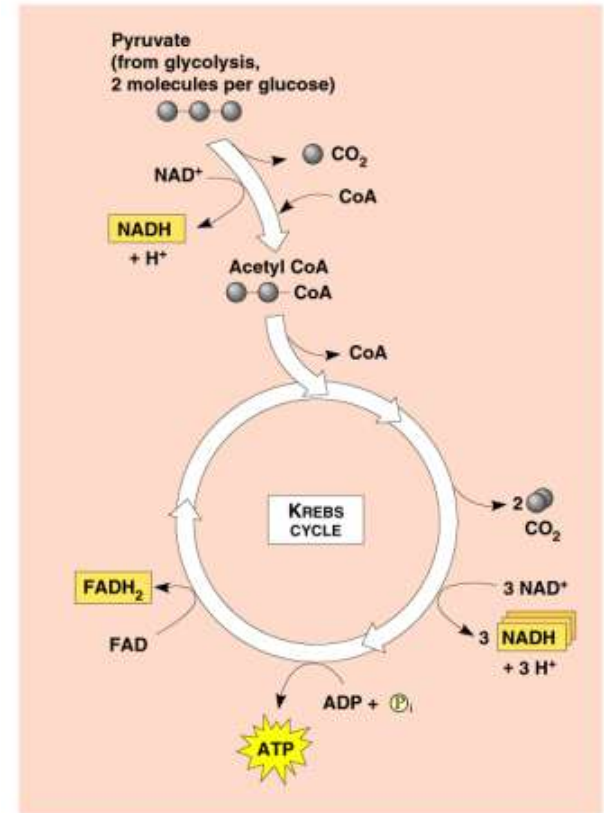
# Glycolysis

- 1 Glucose ---> 2 pyruvate molecules
- Energy investment phase: cell uses ATP to phosphorylate fuel
- Energy payoff phase: ATP is produced by substrate-level phosphorylation and NAD<sup>+</sup> is reduced to NADH by food oxidation
- Net energy yield per glucose molecule: 2 ATP plus 2 NADH; no CO<sub>2</sub> is released; occurs aerobically or anaerobically



# Kreb's Cycle

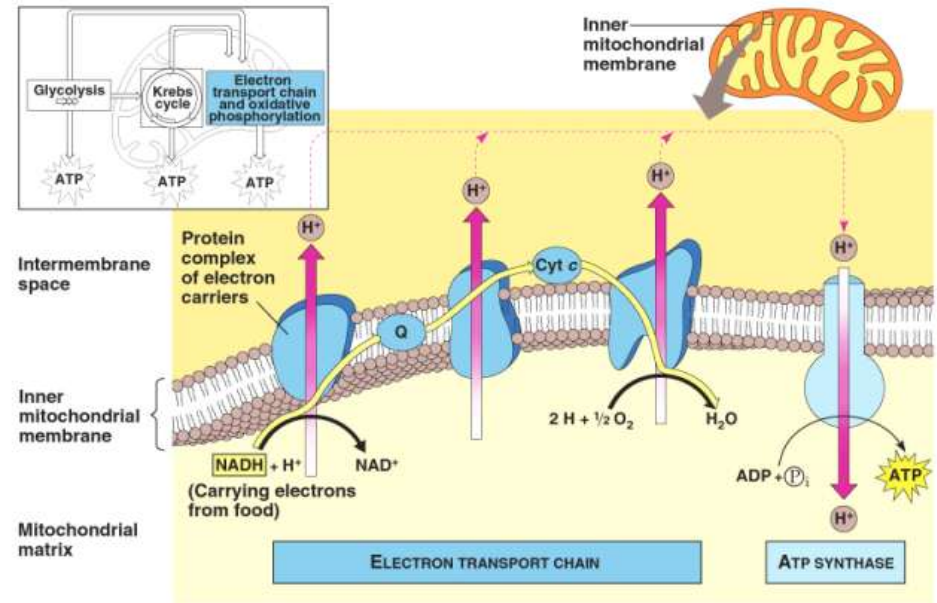
- If molecular oxygen is present.....
- Each pyruvate is converted into acetyl CoA (begin w/ 2):CO<sub>2</sub> is released;
- NAD<sup>+</sup> ---> NADH;
- coenzyme A (from B vitamin),
- makes molecule very reactive
- From this point, each turn 2 C atoms enter (pyruvate) and 2 exit (carbon dioxide)
- Oxaloacetate is regenerated (the "cycle")
- For each pyruvate that enters:
  - 3 NAD<sup>+</sup> reduced to NADH;
  - 1 FADH reduced to FADH<sub>2</sub>
  - 1 ATP molecule



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# Electron transport chain

- Cytochromes carry electron carrier molecules (NADH & FADH<sub>2</sub>) down to oxygen
- Chemiosmosis: energy coupling mechanism
- ATP synthase: produces ATP by using the H<sup>+</sup> gradient (proton-motive force) pumped into the inner membrane space from the electron transport chain; this enzyme harnesses the flow of H<sup>+</sup> back into the matrix to phosphorylate ADP to ATP (oxidative phosphorylation)

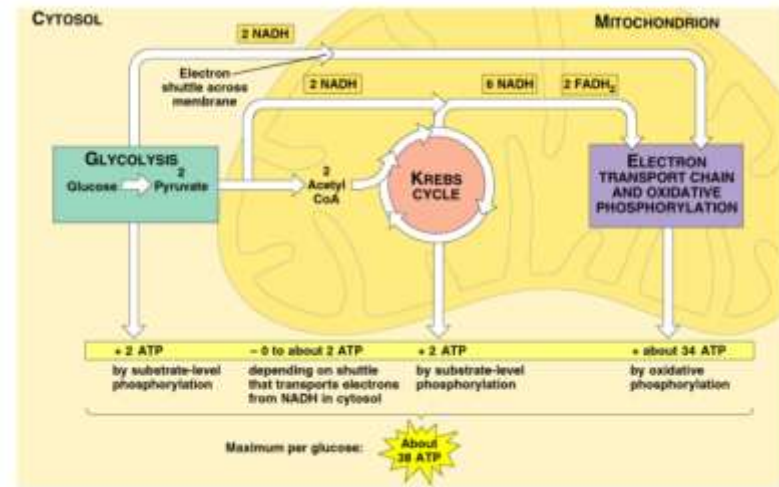


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# Review: Cellular Respiration

- Glycolysis:
- 2 ATP (substrate-level phosphorylation)
- Kreb's Cycle:
- 2 ATP (substrate-level phosphorylation)
- Electron transport & oxidative phosphorylation:

	2
NADH (glycolysis) = 6ATP	2
NADH (acetyl CoA) = 6ATP	6
NADH (Kreb's) = 18 ATP	2 FADH <sub>2</sub>
(Kreb's) = 4 ATP	
- 38 TOTAL ATP/glucose



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# Related metabolic processes

- Fermentation:
- alcohol ~ pyruvate to ethanol
- lactic acid ~ pyruvate to lactate
- Facultative anaerobes  
(yeast/bacteria)
- Beta-oxidation
  - lipid catabolism

