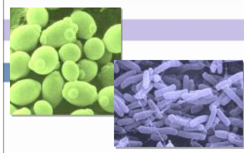
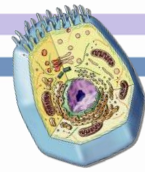
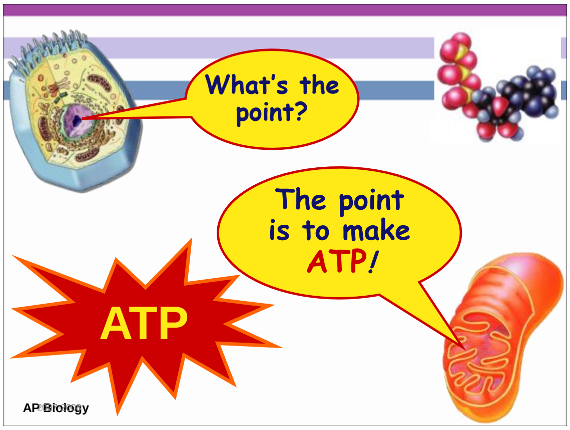




Cellular Respiration
Stage 1: Glycolysis

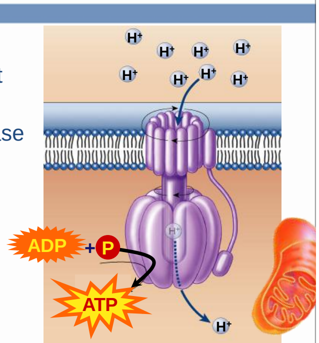


AP Biology

And how do we do that?

- ATP synthase
  - set up a H^+ gradient
  - allow H^+ to flow through ATP synthase
  - powers bonding of P_i to ADP

$ADP + P_i \rightarrow ATP$



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Glycolysis

- Breaking down glucose
  - "glyco – lysis" (splitting sugar)

glucose → → → → → pyruvate
6C 2x 3C

  - ancient pathway which harvests energy
    - where energy transfer first evolved
    - transfer energy from organic molecules to ATP
    - still is starting point for ALL cellular respiration
  - but it's inefficient
    - generate only 2 ATP for every 1 glucose
  - occurs in cytosol

In the cytosol? Why does that make evolutionary sense?

That's not enough ATP for me!

AP Biology

Evolutionary perspective

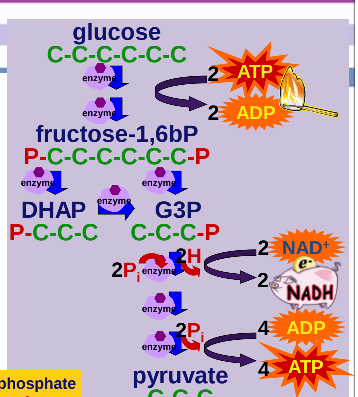
- Prokaryotes
  - first cells had no organelles
- Anaerobic atmosphere
  - life on Earth first evolved without free oxygen (O_2) in atmosphere
  - energy had to be captured from organic molecules in absence of O_2
- Prokaryotes that evolved glycolysis are ancestors of all modern life
  - ALL cells still utilize glycolysis

Enzymes of glycolysis are "well-conserved"

AP Biology

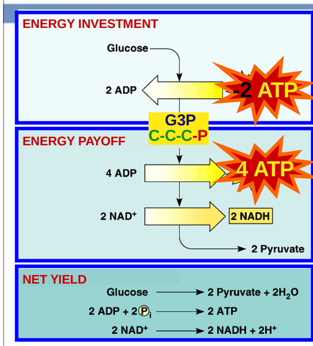
Overview

10 reactions
- convert glucose (6C) to 2 pyruvate (3C)
- produces: 4 ATP & 2 NADH
- consumes: 2 ATP
- net yield: 2 ATP & 2 NADH

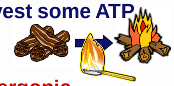


DHAP = dihydroxyacetone phosphate
G3P = glyceraldehyde-3-phosphate

Glycolysis summary

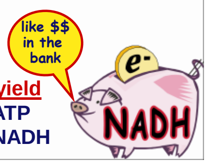


endergonic
invest some ATP



exergonic
harvest a little ATP & a little NADH

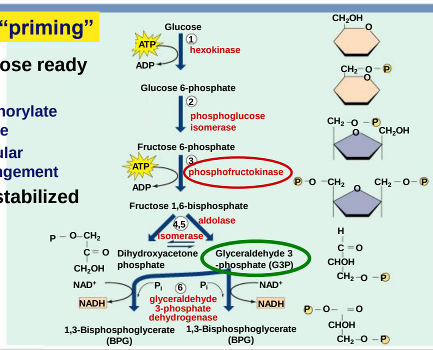
net yield
✓2 ATP
✓2 NADH



1st half of glycolysis (5 reactions)

Glucose "priming"

- get glucose ready to split
  - phosphorylate glucose
  - molecular rearrangement
- split destabilized glucose



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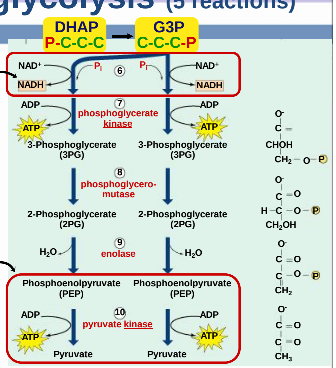
2nd half of glycolysis (5 reactions)

Energy Harvest

- NADH production
  - G3P donates H
  - oxidizes the sugar
  - reduces NAD+
  - NAD+ → NADH
- ATP production
  - G3P → → → pyruvate
  - PEP sugar donates P
    - "substrate level phosphorylation"
  - ADP → ATP



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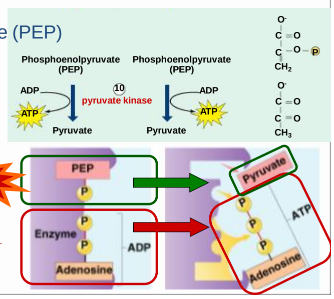
Substrate-level Phosphorylation

- In the last steps of glycolysis, where did the P come from to make ATP?
  - the sugar substrate (PEP)

P is transferred from PEP to ADP
✓kinase enzyme
✓ADP → ATP

ATP

The P_i came directly from the substrate!



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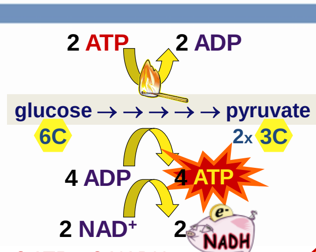
Energy accounting of glycolysis



- Net gain = 2 ATP + 2 NADH
  - some energy investment (-2 ATP)
  - small energy return (4 ATP + 2 NADH)
- 1 6C sugar → 2 3C sugars

All that work! And that's all I get?

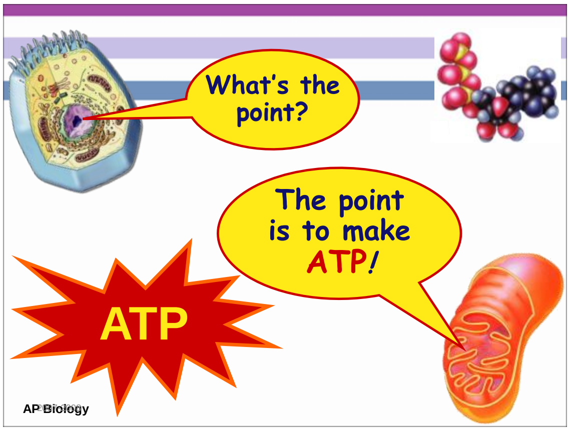
But glucose has so much more to give!

Is that all there is?

- Not a lot of energy…
  - for 1 billon years+ this is how life on Earth survived
    - no O_2 = slow growth, slow reproduction
    - only harvest 3.5% of energy stored in glucose
      - more carbons to strip off = more energy to harvest

glucose → → → → pyruvate
6C 2x 3C

AP



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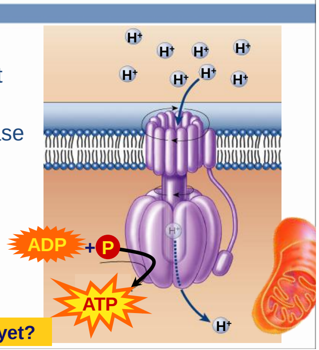

But… Have we done that yet?