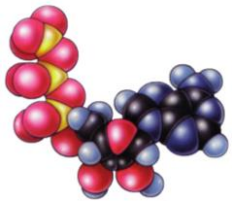
Chapter 9.2 & 9.4
Cellular Respiration
STAGE 1: Glycolysis




Glycolysis

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

glucose → → → → → pyruvate
6C 2x 3C

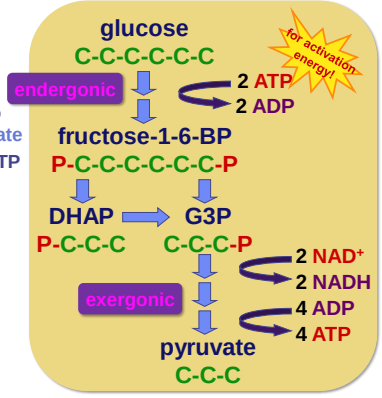
  - inefficient
    - generate only 2 ATP for every 1 glucose
  - most ancient form of energy capture
    - starting point for *all* cellular respiration
  - in cytosol… Why does this make evolutionary sense?

Evolutionary Perspective

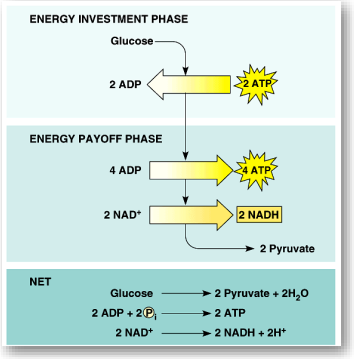
- Life on Earth first evolved without free oxygen (O_2) in atmosphere
  - energy had to be captured from organic molecules in absence of O_2
- Organisms that evolved glycolysis are ancestors of all modern life
  - before endosymbiotic event
  - all organisms still utilize glycolysis!

Overview

- 10 reactions
  - convert 6C glucose to two 3C pyruvate
  - produces 2 ATP & 2 NADH



Glycolysis Summary

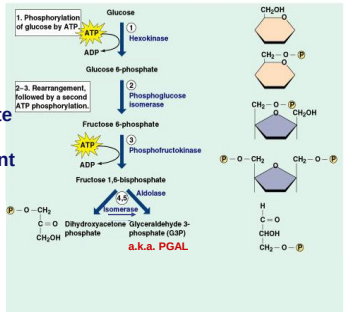


endergonic
invest some ATP

exergonic
harvest a little more ATP & a little NADH

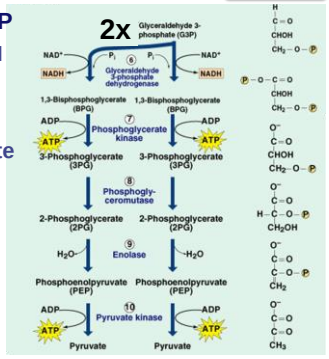
1st half of Glycolysis (5 reactions) endergonic

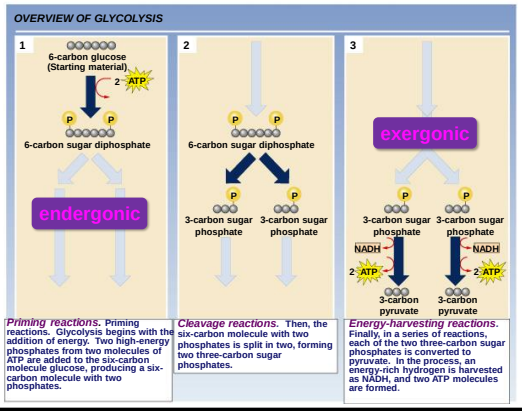
- Glucose "priming"
  - get glucose ready to split
    - phosphorylate glucose
    - rearrangement
  - now split 'destabilized glucose'



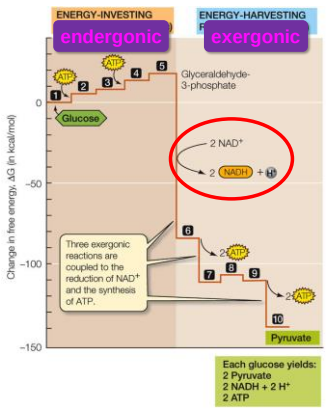
2nd half of Glycolysis (5 reactions) exergonic

- Oxidation of G3P
  - G3P donates H
  - NAD → NADH
- ATP generation
  - G3P → pyruvate
  - donates P
  - ADP → ATP

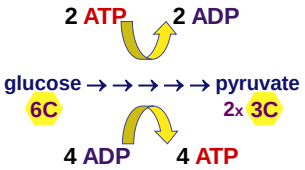




Glycolysis Summary



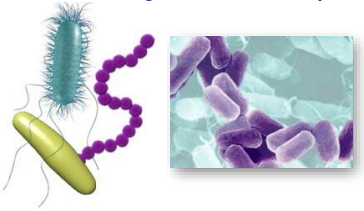
Energy accounting of Glycolysis



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

Is that all there is?

- Not a lot of energy…
  - for 1 billon years+ this is how life on Earth survived
    - only harvest ~3.5% of energy stored in glucose
    - slow growth, slow cell reproduction

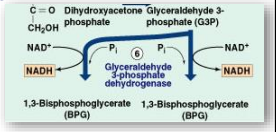


We can't stop there….

- Glycolysis

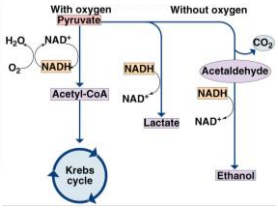
glucose + 2ADP + 2P_i + 2 NAD^+ →
2 pyruvate + 2ATP + 2NADH

- Going to run out of NAD^+
- How is NADH recycled to NAD^+?
  - without regenerating NAD+, energy production would stop
  - another molecule must accept H from NADH



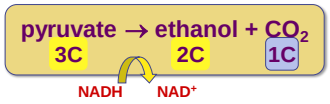
How is NADH recycled to NAD⁺?

- Another molecule must accept H from NADH
  - fermentation step (NO OXYGEN NEEDED!)
    - ethanol fermentation
    - lactic acid fermentation
  - aerobic respiration (WHEN OXYGEN IS PRESENT)

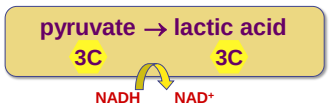


Anaerobic Fermentation

- Bacteria, yeast



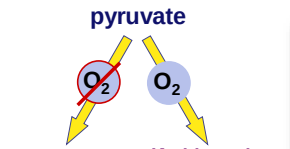
  - beer, wine, bread
  - at ~12% ethanol, kills yeast
- Animals, some fungi



  - cheese, yogurt, anaerobic exercise (no O_2)

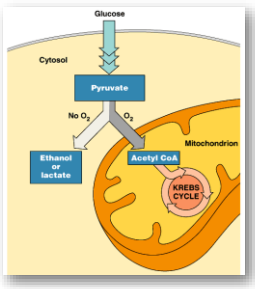
Pyruvate is a branching point

pyruvate

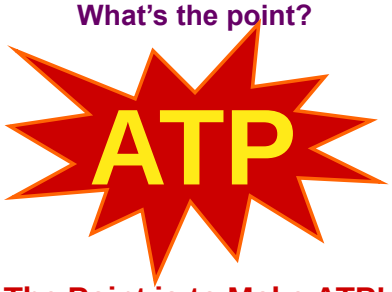


fermentation

Kreb's cycle (Citric Acid Cycle) mitochondria



What's the point?



The Point is to Make ATP!

Any Questions??