

Chapter 5 Outline

- ▶ Glycolysis
- ▶ Aerobic Respiration
- ▶ Lactic Acid Pathway
- ▶ Glycogenesis, glycogenolysis, gluconeogenesis

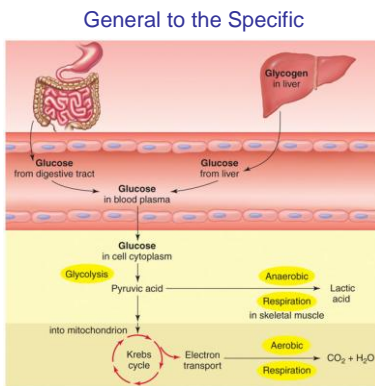
Cellular Respiration

Occurs in a series of reactions:

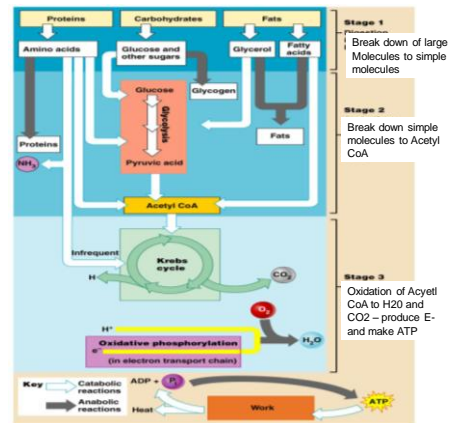
1. Glycolysis
2. Citric acid cycle (aka TCA or Kreb's Cycle)
3. Electron transport system

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Carbohydrate Catabolism

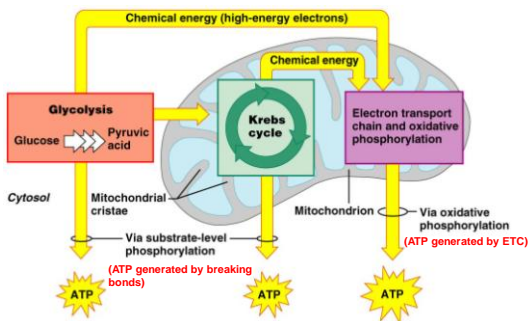


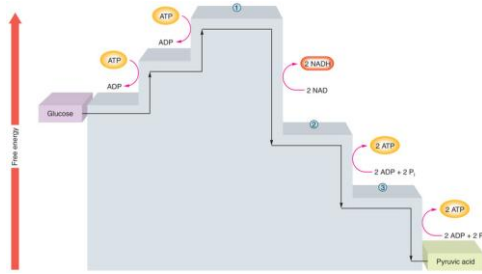
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Glycolysis

Glycolysis (General)

- In glycolysis 2 ATPs are added and 4 are produced for a net gain of 2 ATP

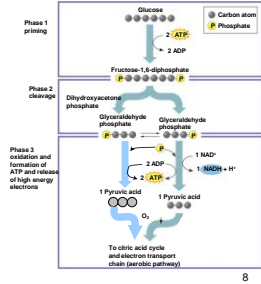


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Glycolysis (Specific)

- Event 1 - **Phosphorylation**
- Two phosphates added to glucose
 - Requires ATP

- Event 2 - **Splitting (cleavage)**
- 6-carbon glucose split into two 3-carbon molecules

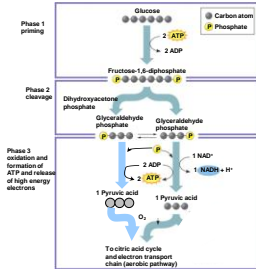


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Glycolysis

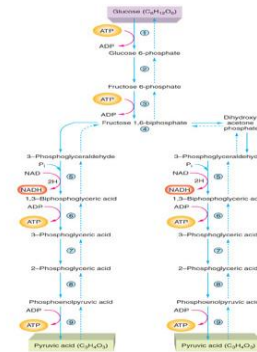
Event 3 - Production of NADH and ATP

- H atoms released
- Bind to NAD⁺ to produce NADH
- NADH delivers H⁺ to ETC
- ADP is phosphorylated to ATP
- 2 pyruvic acid are produced
- 2 ATP are generated (4 - 2 [used to start] = 2)



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Glycolysis



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How Glycolysis Works

6-carbon glucose

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Cells derive energy from the oxidation of nutrients such as glucose. The oxidation of glucose to pyruvate occurs through a series of steps called glycolysis.

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Aerobic Respiration

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Carbohydrate Catabolism

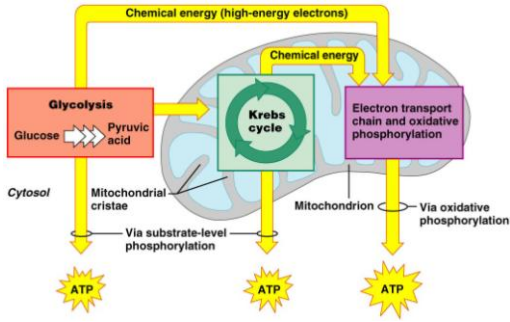
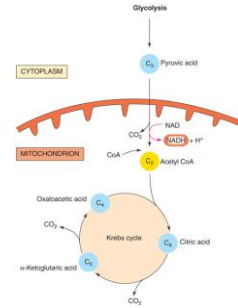


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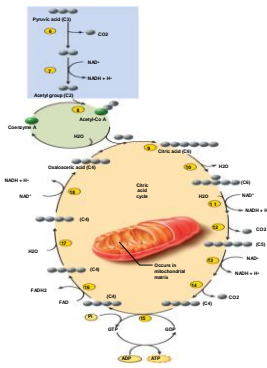
Krebs Cycle (General)

- ▶ In mitochondria matrix
- ▶ Begins with acetyl CoA combining with oxaloacetic acid to form citric acid
- ▶ In a series of reactions citric acid converted back to oxaloacetic acid to complete the pathway



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Mitochondrial Matrix Reactions (Specific)



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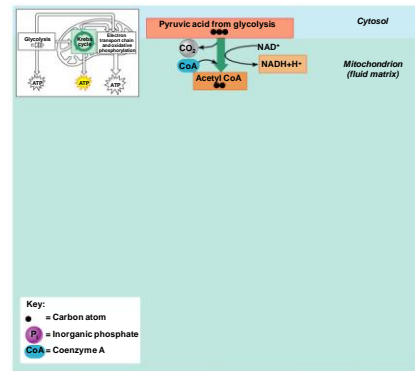


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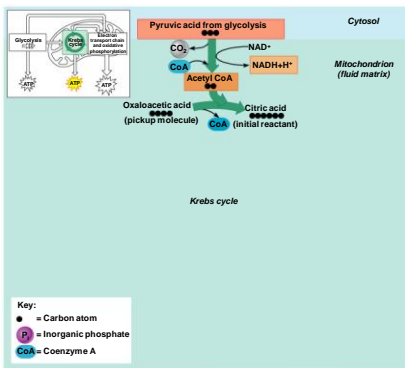


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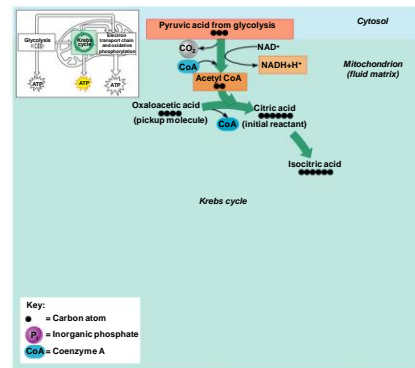


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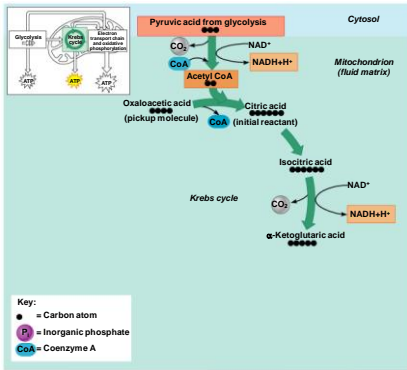


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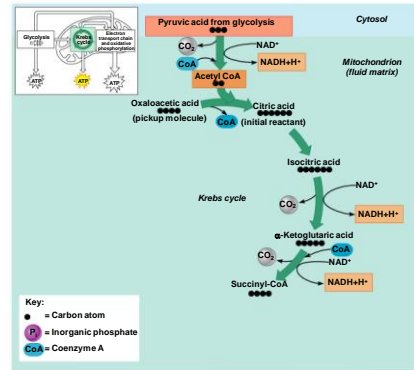


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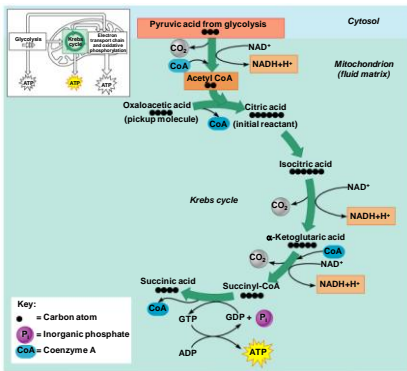


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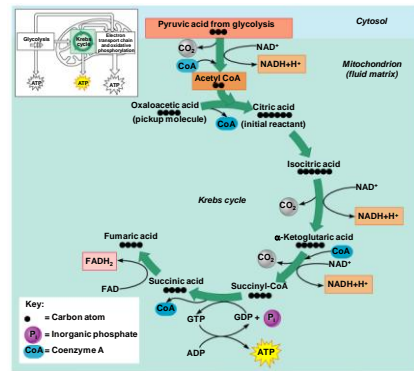


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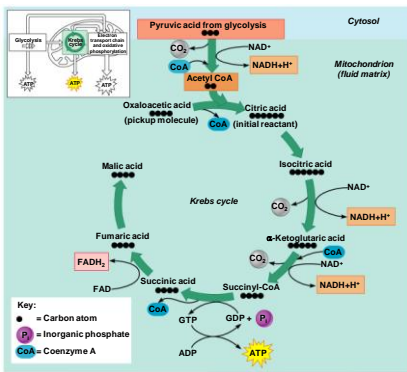


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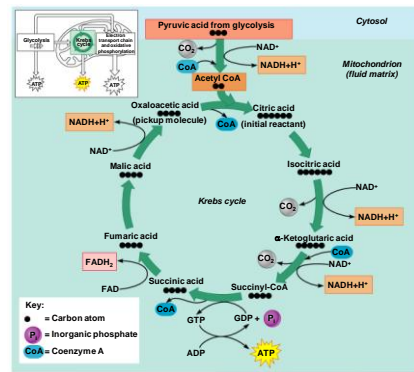
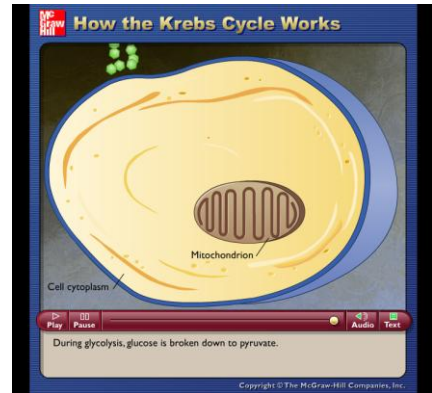
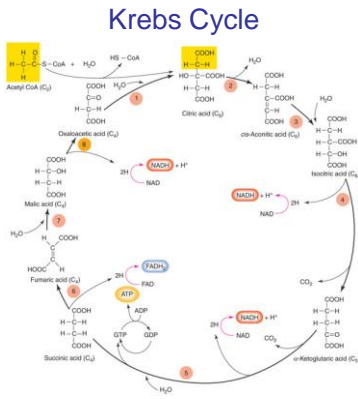
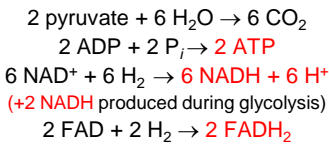


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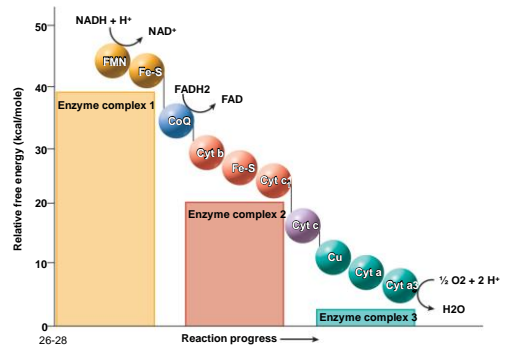
Summary of Matrix Reactions



- ▶ carbon atoms of glucose have all been carried away as CO₂ and exhaled
- ▶ Also, citric acid cycle is a source of substances for synthesis of fats and nonessential amino acids (later)

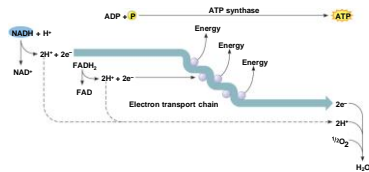
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Electron Transport Chain



Electron Transport System

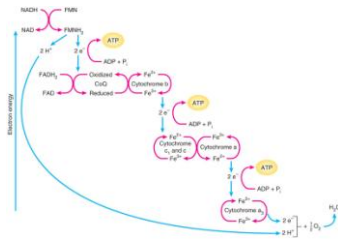
- NADH and FADH₂ carry electrons to the ETS
- ETS is a series of electron carriers (proteins) (in **cris^tae** of mitochondria)
- Energy from electrons transferred to ATP synthase
- ATP synthase catalyzes the phosphorylation of ADP to ATP
- Water is formed



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Electron Transport and Oxidative Phosphorylation

- ▶ The electron transport chain is a linked series of proteins on the cris^tae of mitochondria
 - ▶ Proteins are FMN, coenzyme Q, and cytochromes



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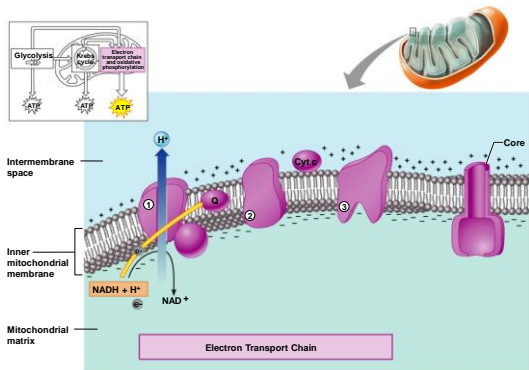


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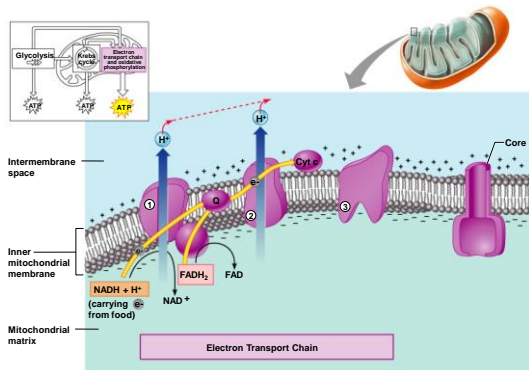


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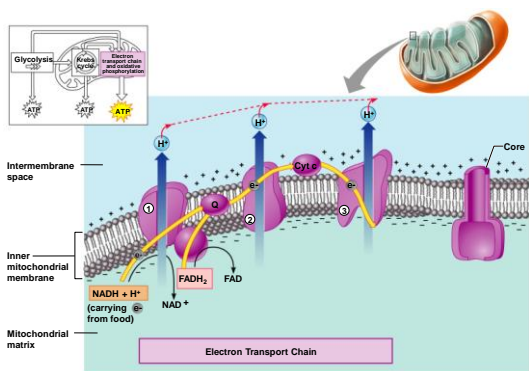


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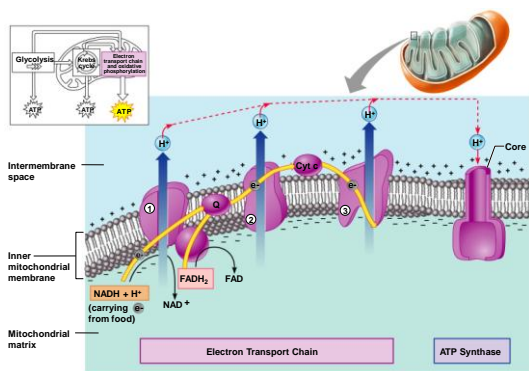


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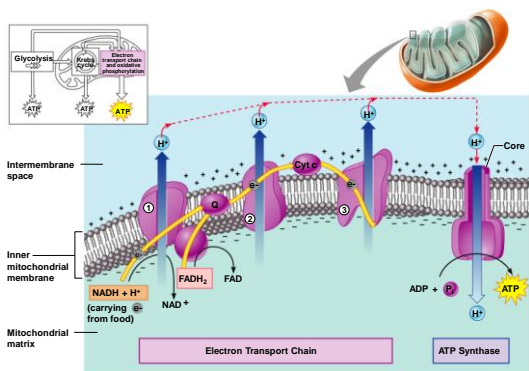


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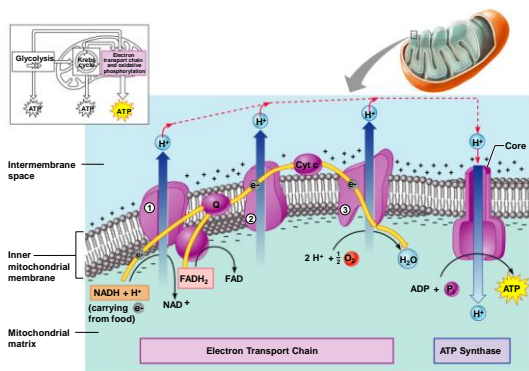
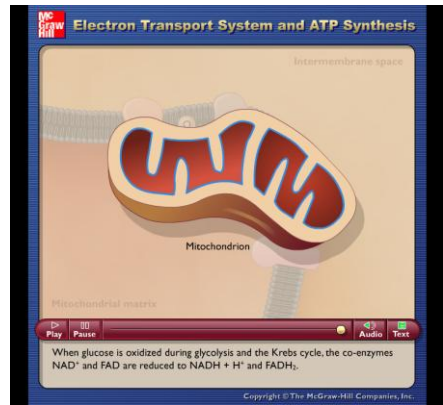
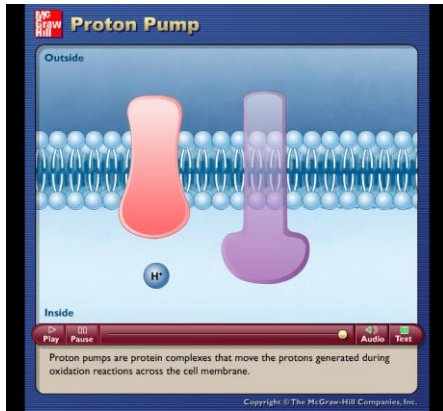
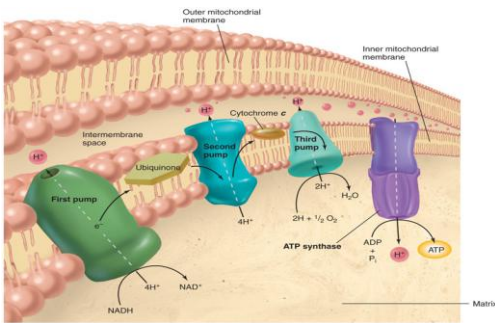


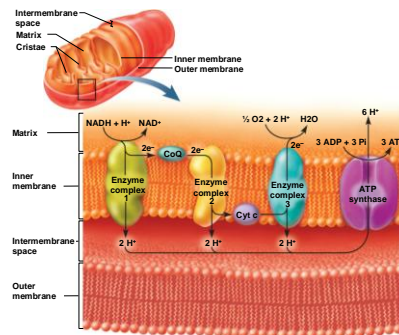
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ETC

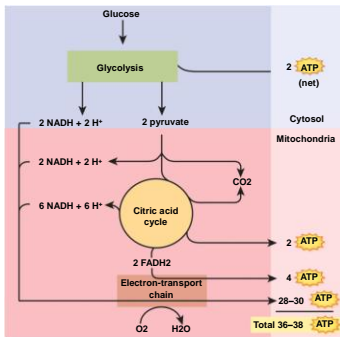


Chemiosmotic ATP Synthesis



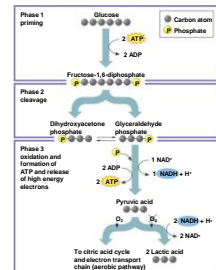
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ATP Generated by Oxidation of Glucose



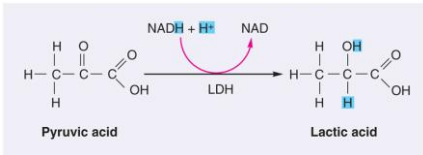
Anaerobic Reactions

- If oxygen is not available:
 - ETC cannot accept electrons from NADH
 - Pyruvic acid is converted to lactic acid
 - Glycolysis is inhibited
 - Less ATP produced



Lactic Acid Pathway

- ▶ In absence of O₂ - - NADH + H gives its Hs to pyruvic acid creating lactic acid
- ▶ Anaerobic metabolism or Lactic acid fermentation

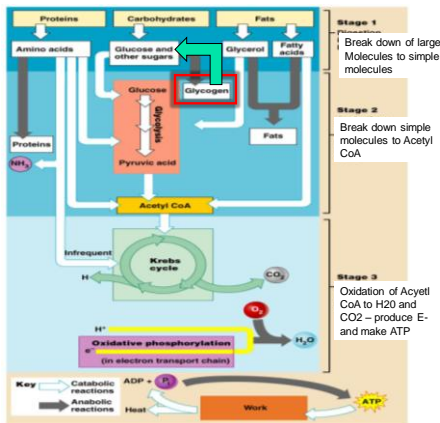


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Lactic Acid Pathway

- ▶ Only yields a net gain of 2 ATPs per glucose
- ▶ RBCs don't have mitochondria; use only lactic acid pathway
- ▶ Occurs in skeletal and heart muscle when oxygen supply falls below critical level
 - ▶ During heavy exercise or vascular blockage

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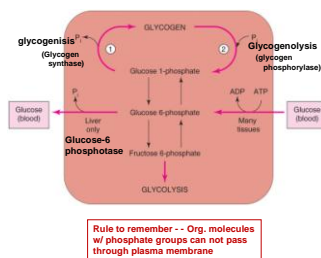
Glycogenesis and Glycogenolysis

- ▶ For osmotic reasons cells can't store lots of free glucoses in cells – we change it to glycogen
- ▶ Glycogen = polymers of glucose
 - ▶ Glucose to Glycogen = (Glycogenesis)
 - ▶ Place a P group on glucose and take it back off
 - ▶ Polymerizes glucose to glycogen
 - ▶ **Skeletal muscle & liver store glycogen**
 - ▶ Glycogenolysis = glycogen to glucose
 - ▶ Add the P back to Glucose (glucose 6 phosphate)
 - ▶ Most cells can use for glycolysis
 - ▶ If P attached to Glucose – it can't leave cell

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Glycogenesis and Glycogenolysis

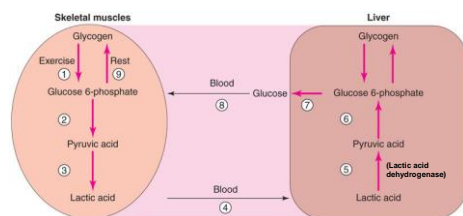
- ▶ Skeletal muscles use trapped glucose-6-phosphate for own energy needs
 - i.e., uses it for glycolysis
 - **cannot release into blood**
- ▶ Only liver has glucose-6-phosphatase that removes phosphate groups
 - ▶ So it can secrete free glucose into blood



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Cori Cycle

- ▶ Some skeletal muscle lactic acid goes to liver
 - ▶ **Gluconeogenesis**: convert non-carb molecules (e.g. lactic acid) back through pyruvic acid to glucose and glycogen



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