



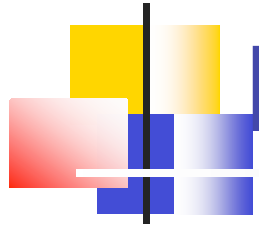
Energy Metabolism

- Chemical energy
 - Combustion
 - Respiration
- Energy substrates
 - Category
 - Sources
- Energy use
 - Muscle contraction
 - Hierarchy for physical activity



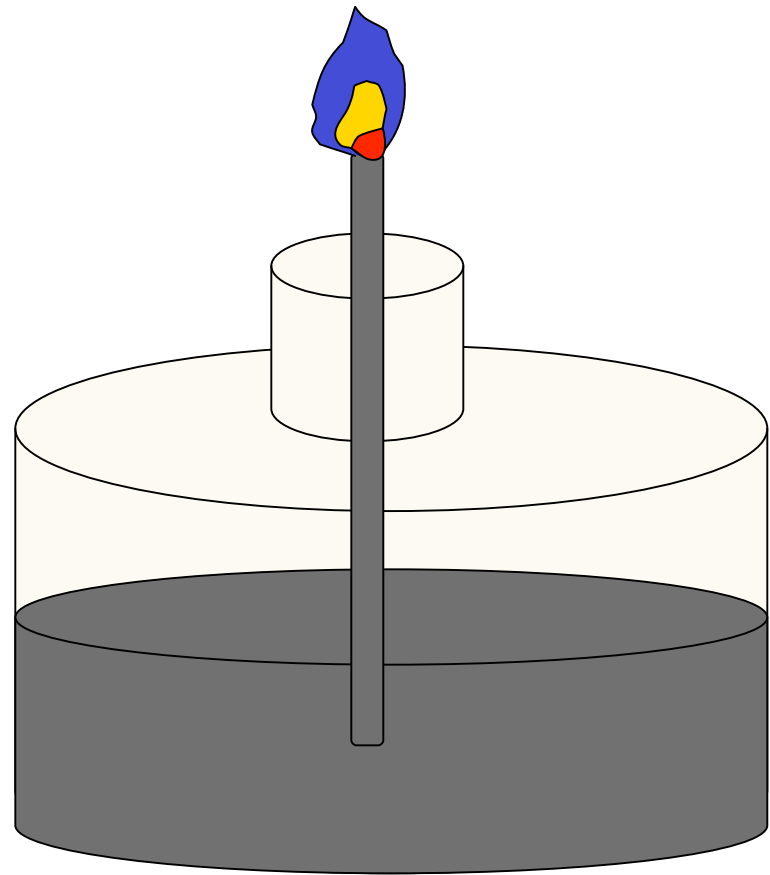
Abbreviations & acronyms

- TCA-tricarboxylic acid cycle (citric acid cycle)
- NAD (NADH⁺)-nicotinamide adenine dinucleotide (reduced NAD)
- ATP-Adenosine triphosphate
- RMR-resting metabolic rate
- CrP-creatine phosphate
- ETC-electron transport chain



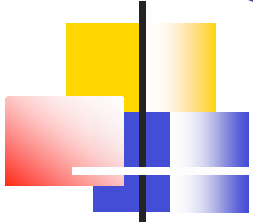
Flame - combustion

- Observations



Sugar refinery fire

Port Wentworth, GA, 2007

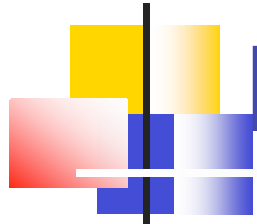




Respiration

- Observations





Respiration vs. Combustion

■ Similarities

- Fuel + oxygen
- Produce $\text{CO}_2/\text{H}_2\text{O}$
- Release chemical energy
- Produce heat
- Regulated rate
- Rate ca. 1 kcal/min

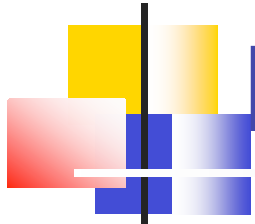
■ Contrasts

- Multiple fuels
 - Free fatty acids
 - Glucose
 - Amino acids
- Heat + ATP
- C: push system - rate of fuel delivery
R: thermostat-product need (ATP)

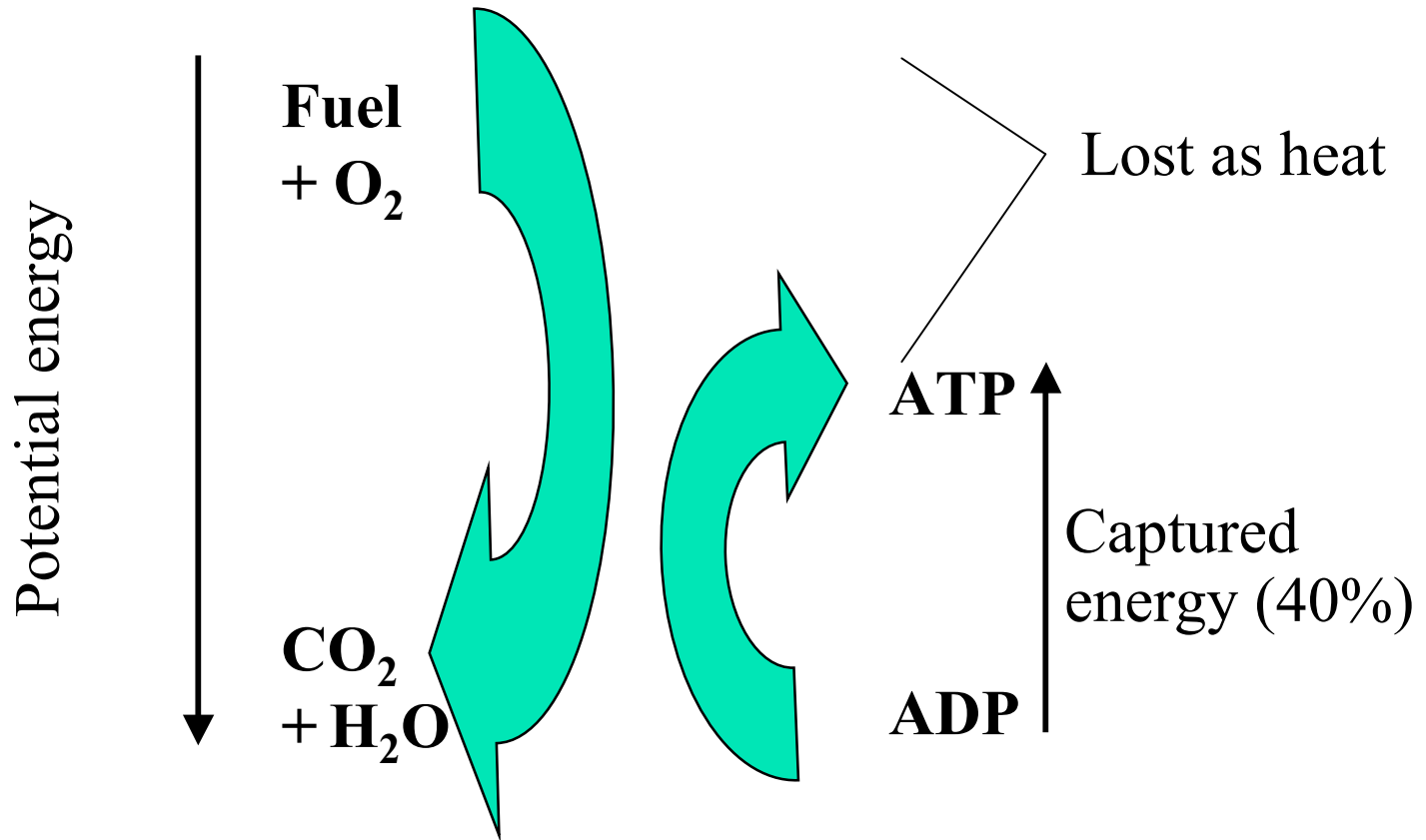


Energy substrates

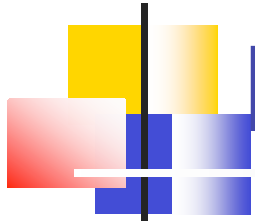
- Free fatty acids
 - Triglycerides
 - Diet
 - Adipose tissue
- Glucose
 - Starches and sugars
 - Diet
 - Glycogen
- Amino acids
 - Protein
 - Diet
 - Tissue



Metabolic coupling



Reality: multiple steps with multiple intermediates, but this net reaction.



Mitochondria

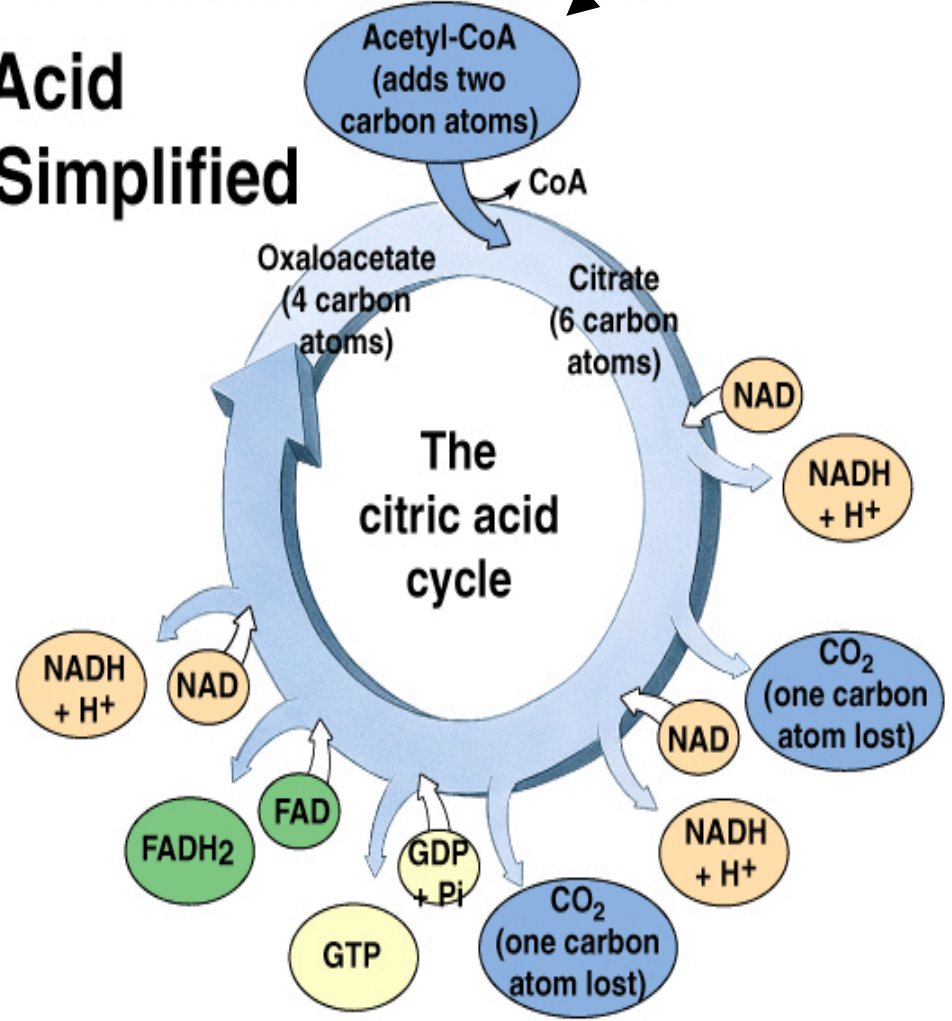
Carbohydrates

Fats

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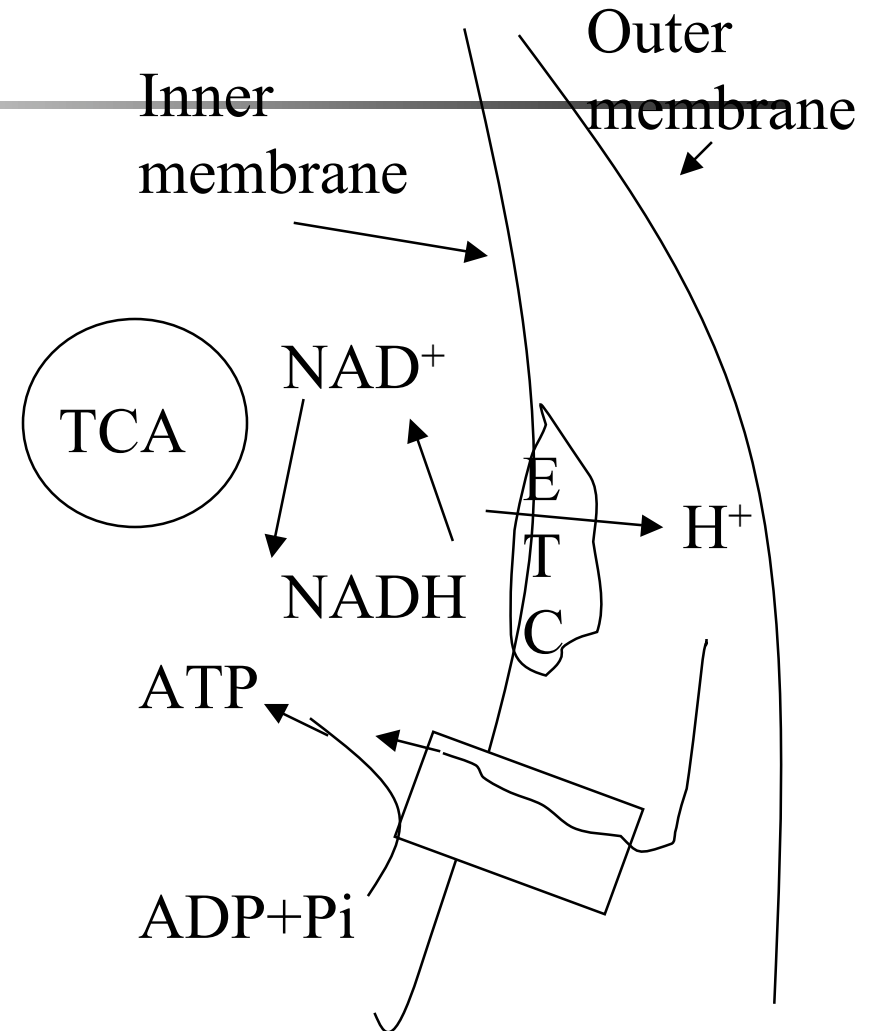
- Couple
 - Oxidation
 - Phosphorilation
- Components
 - TCA cycle
 - NADH and CO₂

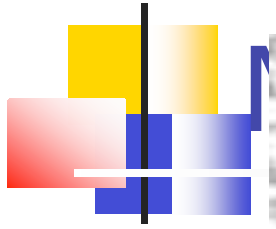
Citric Acid Cycle Simplified



Mitochondria

- Couple
 - Oxidation
 - Phosphorilation
- Components
 - TCA cycle
 - NADH and CO_2
 - Electron transport chain
 - Proton gradient
 - ATP synthesized



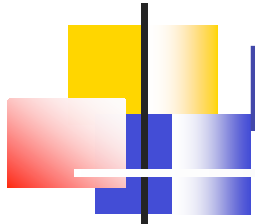




Energy use

- Rest
- 100 m sprint
- 400 m sprint
- marathon





Rest

- RMR
 - Male: 1 kcal/kg/hr
 - Female: 0.9 kcal/kg/hr
- Tissues
 - CNS, 25% of RMR, glucose
 - Muscle, 25% of RMR, fatty acid
 - Viscera, 40% of RMR,
 - Glucose after meals
 - Fatty acids after fast

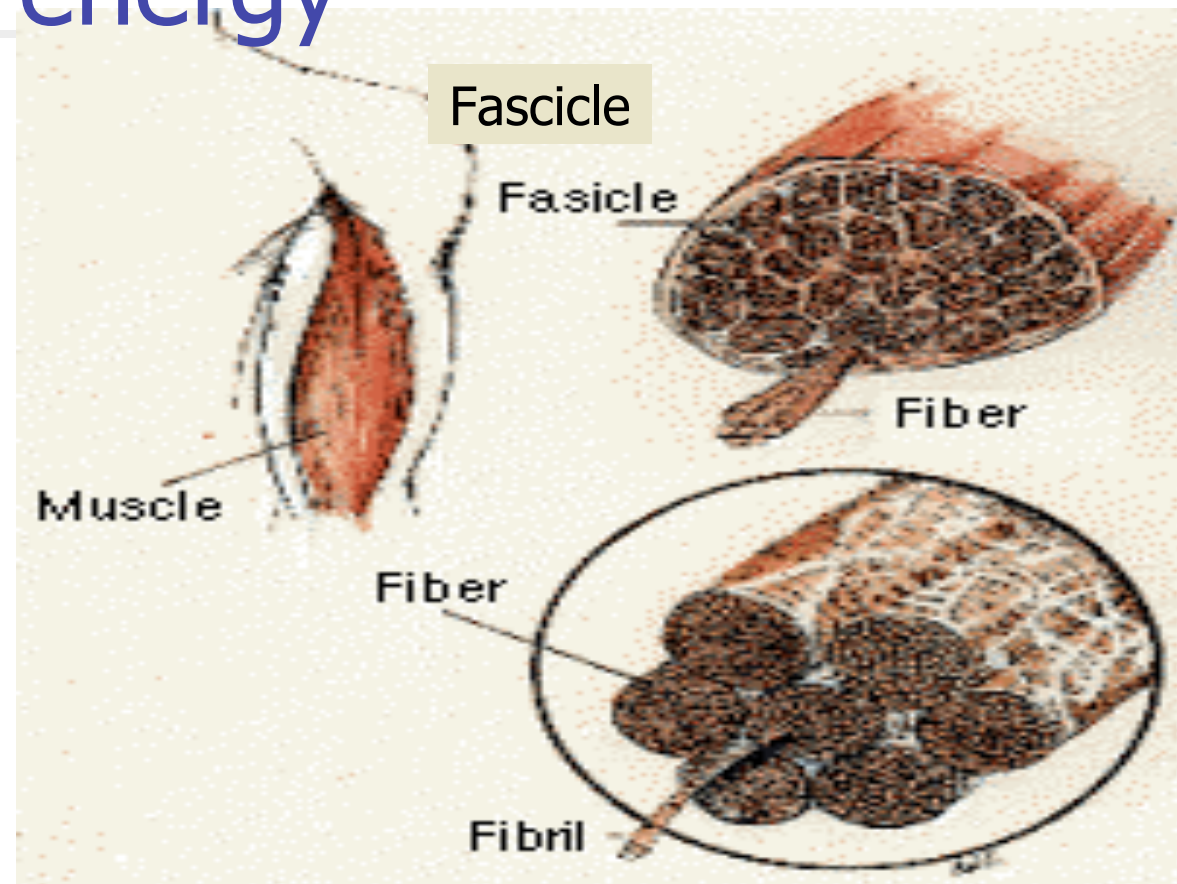


Physical Activity

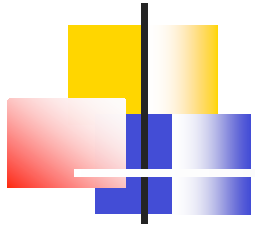
“bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above the basal level”

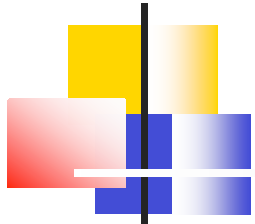
**Physical Activity and Health: A Report of the Surgeon General,
1996**

Muscle converts chemical energy into kinetic energy



From Muscle Physiol Lab, VA Medical Cntr,
San Diego, CA



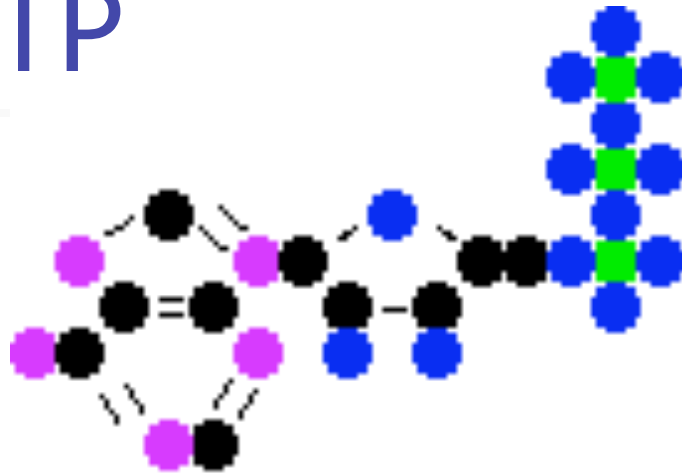


100 m sprint

- 20 x RMR or 0.3 kcal/s
- 10-14 seconds, 3.6 kcal
- Primary energy sources
 - [ATP, max 0.6 kcal or 2 sec.]
 - CrP, max 3 kcal
- Anaerobic
- Cytosol
- Oxygen debt



ATP



Adenosine Triphosphate



Adenosine Diphosphate

● Carbon

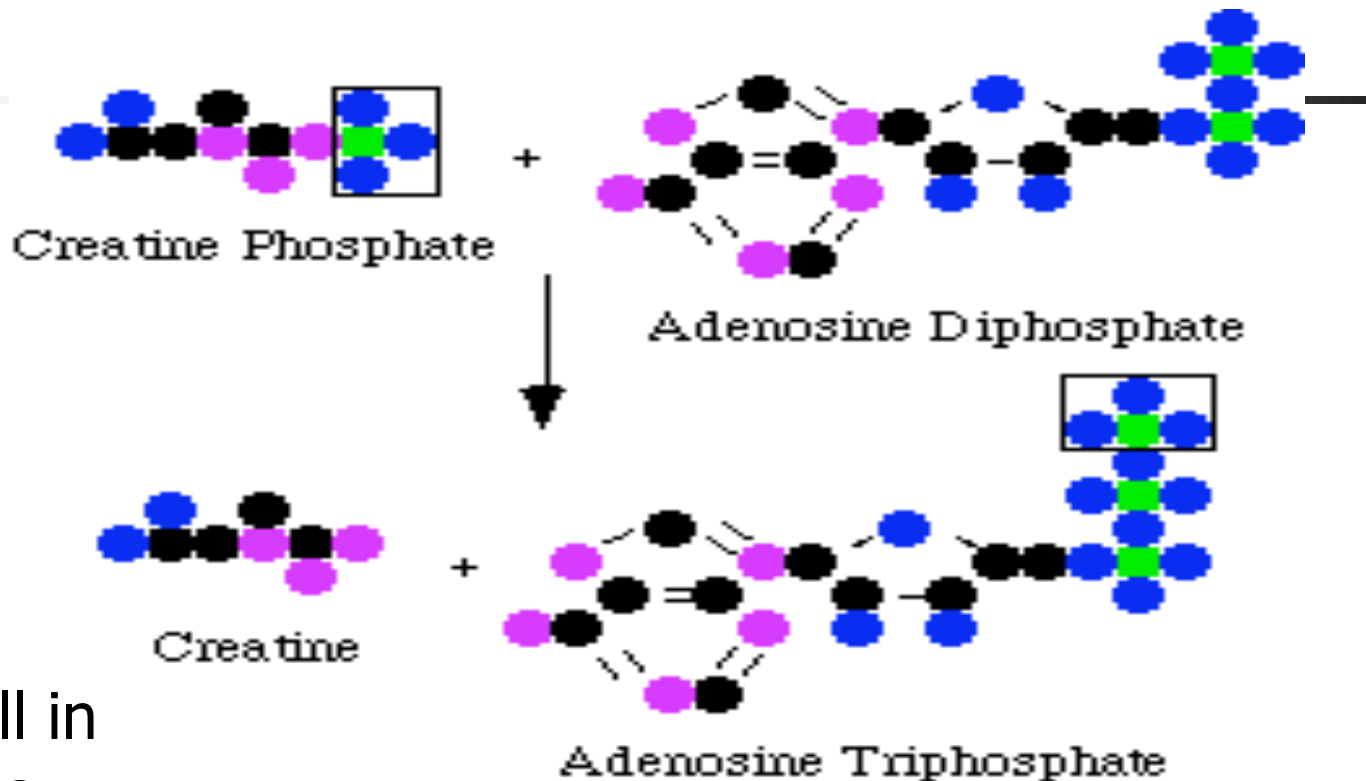
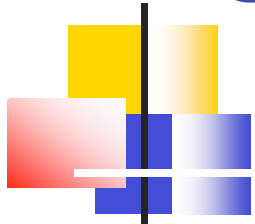
● Nitrogen

● Oxygen

● Phosphorous

From Muscle Physiol Lab, VA
Medical Cntr, San Diego, CA

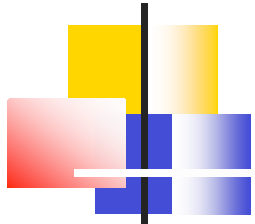
Creatine Phosphate



Prevents fall in
ATP levels

- Carbon
- Nitrogen
- Oxygen
- Phosphorous

From Muscle Physiol Lab, VA
Medical Cntr, San Diego, CA



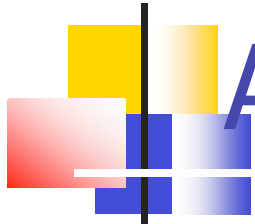
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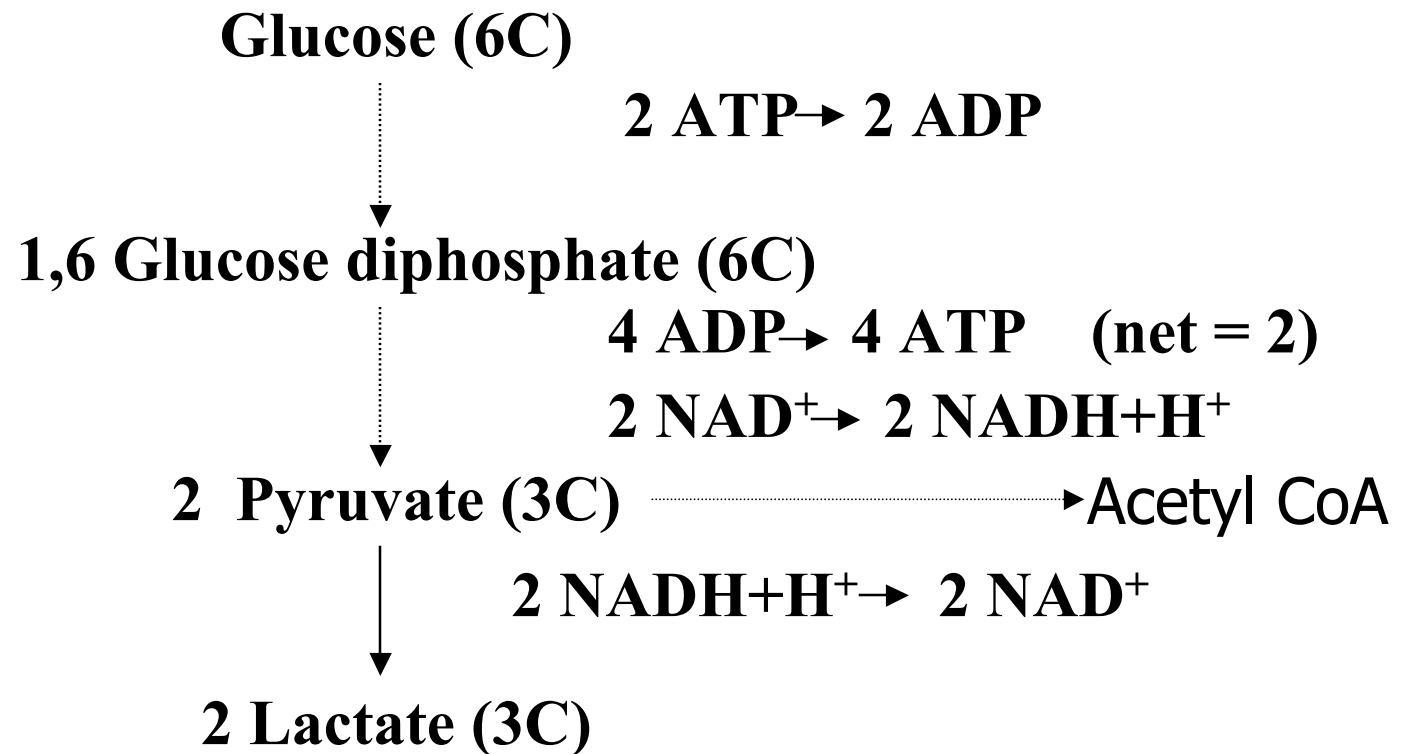


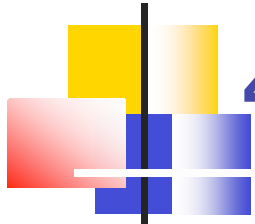
400 m sprint

- 15 x RMR or 0.25 kcal/s
- 1 min, 15 kcal
- Primary energy source
 - Anaerobic glycolysis or fast glycolytic
 - Muscle glycogen – 200 to 300 g
 - Theoretical max 5-8 min
 - Practical max 1 min
- Anaerobic
- Cytosol



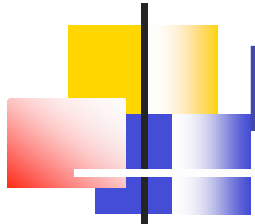
Anaerobic pathway





400 m sprint

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- 1 min, 15 kcal
- Primary energy source
 - Fast glycolytic
 - Muscle glycogen – 200 to 300 g
 - Theoretical max 5-8 min
 - Practical max 1 min
- Anaerobic
- Cytosol



Marathon

- 10 x RMR, 0.17 kcal/sec
- 2 to 3 hr, 1200 kcal
- Primary energy source
 - Muscle glycogen
 - 300 g, 1200 kcal
- Aerobic
- Mitochondria

AEROBIC PATHWAY

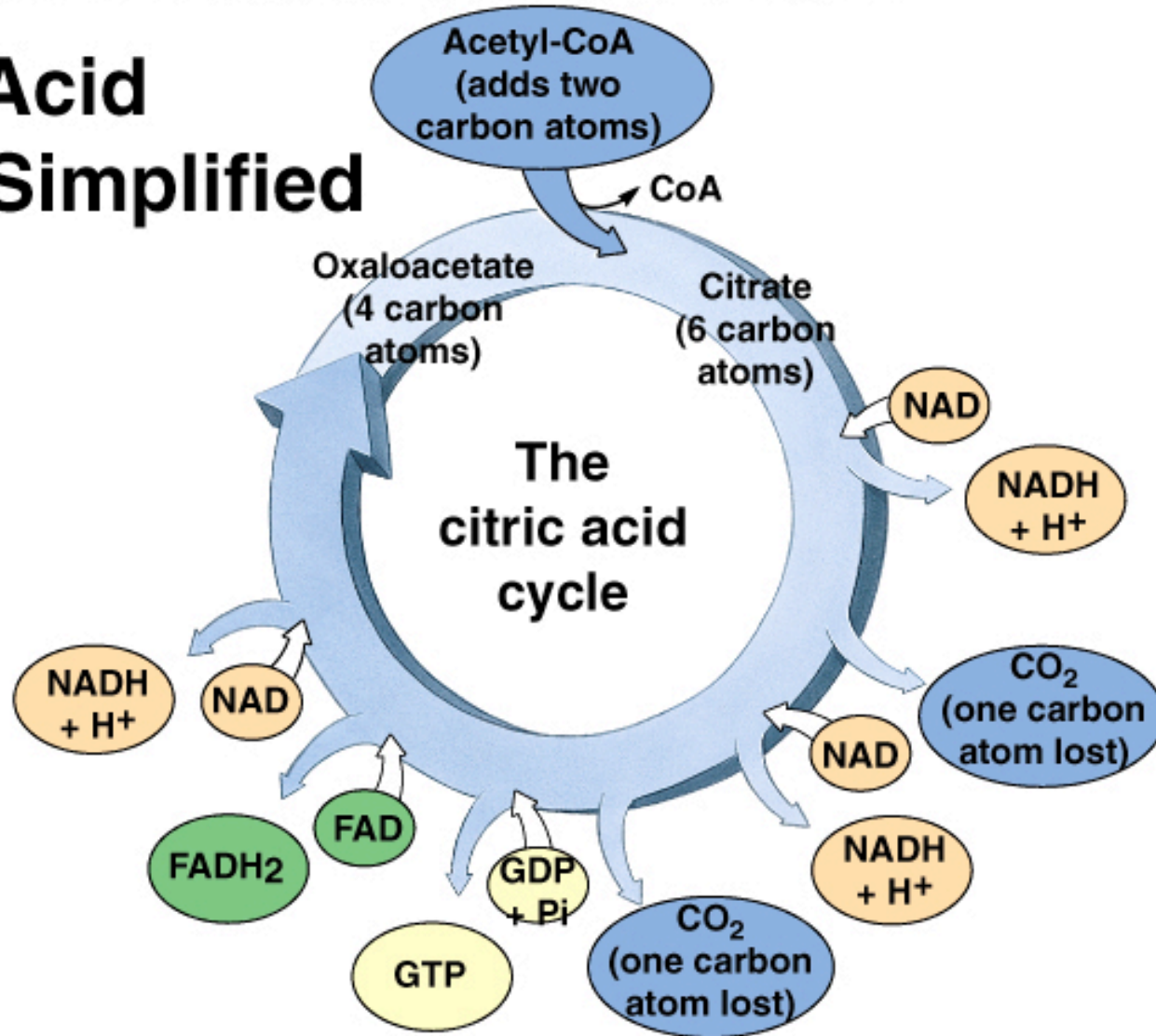
Location: mitochondria

Input: 2C units

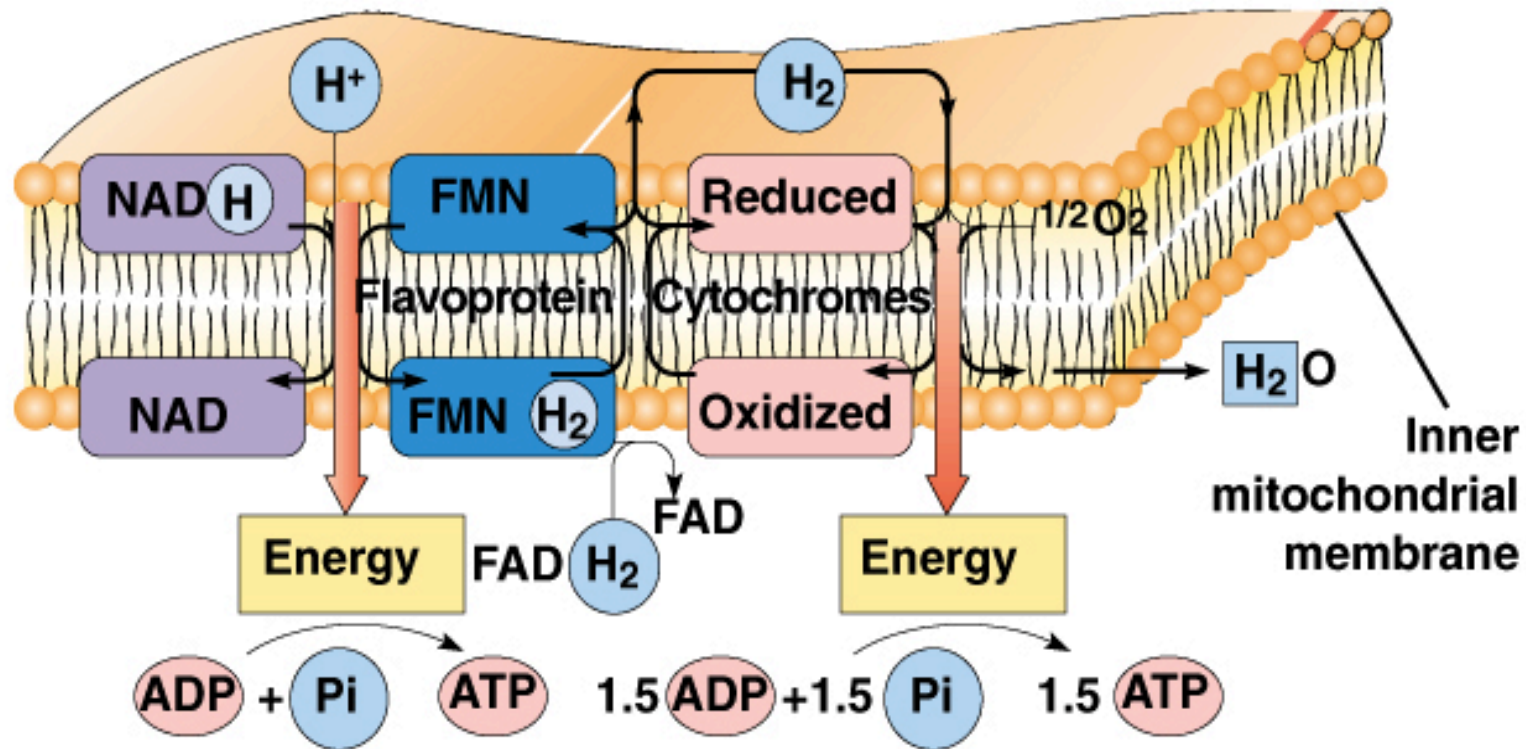
Output: NADH & CO₂

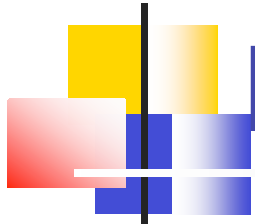
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Citric Acid Cycle Simplified



Electron Transport Chain Simplified



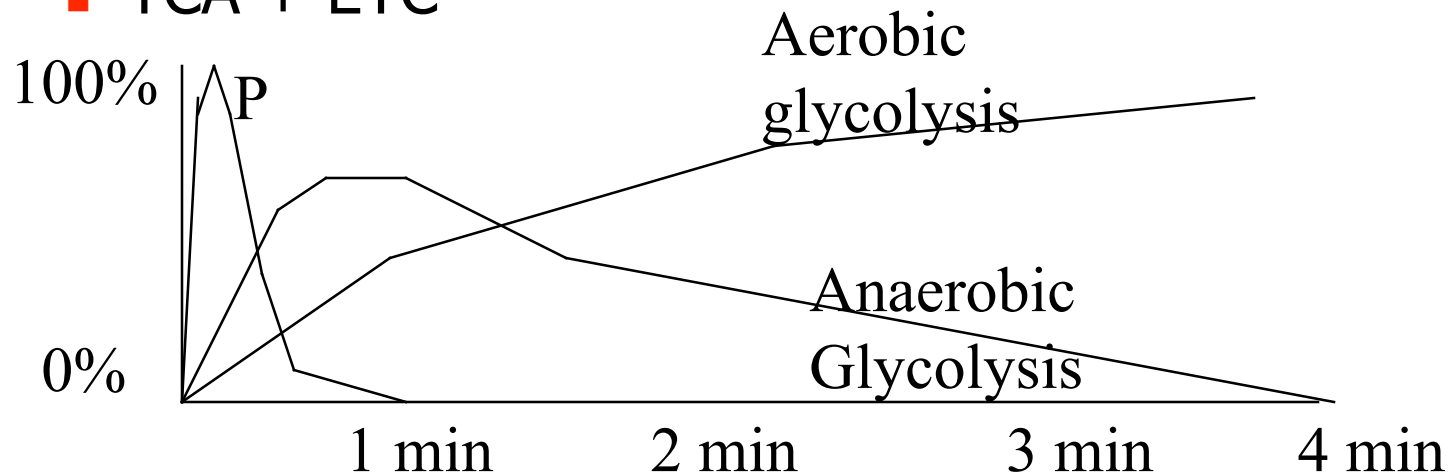


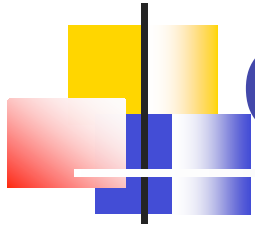
Marathon

- 10 x RMR, 0.17 kcal/sec
- 2 to 3 hr, 1200 kcal
- Primary energy source
 - Muscle glycogen
 - 300 g, 1200 kcal
- Aerobic
- Mitochondria

Energy Hierarchy

- Anaerobic
 - ATP
 - CrP
 - Anaerobic Glycolysis
- Aerobic
 - TCA + ETC





Girls H.S. Cross Country

4K run

