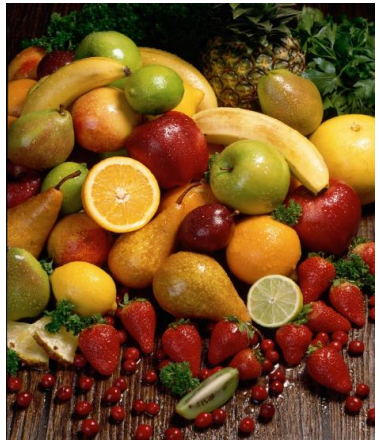
Energy Systems

Three Key Energy Nutrients

- The food that we eat is broken down into three nutrients during digestion:
- **Protein**
- **Fats**
- **Carbohydrates**



Carbohydrates

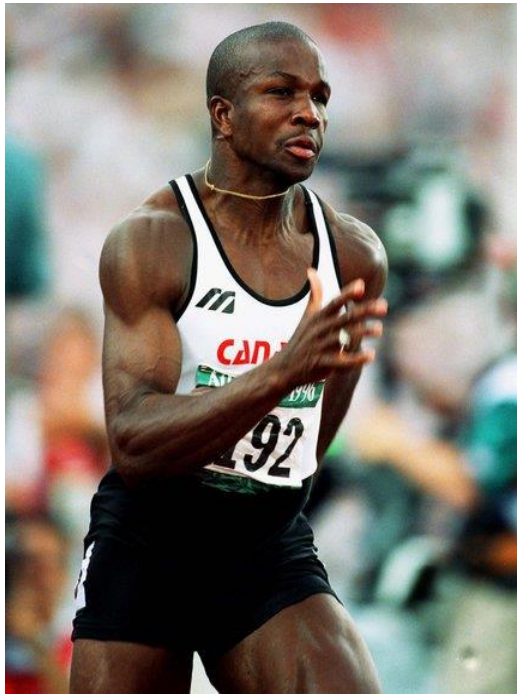
- Yield 4 calories per gram
- Originate from plants i.e. Fruits and vegetables, and grains i.e. Bread and pasta
- In the body carbohydrates are broken down into **glucose**
  - Stored in the liver as ***glycogen*** : glucose that is stored in this way can be broken down as needed and carried through the body by blood and used as an energy source

ATP – Adenosine Triphosphate

- Before nutrients can be used as energy they need to be reformed into a universal form of energy that can be used for muscle contraction
- This form of energy is ATP
- ATP consists of 3 phosphates attached by high-energy bonds to adenosine
- Energy is released when phosphate is broken from the ATP molecule
- **ATP --> ADP + P +ENERGY**

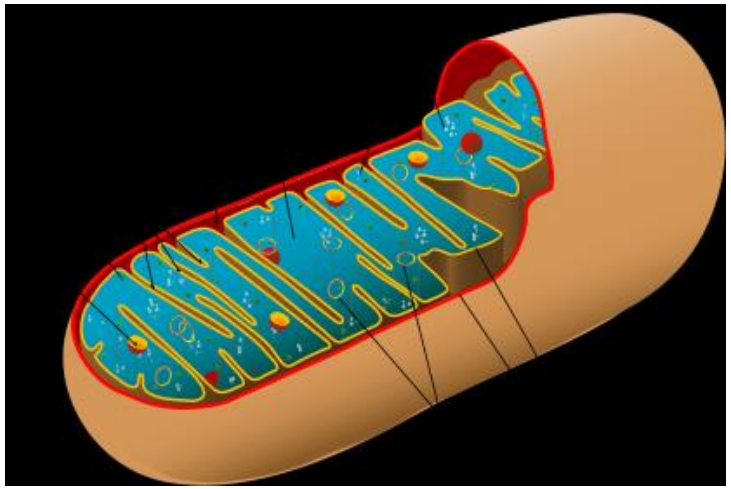
Two Energy Systems - Anaerobic

- anaerobic (without oxygen): occurs quickly in the muscle fibre
- uses chemicals and enzymes that are already present
- Short-lived physical actions



Two Energy Systems - Aerobic

- Occurs in mitochondria
- Leads to complete breakdown of glucose
- Fats and proteins are also used



Three Metabolic Pathways

- Anaerobic and aerobic systems overlap
- Used in all physical activity
- Within the 2 energy *systems* there are 3 *metabolic pathways*
  - ATP-PC (anaerobic alactic)
  - Glycolysis pathway (anaerobic lactic)
  - Cellular respiration (aerobic)

ATP-PC (Anaerobic alactic)

- First and simplest pathway
- Yields enough ATP for about 10-15 seconds of work
- PC = phosphocreatine, a compound that is stored in the muscle and readily accessible
  - Can be broken off easily and can be used to convert ADP back to ATP
  - PC + ADP --> ATP + CREATINE
  - Ex: 100 m, high jump, etc.

ATP-PC cont...

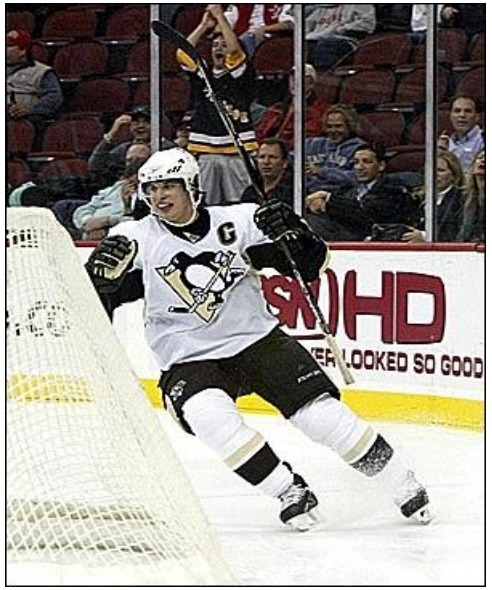
- “alactic” since it doesn't create lactic acid as a by-product
- This system relies solely on readily available phosphocreatine found in the muscles
- Does NOT involve the metabolism (breakdown) of glucose as an energy source

Glycolysis (Anaerobic Lactic)

- This pathway is the first step to the complete breakdown of glucose
- The amount of ATP produced by this process will allow an athlete to engage in a high level of performance for an additional 1-3 minutes
- Glucose is partially broken down to provide ATP
- More complex than ATP-PC – involves 11 reactions and yields twice as much ATP
- Does not require oxygen to rapidly produce ATP

Glycolysis cont...

- Through a series of reactions, glycolysis transfers energy from glucose and rejoins phosphate to ADP (creates 2 molecules of ATP)
- C6H12O6 + 2ADP + 2P --> 2 C3H6O3 + 2ATP + 2 H20
- (glucose) (lactate)



Glycolysis – Pyruvate and Lactic Acid

- **Pyruvate** (pyruvic acid) is the main product of glycolysis
- Because there is no oxygen this process stops at the glycolysis stage
- Pyruvic acid is then converted into **lactic acid**
  - Leads to muscle pain and exhaustion
  - Ex: hockey shift, 400-800m in track, etc.
  - With the presence of oxygen, pyruvate begins the aerobic system

Aerobic System

- Occurs in mitochondria therefore referred to as **cellular respiration**
- At this stage fats and proteins can be used as energy sources
- Fats are the predominant source of energy in exercise lasting longer than 20 min., proteins are used in chronic situation such as starvation
- Results in the complete breakdown of glucose

Aerobic System cont...

- $C_6H_{12}O + 6O_2 + 36ADP + 36P \rightarrow 6CO_2 + 36\ ATP + 6H_2O$
- Yields the highest quantity of ATP (36)
- Ex: marathon running, triathlon, etc.
- Cellular respiration involves three separate sub-pathways:
  - Glycolysis
  - Krebs cycle
  - Electron transport chain

Sub-pathway: Glycolysis

- Same as the anaerobic lactic system **EXCEPT**:
- In the presence of oxygen, pyruvic acid is converted to **acetyl CoA** instead of lactic acid
- Acetyl CoA then enters Krebs cycle

Sub-pathway: Krebs Cycle

- After 8 reactions, 2 ATP molecules are produced
- Also produced are new compounds capable of storing “high energy” electrons
- The high energy electrons produced in the Krebs cycle are sent to the mitochondria (electron transport chain)

Sub-pathway: Electron Transport Chain

- Final stage of cellular respiration
- Large amounts of ATP are produced
- Carbon dioxide and water are the only by-products