Three Metabolic Pathways
(Text Pg 82 – 86)

1. ATP – PC (Anaerobic Alactic)

2. Glycolysis (Anaerobic Lactic)

3. Aerobic Oxidative (Aerobic Alactic)
   - Oxidative Phosphorylation
   - CELLULAR RESPIRATION (Glycolysis → Krebs Cycle → Electron Transport Chain)

1. The High Energy Phosphate System

   When? Initial onset of activity (quick bursts)
   Where? Cytoplasm
   Peak Production Lasts? 10 – 15 seconds
   Substrate? Phosphocreatine
   Process? One reaction regulated by enzymes (Creatine Kinase)
      - PC + ADP → ATP + Creatine (See diagram below)

   Limitations:
      - Muscle only has small amounts of PC available
      - Only one ATP per reaction
   Benefits: Very fast rate of production of ATP
   Replenishment: during recovery phase (2 – 5 minutes) requires ATP (P, + creatine + energy ↔ ATP)
   Where in sports? Sprints, throws, jumps, power moves or explosive power

![Diagram of the High Energy Phosphate System]

Creatine Kinase (ENZYME) is responsible for the breakdown of CREATINE PHOSPHATE.
2. Anaerobic Glycolytic System (Glycolysis / Lactic Acid System)

**When?** All activities yet takes time to reach max output  
**Where?** Cytoplasm  
**Peek Production Lasts:** ~ 1 – 3 minutes  
**Substrate:** Glucose (6 carbon sugar molecule)  
**Process:** 11 Reactions Total  
- 10 reactions: 1 glucose → 2 Pyruvate molecules  
- 1 reaction: 1 Pyruvate → Acetly CoA (pyruvate oxidation)  
**Overall reaction**  
- \( \text{C}_6\text{H}_{12}\text{O}_6 + 2\text{ADP} + 2\text{P}_i \rightarrow 2\text{C}_3\text{H}_6\text{O}_3 + 2\text{ATP} + 2\text{H}_2\text{O} \)  
- Uses energy from glucose to join Pi to ADP → ATP  
- Also Get 2 NADH molecules (Nicotinamide Adenine Dinucleotide) *(See diagram below)*

**Limitations:** produces lactic acid when there is insufficient O2  
- Lactic Acid = fatigue & pain  
- Build up of lactic acid = inability to breakdown glucose  
- Can metabolize lactic acid during cool down (aerobic exercise)  

**Benefits:**  
- Twice as many ATP as (ATP-PC system)  
- Relatively quick rate of ATP production,  
- Glucose is readily available in muscle and blood for this process (stored form of glucose is called glycogen)  

**Replenishment:** During exercise and cool down to eliminate lactic acid, food consumption to replenish glucose stores  
**Where in sports?** Middle distance (400 – 800 m), hockey shift
3. The Aerobic Oxidative Systems (Cellular Respiration)

Aerobic catabolism (in the presence of O₂) of Carbohydrate’s, fats & proteins to make ATP

**When?**
- Always running, takes upwards of a minute to reach full capacity (depends on intensity)
- Major contributor after ~ 90 seconds of exercise.

**Where?** Mitochondrion

**Peak Production Lasts?** indefinitely (we stop exercising before the pathways stops or before we run out of substrates)

**Substrates:** glucose, fats & proteins

**Process:**
- **Aerobic Glycolysis** (Cytoplasm)
  - 2 ATP, 2 NADH and 2 Pyruvate
- **Pyruvate Oxidation**
  - 2 Pyruvate → Acetyl CoA (2 more NADH)
- **Krebs Cycle** (Mitochondrion)
  - 6 NADH & 2 FADH₂ + 2 ATP

This cycle (also called Citric acid cycle) happens twice for each glucose molecule. This is because the result of Glycolysis is 2 Pyruvate molecules.
• **Electron Transport Chain** (in mitochondrion)
  > Converts NADH (3 ATP) and FADH\(^2\) (2 ATP)

All together we get the following:

\[
\begin{align*}
C_6H_{12}O_6 + 6O_2 + 38ADP + 38P_i & \rightarrow 6CO_2 + 38ATP + 6H_2O \\
C_6H_{12}O_6 + 6O_2 + 36ADP + 36P_i & \rightarrow 6CO_2 + 36ATP + 6H_2O
\end{align*}
\]

**Limitations:** Takes longer to start i.e. there is a lag period before production of ATP meets demands of activity

**Benefits:** One glucose = 36 – 38 ATP (18 - 19 X’s better than glycolysis)

**Replenishment:** During recovery & food consumption

**Where in sports?** Distance running, soccer, rugby, triathlon

**NOTE:** Cellular respiration also includes:
- Beta Oxidation (breakdown of fats to produce ATP in the presence of O\(_2\))
- Oxidative Deamination (breakdown of protein to produce ATP in the presence of O\(_2\))