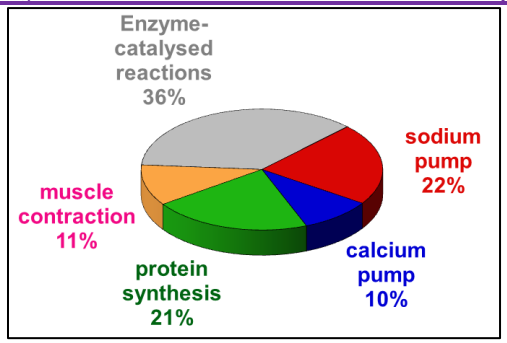
# Unit VII – Problem 1 – Biochemistry: Muscle Energetics

- **Energy is required to perform work such as:**
  - Muscle contraction (using ATP to attach and detach myosine heads from actin filaments).
  - To control the work of ionic pumps thus maintaining the concentration of different ions inside and outside the cell.
  - Synthetic processes (anabolism).
  - Digestion/absorption of nutrients and glandular secretions.
- **Energy cannot be created or destroyed but we can transform it from one different type to another** (example: chemical energy stored in food will be transferred to kinetic energy in muscles).
- **The main source of energy in our body is ATP (Adenosine Tri-Phosphate)**. It is composed of adenosine (which is a nucleoside) and one (AMP), two (ADP) or three (ATP) phosphate groups.
- **There is a 10g total body content of ATP. Most of this energy is used in:**



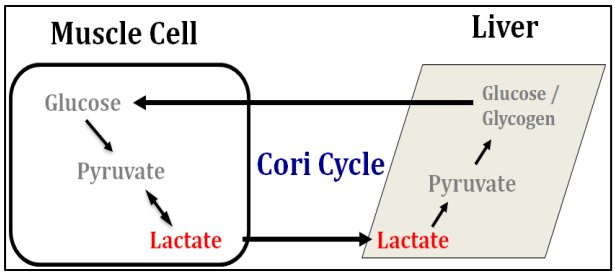

- **Fuel sources for muscle contraction can be those in the muscle itself:**
  - Breakdown of glycogen stored in muscles (for local use only: this glycogen will not elevate blood glucose levels).
  - Fat stored in muscles in the form of TAG.

  Or those in blood:
  - Glucose.
  - Fatty acids carried by plasma lipoproteins.

  ***Note***: ketone bodies (produced by the liver) are used in prolonged starvation.
- **Selection of muscle fuel depends on:**
  - **The type of muscle fiber:**

| Type I – red muscle fibers - slow twitch fibers | Type II – white muscle fibers – fast twitch fibers |
|---|---|
| Rich in mitochondria and myoglobin, high citric acid cycle activity, relatively low rate of glycolysis | Poor in mitochondria and myoglobin, high rate of glycolysis, type IIA have high citric acid cycle activity, type IIB have low citric acid cycle activity |

  - **Whether in fed (using glucose) or fasting state (using fatty acids and ketones).**
  - **Intensity of exercise.**
- **ATP sources form muscle contraction:**
  - **Creatine-phosphate pathway**: fastest – only for seconds (5-10 sec) – creatine phosphate will be converted to creatine by the action of the enzyme creatine kinase providing a phosphate group to generate ATP from ADP.
  - **Glycolysis (anaerobic)**: fast – only for 1-3 min - accumulation of lactate leading to fatigue (> 80% of lactic acid will circulate to the liver in a cycle known as Cori cycle and it will be converted to glucose which can be used again by the muscles: look to the figure)



- **Cellular respiration (aerobic):** the best long term source – occurring when there is enough oxygen (pyruvate will be converted to acetyl CoA which will enter the citric acid cycle and then complete in the oxidative phosphorylation).

- **Creatine + ATP** $\overset{\text{CK}}{\rightleftharpoons}$ **creatine phosphate + ADP**
- **Creatine and creatinine**: arginine is converted to guanidoacetate which will further be converted to phosphocreatine. Phosphocreatine is converted to creatine by creatine kinase. It can also be converted to creatinine non-enzymatically (a useless product which will be excreted rapidly).
- **Respiratory Exchange Ratio (RER)** = $\frac{CO_2\ produced}{O_2\ consumed}$
  - It can be measured at the nose or mouth unlike Respiratory Quotient (RQ).
  - Serves as an estimate of RQ.
  - RER of carbohydrate = 1.00
  - RER of lipids = 0.7
- **Respiratory Quotient (RQ)** = $\frac{CO_2\ produced}{O_2\ consumed}$ **at cellular levels.**
- **Lactic acid:**
  - **Causes fatigue:**
    - ✓ Irritation of local muscle.
    - ✓ Decreased pH of cellular environment & bloodstream.
  - **Effect of training:**
    - ✓ Increased lactate tolerance.
    - ✓ Decreased lactate formation by 20%-30% at any given workload.