Aerobic and Anaerobic Metabolism in Muscle

Types of Skeletal Muscle Fibers

Fast Fibers
Type II, White, Glycolytic
Large diameter
Pale color
Easily fatigued (Anaerobic)
Rapid powerful contractions
Densly Packed Myofibrils
Short Duration

ATP FROM: Anaerobic Glycolysis

Slow Fibers
Type I, Red, Oxidative
Small diameter (1/2 of fast)
Darker color due to mygolobin
Fatigue-resistant (no lactic acid)
3 times as long to contract
Abundant Mitochondria+Capillaries
Can contract for long period of time

ATP FROM: FA B-Oxidation, TCA cycle (Krebs) & ETC

Because skeletal muscles contain both types of muscle fibers they have the capability to undergo aerobic or anaerobic metabolism

Energy Source:

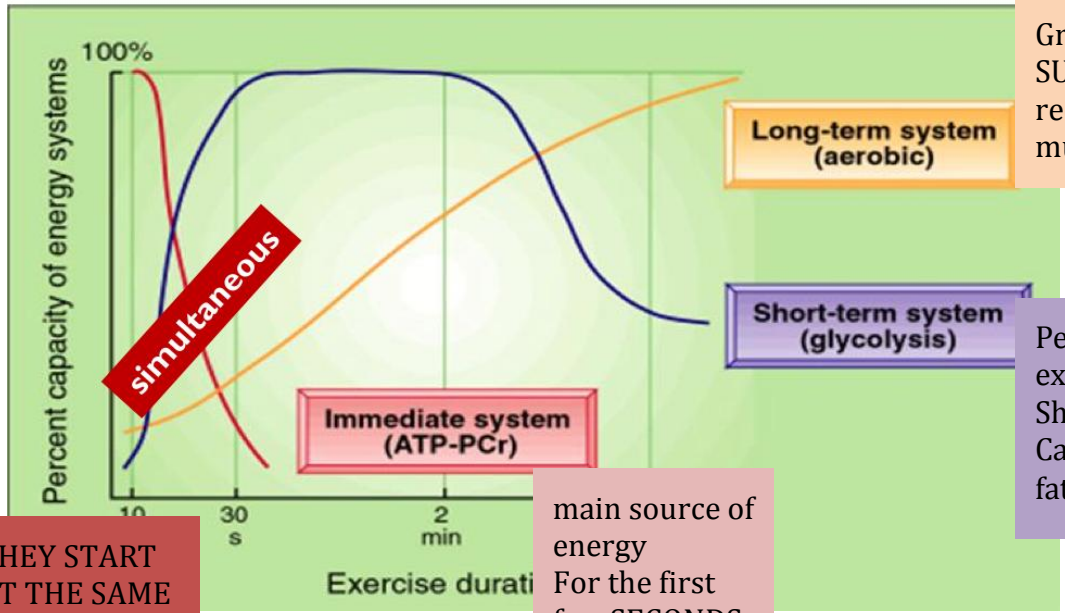
1. **ATP** a nucleotide coenzyme Adenosine Triphosphate
   the most important form of chemical energy stored in the cells.
   the currency for energy throughout entire body

   To release energy: Breakdown of ATP into ADP+PO4
   This energy is used for ALL body functions. Ex: biosynthesis, membrane transport and muscle contraction

Muscles store limited amount of ATP, enough to power 4-6 seconds of activity ONLY
➔ resting muscles must have OTHER stored energy

How to produce ATP?

1. Creatine Phosphate
2. Aerobic Metabolism**
3. Anaerobic Metabolism **



Gradual then SUSTAINED & reduces risk of muscle fatigue

Peaks with intense exercise
Short lasing
Causes muscle fatigue by lactic acid

THEY START AT THE SAME TIME

main source of energy
For the first few SECONDS

*Contribution of each system differs depending on exercise Intensity & Duration
For example when the exercise is highly intense and short ➔ ANAEROBIC SYSTEM
When the exercise is of low intensity and long duration (over 4mins) ➔AEROBIC SYSTEM

MAGNITUDE OF ENERGY FROM ANAEROBIC SOURCES

Depends on person's capacity and tolerance for lactic acid accumulation
Athletes have better tolerance for lactic acid

AEROBIC	ANAEROBIC
With OXYGEN	Without oxygen
Source: FATTY ACIDS then carbohydrates	Source: Carbohydrates (glycolysis)
End Products: CO2, H20 & ATP	End Products: Lactate & ATP

Resting Muscle: Fatty acids are used to build ATP reserve
Moderate Activity: Fatty acids and glucose are used ➔ATP ➔ power the contractions
Peak Activity: ATP is produced through glycolysis (anaerobic) with lactic acid which contributes to muscle fatigue

MUSCLE FATIGUE Can No Longer Contract

What Causes Muscle Fatigue??

1. Build up of lactic acid (low PH of sarcoplasm)
2. Exhaustion of Energy resources (Increased ADP & Reduced ATP)
3. Ionic Imbalance (Na-K pumps)

How will it be able to Contract Again??

Recovery Period: begins IMMEDIATELY after the intense activity ends
Oxygen Debt: excess post-exercise oxygen consumption (to make up for the Anaerobic activity) by 1. Increased respiration and 2. Increased blood vessel permeability.
Amount of oxygen required during resting period to restore muscle to normal conditions

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RESTING MUSCLE

Take up fatty acids from the blood stream (produced by lysis of adipose tissue)
Fatty Acids are oxidized inside the mitochondria of the muscle to produce ACETYL-CoA + Several NADH & FADH2

What Happens to Acetyl-CoA? It enters the **KREBS CYCLE** and produces:
CO2, ATP, NADH, FADH2 and oxaloacetate

**NB: NADH & FADH2 enter the electron trasport chain to produce ATP (By OXIDATIVE PHOSPORYLATION)

ATP USE: used to maintain cellular housekeeping duties
Ex: for glycogenesis and to create creatine phosphate
REMEMBER: creatine + ATP ➔Creatine phosphate

CONTRACTING MUSCLE

PEAK ACTIVITY:

At exercise, first we use the stored ATP ➔ after 15 seconds we start using the creatine phosphate. ((this phosphagen system dominates for 100m dash events and weight lifting 'High Intensity Short duration exercises/activities'))
➔AFTER this system is used the cell must find another ATP source!!
*__ANAEROBIC METABOLISM__ (lasts 45 – 60 seconds)

REMEMBER: Glycogen → Glucose ➔ 2 Pyruvic acid -- Releasing 2 ATP and 2 NADH
2 pyruvic acid ➔ lactic acid (restores 2 NAD+)
Lactic acid leaves muscle ➔ blood ➔ liver (turns it back to GLUCOSE) ➔blood ➔muscle again

WHY IS ANAEROBIC METABOLISM INEFFICIENT??

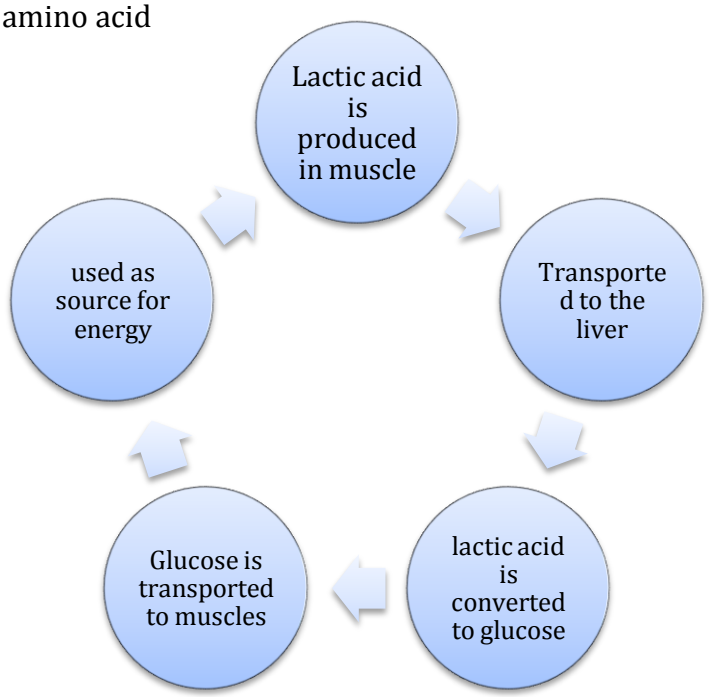
Because large amount of glucose is used for VERY SMALL amount of ATP
+ produces lactic acid which contribute to muscle fatigue.
this is used for sports that require bursts of speed and activity. Ex: BASKETBALL!

*AEROBIC METABOLISM (COMPLETE COMBUSTION)

is more persistent, fatigue resistant and produces high amounts of energy (38 ATP)
Mainly when respiratory and CVS 'catch up' .. but even before it does some aerobic respiration will occur by MYOGLOBIN (muscle protein)
It binds and stores OXYGEN (reservoir for O2 in muscles)
During rest and moderate exercise, AEROBIC metabolism gives 95% of necessary ATP
Source: Fatty Acids, Pyruvic ACID and amino acid

THE CORI CYCLE:

Also known as the lactic acid cycle



THE GLUCOSE ALANINE CYCLE: [TRANSAMINATION]

In the MUSCLE:

PYRUVATE + NH2
from glycolysis — from normal protein degradation

Alanine → via BLOOD to → LIVER

In the lLIVER:
Removal of the NH2* to convert it back to pyruvate
Pyruvate converted to glucose (via gluconeogenesis), transported back to MUSCLE and used as an energy source
*the NH2 is converted into urea and excreted