Energy Systems and How Muscles Work Talk

ATP

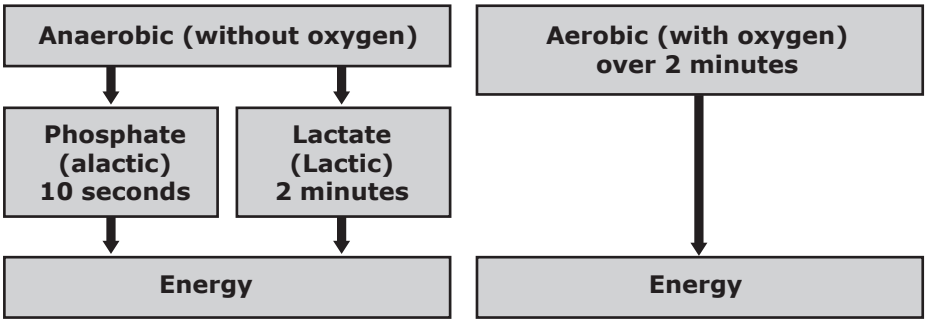
ATP is used for muscle contractions, chemical reactions, circulation, reproduction and lactation, gland secretion, nervous system, immune system

ATP used for activity to release energy for muscle contraction comes from food substrates.

Energy + ADP + P = ATP

The energy system that muscles use to rebuild ATP depends on intensity and duration

Ways to produce energy

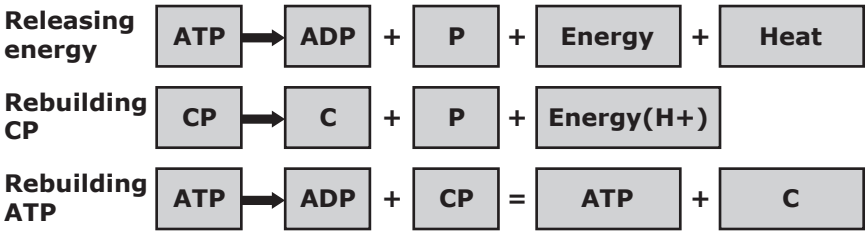


Phosphate energy system

- For short bursts of energy
- High force and energy production
- Short term (10 seconds)

Fuel - creatine phosphate (CP)
- Poor endurance

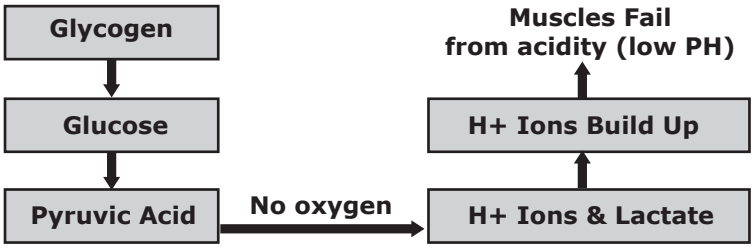
Recovery - Quick (2 minutes to 5 minutes)
Metabolic by-product - None



Lactate energy system

- For short sustained burst of energy
- Medium force and energy production
- Medium term (2 minutes)
- Average endurance

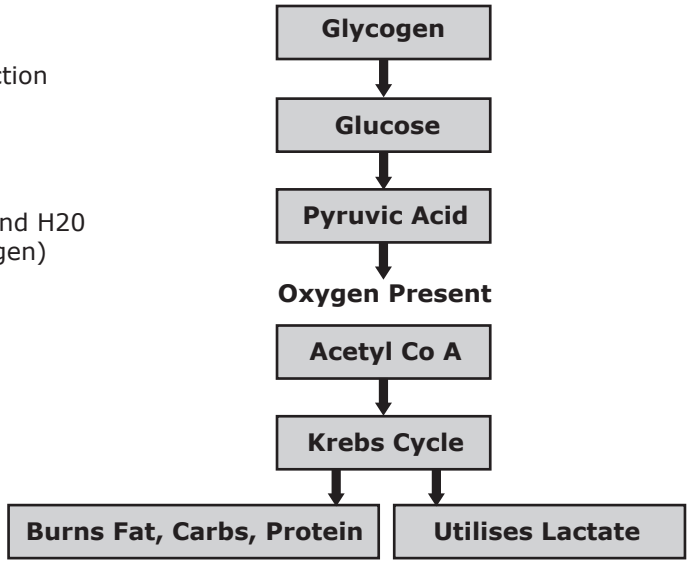
Fuel - Glycogen
Recovery - Significant (30 minutes to 120 minutes)
Metabolic by-product - Hydrogen ions and lactate
Limitations - Hydrogen ions (not lactate)



Aerobic energy system

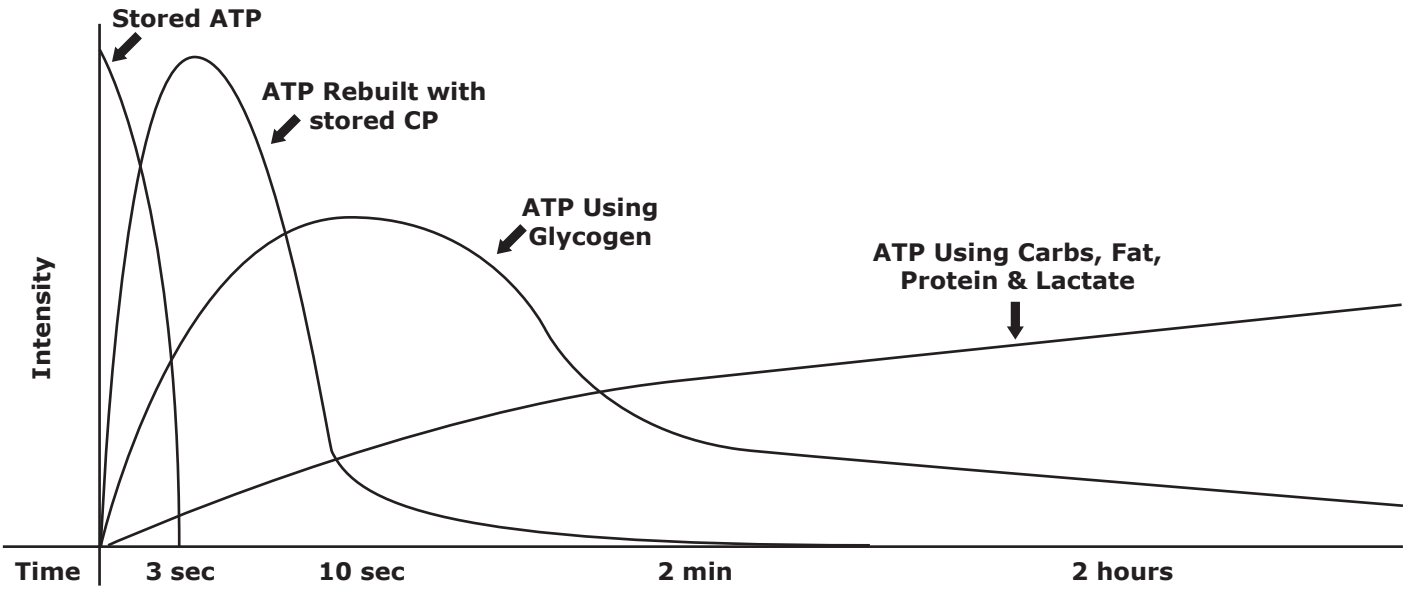
- For sustained energy
- Low force and energy production
- Long term (2 min onwards)
- Great endurance

Fuel - Glycogen, fat, protein
Recovery - Long
Metabolic by-products - CO2 and H20
Limitation - fuel supply (glycogen)



	Phosphate	Lactate	Aerobic
Intensity	Explosive Very High Intensity 95-100% of max effort	High Intensity 60-95% of max effort	Low Intensity Up to 60% of max effort
Duration	1-10 Seconds of explosive activity	10 seconds to 2 minutes 95% at 30 seconds 60% at 2 minutes	At low intensity there is no limit (glycogen amount)
Fuel	Phosphocreatine	Carbohydrates only in the form of muscle glycogen and blood sugar	Carbohydrates Fat, Protein, Lactate
Waste Products	No waste products	Lactate	Carbon Dioxide and water
Recovery	100% 2 minute plus 50% after 30 seconds	30 minutes - 2 hours to remove waste products	Time to replace fuel stores

Energy Timeline



What are muscles?

Muscles come in 3 kinds: smooth, skeletal and cardiac
Smooth: blood vessels, digestive tract and airways - non striated, involuntary
Skeletal: the muscles that make us move - striated, voluntary
Cardiac: the heart - striated, involuntary

Type 1 vs Type 2a vs Type 2b

Muscle are generally broken down into 2 categories slow twitch and fast twitch.
Type 1 are also known as red fibres, and slow twitch. They are the muscle we use most often throughout the day and have the highest endurance and lowest strength. They are also postural muscles.

Type 2a are a blend of fast and slow twitch and can take the characteristics of the dominant usage i.e. a marathon runners type 2a will be more like type 1, vs a powerlifter's will be more like 2b

Type 2b are also known as white fibres and fast twitch. The are high force and have a very short usage before they tire. They are also the muscle that will most likely grow thicker and make the muscles look larger.

Activation order

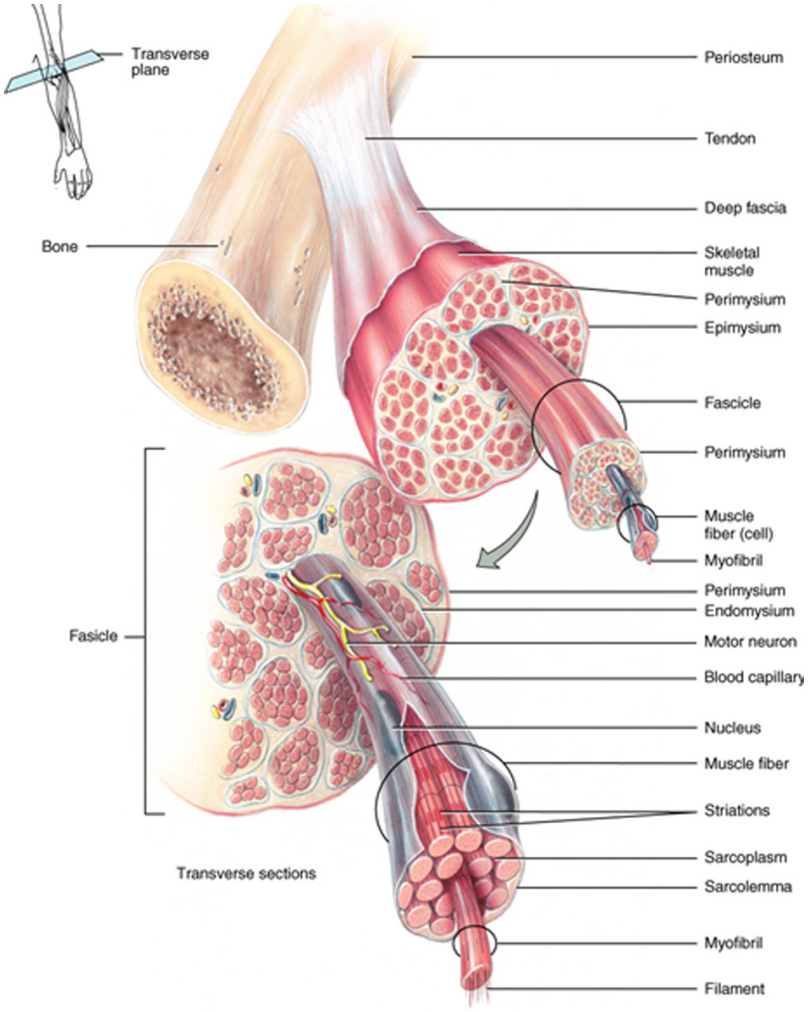
The most popular theory of activation is that the body will only activate type 2b if type 1 and type 2a were unable to perform the task. So if you are exercising with a very light weight you may be only recruiting type 1 or type 2a. This means that you are most likely using your endurance fibres that are conditioned to put up with repetition of lighter weights without stressing the body to change.

An example of this sequence is when you tried to lift an object you thought would be light and felt your body initial struggle with the surprise heaviness. But then you prepared your body and the box was lifted with a little effort.

Motor Units

Muscle are grouped together in motor units. It would be impossible to have one motor nerve attached to every individual muscle fibre in the body, so the body has a system that groups muscle together in units.

For example in the eye there are an almost 1:1 ratio whereas in the quads the ratio could be 1:150.



Muscular Contractions

Rest
Muscle Activation
Muscle Contraction
Recharging
Relaxation

Step 1: Rest
- Cross bridges not engaged with active sites of active filaments
- No muscle tension

Step 2: Muscle Activation
- Neural impulse from central nervous system at motor endplate
- Depolarisation occurs at motor endplate
- Release of transmitter substance (acetylcholine)
- Acetylcholine transported into muscle fibres via the transverse tubule system
- Calcium released from the sarcoplasmic reticulum
- Calcium binds with troponin tropomyson complex on actin filament
- Active site exposed
- Cross bridges bind with active sites on actin filaments

Step 3: Muscle Contraction
- Energy produced by ATP
- Cross bridges swivel and collapse (power stroke)
- Actin filaments slide over myosin filaments

Step 4: Recharging
- ATP on cross bridges are resynthesised
- Cross Bridges dissociates from active sites
- Cross bridges contact new binding sites

Step 5: Relaxation of Muscle
- Nerve impulses cease
- Calcium pumped back into sarcoplasmic reticulum
- Active sites are shut
- Muscle tension ceases and muscles return to resting state

Muscle Growth

There are commonly discussed two different types of muscular hypertrophy: sarcoplasmic and myofibrillar. Sarcoplasmic hypertrophy is characteristic of the muscles of certain bodybuilders while myofibrillar hypertrophy is characteristic of Olympic weightlifters. These two forms of adaptations rarely occur completely independently of one another, one can experience a large increase in fluid with a slight increase in proteins, a large increase in proteins with a small increase in fluid, or a relatively balanced combination of the two.

During myofibrillar hypertrophy, actin and myosin contractile proteins increase in number and add to muscular strength as well as a small increase in the size of the muscle. Microtrauma, which is tiny damage to the fibres, may play a significant role in hypertrophy. When microtrauma occurs (from weight training or other strenuous activities), the body responds by overcompensating, replacing the damaged tissue and adding more, so that the risk of repeat damage is reduced. Damage to these fibres have been theorized as the possible cause for the symptoms of delayed onset muscle soreness (DOMS), and is why progressive overload is essential to continued improvement, as the body adapts and becomes more resistant to stress.

Sarcoplasmic hypertrophy is an increase in the volume of the non-contractile muscle cell fluid, sarcoplasm. This fluid accounts for 25-30% of the muscle's size. Although the cross sectional area of the muscle increases, the density of muscle fibres per unit area decreases, and there is no increase in muscular strength. This type of hypertrophy is mainly a result of high rep, "bodybuilder-type" training.

Muscle tension

Muscle tension is the most important ingredient in muscle growth. Increased muscle tension speeds the rate that amino acids enter muscle cells. Muscle is made of proteins, and proteins are made of amino acids. The faster amino acids enter cells, the bigger muscles grow.

Muscles will not grow unless they are stressed. All the supplements in the world will do you absolutely no good unless you have a well structured training program that puts your muscles under the right amount of tension. Tension creates different effects that increase muscle size. It stimulates cellular processes that form proteins. This occurs in the genetic material of the cells. When muscles are put under tension, genes instruct the muscles to make new contractile proteins. (It's still unknown what mechanism makes genes do this.) When tension ceases, genes instruct muscle cells to remove contractile proteins. Tension also increases the sensitivity of two anabolic hormones important for muscle growth: insulin and testosterone.

The quality and duration of tension are critical. You must balance absolute intensity (i.e. how much weight you lift) with the length of time the tension exerted (i.e. how many reps you do). Maximum tension occurs during an isometric contraction or when you do only one max rep. However, during single reps, the length of time tension is exerted may be less than optimal. Therefore, most people usually do multiple reps. However, if you do too many reps, you have to cut down on intensity, which decreases potential muscle growth. It's a delicate balance.