ENERGY SYSTEMS

AEROBIC METABOLISM

We obtain energy from fuels (carbohydrate, protein and fat) in the presence of oxygen by means of aerobic metabolic pathways. The controlled release of energy during aerobic metabolism allows for a large amount of energy in glucose to be stored as energy in ATP:

Glucose + 6 O_2 + 38 ADP + 39 Phosphate = 6 CO_2 + 6H_2O + 38 ATP

ANAEROBIC METABOLISM

In anaerobic metabolism, pyruvate is converted to lactate. However, in the presence of sufficient oxygen, pyruvate can be oxidised for energy in the mitochondria (the energy factories of the cell). Glucose, a six carbon molecule, is converted to two molecules of pyruvate, a three carbon molecule. When pyruvate enters the mitochondria, it undergoes further conversion to a two carbon molecule to form acetyl-coenzyme A (CoA). Coa can also be created from the beta-oxidation of fatty acids that reside in the mitochondria. During beta-oxidation, carbon is cleaved from the long carbon chains of fatty acids in two-carbon units. These two carbon molecules form acetyl-CoA.

The newly created acetyl-CoA from pyruvate or beta-oxidation of fats can be oxidised to carbon dioxide (CO_2) in the tricarboxylic acid cycle (TCA). The critical aspect of the TCA cycle is producing hydrogen atoms for transport to the electron transport chain. It is in the electron transport chain that oxidative phosphorylation occurs to create ATP from ADP. With sufficient hydrogen to feed into the lectron transport chain and enough oxygen for oxidative phosphorylation, the electron transport chain can continuously produce energy in the form of ATP.

Anaerobic metabolic processes have the capacity to provide ATP energy immediately but only for a short duration, while aerobic metabolic processes begin providing ATP energy more slowly but for long durations, provided there is sufficient substrate and oxygen available to the cells. We have large stores of energy that we can call upon to create ATP energy for muscular work: These are liver glycogen (enough energy to last 16 minutes), muscle glycogen (80 minutes), blood glucose (2 min), Fat (4856 minutes) and protein (2550 minutes).

ENERGY STORAGE

Of the energy stores available to us, fat is the most efficiently stored and provides the greatest mass from which ATP energy can be derived. Glycogen requires approximately 3g of water for storage, while fat storage is essentially anhydrous, making fat a more efficient form of energy storage. Muscle and liver glycogen stores are small compared to fat storage, but it has the advantage that it can be metabolised aerobically or anaerobically, while fat can only be metabolised aerobically. Protein stores are from functional tissue that, under ideal conditions, would never be catabolized as a source of energy. Nevertheless, a small amount of protein (approximately 5% of total energy needs) does appear to be metabolized to meet energy requirements in most activities. Protein catabolism is not desired and can be prevented with a regular supply of carbohydrates and adequate total energy consumption.

At the initiation of exercise, the majority of ATP is derived anaerobically. For highly intense, maximal effort activities, the requirement for a high volume of energy mandates a continuous dependence on anaerobic processes. However, for lower-intensity activities the majority of ATP is initially provided anaerobically, but then the activity switches to aerobic metabolism to meet most ATP needs. Anaerobic and aerobic metabolic processes proceed simultaneously, with the intensity of the activity determining the predominant metabolic pathway for the supply of ATP. Because far more energy is available to us aerobically (fat is only metabolized aerobically), the high energy needs of the endurance athlete force them to train muscles to be more aerobically competent. Cells of well-trained athletes have more mitochondria and more aerobic enzymes in the mitochondria, resulting in a higher capacity to derive energy aerobically.

ATP as an energy source:
Stored ATP is the only fuel instantly available for energy and is therefore the only fuel capable of generating 100% muscle contraction. As ATP levels decline, other fuels begin to take over but as all of them ultimately need to be converted to ATP, available energy per second declines, so maximum muscle contraction declines accordingly. We can store roughly enough ATP for about 4 or 5 seconds of maximum muscular effort i.e. enough to perform one or two max effort reps or sprint 40 to 50 metres. This short intense effort requires no oxygen, no carbs, no fat or protein.

Because muscle contraction using ATP alone is the only way you can put maximum load on your muscles, it is the most effective way to build strength. It creates the most extensive micro-damage which in turn triggers the greatest adaptive muscle growth. Problem is that it is also the most risky way to train as at 100% contraction, muscles, tendons and ligaments are at greatest risk.

Creatine Phosphate as an Energy Source:
After 4 or 5 seconds of maximal effort, creatine phosphate (CP) becomes the dominant fuel source, allowing another 5 or 6 seconds of near maximum effort – for a total of around 11 seconds. I.e. enough to sprint 100m or perform 5 or 6 max effort reps. Again this is an anaerobic process requiring no oxygen, glycogen, glucose, fatty acids or amino acids.
Because the ATP / CP system permits close to maximum effort it generates significant micro damage, which in turn triggers near maximum muscle growth. Overall this 10 or 11 second ATP/CP "window for max effort" provides the best combination of safety and efficacy for optimum strength training and muscle building.
Biogen has a few creatine offerings in the Core Muscle range, namely Creatine Monohydrate and Creatine Ultra Load. We also have the Creatine HCL Tablets in the Black range, and RAPID HCL in the Elite Series.

Glycogen & Glucose as an Energy Source:
Beyond 11 or 12 seconds, glycogen and glucose become the predominant substrates for ATP production. Together they can fuel sub-maximal performance for up to about two minutes. Because performance for this length of time is restricted to 70% or less of max, it is not the best way to train for muscle and strength gains.

Fatty Acids & Amino Acids as an Energy Source:
After about two minutes of exercise, fatty acids begin to dominate as a fuel source whilst your body also draws upon amino acid reserves, which can provide as much as 10% of the total energy. We know this as endurance exercise, which can be sustained for hours. Endurance training is an aerobic activity (requires oxygen) and is catabolic to both body fat and muscle. **Check out some of our Biogen Essential Fatty Acid EFA options here**