Definition of Biochemistry, nutrition and nutritional biochemistry

Biochemistry: Biochemistry, sometimes called biological chemistry, is the study of chemical processes within and relating to living organisms. Biochemical processes give rise to the complexity of life.

Nutrition: Nutrition is the science that interprets the interaction of nutrients and other substances in food in relation to maintenance, growth, reproduction, health and disease of an organism. It includes food intake, absorption, assimilation, biosynthesis, catabolism, and excretion.

Nutritional Biochemistry:

Nutritional Biochemistry takes a scientific approach to nutrition. It covers not just "whats"--nutritional requirements--but why they are required for human health, by describing their function at the cellular and molecular level.

Or

Nutritional biochemistry is the study of nutrition as a science. Nutritional biochemistry deals with various studies in nutrients, food constituents and their function regarding humans and other mammals, nutritional biochemistry specifically focuses on nutrient chemical components, and how they function biochemically, physiologically, metabolically, as well as their impact on disease.

Nutrition basics

A	B
nutrition	The science of food and how the body uses it in health and disease.
essential nutrients	Substances the body must get from foods because it can't manufacture them at all or fast enough to meet its needs.
digestion	The process of breaking down foods in the gastrointestinal tract into compounds the body can absorb.
kilocalorie	A measure of energy content in food; commonly referred to as calorie

protein	An essential nutrient; a compound made of amino acids that contain carbon, hydrogen, oxygen, and nitrogen.
amino acids	The building blocks of proteins.
legumes	Vegetables such as peas and beans that are high in fiber and are also important sources of protein.
saturated fat	A fat with no carbon-carbon double bonds; usually solid at room temperature.
monounsaturated fat	A fat with one carbon-carbon double bond; liquid at room temperature.
polyunsaturated fat	A fat containing two or more carbon-carbon double bonds; liquid at room temperature.
hydrogenation	A process by which hydrogens are added to unsaturated fats.
trans fatty acid	A type of unsaturated fatty acid produced during the process of hydrogenation.
cholesterol	A waxy substance found in the blood and cells and needed for cell membranes, vitamin D, and hormone synthesis.
low-density lipoprotein (LDL)	Blood fat that transports cholesterol to organs and tissues.
high-density lipoprotein (HDL)	Blood fat that helps transport cholesterol out of the arteries, thereby protecting against heart disease.

omega-3 fatty acids	Polyunsaturated fatty acids commonly found in fish oils that are beneficial to cardiovascular health.
carbohydrate	An essential nutrient; sugars, starches, and dietary fiber are all carbohydrates.
glucose	A simple sugar that is the body's basic fuel.
glycogen	An animal starch stored in the liver and muscles.
whole grain.	The entire edible portion of a grain, including the germ, endosperm, and bran
dietary fiber	Carbohydrates and other substances in plants those are indigestible by humans.
soluble fiber	Fiber that dissolves in water or is broken down by bacteria in the large intestine.
insoluble fiber	Fiber that does not dissolve in water and is not broken down by bacteria in the large intestine.
diverticulitis	A digestive disorder in which abnormal pouches form in the walls of the intestine and become inflamed.
vitamins	Carbon-containing substances needed in small amounts to help promote and regulate chemical reactions and processes in the body.
antioxidant	A substance that can lessen the

	breakdown of food or body constituents by free radicals.
free radical	An electron-seeking compound that can react with fats, proteins, and DNA, damaging cell membranes and mutating genes
phytochemical	A naturally occurring substance found in plant foods/may help prevent/treat chronic diseases like cancer/heart disease.
cruciferous vegetables	Vegetables of the cabbage family, including cabbage, broccoli, and brussel sprouts.
Dietary Reference Intakes (DRIs)	An umbrella term for four types of nutrient standards.
Food Guide Pyramid	A food-group plan that provides practical advice to ensure a balanced intake of the essential nutrients.
Dietary Guidelines	General principles of good nutrition intended to help prevent certain diet-related diseases.
Recommended Dietary Allowances (RDAs)	Amounts of certain nutrients considered adequate to prevent deficiencies in most healthy people.
Daily Values	A simplified version of the RDAs used on food labels.
vegan	A vegetarian who eats no animal products at all.

lacto-vegetarian	A vegetarian who includes milk and cheese products in the diet.
lacto-ovo-vegetarian	A vegetarian who eats no meat, poultry, or fish, but does eat eggs and milk products.
partial vegetarian, semivegetarian, or pescovegetarian	A vegetarian who includes eggs, dairy products, and small amounts of poultry and seafood in the diet.
functional foods	Foods and beverages that contain biologically active compounds that provides health benefits beyond basic nutrition.
genetically modified (GM) organism	A plant, animal, or microorganism in which genes have been added, rearranged, or replaced through genetic engineering.
pathogen	A microorganism that causes disease.
polychlorinated biphenyl (PCB)	An industrial chemical used as an insulator in electrical transformers and linked to certain human cancers.
organic	A designation applied to foods grown and produced according to strict guidelines limiting the use of pesticides, hormones, etc.
food irradiation	Treating foods with gamma rays, X rays, or high-voltage electrons to kill potentially harmful pathogens & incr. shelf life.

food allergy	Adverse reaction to a food/food ingredient in which the immune system perceives a particular substance as foreign and acts to destroy it.
food intolerance	An adverse reaction to a food or food ingredient that doesn't involve the immune system.
scurvy	A disease caused by a lack of Vitamin C - bleeding gums, loosening teeth, and poor wound healing.
minerals	Inorganic compounds needed for regulation, growth and maintenance of body tissues and functions.
anemia	A deficiency in the oxygen-carrying material in the red blood cells.
osteoporosis	A condition in which the bones become extremely thin and brittle and break easily.

Importance of food

A food is something that provides nutrients. Nutrients are substances that provide: energy for activity, growth, and all functions of the body such as breathing, digesting food, and keeping warm; materials for the growth and repair of the body, and for keeping the immune system healthy.

Or

Food is an essential part of everyone’s lives. It gives us the energy and nutrients to grow and develop, be healthy and active, to move, work, play, think and learn.

The body needs a variety of the following 5 nutrients - protein, carbohydrate, fat, vitamins and minerals - from the food we eat to stay healthy and productive.

Protein - is needed to build, maintain and repair muscle, blood, skin and bones and other tissues and organs in the body. Foods rich in protein include meat, eggs, dairy and fish.

Carbohydrate - provides the body with its main source of energy.

Carbohydrates can be classified into two kinds; starches and sugars. Food rich in starches include rice, maize, wheat and potatoes and food rich in sugars include fruit, honey, sweets and chocolate bars.

Fat - This is the body's secondary source of energy. Fat actually provides more energy/calories per gram than any other nutrient, but is more difficult to burn. Food rich in fats are oils, butter, lard, milk, cheese and some meat.

Vitamins and Minerals - Vitamins and minerals are needed in very small amounts and are sometimes called micronutrients, but are essential for good health. They control many functions and processes in the body, and in the case of minerals also help build body tissue such as bones (calcium) and blood (iron).

In addition to the above nutrients fiber and Water are also essential for a good healthy diet.

How the body uses food

The fuel or energy that the body uses comes from the food and drink that we consume in our diet. From the moment a bite of food enters the mouth, each morsel of nutrition within starts to be broken down for use by the body. So begins the process of metabolism, the series of chemical reactions that transform food into components that can be used for the body's basic processes. Proteins, carbohydrates, and fats move along intersecting sets of metabolic pathways that are unique to each major nutrient.

Carbohydrates, proteins, and fats are digested in the intestine, where they are broken down into their basic units:

- Carbohydrates into sugars
- Proteins into amino acids
- Fats into fatty acids and glycerol
- The body uses these basic units to build substances it needs for growth, maintenance, and activity (including other carbohydrates, proteins, and fats).

Carbohydrates: Carbohydrates will be used in three different ways. Immediate energy, stored energy and stored fat. During the digestion process carbohydrates will be converted into glucose, a prime source of energy used by cells. The liver senses this glucose in to the blood stream to be used as immediate energy for cells. Once the blood stream has enough glucose in it liver takes the extra glucose and converts it to the glycogen which is a stored form of glucose energy. Glycogen gets stored in the liver and muscle. Once the glycogen storage is full, the extra glucose is stored as fat in the adipose tissue.

Proteins: proteins are also going to be used mainly in three different ways: as building other components, used as energy and stored as fat. During the digestive process proteins were broken down into their main components of amino acids. These amino acids will be used to make other proteins such as enzymes, hormones, transport proteins and build and maintain tissue etc. If body is low on energy liver converts proteins into energy. In a quite complex proteins also be converted into fats for storage.

Fats: fats are also going to be used mainly in three different ways: make up cells membranes, stored as energy (in liver and adipose tissue) and used as energy in the form of ketone bodies or glucose.

Order of macronutrient used by body

The three main fuel sources in humans are carbohydrates, fats, and proteins were used preferentially under different conditions. In general, the body burns carbohydrates, then fats, and then proteins, in that order. It is important to realize that energy metabolism is not an "all-or-none" phenomenon. The body is constantly fine tuning the exact blend of carbohydrate, fat, and protein metabolism to ensure the appropriate supply of energy to the body’s tissues.

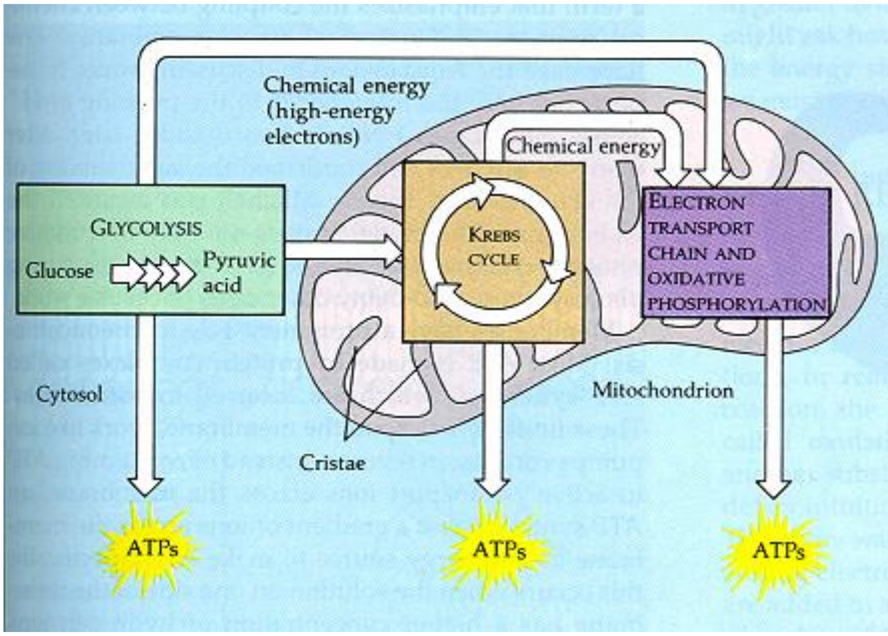
Cellular respiration

Cellular respiration is the process by which the chemical energy of "food" molecules is released and partially captured in the form of ATP. Carbohydrates, fats, and proteins can all be used as fuels in cellular respiration, but glucose is most commonly used as an example to examine the reactions and pathways involved.

During Cellular Respiration, sugar is broken down to CO_2 and H_2O, and in the process, ATP is made that can then be used for cellular work.

The overall reaction for cellular respiration:

$C_6H_{12}O_6 + 6O_2$ -------------------> $6CO_2 + 6H_2O$ + ~38 ATP



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Cellular respiration can be broken down into 4 stages:

Essentially, sugar ($C_6H_{12}O_6$) is burned, or oxidized, down to CO_2 and H_2O, releasing energy (ATP) in the process. A lot of oxygen is required for this process! The sugar and the oxygen are delivered to your cells via your bloodstream. This process occurs partially in the cytoplasm, and partially in the mitochondria.

1: **Glycolysis** ("splitting of sugar"): This step happens in the cytoplasm.

One Glucose ($C_6H_{12}O_6$) is broken down to 2 molecules of pyruvic acid. This results in the production of 2 ATPs and 2 NADH for each molecule of glucose.

2: **Transition Reaction**: Pyruvic acid is shuttled into the mitochondria, where it is converted to a molecule called Acetyl CoA for further breakdown. 2 molecules of NADH will be produced.

3: **The Krebs Cycle, or Citric Acid Cycle**: Occurs in the mitochondrial matrix, the liquid part of the mitochondria.

In the presence of Oxygen gas (O_2), all the hydrogens (H_2) are stripped off the Acetyl CoA, two by two, to extract the electrons for making ATP, until there are no hydrogens left - and all that is left of the sugar is

CO_2 - a waste product - and H_2O (exhale). The Krebs cycle results in the production of only 2 ATPs, 6 NADH and 2 $FADH_2$ molecules.

4: **The Electron Transport Chain and Chemiosmosis ("the big ATP payoff"):** Occurs in the christae of the mirochondria.

Electrons from Hydrogen are carried by NADH and passed down an electron transport chain to result in the production of ATP. This results in the production of 34 ATPs.

Energy systems of the body

The human body uses energy from food to fuel movement and essential body functions, but the body cells don't get energy directly from food. After food is digested, the carbohydrates, protein and fat break down into simple compounds -- glucose, amino acids and fatty acids -- which are absorbed into the blood and transported to various cells throughout the body. Within these cells, and from these energy sources, adenosine triphosphate (ATP) is formed to provide fuel. The body uses 3 different systems to supply cells with the necessary ATP to fuel energy needs.

1. ATP-PC System

2. Glycolytic system

3. Oxidative system

Systems 1 and 2 are anaerobic as no oxygen needed. However, System 3 need oxygen thus aerobic.

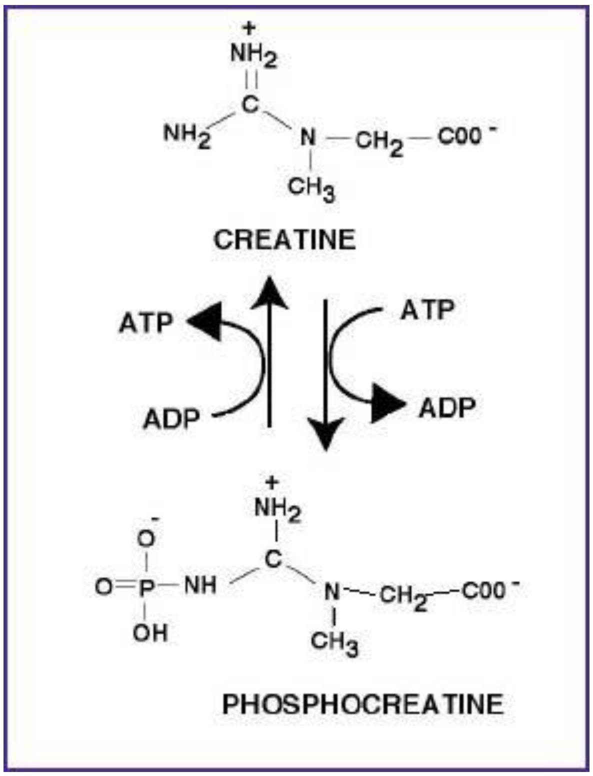
1. ATP-PC system

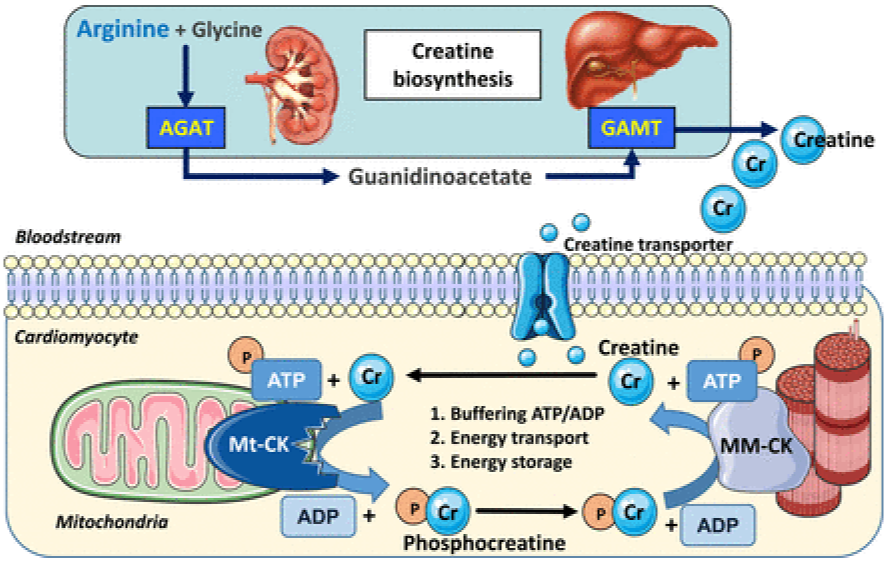
As the name suggests the ATP-PC system consists of adenosine triphosphate (ATP) and phosphocreatine (PC). This energy system provides immediate energy through the breakdown of these stored high energy phosphates. If this energy system is 'fully stocked' it will provide energy for maximal intensity, short duration exercise for between10-15 seconds before it fatigues.

This system is anaerobic, which means it does not use oxygen. The ATP-PC system utilizes the relatively small amount of ATP already stored in the muscle for this immediate energy source. When the body's supply of ATP is depleted, which occurs in a matter of seconds, additional ATP is formed from the breakdown of phosphocreatine (PC) -- an energy compound found in muscle.

Creatine kinase (CK), also known as creatine phosphokinase (CPK) or phosphocreatine kinase, is an enzyme (EC 2.7.3.2) expressed by various tissues and cell types. CK catalyses the conversion of creatine and uses adenosine triphosphate (ATP) to create phosphocreatine (PCr) and adenosine diphosphate (ADP). This CK enzyme reaction is reversible and thus ATP can be generated from PCr and ADP.

In tissues and cells that consume ATP rapidly, especially skeletal muscle, but also brain, photoreceptor cells of the retina, hair cells of the inner ear, spermatozoa and smooth muscle, PCr serves as an energy reservoir for the rapid buffering and regeneration of ATP in situ, as well as for intracellular energy transport by the PCr shuttle or circuit. Thus creatine kinase is an important enzyme in such tissues.





Creatine biosynthesis and the myocardial creatine kinase system.

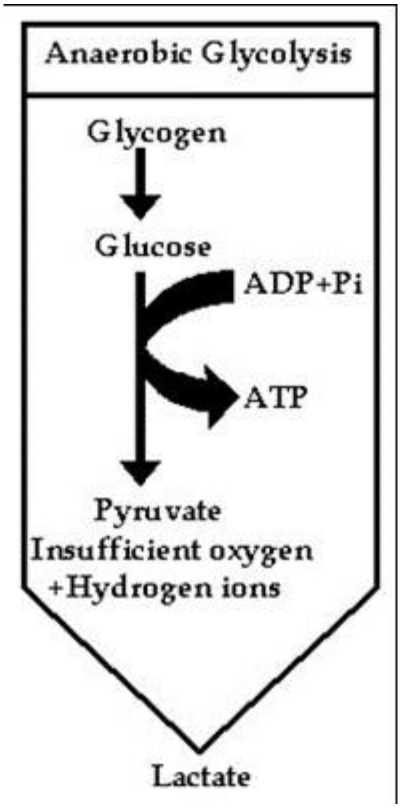
Creatine is a β-amino acid obtained in the diet from animal products or by *de novo* synthesis (~50%). Arginine-glycine amidinotransferase (AGAT, EC 2.1.4.1) located predominantly in the kidney combines glycine and arginine to form the creatine precursor guanidinoacetate (GAA). GAA is carried in the bloodstream to the liver and pancreas, where it is methylated by guanidinoacetate *N*-methyl transferase (GAMT, EC 2.1.1.2) to form creatine, which is released back into the bloodstream. Uptake into cardiomyocytes is via the specific plasma membrane creatine transporter (SLC6A8), where Mt-CK catalyses the transfer of a phosphoryl group from ATP to form ADP and PCr. PCr accumulates to high levels and is available for the regeneration of ATP at times of high demand catalysed by cytosolic isoforms such as MM-CK. Liberated creatine diffuses back to mitochondria to stimulate further oxidative phosphorylation.

2. Glycolytic system

The glycolytic energy system (another anaerobic system) draws on carbohydrates to create ATP for energy. This is a two-phase energy system where glucose (sugar) is broken down to form ATP and pyruvic acid molecules (lactic acid). It is the system used for **relatively short periods of high-intensity work**, **lasting only a few minutes**. After a few minutes of intense workout the accumulation of lactic acid will reach a point where pain and fatigue will begin to hinder performance. This is referred to as the lactate threshold.

How does the anaerobic glycolytic system work?

There are four key steps involved in the anaerobic glycolytic system. However they take longer to be carried out compared to the steps in the ATP-PC system. This is why it doesn't start working as quickly and as these steps are more complex than the ATP-PC system, energy isn't produced as quickly.



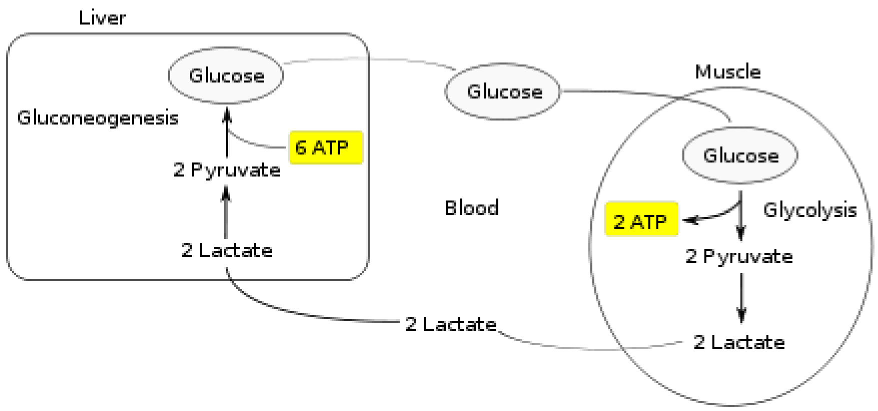
Steps of the anaerobic glycolytic system:

1. Initially stored glycogen is converted to glucose. Glucose is then broken down by a series of enzymes.
2. 2 ATP are used to fuel glycolysis and 4 are created so the body gains 2 ATP to use for muscular contraction.
3. The breakdown of glucose to synthesize ATP results in the creation of a substance called 'pyruvate' and hydrogen ions. The muscle becomes increasingly acidic as more hydrogen ions are created.
4. Because this system is ‘anaerobic’ there isn’t enough oxygen to break down pyruvate and synthesize anymore ATP.

This result in pyruvate binding with some of the hydrogen ions and converting them into a substance called lactate (completely different to 'lactic acid').

Lactate acts as a temporary buffering system to reduce acidosis (the buildup of acid in muscle cell) and no further ATP is synthesized.

The Cori cycle (also known as the Lactic acid cycle), named after its discoverers, Carl Ferdinand Cori and Gerty Cori, refers to the metabolic pathway in which lactate produced by anaerobic glycolysis in the muscles moves to the liver and is converted to glucose, which then returns to the muscles and is cyclically metabolized back to lactate.



Significance

- The cycle's importance is based on the prevention of lactic acidosis in the muscle under anaerobic conditions.
- The cycle is also important in producing ATP, an energy source, during muscle activity.
- The drug metformin can cause lactic acidosis in patients with renal failure because metformin inhibits the hepatic gluconeogenesis of the Cori cycle, particularly the mitochondrial respiratory chain complex 1

3. Oxidative system/aerobic system

The most complex energy system is the aerobic or oxygen energy system, which provides most of the body's ATP. The aerobic energy system utilizes fats, carbohydrate and sometimes proteins for re-synthesizing ATP for energy use.

The aerobic system consists of three processes or ‘stages’ each of which produce ATP.

These stages involve more complex chemical reactions than the other energy systems which is why ATP production is much slower. (The more complex the process - the longer it takes to produce ATP)

The three stages which will be discussed in greater detail are:

1. Aerobic glycolysis (slow glycolysis)

2. Krebs cycle (also known as the citric acid cycle)

3. Electron transport chain

In summary the ATP gained from the complete breakdown of 1 glucose molecule in the aerobic system is as follows:

Glycolysis	2 ATP
Krebs cycle	2 ATP
Electron transport chain	34 ATP
Total	**38 ATP**

Sources

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Video links:

What is Nutrition?: https://www.youtube.com/watch?v=uYamwNVnCVU

Why do we eat?: https://www.youtube.com/watch?v=brKgffGPfmA

Gotta Eat! – Crash Course Kids 1.1: https://www.youtube.com/watch?v=z9TIlM96lT8

How The Body Uses Food - You Are What You Eat. : https://www.youtube.com/watch?v=AA0QMn9VfoE

What Is Cellular Respiration - What Is Cellular Energy - Food Converted Into Energy – Glycolysis: https://www.youtube.com/watch?v=hMK1-bgTAtQ

Energy Systems - ATP Energy In The Body - Adenosine Triphosphate – Glycolysis: https://www.youtube.com/watch?v=dWe8vtztW-4

ATP Phosphocreatine System Overview (V2.0): https://www.youtube.com/watch?v=BhJtogLY0e4

Cellular Respiration

https://www.youtube.com/watch?v=eBl3U-T5Nvk