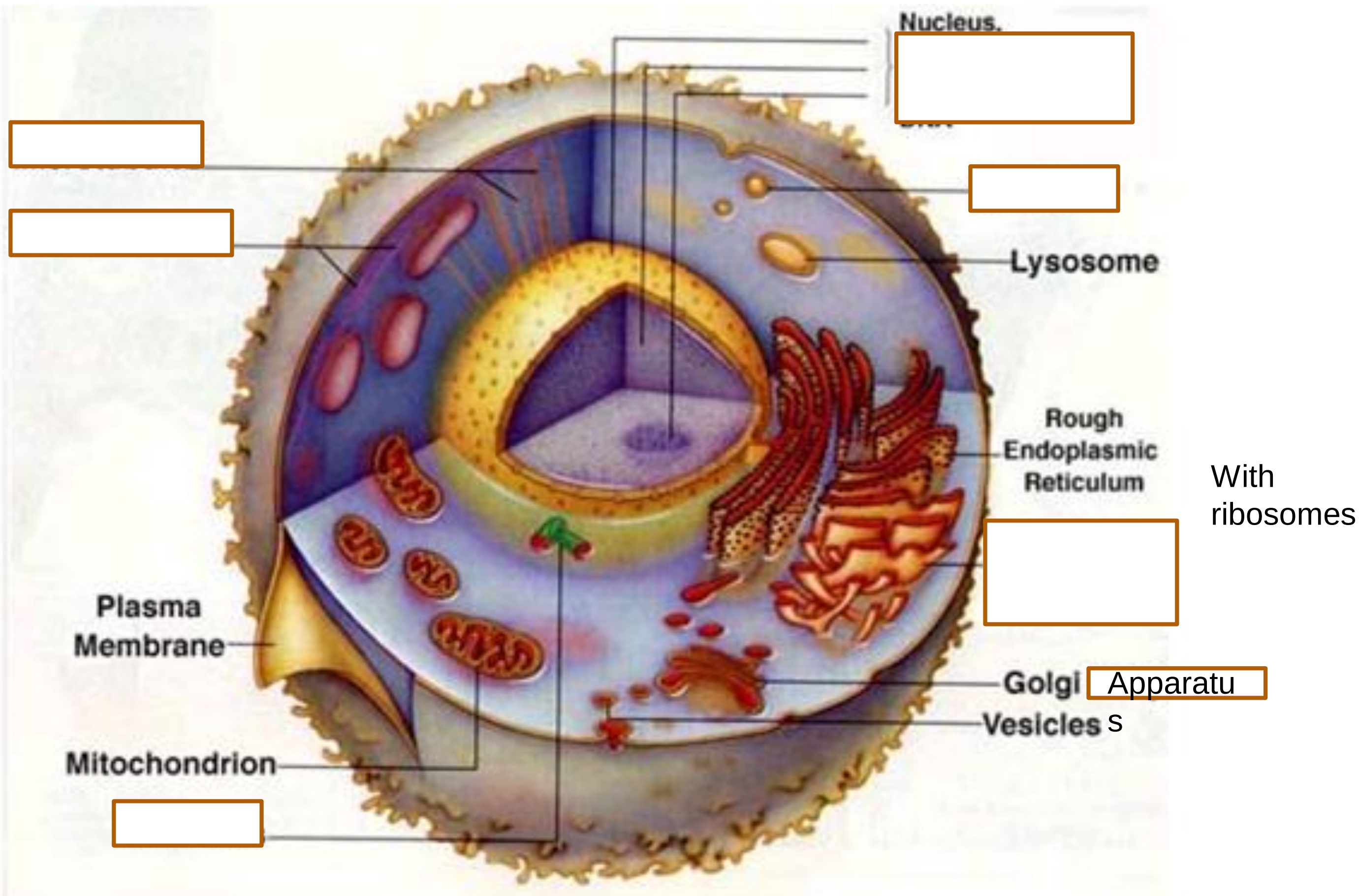
3.3.1 Draw a diagram to show the ultrastructure of a generalized animal cell.



- **Nucleus**: A membrane bound structure found in eucaryotic cells. It contains chromosomes made up of DNA and protein. The DNA component of the chromosomes forms the genes which direct what proteins the cell will make.

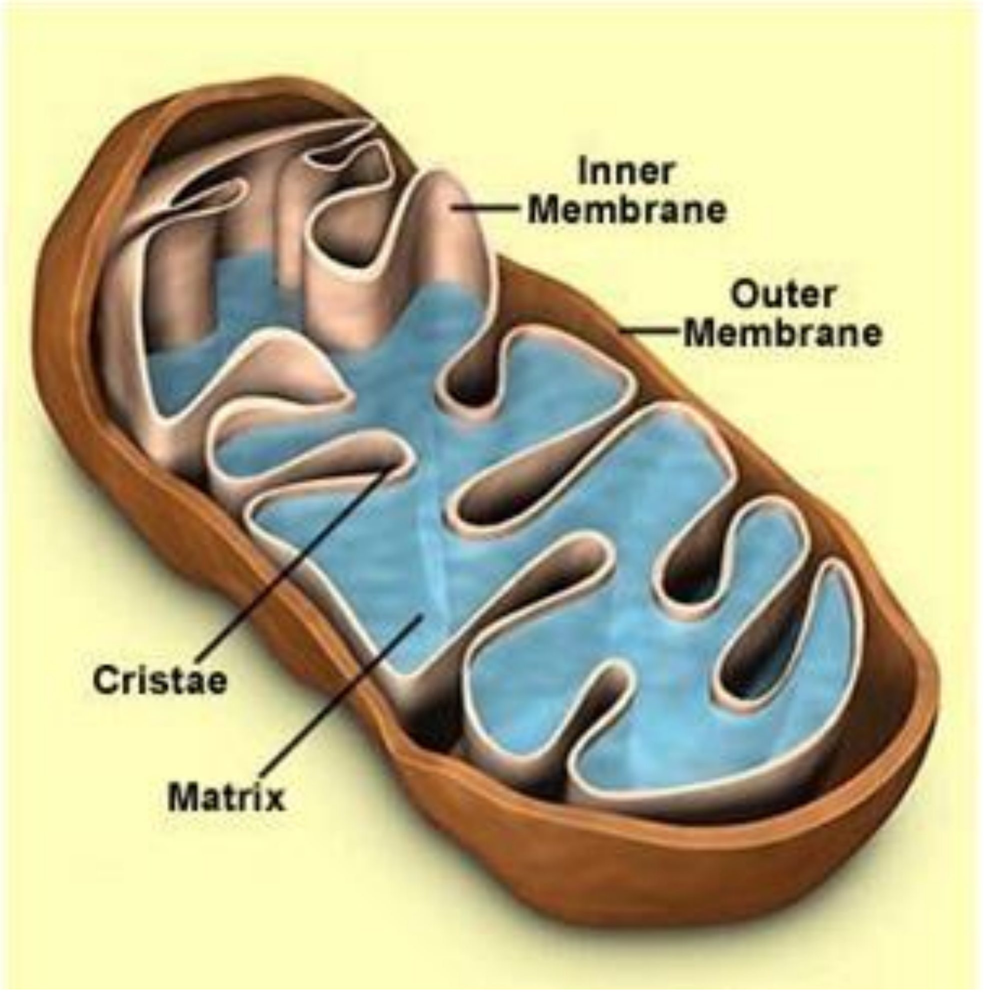
- **Ribosomes**: responsible for the manufacture of proteins. They are often found in the endoplasmic reticulum but can also be found in other areas of the cell.
- **Endoplasmic reticulum**: (literally translated: ‘network within the cytoplasm). A network of membrane-bound channels providing a means of transport within the cells.
- Rough endoplasmic reticulum: is coated with ribosomes.
- (Smooth endoplasmic reticulum: generally found in cells producing lipids (fat), is devoid of

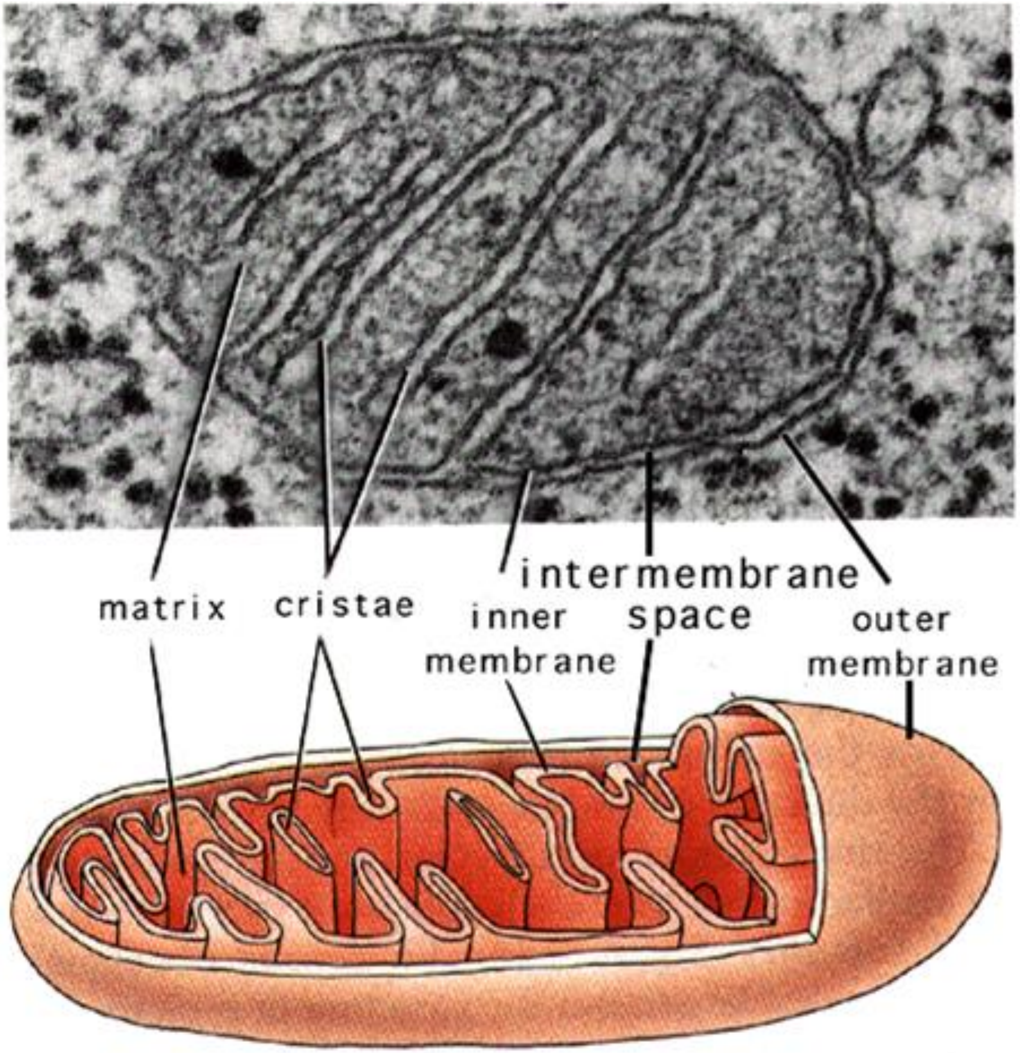
- **Golgi apparatus**: a series of flattened membranous sacs which are believed to store materials prior to secretion from the cell. This is achieved by small vesicles which break off from the golgi apparatus and fuse with the cell membrane.

- **Lysosome**: a membrane bound structure found in animal cells which contain very powerful digestive enzymes.

- **Mitochondrion**: a membrane bound structure consisting of a series of folded membranes. On these membranes, the reactions of aerobic respiration occur which produces energy for use by the cell.

3.3.2 Draw a diagram to show the ultrastructure of a mitochondrion.




matrix
cristae
inner membrane
intermembrane space
outer membrane

- Mitochondria are membrane-enclosed organelles distributed through the cytosol of cells.
- Their number within the cell ranges from a few hundred to, in very active cells, thousands.
- Their main function is the conversion of the potential energy of food molecules into ATP. Mitochondria have: an **outer membrane** that encloses the entire structure
- an **inner membrane** that encloses a fluid-filled **matrix**
- between the two is the **intermembrane space**
- the inner membrane is elaborately folded with shelflike **cristae** projecting into the **matrix**.
- The number of mitochondria in a cell can
  - increase by mitosis (after aerobic training)
  - decrease by their fusing together. (after a period of inactivity)

Energy Systems

3.3.3

Define the term cell respiration.

Cell Respiration is defined as the controlled release of energy in the form of ATP from organic compound in cells. ATP is a chemical compound that provides energy for muscle contraction. Cellular respiration can also be fueled by carbohydrates, fats and proteins. These are all macronutrients.

There are two types of respiration: aerobic respiration, and anaerobic respiration. Aerobic respiration results in MORE energy for cell use. It also NEEDS the presence of oxygen. Anaerobic respiration results in LESS energy for cell use. This happens in LOW or ABSENCE of oxygen.

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Energy Systems

Topic 3

Energy Systems

Sub-topics

1. Nutrition

2. Carbohydrate and fat metabolism

3. Nutrition and energy systems

3.3.3

Define the term cell respiration.

Energy Systems:

Any movement made by the body requires a series of coordinated muscle contractions, which requires energy. For movement to happen, the body converts stored chemical energy to mechanical energy. Adenine triphosphate needs to be broken down to meet the chemical energy requirement.

Energy Systems

3.3.3 - Define the term cell respiration.

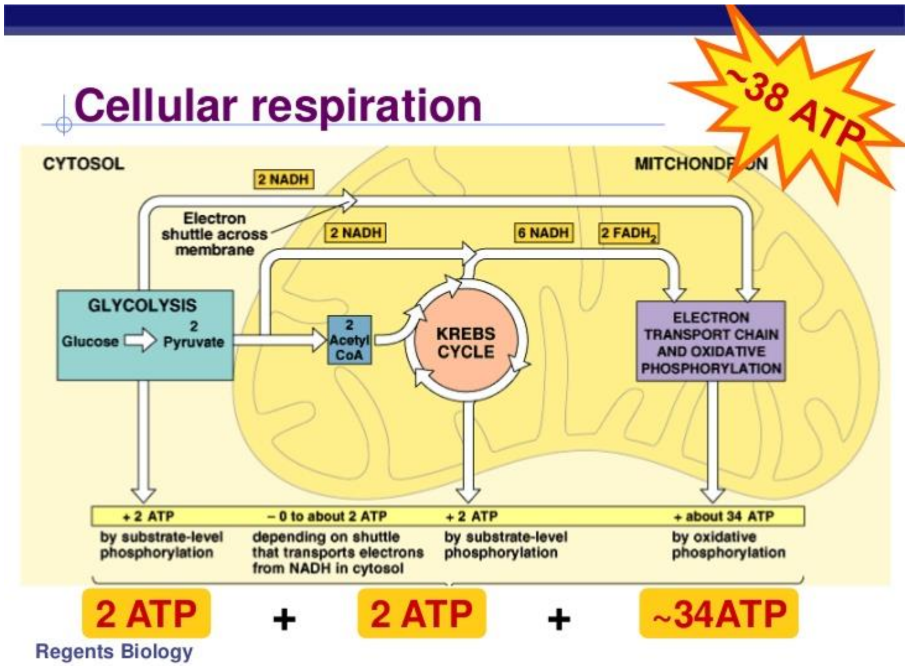
Cellular respiration is a set of metabolic reactions and processes that take place in the **cells** of organisms to convert biochemical energy from nutrients into adenosine triphosphate (ATP), and then release waste products.

Equation:

Glucose + Oxygen → Carbon Dioxide + Water + ATP

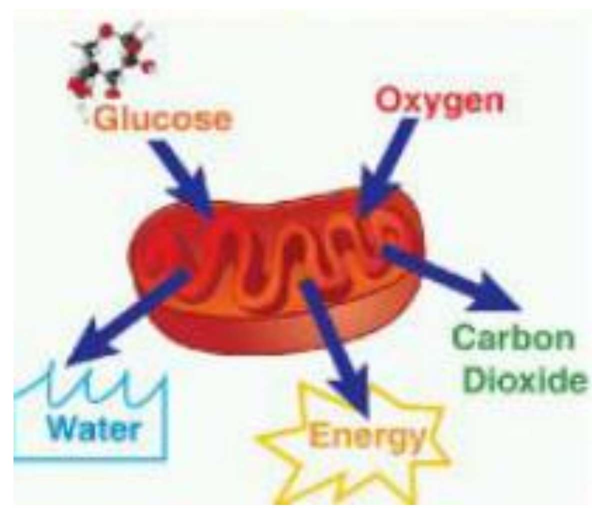
$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O + ATP$

How Cellular Respiration Works



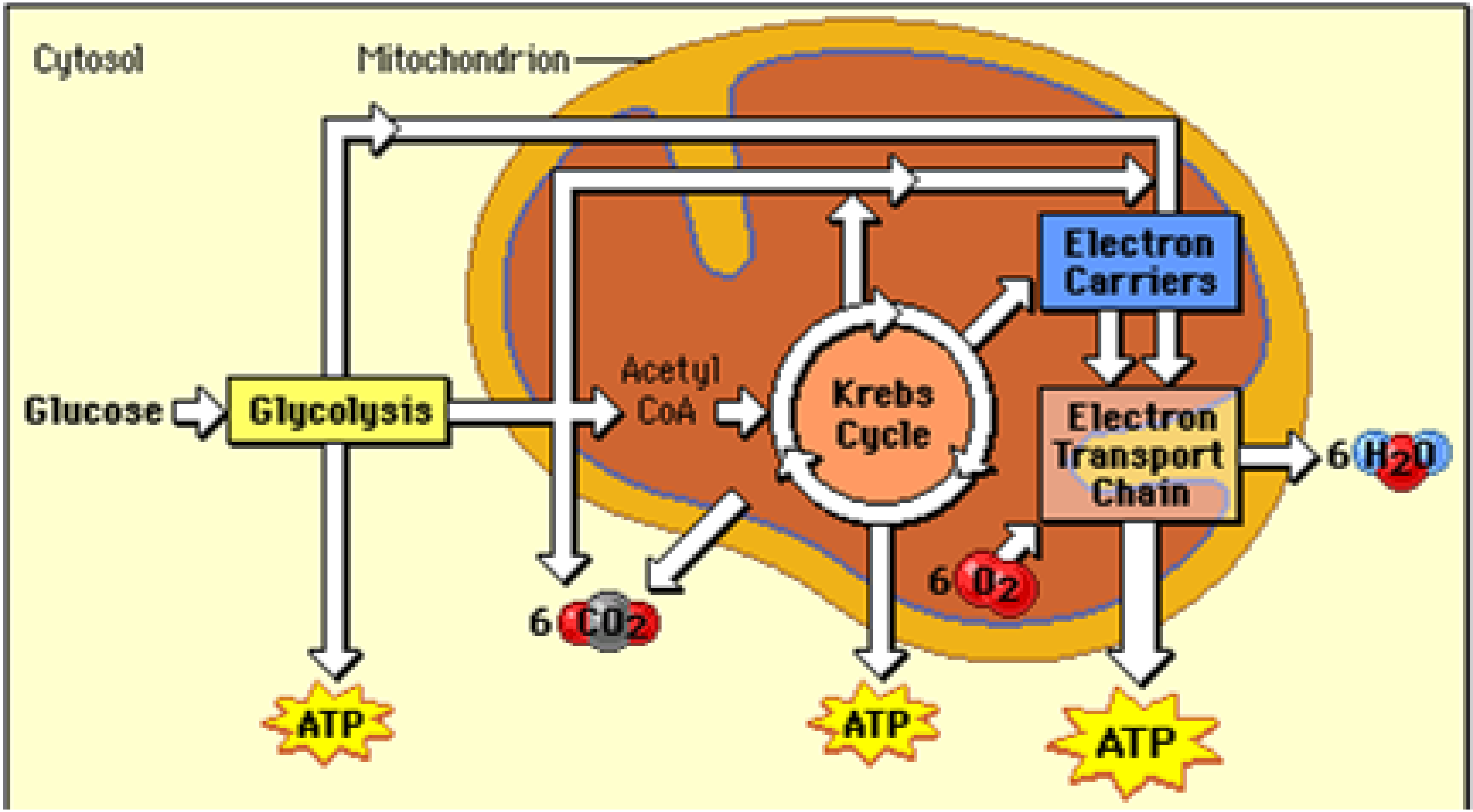
Complex Diagram

Simple Diagram



- **We can divide cellular respiration into three metabolic processes: glycolysis, the Krebs cycle, and oxidative phosphorylation. Each of these occurs in a specific region of the cell.**
- 1. Glycolysis occurs in the cytosol.
  2. The Krebs cycle takes place in the matrix of the mitochondria.
  3. Oxidative phosphorylation via the electon transport chain is carried out on the inner mitochondrial membrane.

  In the absence of oxygen, glycolysis occurs in the cytosol.

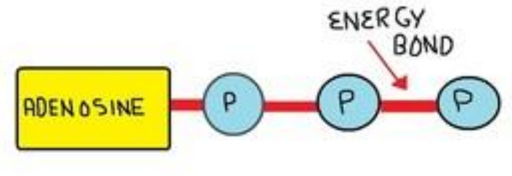


Cytosol
Mitochondrion
Glucose
Glycolysis
Acetyl CoA
Krebs Cycle
Electron Carriers
Electron Transport Chain
6 H_2O
6 O_2
6 CO_2
ATP
ATP
ATP

Energy Systems

3.3.4 Explain how adenosine can gain and lose a phosphate molecule.

ATP consists of one molecule of adenosine and three molecules of phosphate. Energy is released from ATP by the breaking of the bonds that hold the molecules together.



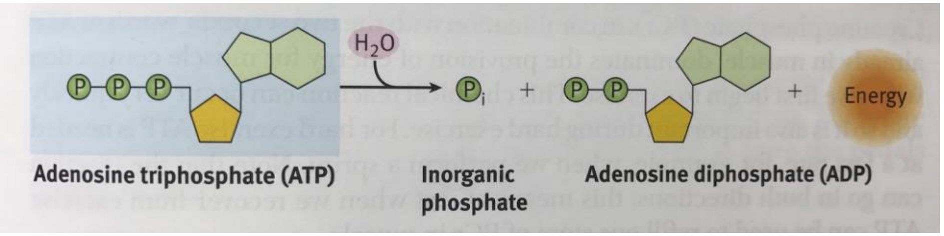
Energy bond is eventually broken and phosphate molecule is lost.

Energy Systems

3.3.4

The adenosine triphosphate (ATP) molecule stores energy when it is not needed, but is able to release it when the body needs it.

ATP works by losing the endmost phosphate group when told to do so by an enzyme. This releases a lot of energy, which can then be used to build proteins, contract muscles, etc.



Energy Systems

3.3.4

The end product is adenosine diphosphate (ADP), and a phosphate molecule.

Additional energy can be extracted by removing a second phosphate group to produce adenosine-monophosphate (AMP).

Energy Systems

3.3.4

When the body is resting and energy is not immediately needed, the reverse reaction takes place and the phosphate group is reattached to the molecule using energy obtained from food.

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Energy Systems

Topic 3
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Sub-topics

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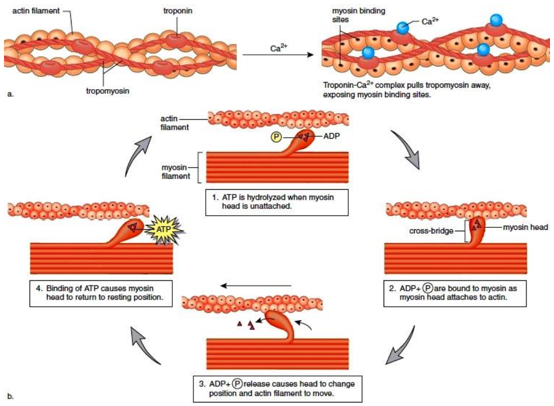
3.3.5 Explain the role of ATP in muscle contraction

- ATP provides short amount of energy for muscle contraction
  - 2 second supply of energy
- ATP breaks down the myosin-actin cross-bridge, freeing the myosin for the next contraction



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Energy Systems

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Sub-topics

1. Nutrition

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3. Nutrition and energy systems

3.3.5 Explain the role of ATP in muscle contraction

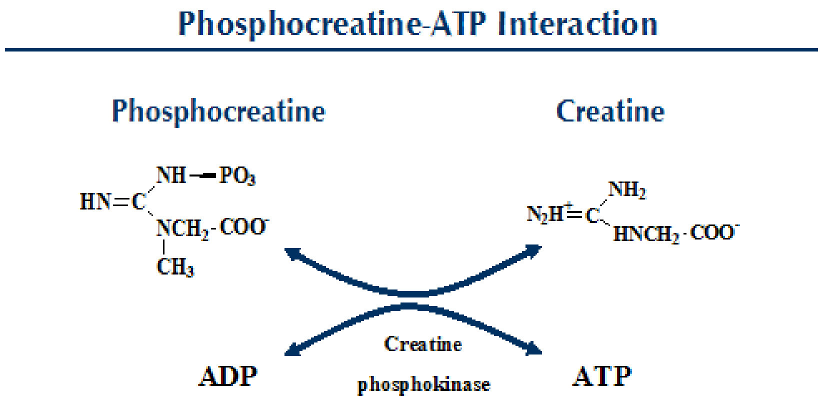
- First, ATP binds to myosin, breaking down an actin-myosin bridge and causing muscle contractions to stop.
- The free myosin and its bridge then move to a point where they can attach to actin. At this point, ATP is broken down into adenosine diphosphate and P (inorganic phosphate), generating energy.
- ADP (adenine diphosphate), P and the myosin bridge then attach to actin, causing muscle contraction.
- During the muscle relaxation phase, actin displaces ADP and P at the myosin cross bridge. ADP and P are then reconstituted into ATP by the body, and the process starts again.
- Muscle contraction also requires the brain, the nervous system and other body systems to function properly.

Energy Systems

3.3.6 Describe the re-synthesis of ATP by the ATP–CP system.

Creatine phosphate (a high energy molecule) is broken down to provide energy for the re-synthesis of ATP that has been utilized during the initial stages of exercise.

The ATP-PCr energy system can operate with or without oxygen but because it doesnt rely on the presence of oxygen it said to be **anaerobic**.

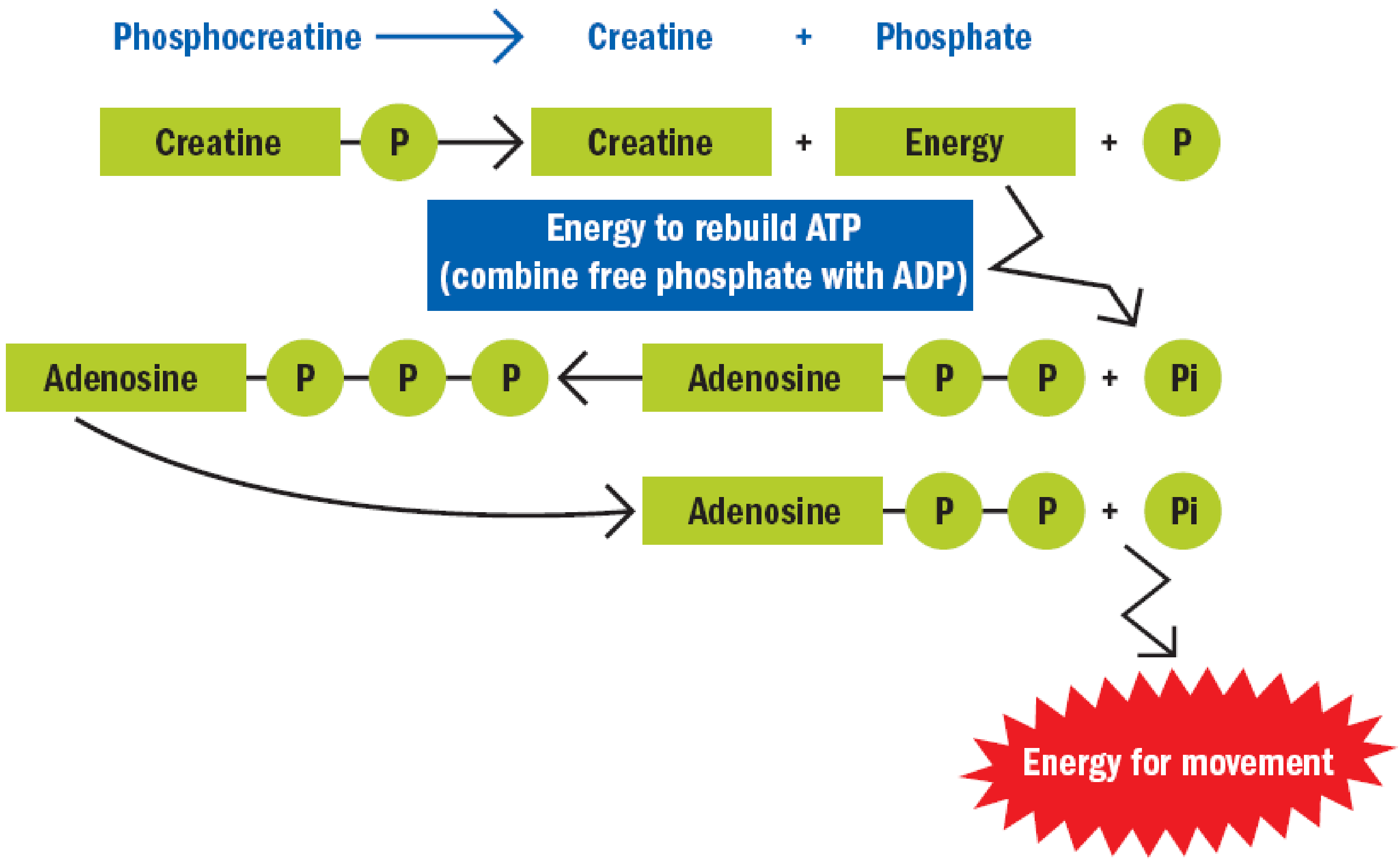


Energy Systems

3.3.6 Describe the re-synthesis of ATP by the ATP–CP system.

- During the first 5 seconds of exercise **regardless of intensity**, the ATP-PCr is relied on almost exclusively. ATP concentrations last only a few seconds with PCr buffering the drop in ATP for another 5-8 seconds or so.
- Combined, the ATP-PCr system can sustain all-out exercise for 3-15 seconds and it is during this time that the potential rate for power output is at its greatest.

3.3.6 Describe the re-synthesis of ATP by the ATP–CP system.

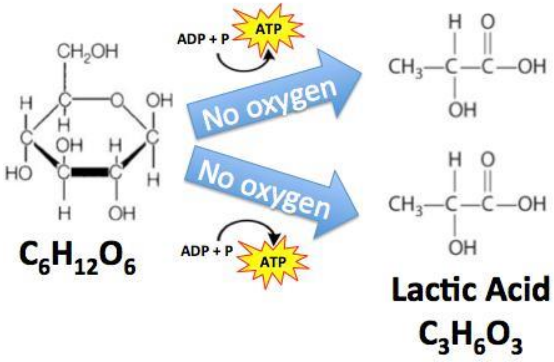


3.3.7 Describe the production of ATP by the lactic acid system

Glycolysis is a metabolic pathway present in the cytoplasm that allows all cells to utilize carbohydrates. It releases some of the energy in glucose as ATP and creates pyruvate.

- ATP → Adenosine triphosphate; a molecule that is created from a biochemical energy (found in organic molecules) by catabolic reactions
- Pyruvate → an organic molecule that helps the body build glucose

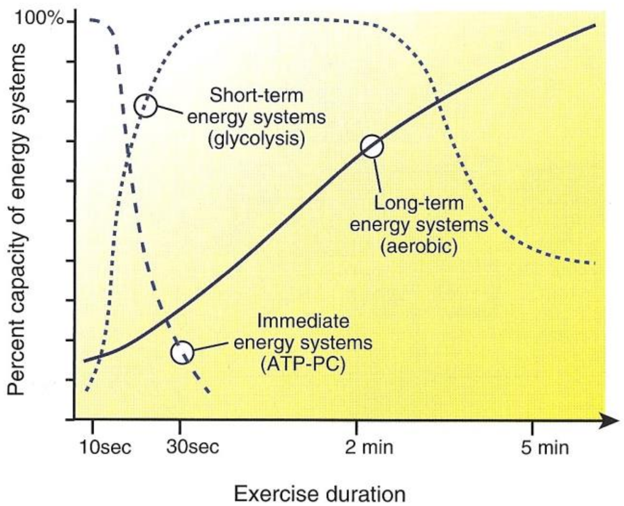
The way the process occurs is dependent upon the amount of oxygen available. For instance, when the capacity for aerobic metabolism is limited, the pyruvate is converted to lactate (lactic acid). Glycolysis occurs quickly despite producing the small amount of ATP. This energy system **is optimal for exercise that requires high levels of energy**.



3.3.7 Describe the production of ATP by the lactic acid system

However, the downside of this energy system is that it **can only be sustained for a small duration of time**. The lactic acid builds up within muscle, reducing the muscle pH since it is a strong acid. This in turn causes discomfort and also makes it harder for the muscle to contract.

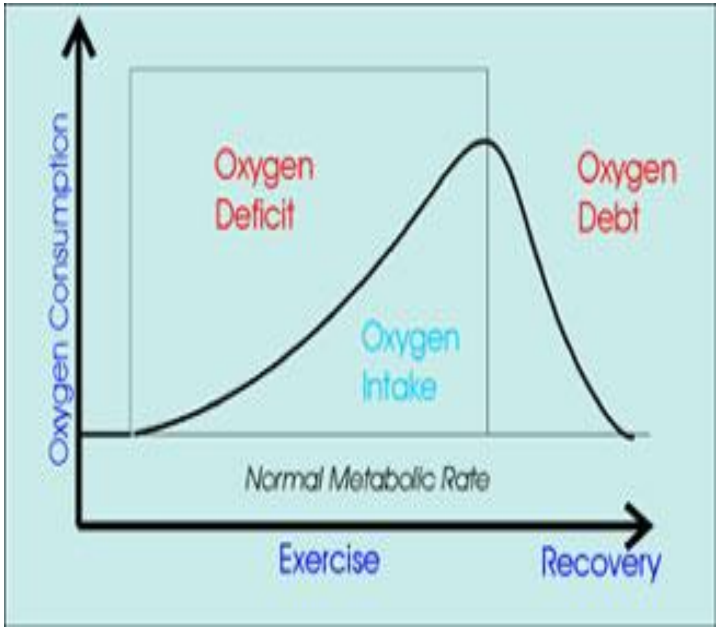
During more moderate levels of exercise, other energy systems are able to supply the body with sufficient amounts of ATP. This implies that anaerobic glycolysis is not needed during lower intensity workouts.



Energy Systems

3.3.8 Explain the phenomena of oxygen deficit and oxygen debt.

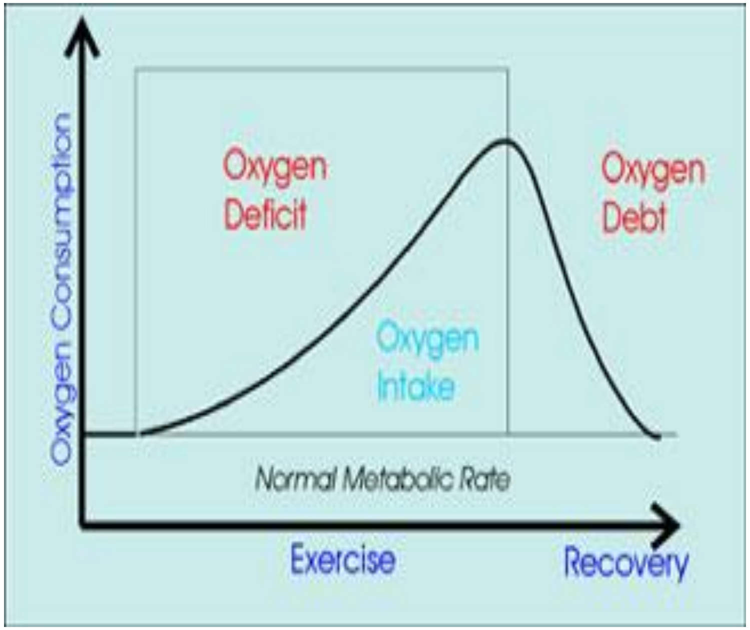
- These terms refer to a lack of oxygen while training/racing and after such activity is over.
- **Oxygen Deficit.** While exercising intensely the body is sometimes unable to fulfill all of its energy needs.
- In order to make up the difference without sacrificing the output, the body must tap into its anaerobic metabolism.



Energy Systems

3.3.8 Explain the phenomena of oxygen deficit and oxygen debt.

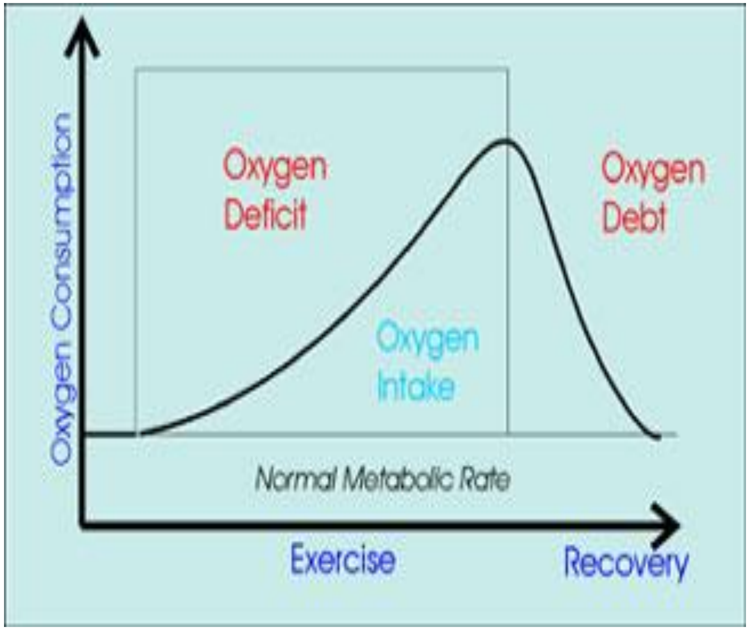
- This where the body goes into a mix of aerobic and anaerobic energy production.
- While not hugely detrimental, oxygen deficits can grow to a level that the anaerobic energy system cannot cover.
- This can cause performance to deteriorate.



Energy Systems

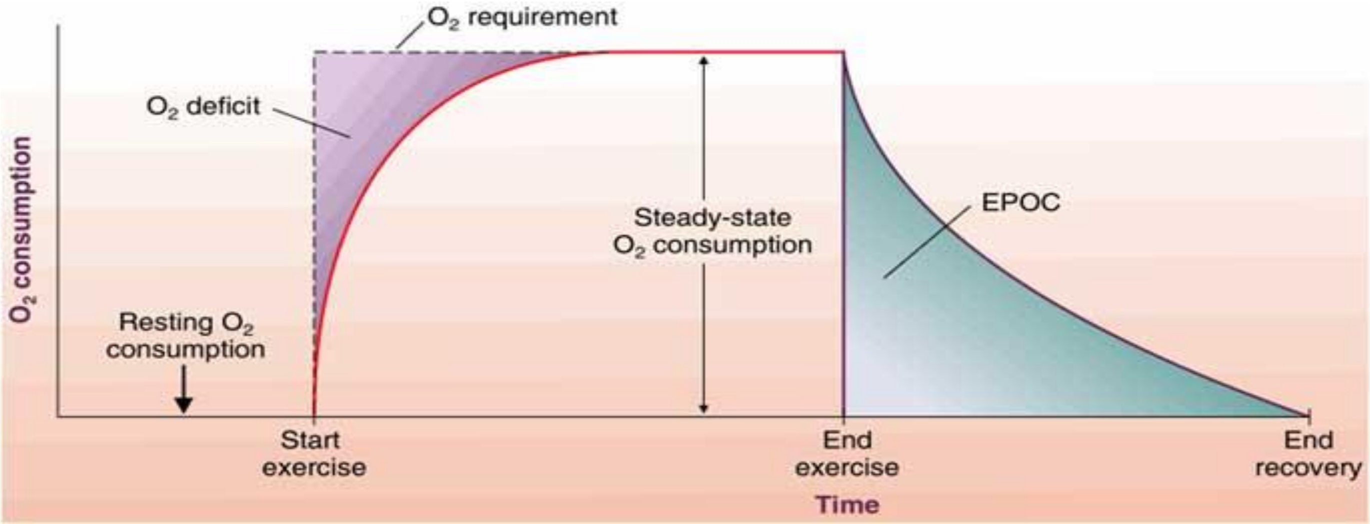
3.3.8 Explain the phenomena of oxygen deficit and oxygen debt.

- **Oxygen Debt.** This term describes how the body pays back its debt incurred above after the exercise is over.
- You will notice that even after you have finished racing you will continue to breath hard.



3.3.8 Explain the phenomena of oxygen deficit and oxygen debt.

- At this point your body is still trying to repay the oxygen debt that was created when you were working hard.
- Technically, it is excessive post-exercise oxygen consumption (EPOC).



Energy Systems

3.3.9 Describe the production of ATP from glucose and fatty acids by the aerobic system.

- ATP is produced by the Krebs cycle and the electron transport chain
- All depends on metabolic conditions in cells

3.3.9 Describe the production of ATP from glucose and fatty acids by the aerobic system.

Glucose:

- Less demanding metabolic conditions pyruvate is converted to acetyl CoA
- This enters the Krebs cycle in the mitochondria where chemical reactions that involve oxygen turn it into water and carbon dioxide
- During glycolysis & Krebs cycle, hydration ions are released
- Specific coenzymes bind the hydrogen ions and carry them to the electron transport chain where energy is produced
- This energy forms ATP

Energy Systems

3.3.9 Describe the production of ATP from glucose and fatty acids by the aerobic system.

Lipids / fatty acids

- Free fatty acid molecules enter mitochondria and a process called β-oxidation sequentially removes two-carbon units from fatty acid chains
- Enzymes of the β-oxidation are in the matrix of the mitochondria
  - →this process produces acetyl CoA (shares same fate in oxidative metabolism as the produced from glucose)
- Fat cannot (in any way) be used anaerobically

3.3.9 Describe the production of ATP from glucose and fatty acids by the aerobic system.

After all this has happened…..another G word….

- **Gluconeogenesis** is a metabolic pathway that results in the generation of glucose from certain non-carbohydrate carbon substrates
- Gluconeogenesis is one of several main mechanisms used by humans and many other animals to maintain blood glucose levels

3.3.10 Discuss the Characteristics of the Three Energy Systems

Creatine Phosphate System:

- The phosphocreatine system is the most powerful when it comes to providing your body with energy.
- This system provides the fastest form of energy that is burned very quickly; energy from this system is needed typically during high intensity activities for short bursts of time.
- Examples of this systems energy aid in exercise include:

  -High weight/low rep weightlifting

  -Sprinting

  -Boxing

3.3.10 Discuss the Characteristics of the Three Energy Systems

Creatine Phosphate System: How it works

- ATP is broken down during muscle contraction, leaving ADP and Phosphate.
- Then, the enzyme creatine kinase breaks down phosphocreatine into creatine and phosphate.
- Energy is released when PC is broken down
- Byproducts ADP and Pi(single phosphate) rejoin to produce more ATP, which means more fuel for cellular activity.

3.3.10 Discuss the Characteristics of the Three Energy Systems

Lactic Acid System:

- Glycolysis in cytoplasm→ Glucose split into pyruvate
- Releases some energy as ATP
- When the cells run out of oxygen, the pyruvate is converted into lactic acid.
- This makes this system optimal for short intense exercise → as more lactic acid is produced, the pH in the cells is reduced, limiting their ability to contract

3.3.10 Discuss the Characteristics of the Three Energy Systems

Aerobic System:

- Includes the Krebs cycle and electron transport chain (ETC)
- Pyruvate from glycolysis → Acetyl CoA, which enters Krebs cycle in mitochondria
- Through reactions involving oxygen, acetyl CoA→ water, carbon dioxide, and hydrogen ions
- These ions are taken to the ETC→ energy is produced, and ATP is formed

Energy Systems

3.3.10 Discuss the Characteristics of the Three Energy Systems

	Creatine Phosphate System	Lactate Acid System	Aerobic System
Fuel Used	• Creatine Phosphate • Stored ATP	• Blood Glucose • Muscle & Liver Glycogen	• Blood Glucose • Muscle & Liver Glycogen • Adipose & intramuscular fat
Energy (ATP) Produced	• Very Low	• Low	• Very High
ATP production speed	• Very High	• High	• Low
Duration of Activity Used	• 5-15 seconds	• 30 seconds to 2 minutes	• Any exercise longer

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2. Carbohydrate and fat metabolism

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3.3.11 Evaluate the relative contributions of the three energy systems during different types of exercise.

	Creatine Phosphate System	Lactate Acid System	Aerobic System
Fuel Used	• Creatine Phosphate • Stored ATP	• Blood Glucose • Muscle & Liver Glycogen	• Blood Glucose • Muscle & Liver Glycogen • Adipose & intramuscular fat
Energy (ATP) Produced	• Very Low	• Low	• Very High
ATP production speed	• Very High	• High	• Low
Duration of Activity Used	• 5-15 seconds	• 30 seconds to 2 minutes	• Any exercise longer