Biochemical Systems Handout

All living cells need energy to function in order for the chemical reactions occurring in the cells to take place. In humans this energy is obtained by breaking down organic molecules such as carbohydrates, fats and proteins. When the previous substances are broken down at molecular level, bonds breaking and forming between the atoms in the molecules release or require energy. The biochemical reactions, which take place in cells when a fuel substance such as carbohydrate (e.g. glucose or fructose) is broken down, will normally release more energy than they use.The energy required for muscle contraction comes from a molecule called adenosine triphosphate or ATP (adenosine triphosphate). At any one time, we only have a small amount of ATP in our muscles and so ATP must be regenerated in our bodies.

In humans, energy is produced through three main biochemical systems:

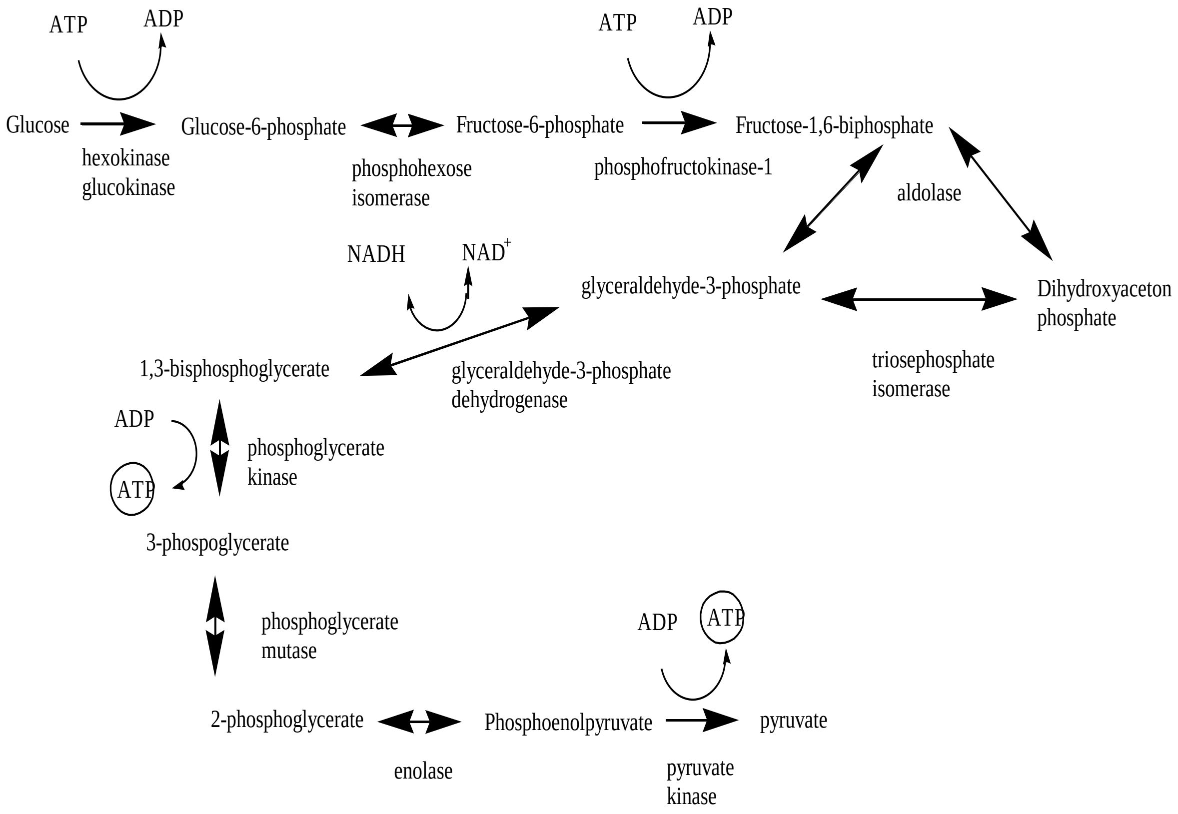
- ATP-PC (phosphagen) system;
- anaerobic glycolytic, or lactic acid system; and
- aerobic system – comprising the glycolytic (carbohydrate) and lipolytic (fat) systems.

The ATP – PC System

This system of energy provision is used for sudden bursts of energy but cannot be sustained for more than about 6 − 10 seconds. PC stands for phosphocreatine a substance which is stored within the muscle cells but in relatively low amounts. Once the store is depleted it takes time for the stores to be restored. Creatine is produced in the liver from the amino acids glycine, arginine and methionine. It is transported from the liver via the blood mainly to skeletal muscles, where it is combined with phosphate to make phosphocreatine (PC). Once PC has been broken down to produce ATP (adenosine triphosphate) it can be recycled into PC or is converted in creatinine, which is then removed via the kidneys in urine. Certain fish and meats are a good source of creatine in the diet.

Anaerobic glycolytic or lactic acid system

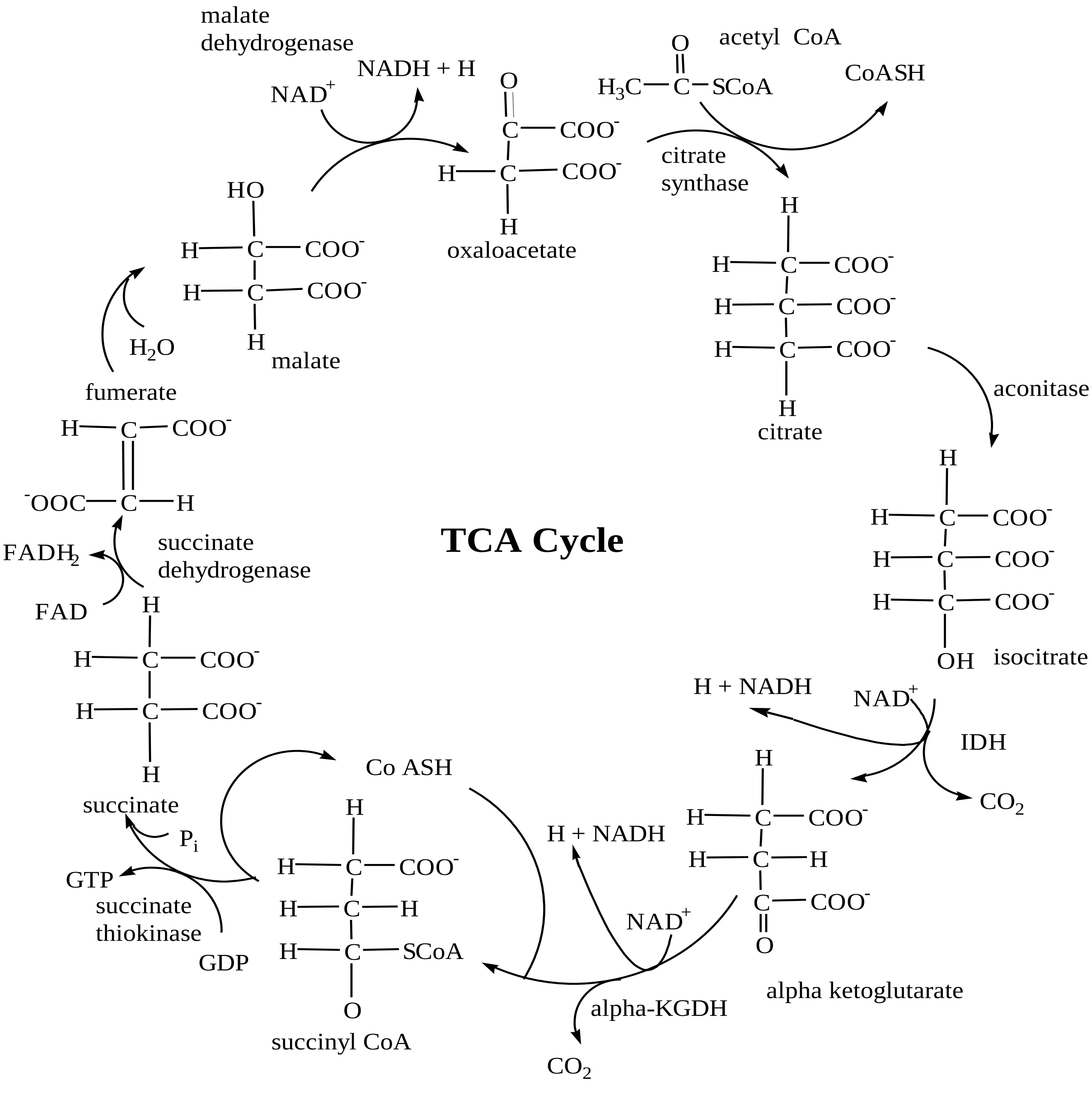
Glucose, normally found in the muscles as glycogen can be broken down to provide chemical energy by a process known as glycolysis. In both aerobic an anaerobic glycolysis the first steps are the same. The flow chart shows the pathway of the breakdown of glucose into pyruvate.



In the anaerobic system the pyruvate is converted to lactate by the enzyme lactate dehydrogenase (LDH). This anaerobic process can only take place for a short time before the lactate produced builds to a level which stops the process. This is known as the lactate tolerance level.

Aerobic System

In the aerobic system, oxygen being present, the pyruvate is further metabolised via the tricarboxylic acid cycle (TCA cycle). The pyruvate enters the TCA cycle as acetyl – CoA which is the product of another reaction known as the pyruvate dehydrogenase reaction involving further enzymes. The purpose of the TCA cycle is to provide NADH + H, GTP and $FADH_2$ molecules. These molecules then provide energy for reactions in oxidative phosphorylation pathways producing ATP. This is the energy source needed for the majority of cellular processes including transportation of molecules across cell membranes resulting, eventually, in muscle contraction.



The net result of all the reactions is the breakdown of a glucose molecule into water and carbon dioxide producing energy during the process.

$$C_6H_{12}O_6 + 6\,O_2 \xrightarrow{\text{energy released}} 6CO_2 + 6H_2O$$

Questions

1. What are the three basic energy provision mechanisms found in humans?
2. What do the abbreviations ATP and PC stand for?
3. During the glycolysis of glucose to pyruvate ADP and NAD^+ are converted into molecules which can provide energy for further processes. Write an equation to show this.
4. Is the phosphocreatine system anaerobic or aerobic?
5. Which system do you think sports drinks will affect the most and why?