8.5 Biochemistry

You eat chemicals in order to stay alive. You get the energy to move and work from combustion reactions between the food and oxygen gas.

food +
$$O_2(g)$$
 -----> $CO_2(g)$ + $H_2O(l)$ + energy

The main ingredients in foods which produce this energy are carboxylic acids, amino acids, and carbohydrates.

Carboxylic acids are called fatty acids by nutritionists. The functional group of a carboxylic acid is -COOH. The bond angle around the carbonyl carbon is 120°, and its shape is trigonal planar. The bond angle around the oxygen on the -OH group is 105°, and it is bent. Its structural formula is given below. The R-stands for a hydrocarbon chain.

Fatty Acids CH ₃ COOH CH ₃ CH ₂ COOH	Name ethanoic acid (acetic acid) propanoic acid	Found In vinegar antifungal agent
CH3CH2CH2COOH	butanoic acid (butyric acid)	butter flavoring
CH ₃ (CH ₂) ₂ CH ₂ COOH C ₁₅ H ₃₁ COOH	hexanoic acid palmitic acid	vegetable fats
C ₁₇ H ₃₃ COOH	octadecenoic acid (oleic acid) octadecanoic acid (stearic acid)	vegetable oil animal fat
C ₁₇ H ₃₅ COOH C ₂₅ H ₅₁ COOH	cerotic acid	beeswax

Vinegar is dilute ethanoic acid (acetic acid). Bee and wasp stings inject methanoic acid (formic acid) into your body. Propanoic acid is an antifungal agent used in the baking industry. Butanoic acid (butyric acid) is one of the ingredients of "body odor" and is a component of rancid butter. Hexanoic acid is used as a flavoring and has the odor of Limburger cheese. Benzoic acid is a common food preservative often found in soft drinks. Octadecenoic acid (oleic acid) is a vegetable oil. Octadecanoic acid (stearic acid) is an animal fat.

Long chains of carboxylic acids are found in fats. Vegetable fats contain unsaturated acids such as oleic acid. Unsaturated fats are liquids at room temperature. Animal fats contain saturated fats such as stearic acid. Saturated fats are solids at room temperature.

Hydrogenation is used to change liquid unsaturated fats to solid saturated hydrocarbons. Vegetable oils, which are unsaturated, are used to make margarine, whereas animal fats, which are saturated hydrocarbons, are used to make butter. Unsaturated oils are healthier for you to eat than saturated fats, and margarine ads point this out. The only problem is, in order to make the margarine solid so that it can be spread on your toast with a knife, it must be hydrogenated, that is, turned into a saturated hydrocarbon. Look at the fine print on the label to see that margarine is indeed hydrogenated!

When ethanol is metabolized in the body, the alcohol is first converted to acetaldehyde and then to ethanoic acid (acetic acid = vinegar).

$$CH_3CH_2OH(l) + O_2(g) -----> CH_3COOH(l) + HOH(l) + 2O_2(g) -----> 2CO_2(g) + 3HOH(l) + energy$$

The final products of ethanol reacting with oxygen are carbon dioxide and water.

$$CH_3CH_2OH(l) + 3O_2(g) -----> 2CO_2(g) + 3HOH(l) + energy$$

This same process causes wine to turn to vinegar. When you are offered a bottle of wine in a restaurant, the waiter waits for you to taste it so that you can be sure that oxygen has not gotten into the bottle and turned the wine to vinegar. Wine bottles are stored on their sides to keep the cork moist and tight in the bottle to keep the oxygen gas out! Note that with only one mole of oxygen, wine turns to vinegar.

Esters are formed when fatty acids reacts with alcohols. The functional group of all esters is -COOR. The bond angle around the carbonyl carbon is 120° with a trigonal planar configuration. Natural scents and flavors of many flowers and fruits are due to esters. Artificial fruit flavors are made by mixing several esters to give the flavor and aroma of the natural product. The natural flavors and odors are not exactly duplicated, but most people can be fooled. Although the "fruity" tastes and odors of esters are pleasant, they are not used to make perfumes. This is because ester groups can react with perspiration, changing the esters back into carboxylic acids and alcohols. Carboxylic acids do not have pleasant odors. Remember, butyric acid is body odor! On the other hand, methyl-butyrate and ethyl-butyrate are the esters of apple and pineapple, respectively. Perfumes are made from hydrocarbons and ketones. Esters are used only for the cheapest toilet waters.

More about drinking alcohol

When a person has been drinking for a while and continues to drink, the alcohol can react with the ethanoic acid (acetic acid) which is in the blood from the metabolism of the previously drunk alcohol to produce an ester (ethyl-ethanoate). The ester is not tolerated well by the body, and the person gets sick and vomits. The ester produces the morning-after sweet breathe associated with hang overs.

When large amounts of ethanol are drunk, the alcohol can react to produce ethyl ether. Ethyl ether used to be used as an anesthetic. It has the same effect on a person who drinks heavily, causing the person to pass out. If a lot of alcohol is chugg-a-lugged, the drinker may pass out before vomiting. This can cause death.

Amino acids have two functional groups. One functional group is an amine group, -CH₂NH₂, and the other is a carboxylic acid group, -COOH, thus the name amino acid. Amino acids are essential in the diet because they form proteins. Proteins in the diet are broken down into amino acids, and the amino acids are used to replace the cell protein.

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Protein is essential in the diet because proteins catalyze body reactions. Without enzymes, the bodily chemical reactions would be too slow for you to stay alive. Proteins are also used to make cells, glycogen, or fat, and are broken down and used for energy.

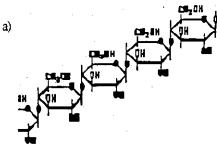
Carbohydrates are sugars. Sucrose, table sugar, is a carbohydrate. Sucrose is a complex carbohydrate. It is actually two simple carbohydrates bonded together and is therefore called a disaccharide. The bond between the two carbohydrates making up sucrose can be broken down with energy to form glucose and fructose.

Glucose is the only sugar the body can use. Therefore, other sugars in the diet, such as sucrose, must be converted to glucose by digestion before they can be used for energy or stored. Glucose is found in corn syrup and honey. Fructose is fruit sugar and has the same molecular formula as glucose but a different structural formula. It is a structural isomer of glucose. It can be digested into glucose.

Starch and cellulose are examples of polysaccharides. They are made up of several monosaccharides.

Self Test 8.5

1. Match the following



fatty acid

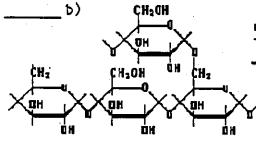
carbohydrate

- $_{15}^{\mathrm{H}}\,_{31}^{\mathrm{C-O-CH}_2}\,_{0}^{\mathrm{CH}_2}\,_{3}^{\mathrm{CH}_3}$
- amino acid

C₁₇ H₃₅ COOH

ester

- 2. Proteins are composed of
- a) amines
- b) carboxylic acids
- c) fatty acids
- d) carbohydrates e) amino acids
- 3. Indicate whether each of the following is a monosaccharide, disaccharide, or polysaccharide.



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- 4. List the following in order of most saturated to least saturated. a) Promise Margarine® in a tub

most saturated

- b) Crisco®
- c) butter
- d) sunflower oil
- e) peanut oil

least saturated