Lesson 1-digestion- part 1 - hydrolysis reactions

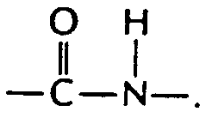
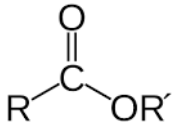
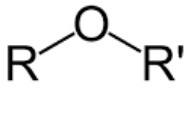
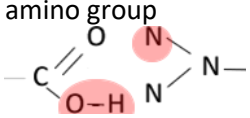
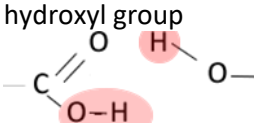
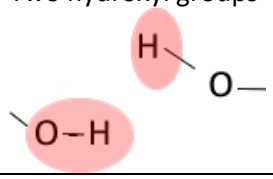
Digestion involves the breakdown of food molecules so that they can be absorbed into the blood stream and processed at various organs around the body. Digestion and absorption involves hydrolysis and condensation reactions.

In all cases of condensation reactions, a hydrogen atom protruding form a molecule is linked to an OH protruding from another molecule, producing a **H_2O** molecule. The reaction can be summarised by the equation below.

A-H+ B-OH → A-B + H_2O

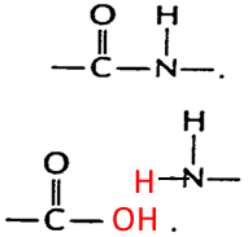
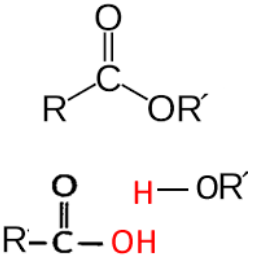
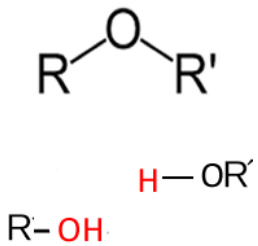
In the formation of:

- proteins the H comes from the amino group (NH_2) while the OH comes from the carboxyl group of the acid.
- triglycerides the **H** comes from the hydroxyl group (O**H**) of the alcohol (glycerol) while the OH comes from the carboxyl group of the acid.
- carbohydrates the H comes from the hydroxyl group of one monosaccharide while the OH comes from the other monosaccharide.

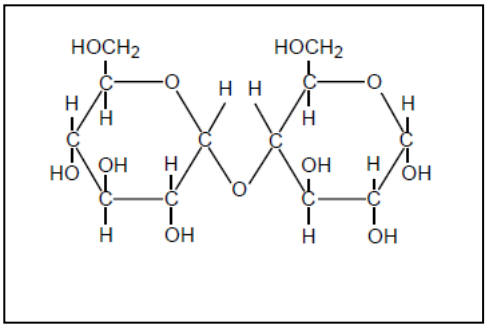
Condensation	Proteins	Fats	Carbohydrates
Subunits	Amino acids	Glycerol and fatty acids	monosaccharides
Type of functional group linking the subunits	 Amide group	 Ester group	 Ether group
Two functional groups that form the link between subunits	A carboxyl and an amino group 	A carboxyl and a hydroxyl group 	Two hydroxyl groups 

Hydrolysis reactions are the opposite to condensation reactions. Large molecule are split into smaller units by the breaking of bond through the addition of a **H** to one section and **an OH** to the other. Essentially by the bond is broken by the addition of water, hence the name ***hydrolysis.*** The reaction is represented by the equation below.

A-B + H_2O --> A-H+ B-OH

	Proteins	Fats	Carbohydrates
	Amino acids	Glycerol and fatty acids	monosaccharides
Hydrolysis			

1) Consider the molecule of maltose shown on the right.
It has the molecular formula $C_{12}H_{22}O_{11}$



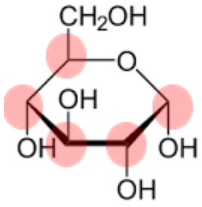
a) What is the molecular formula of the product of hydrolysis of maltose? *$C_6H_{12}O_6$*

b) Write a balanced chemical equation, no states required, for the hydrolysis of maltose, using chemical formulae.
$C_{12}H_{22}O_{11} + H_2O \rightarrow 2\ C_6H_{12}O_6$

c) Write a balanced chemical equation, no states required, for the combustion of maltose, in excess oxygen.
$C_{12}H_{22}O_{11} + 12O_2 \rightarrow 12\ CO_2 + 11H_2O$

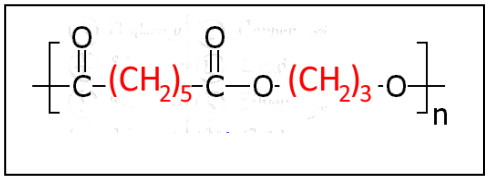
d) Draw the structural formula of the molecule that formed maltose.

e) How many chiral centres are present in this molecule. Label each one. *5*



Alpha glucose

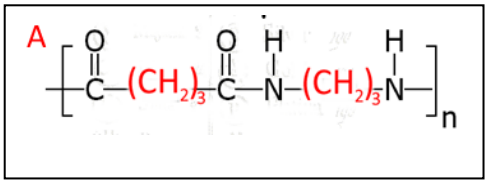
2) A repeating section of a polymer is shown on the right.



a) What type of reaction formed this polymer?
Condensation polymerisation
b) The polymer is subjected to hydrolysis.
Name the products formed?
heptandioic acid and *propane-1,3-diol*

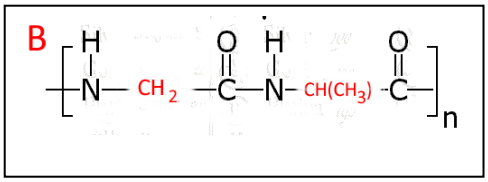
c) Name the functional groups present *Ester*

3) A repeating section of a polymer is shown on the right.



a) What type of reaction formed this polymer
Condensation polymerisation
b) The polymer is subjected to hydrolysis.
I. Name the products formed?
pentandioic acid and propane-1,3-diamine
ii. Are these products 2-amino acids? Explain.
No. An amino acid has a carboxyl functional group on carbon number 1 and an amino group (NH_2) on carbon number 2.
c) Name the functional groups present in the polymer. *amide*

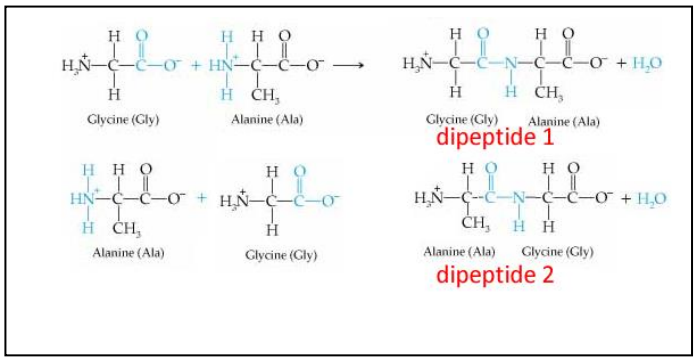
d) Another polymer is formed from the repeating unit shown on the right.



i. Give the systematic names of the products of hydrolysis?
2-aminoethanoic acid and 2-aminopropanoic acid

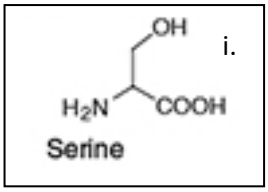
ii. *Explain* why many forms of polymer B are possible but only one form of polymer A is possible.

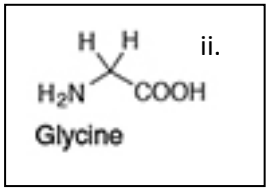
Depending on which orientation the amino acids are in when they bond a new peptide is formed. As shown on the right when alanine and glycine bond to form a dipeptide. Notice how the two dipeptides are different.

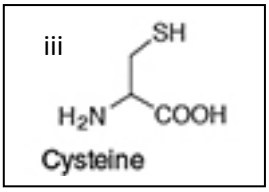


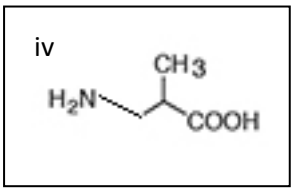
Peptide A is formed from monomers which have the same orientation no matter which way the turn hence will always produce the same polymer.

4) Consider the molecules given below in their semi-structural formulae.
a) Draw their structural formulae.
b) Which of the following are likely to be an amino acid obtained by the hydrolysis of protein in food? Explain.
i. $H_2NCH(CH_2OH)COOH$, ii. H_2NCH_2COOH, iii. $H_2NCH(CH_2SH)COOH$,
iv. $H_2NCH_2CH(CH_3)COOH$









I, ii, and iii are all 2-amino acids and hence will be found in proteins.
iv is not a 2-amino acid it is a 3-amino acid.

5) Pasta is considered a low GI food, but if overcooked becomes a high GI food.

i. Explain why.
When boiled in water the starch polymer starts to hydrolyse to release glucose monomers.

ii. What type of foods are considered low GI Explain why
Foods that contain starch with a high percentage of amylose. High GI foods tend to cause a sudden increase in blood sugar as they are absorbed quickly into the blood stream. Low GI foods such as starch rich in amylose, which is less soluble than amylopectin and hence slower to be broken down by enzymes, take longer to be broken down by enzymes in the digestive system and hence the release of glucose or other monosaccharides is slower.

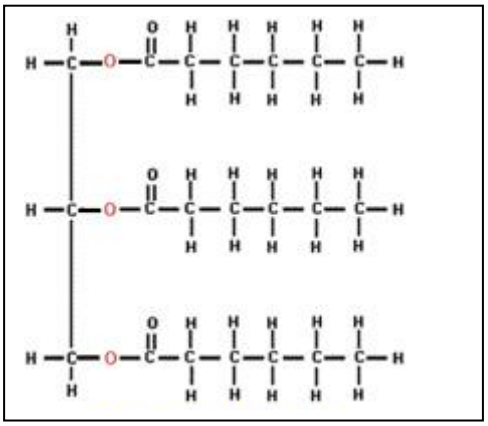
iii. What types of food are considered high GI.
Foods that contain monosaccharides, such as glucose. Foods such as confectionary.

6)The monosaccharide glucose is obtained from the hydrolysis of starch and undergoes combustion in excess oxygen. A 0.360 gram sample of glucose (molar mass 180.2 amu) is placed in a bomb calorimeter and completely burnt in excess oxygen. The calorimeter was filled with 200.0 mL of water at 25.0 °C. Calculate the molar heat of combustion of glucose if the final temperature of the water increased to 31.7 °C.

Step 1Calculate the mol of glucose
=> 0.360 / 180.2 = 0.00200
Step 2 Calculate the amount of energy given out by this amount of glucose
=> E = 4.18 X mass X ΔT
=> E = 4.18 X 200.0 X (31.7 - 25.0) = 5601 J
Step 3 Find the molar heat of combustion
=> 5601/0.00200 = 2801 kJ/mol

7) Most fats and oils are formed of triglycerides which contain the ester functional group formed by a condensation reaction between 1 molecule of glycerol and 3 molecules of fatty acids. After hydrolysis of a triglyceride a 16 carbon long, monounsaturated fat was recovered. How many hydrogen atoms are there in a molecule of the fatty acid?
The general formula for a saturated fatty acid is $C_nH_{2n+1}COOH$
So a 16 carbon fatty acid will have 32 hydrogen atoms.

8) Consider the hydrolysis of the compound shown on the right.



a) To what class of compounds does it belong to? *triglycerides*

b) Give the systematic names to the products formed after hydrolyisis. *Propane-1,2,3-triol and hexanoic acid.*

c) Write a balanced chemical equation for the hydrolysis of this compound. States are not necessary.
$C_{21}H_{38}O_6 + 3H_2O \rightarrow CH_2OHCHOHCH_2OH + 3C_6H_{12}O_2$

9) The three major food groups are fats, carbohydrates and proteins. A compound was analysed and found to contain carbon, hydrogen and nitrogen. To which food group does it belong? Explain. *Proteins. Fats and carbohydrates do not contain nitrogen*.