UNIT 2 BIOCHEMISTRY: THE CHEMISTRY OF THE LIVING WORLD

A. CARBOHYDRATES

NOT ALL CARBOHYDRATES ARE CREATED EQUAL

Plants are the main source of carbohydrates for both human food and other commercial uses. They synthesise carbohydrate from carbon dioxide and water (photosynthesis) and use it as an oxidisable fuel (source of energy to the plant), store it for later use as a fuel (for example, starch in potatoes) or convert it into structural material (for example, cellulose). Most animals obtain their carbohydrate by eating plant material directly or indirectly

The monomeric units of carbohydrates are called monosaccharides. When two monosaccharides are condensed together by elimination of a molecule of water, a disaccharide is formed. Together the mosaccharides and the disaccharides are known as the sugars. They are crystalline solids which dissolve readily in water. Polysaccharides are formed when many hexose units are joined. They may be extremely insoluble in water (such as cellulose) or rather soluble (such as glycogen).

The most important monosaccharides are glucose and fructose. Glucose is a white crystalline solid, soluble in water but insoluble in most organic solvents. Glucose is commonly used as a source of energy by plants, animals and bacteria. Animals normally ingest it in the form of starch and sucrose (cane sugar) which are hydrolysed to glucose by enzymes. Mammals do not possess an enzyme capable of hydrolysing cellulose to glucose, which is why cellulose is useless as a foodstuff. Energy is obtained from glucose by oxidation which occurs in the cell by a sequence of enzyme-catalysed reactions.

Human beings obtain most of their energy from oxidising fat rather than carbohydrates. But the use of carbohydrate can provide a supply of energy during particularly intense muscular activity when oxygen cannot be obtained rapidly enough.

Disaccharides consist of two monosaccharide molecules joined together with the loss of a molecule of water. Naturally occurring disaccharides are maltose, lactose and sucrose. They all have similar physical properties, being white crystalline solids which are soluble in water.

Polysaccharides are polymers, made up of monosaccharide units, which occur in both animals and plants. The two most widely occurring polysaccharides are starch and cellulose. Starch is the main carbohydrate reserve of plants. It is also an important ingredient of animal foods since it provides a source of glucose; it is hydrolysed to glucose by enzymes in saliva. Cellulose is the principal constituent of the cell walls of plants.

(From: Norman-Waddington, Modern Organic Chemistry, Bell & Hyman)

1 *Answer these questions about* Not all carbohydrates are created equal.

a. Where do we get the carbohydrates we need from?

b. What do plants synthesise carbohydrates from?

c. How do animals get the carbohydrate they need?

d. What are monosaccharides?

e. When is a disaccharide formed?

f. What are sugars like?

g. When are polysaccharides formed?
h. What are the physical properties of glucose?
i. How is energy obtained from glucose?
j. What are the naturally occurring disaccharides?
k. What is the nutritive value of starch?
l. Where is cellulose found?

2 *Use these words to complete the concise summary of* Not all carbohydrates are created equal: bloodstream, disaccharides, enzyme, glucose, molecular size, monosaccharides, photosynthesis, polymers, polysaccharides, starch.

Carbohydrates are formed in plants by the process of (1) ..... from carbon dioxide, water and sun energy. Carbohydrates are placed in one of the three classes, depending on their (2) ..... (3) ....., like glucose and fructose, are the simplest monomeric units and are the building blocks of (4) ....., like sucrose, which contain two monosaccharide units, and of (5) ....., like cellulose, starch and glycogen, which are (6) ..... of monosaccharides. Since we lack the necessary (7) ....., we cannot digest cellulose, therefore we must rely partly on (8) ..... as a source of glucose. Starch is broken down by amylase, an enzyme present in saliva and pancreatic juice, into (9) ..... which is then absorbed into the (10) .....

3 *Match adjectives* a-h*, as they are used in the passage* Not all carbohydrates are created equal*, with their synonyms* 1-8*. Tip: copy the pairs in your indexed book.*

a. empirical	☐	**1.** able
b. several	☐	**2.** analogous
c. convenient	☐	**3.** numerous
d. main	☐	**4.** practical
e. capable	☐	**5.** principal
f. useless	☐	**6.** strong
g. intense	☐	**7.** unusable
h. similar	☐	**8.** useful

4 *Tick among the following which are the pros and which are the cons of simple sugars in the diet. Add any more you can think of.*

	PROS	CONS
a. are a sweet treat	☐	☐
b. boost blood triglycerides	☐	☐
c. cause tooth decay	☐	☐
d. give quick energy	☐	☐
e. if not burned as energy, they accumulate as fat	☐	☐
f. increase blood glucose levels	☐	☐
g. make food tasty	☐	☐
h. weaken the immune system	☐	☐

B. PROTEINS

BODY BUILDERS

Protein accounts for about 80 per cent of the dry mass of all the soft parts of an animal body (i.e. excluding the skeleton). Plants contain a lower proportion.
Proteins are derived from amino acids joined together by peptide bonds.
The name protein is given to naturally occurring polypeptides containing more than about 40 amino-acid residues (the term 'residue' is used for an a-amino acid which has lost the elements of water in forming a peptide bond). The number of potentially different proteins is virtually infinite: 20 a-amino-acids are used in their formation, and they can, in theory, be linked in any possible permutations of sequences and total number.
Living organisms need to synthesise new protein continuously, partly to support growth and partly to replace proteins which are broken down during the process of living. In contrast to plants and bacteria, animals must obtain their amino acids from proteins in their diet. The proteins are first hydrolysed to their constituent amino acids, in processes catalysed by enzymes in the stomach and in the intestine. The constituent amino acids pass into the blood stream and then to the liver and other tissues where, under the influence of nucleic acids, they are converted into the proteins required by the body. Of the 20 amino acids that constitute naturally occurring proteins, 12 can be synthesised in the human body from other amino acids. However, eight are described as essential amino acids; their residues must be present in the diet since they cannot be synthesised in the human body.
Each protein is defined by the number and nature of its constituent amino-acid residues and the sequence in which these are arranged.
Folded proteins can be assigned to one of two groups, the fibrous proteins and the globular proteins. Fibrous proteins are usually insoluble in water and form important structural features. Examples are keratin (in hair and feathers) and collagen, the material which makes up tendons, ligaments and connective tissue.
Globular proteins are mostly soluble in water. Enzymes are a particularly important group of globular proteins. They are the catalysts which enable living organisms to bring about necessary reactions at body temperature.
Since the forces that determine the shape of a protein are relatively weak, the shape can readily be disrupted, and this is known as denaturation. Denaturation can usually be reversed.

(from: Norman-Waddington, *Modern Organic Chemistry*, Bell & Hyman)

5 *Answer these questions about* Body builders.

a. Do animals and plants contain the same proportion of proteins?
b. What are proteins?
c. How many amino acids are proteins derived from?
d. Why do living organisms need to synthesize proteins?
e. How do animals get their amino acids?
f. What is meant by 'essential amino acids'?
g. Can you name some fibrous proteins and say where they are found?
h. What are enzymes and what is their task?
i. What is meant by 'protein denaturation'?

6 *Which of these verbs can replace the phrasal verbs below as they are used in* Body builders: enter, explain, form, produce? *Tip: copy the pairs in your indexed book.*

a. account for .....
b. bring about .....
c. make up .....
d. pass into .....

7 *Match past participles* a-f, *as they are used in* Body builders, *with their synonyms* 1-6. *Tip: copy the pairs in your indexed book.*

a. derived from	☐	**1.** defined
b. broken down	☐	**2.** developed out of
c. converted into	☐	**3.** disrupted
d. required by	☐	**4.** divided into
e. described as	☐	**5.** necessary to
f. assigned to	☐	**6.** transformed into

8 *Use the nouns below to complete the passage* Proteins in the diet.

adult, amino acids, animal, antibodies, carbohydrates, child, children, cultures, deficiencies, diet, enzymes, haemoglobin, insulin, machinery, plant, protein, sources, strength

We need protein in our food because it constitutes the basic (1) ..... of all life. Take away the water in our bodies, and most of what is left in our muscles, organs, blood cells, skins, nail, hair, teeth and bones is (2) ..... The (3) ..... that build up and break down other molecules, disease-fighting (4) ....., oxygen-carrying (5) ....., certain hormones like (6) .....: all these chemicals are proteins. They are continually being used up or worn away, and protein from our (7) ..... is used to replace them, or, in growing (8) ....., to build them up. Like fats and (9) ....., proteins can be burned for energy. Twenty (10) ..... go to make up all human proteins, of these the (11) ..... needs a dietary supply of 8, the growing (12) ..... 9 or 10. All (13) ..... foods are complete protein (14) .....
(15) ..... proteins are generally incomplete but they are often complementary, that is, the (16) ..... of one food are counterbalanced by the (17) ..... of another. Long before the world knew anything about amino acids, many (18) ..... have adjusted their diets to take advantage of protein complementarity.

C. LIPIDS

FATS AS ELEMENTS OF NUTRITION

Like carbohydrates, fats are used in the body primarily as an energy source, and have several other minor though important functions. Fats store about twice as much energy in a given weight as carbohydrates do, because many fewer of its chemical bonds have been oxidized.
Fats are a universally popular element of food, probably on account of their various flavours, smooth texture, and the sensation of "fullness" they produce when eaten.
Unlike sugars, fats are not soluble in water, the body's chemical medium, and so must receive special treatment during digestion. They are emulsified, or broken down into small droplets, to increase the number of molecules exposed to the digestive enzymes in the small intestine in order to be distributed to the rest of body.
Fats do much more for us than store energy. Certain fatty acids are converted by the body into phospholipids that are the basic material of cell membranes. The brain, nervous system, and liver are especially rich in phospholipids. A few of the fatty acids that go into these materials are, like some vitamins and amino acids, absolutely essential to the diet; the human body cannot synthesize them from related materials.
Cholesterol is not a fat, but a different member of the chemical family called the lipids. It is a uniquely animal product. It is well known that excess cholesterol can be deposited on the walls of our blood vessels and so lead to circulatory problems. It is less well known that cholesterol is a very important molecule, and that the body synthesizes significant quantities of it. Cholesterol forms the nucleus of the vitamin D molecule, of various regulatory and sex hormones, and of the bile salts that emulsify fats in the intestine. Cholesterol synthesis goes on in the liver and intestine, but all cells can apparently supply their own immediate needs. The problem is that synthesis in the body proceeds independently of dietary intake (although it appears to be raised by the ingestion of saturated fats). In addition, we have few mechanisms for getting rid of cholesterol. There is also evidence that both physical inactivity and emotional stress can increase blood cholesterol levels.

(from: Mc Gee, *On Food and Cooking*, Unwin Hyman)

9 *Complete the definitions using the words below which you have found in* Fats as elements of nutrition.

bile salts, blood vessels, brain, carbohydrates, cholesterol, digestion, hormones, liver, nervous system, small intestine, vitamins

a. ..... are organic compounds – including sugars, starches, celluloses and gums – which serve as a major energy source for the body.

b. ..... is the body's method of taking the food we eat and breaking it down to obtain vital nutrients that will allow us to live.

c. The ..... is the part of the gastrointestinal tract where much of the digestion and absorption of nutrients and minerals found in food takes place.

d. The ..... is the body organ which acts as the body control centre, enabling us to think, learn, create, feel emotions and regulating our unconscious body processes, such as digestion and breathing.

e. The ..... is a complex network of nerves and cells that carry messages to and from the brain and spinal cord to various parts of the body.

f. The ..... is a vital organ which plays a major role in metabolism and has a wide range of functions in the body, including detoxification, protein synthesis, production of biochemicals necessary for digestion.

g. ..... are organic compounds required by an organism as a vital nutrient in limited amounts.

h. ..... is a lipid produced by the liver which is vital for normal body function and present in the outer layer of everybody's cell.

i. ..... are arteries, capillaries and veins that transport blood throughout the body.

j. ..... are chemicals that carry messages from body organs to cells.

k. ..... are chemicals produced in the liver and stored in the gallbladder which aid in the digestion of fats and help in the elimination of toxins from the body.

10 *Match adjectives* a-e, *as they are used in* Fats as elements of nutrition, *with their antonyms* 1-5. *Tip: copy the pairs in your indexed book.*

a.	several/various	☐	**1.** few
b.	minor	☐	**2.** major
c.	smooth	☐	**3.** rough
d.	essential	☐	**4.** unknown
e.	well known	☐	**5.** unnecessary

D. NUCLEIC ACIDS

GENETIC INFO CARRIERS

A cell which synthesises proteins needs to be able to store information about the sequences of amino-acids in those proteins and to translate the coded information into a real sequence. Both these properties are conferred by nucleic acids.

Nucleic acids are polymers formed from nucleotides. A nucleotide is composed of a carbohydrate, a phosphate group and a nitrogen base, and in the nucleic acids the polymer chain consists of alternating carbohydrate and phosphate units. There are only two general types of nucleic acid: ribonucleic acid (RNA), in which the carbohydrate is ribose and the bases are cytosine and uracil and adenine and guanine and deoxyribonucleic acid (DNA), in which the carbohydrate is deoxyribose and the bases are the same as in RNA except that thymine replaces uracil.

In DNA, two nucleic acid chains, each in the form of the helix, are intertwined. The two strands are held together by hydrogen bonds between the bases. This arrangement is only possible when the right pairs of bases are opposite each other. In DNA the sequences of the two strands are always complementary to each other.

The double-helical structure of DNA fits it exactly for its role as a store of information. When a cell reproduces itself, the DNA molecules first separate into their individual strands and each then acts as a template for the synthesis of a new strand. The synthesis is carried out by an enzyme. The translation of this coded information for specifying the sequence of amino-acids in a protein involves RNA. RNA molecules have only a single strand, and they are synthesised, using one of the two strands of DNA as a template.

Two types of RNA molecules are synthesised: a smaller type known as transfer RNA (tRNA), and a larger type known as messenger RNA (mRNA). They have different roles in protein synthesis: mRNA specifies the sequence of amino acids in the protein and tRNA translates the message in the mRNA by ensuring that a particular amino-acid recognises the appropriate sequence of three bases in the mRNA.

(from: Norman-Waddington, *Modern Organic Chemistry*, Bell & Hyman)

11 *Answer these questions about* Genetic info carriers.

a. What do nucleic acids enable protein-synthesising cells to do?

b. What are nucleic acids?

c. What is a nucleotide made up of?

d. What does the polymer chain in a nucleic acid consist of?

e. What are the two types of nucleic acids?

f. What do they consist of?

g. What are the two types of RNA molecules?

h. What is their different role in protein synthesis?