The verbs in the box have been taken from the passage POLYMERS. Read the passage and put the verbs back in the correct place.

adding become called classified coated come comes condensed contain degrade depending describes devoted divided eliminating fall harden join together means (2) return soften suggests takes place walk wear

POLYMERS

The word polymer .......... from Greek in which poly .......... “many” and mer .......... “unit” and it .......... a molecule made up of many, small, individual repeating units .......... monomers.

Addition polymers are made by .......... together similar simple molecules. Polyethylene is an addition polymer: the empirical formula of the polymer is the same as that of the monomer.

In condensation polymers the monomers .......... together or “condense” by .......... a small molecule. Polypeptides, in which the monomers have .......... by eliminating a small molecule of water, are condensation polymers - nylon and polyesters are condensation polymers.

Polymers may be .......... into natural (like proteins, carbohydrates and nucleic acids such as DNA) and synthetic (like polyethylene, polyesters, polyvinyl chloride, Teflon).

Synthetic polymers are produced by making relatively simple molecules polymerise, that is .......... to form very big molecules.
In polymers that can easily be made into fibres the molecules of the polymer long chains of atoms. In these cases there is little attraction between the chains, that is there is little cross-linking. In some polymers, however, there is considerable attraction between the polymer molecules and a great deal of cross-linking.

Synthetic polymers are classified as elastomers, plastics, and fibres on their elasticity. As the name, elastomers (e.g. rubber) can be highly stretched and to their normal dimensions many times. Fibres, which may be semi-synthetic (e.g. rayon and cellulose acetate) or purely synthetic (e.g. polyamides like nylon, polyesters like Dacron, and acrylics like Orlon) are the least elastic. Plastics in between.

Polymers are also on the basis of their response to heat.

Thermoplastic polymers (e.g. polyethylene) on heating and then again when they cool down. They are unaltered chemically and can be heated and moulded several times. Thermosetting polymers (e.g. Bakelite and Melamine) or decompose on heating and hard and brittle on cooling.

Approximately 80% of the organic chemical industry is to the production of synthetic polymers. Phonograph records are polyvinyl chloride, the plastic squeeze bottle in your laboratory desk is polyethylene, and frying pans are with Teflon. You may clothes made of polyester, Dacron or Orlon and in shoes made of a synthetic material.

**AFTER READING**

**CONTENT**

*Questions about the text.*

1. What is a polymer?
2. How are addition polymers made?
3. How are condensation polymers formed?
4. How are polymers divided?
5. What is meant by “cross-linking”?
6. How are polymers classified as to their elasticity?
7. How do the physical properties of the three groups differ?
8. How are polymers classified as to their response to heating?
9. What are the different characteristics of the two kinds of plastics?
Join the heads 1-18 and tails a - r into a meaningful introductory passage to PROTEINS.

1. A protein is a polymer of
2. Although there is a wide variety of proteins with very different properties they are all derived from
3. Proteins can be divided into
4. Simple proteins consist only of
5. Conjugated proteins contain
6. Proteins occur in
7. Insulin has
8. Human haemoglobin contains
9. The primary structure of a protein is determined by
10. The secondary structure depends on
11. Fibrous proteins, which form wool, hair, skin, beaks, nails and claws, have
12. Silk and other insect fibres are neither stretchable nor elastic because they have
13. α-helix and β-sheet structures are common in
14. Haemoglobin is the protein which carries
15. Myoglobulin is the protein which stores
16. As enzymes proteins serve as
17. Hormones serve
18. Antibodies protect us against

a. a regulatory role.
b. a variety of sizes.
c. amino acids.
d. amino acids linked by peptide bonds.
e. an α-helix structure which makes them rather stretchable and elastic.
f. β-pleated sheet structure.
g. catalysts in biological synthesis and degradation reaction.
h. disease.
i. four protein chains: two identical chains of 141 amino acids and two, again identical, of 146 amino acids.
j. globular proteins, like haemoglobin and myoglobin.
k. $O_2$ in muscles.

l. only about 20 amino acids.

m. only 51 amino acid units in two linked chains.

n. oxygen in the blood from the lungs to the tissues.

o. some other group in addition to the amino acid.

p. the sequence of amino acids.

q. two classes: simple and conjugated.

r. whether the protein chains are straight or folded up in a particular pattern.

### WHILE READING

Read the text and find words that match these definitions:

1. plants producing edible grains like wheat, corn, barley, oats, rye, etc. - __________ S
2. plants that have their seeds in pods - __________ E
3. plant on which parasites live - __________ T __________ T
4. framework of bones supporting the body - __________ N
5. intentional changes made to hereditary features by altering the structure or position of individual genes - __________ C __________ G
6. outward curve of the surface of something defining its shape - __________ R

### Proteins

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 $\alpha$-amino-acids which are joined together by the elimination of a molecule of water from the carboxyl group of one molecule and the amino group of the next, so that they contain peptide bonds, $–CO–NH–$. When only two amino-acids are joined in this way the compound is called a dipeptide. A tripeptide is made up from three amino-acid molecules, a tetrapeptide from four and so on.

The name protein is given to naturally occurring polypeptides containing more than about 40 amino-acid residues (the term ‘residue’ is used for an $\alpha$-amino acid which has lost the elements of water in forming a peptide bond). The number of potentially different proteins is virtually infinite: 20 $\alpha$-amino-acids are used in their formation, and they can, in theory, be linked in any possible permutations of sequences and total number. In practice, not all possibilities occur, but the total number is nevertheless enormous.

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. Some bacteria can use air as a source of nitrogen for amino-acid, and thence protein, synthesis: this ‘nitrogen fixation’ involves its reduction to ammonia and occurs at room temperature and pressure. Some
of these bacteria are found in nodules in the roots of plants belonging to the pea family (Leguminosae). The excess of fixed nitrogen is available to the host plant which, in return, supplies the nitrogen-fixing bacteria with other necessary nutrients. Other plants and bacteria need a supply of nitrate ions or ammonia from which they make the amino groups of their amino-acids. An interesting area of current research is to try to develop, possibly by genetic engineering, a variety of bacterium which would form root nodules in cereals and other commercially important crops and thereby reduce the need to supply these plants with nitrogen-containing compounds. In contrast to plants and bacteria, animals must obtain their \( \alpha \)-aminoacids from proteins in their diet. The proteins are first hydrolysed to their constituent amino-acids, in processes catalysed by the enzymes pepsin in the stomach, and chymotrypsin, trypsin and other enzymes 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 \( \alpha \)-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 \( \alpha \)-amino-acids; their residues must be present in the protein diet since they cannot be synthesised in the human body.

**Isolation and purification of proteins**

Most proteins occur in mixtures with other proteins of closely similar properties and their separation is therefore difficult. Some purification can usually be achieved by selective precipitation of the protein of interest by careful adjustment of either the pH or the concentration of added salts. Other methods are based on column chromatography. Crystallisation is normally only attempted if X-ray diffraction studies are to be carried out for, although many proteins have now been crystallised, it may take weeks, months or even years to find how to grow satisfactory crystals of a newly isolated protein.

Testing the purity of the protein is also difficult, since they do not have sharp melting-points but decompose on strong heating. Tests are therefore based on other physical differences between proteins. The most reliable method involves electrophoresis, in which the protein is placed as a band on a column of suitable solid support (for example, polyacrylamide gel) and a voltage is applied to the column. Different proteins move at different rates along the column and can be identified (after staining) as bands on the column. A pure protein produces a single band, and a further advantage of this method is that it can also be used to estimate, with reasonable precision, the relative molecular mass of the protein.
Structure of proteins
Each protein is defined by the number and nature of its constituent amino-acid residues and the sequence in which these are arranged. In its natural environment each protein folds up into a specific well-defined shape, known as its native structure, which is held together by a combination of different kinds of interaction between atoms and groups in the molecule. One of the most important of these interactions is the hydrogen bond which occurs between the N–H group of one residue and the C=O group of another. This can lead to the twisting of the protein chain into a helix. Several model helical structures can be built, but the one which occurs most frequently in proteins is the α-helix in which the amino group of one residue is bonded to the carbonyl group of the fourth residue along. Another important factor determining the shape of a protein is the inability of some groups on the protein to interact with water. This leads to a tendency for these non-polar groups to clump together in the centre of a protein from which water is excluded.

Covalent bonds (other than those defining the sequence of amino-acids) are not needed to make a protein fold up. However, in some folded proteins, it happens that two cysteine residues are brought close enough to each other for them to be linked by oxidation. Once these covalent bonds have been formed, they add greatly to the stability of the folded structure.

Folded proteins can be assigned to one of two groups, the fibrous proteins and the globular proteins, which can be distinguished by various physical properties. In fibrous proteins each molecule is folded to form a long, thin shape. These proteins are usually insoluble in water and form important structural features. An example is keratin (in hair and feathers) in which the basic structure is the α-helix; several helical molecules coil together rather like a rope and the elastic nature of these structures results from the ability of the protein chains to stretch out from their helices into extended chains. A more universal fibrous protein is collagen, the material which makes up tendons, ligaments and the sheets of connective tissue which separate the individual muscles of a joint of meat. In collagen, three molecules coil round each other to form a triple-stranded helix.

In globular proteins each molecule is folded into an approximately spherical shape, giving a compact structure; the 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. Some consist solely of protein and others of a protein joined to another molecule (a prosthetic group).

Enzymes are more specific than artificial catalysts, being able to catalyse only the making and breaking of one type of bond, and usually that bond must be located in one of a very limited range of compounds.

This specificity arises from the requirement that the molecules in which reaction is to occur (the substrates) must fit exactly into the contours of the enzyme surface to which it must be attached by non-covalent bonds (such as hydrogen bonds).

Since the forces that determine the shape of a protein are relatively weak (e.g. a hydrogen bond is far weaker than a covalent bond), the shape can readily be disrupted, and this is known as denaturation. It occurs, for example, when an aqueous solution of a protein is warmed, or when the pH is altered, and it is accompanied by changes in physical characteristics and the loss of biological activity. Denaturation can usually be reversed, and biological activity then returns, showing that a protein folds spontaneously into its native state. However, do not expect to be able to ‘unboil’ an egg. Although boiling the egg brings about denaturation, the high temperature also causes disulphide bonds to break and re-form in the wrong places, and these covalent changes cannot be easily reversed.

AFTER READING

CONTENT

Questions about the text.

1. Do animals and plants contain the same proportion of proteins?
2. Which parts of the body contain more protein?
3. What are proteins?
4. How many amino acids are proteins derived from?
5. Why do living organisms need to synthesise proteins?
6. Where are nitrogen-fixing bacteria found?
7. How do animals get their amino acids?
8. What enzymes are involved in protein hydrolysis?
9. How are proteins recombined from amino acids in the body?
10. What is meant by “essential amino acids”?
11. How can proteins be isolated and purified?
12. What are tests about protein purity based on?
13. How does electrophoresis work?
14. What are the characteristics of fibrous proteins?
15. Can you name some fibrous proteins and say where they are found?
16. What are enzymes and what is their task?
17. What is enzyme specificity due to?
18. What is meant by “protein denaturation”?
19. When does it occur?
20. Is it always reversible?
LANGUAGE

Vocabulary

a. Use the words in the box to complete the sentences.

<table>
<thead>
<tr>
<th>brittle</th>
<th>firm</th>
<th>floppy</th>
<th>fluffy</th>
<th>hard</th>
<th>limp</th>
<th>rigid</th>
<th>rock hard</th>
<th>smooth</th>
</tr>
</thead>
<tbody>
<tr>
<td>soft</td>
<td>solid</td>
<td>squishy</td>
<td>stiff</td>
<td>tender</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. The bread was ..................., I had to throw it away.
2. There is no substance as .................. as diamond.
3. The door of the safe room is made of ................. steel.
4. I suffer from backache so I must sleep on a ................. mattress.
5. My collar is so ........ I can hardly bend my neck.
6. The ................... pole around which the plant is growing upward is called “stake”.
7. The meat they served me was so .................. it felt like rubber.
8. Old women often have .................. bones because of osteoporosis.
9. The sofa was covered with .................. silk cushions.
10. A medium steak is usually more .................. than a well-done one.
11. The tomatoes were overripe and too .................. to slice them for the salad.
12. ................... white clouds are called “cumuli”.
14. The lettuce has gone .................., you can throw it away.
15. The puppy is gorgeous, he’s got sweet brown eyes and big .................. ears.

b. Which is the right word to be used in these sentences, host or guest?

1. I’m going to have some .................. for the weekend.
2. I had a very nice time as Lisa’s last night, she’s such a nice ................. .

BEFORE READING

Look these words up in your dictionary and take note of their different meanings then read the text and for each word decide which meaning best applies to the context: machinery, to build up, used up, worn away, to run low, provision, staple, supplementation.
Proteins as elements of nutrition

We need protein in our food because it constitutes the basic machinery of all life. Take away the water in our bodies, and most of what is left in our muscles, organs, blood cells, skin, nails, hair, even our teeth and bones, is protein. The enzymes that build up and break down other molecules, disease-fighting antibodies, oxygen-carrying haemoglobin, certain hormones like insulin: all these chemicals whose incessant activity keeps us going, are proteins. They are continually being used up or worn away, and protein from our diet is used to replace them, or, in growing children, to build them up. Like fats and carbohydrates, proteins can be burned for energy, but this happens only when supplies of these preferred fuels run low. Excess protein in an otherwise adequate diet will be converted to fat, but as one nutritionist has put it, this is analogous to buying fine furniture and then using it as firewood.

Complete and Incomplete Proteins

Twenty amino acids go to make up all human proteins, of these the adult needs a dietary supply of 8, the growing child 9 or 10. Our cells can synthesize the others, and from them the necessary proteins. Dietary protein is classified according to its provision of essential amino acids. Complete proteins include enough of them to allow normal bodily growth and function.

All animal foods – meats, eggs, milk products – are complete protein sources because all animals have the same basic biochemical machinery. Plants are organized in a very different way, however, and so plant proteins are generally incomplete.

All animal foods are the only fully adequate protein sources, then how do strict vegetarians survive? It turns out, fortunately, that plant proteins are often complementary: that is, the deficiencies of one food are counterbalanced by the strengths of another. Long before the world knew anything about amino acids, many cultures had adjusted their diets to take advantage of protein complementarity. Most kinds of beans are deficient in methionine, while grains usually lack lysine, and sometimes threonine and tryptophan.

In the Americas corn and black or pinto beans, and Asia rice and soybeans, have been staple combinations for a good thousand years. In Europe, peas and lentils were grown in association with wheat and barley in prehistoric times. Supplementation can also be achieved by including small amounts of animal protein in grain or legume dishes. Perhaps the most familiar instance of such a combination is macaroni and cheese.

From: Mc Gee, On Food and Cooking, Unwin Hyman.
AFTER READING

LANGUAGE

Vocabulary

a Use the words in the box to complete the table.

<table>
<thead>
<tr>
<th>beef</th>
<th>chicken</th>
<th>game</th>
<th>lamb</th>
<th>mutton</th>
<th>pork</th>
<th>poultry</th>
<th>veal</th>
<th>venison</th>
</tr>
</thead>
<tbody>
<tr>
<td>The meat from ...</td>
<td>is called ...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a cow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a young cow</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>an adult sheep</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a young sheep</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a pig</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a chicken</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>birds like chickens and turkeys</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a deer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wild animals or birds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b What is the opposite of:

white meat – black meat/coloured meat/red meat
fatty meat – lean meat/slim meat/thin meat
tender meat – hard meat/solid meat/tough meat
well-done (meat) – bleeding/bloody/rare

c Match the words in the box with the definitions.

<table>
<thead>
<tr>
<th>bacon</th>
<th>chop/cutlet</th>
<th>kebab</th>
<th>gammon</th>
<th>ham</th>
<th>hamburger</th>
<th>hot dog</th>
<th>joint</th>
</tr>
</thead>
</table>
| 1. thick slice of beef .................................................................
| 2. thick slice of pork or lamb ...........................................................
| 3. beefsteak including a rib ...............................................................;
| 4. large piece of beef that is usually cooked in the oven ........................
| 5. small pieces of meat and vegetables on a stick ......................................
| 6. minced meat formed into a flat round shape ...........................................
7. minced meat in the shape of a ball .................................................................
8. hot sausage in a bread roll ..............................................................................
9. meat from a pig’s leg salted and dried or smoked .........................................
10. mixture of minced meats and flavourings made into a long thin shape ....
11. salted or smoked meat from the back or sides of a pig ..............................
12. bacon from the hind leg or side of a pig ....................................................

Nucleic acids

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 (members of the pyrimidine group) and adenine and guanine (members of the purine group); and deoxyribonucleic acid (DNA), in which the carbohydrate is deoxyribose and the bases are the same as in RNA except that thymine replaces uracil. However, there is an enormous number of individual compounds in each of these two categories because of the variety of possible sequences for the four bases in each case.

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: for example, if the sequence of one strand is AGTCG then the sequence of the other will be TCAGC.

The double-helical structure of DNA fits it exactly for its role as a store of information, since each strand of the DNA carries enough information for the complementary strand to be synthesised on it. 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 which moves along the single strand of DNA, selecting the nucleotide with the appropriate complementary base and linking them together to form an new complementary chain.
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, in an exactly analogous way to the synthesis of a complementary strand of DNA. In RNA, uracil replaces the thymine of DNA.

The relative molecular mass of an RNA is much less than that of a DNA, so that only a comparatively short length of DNA molecule is needed to make an RNA molecule and each DNA carries enough information to make an RNA molecule, and each DNA carries enough information to make several different RNA molecules. 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 for this reason the piece of DNA from which a particular RNA is copied (transcribed) may be called a gene: 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.


**AFTER READING**

**CONTENT**

*Questions about the text.*

1. What do nucleic acids enable protein-synthesising cells to do?
2. What are nucleic acids?
3. What is a nucleotide made up of?
4. What does the polymer chain in a nucleic acid consist of?
5. What are the two types of nucleic acids?
6. How are they made?
7. Which of them has the higher relative molecular mass?
8. What are the two types of RNA molecules?
9. What is their different role in protein synthesis?
10. What is a gene?

**LANGUAGE**

*Vocabulary*

*Match the words in the box to make pairs of synonyms.*

<table>
<thead>
<tr>
<th>analogous</th>
<th>arrangement</th>
<th>complementary</th>
<th>form</th>
<th>helix</th>
<th>interdependent</th>
</tr>
</thead>
<tbody>
<tr>
<td>interwined</td>
<td>sequence</td>
<td>similar</td>
<td>spiral</td>
<td>strand</td>
<td>template</td>
</tr>
<tr>
<td>twisted</td>
<td>thread</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
BEFORE READING

CLASS DISCUSSION

a The pros and cons of sugars in the diet.

Tick (✓) the advantages and cross (✗) the disadvantages of sugars as food substances. Add any more you can think of.

Sugars

- are soluble in water
- provide energy
- are fattening
- taste sweet
- cause tooth decay
- ...

b Which carbohydrates are broken down by the enzymes listed in the table?

<table>
<thead>
<tr>
<th>Place</th>
<th>Enzyme</th>
<th>Carbohydrate</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>mouth and duodenum</td>
<td>amylase</td>
<td></td>
<td>maltose</td>
</tr>
<tr>
<td>small intestine</td>
<td>maltase</td>
<td></td>
<td>glucose</td>
</tr>
<tr>
<td></td>
<td>lactase</td>
<td></td>
<td>glucose + galactose</td>
</tr>
<tr>
<td></td>
<td>sucrase</td>
<td></td>
<td>glucose + fructose</td>
</tr>
</tbody>
</table>

Look these words up in your dictionary and take note of their different meanings then read the text and for each word decide which meaning best applies to the context: misleading, occurring, foodstuff, jet, lustrous, supple, slit.

Carbohydrates

Carbohydrates are so called because of the historical observation that they have the empirical formula \( C_n(H_2O)_y \) — that is, they correspond to “hydrates of carbon”. However, the name gives a misleading impression of their true molecular structure, and furthermore several compounds (such as deoxyribose found in nucleic acids) have been discovered which do not have this general formula but which it is convenient to classify as carbohydrates.

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 grain and sucrose in sugar-beet or sugar-cane) or convert it into structural material (for example, cellulose).

Animals can synthesise carbohydrate from excess of amino-acids in their diet, but most obtain their carbohydrate by eating plant material directly or indirectly. Vertebrate animals use carbohydrate primarily as an oxidisable fuel (to provide the energy for life) and the form in which they store it for this purpose is glycogen. In many invertebrates, chitin, which is closely related to cellulose, forms a structural material.

The monometric units of carbohydrates are called monosaccharides; most of the naturally occurring ones have the formula \( C_5H_{10}O_5 \) (the pentoses) or \( C_6H_{12}O_6 \) (the hexoses). When two monosaccharides are condensed together by elimination of a molecule of water, a disaccharide
is formed; naturally occurring disaccharides are made up from two hexoses and therefore have a formula \( \text{C}_{12}\text{H}_{22}\text{O}_{11} \). 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 together to give compounds of formula \( \text{(C}_6\text{H}_{10}\text{O}_5)_n \), where \( n \) can range from about 200 to several thousand (naturally occurring polysaccharides based on pentoses are unknown). Polysaccharides may be extremely insoluble in water (such as cellulose) or rather soluble (such as glycogen). In summary, carbohydrates can be classified in the following way:

- Monosaccharides
- Disaccharides
- Polysaccharides

**Monosaccharides**

The most commonly occurring group of monosaccharides is the hexoses, with general formula \( \text{C}_6\text{H}_{12}\text{O}_6 \), and of these the most important 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. Oxidation 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 gives added flexibility since it can provide a supply of energy during particularly intense muscular activity when oxygen cannot be obtained rapidly enough.

**Disaccharides**

Disaccharides have the molecular formula \( \text{C}_{12}\text{H}_{22}\text{O}_{11} \), and consist of two monosaccharide molecules, \( \text{C}_6\text{H}_{12}\text{O}_6 \), joined together with the loss of a molecule of water. Three disaccharides occur naturally; these are maltose, lactose and sucrose. They all have similar physical properties, being white crystalline solids which are soluble in water.

**Polysaccharides**

Polysaccharides are polymers, made up of monosaccharide units, which occur in both animals and plants. They are hydrolysed by mineral acid to monosaccharides. The two most widely occurring polysaccharides are starch and cellulose. Starch occurs in wheat, barley, rice, potatoes and all green plants. It 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. It consists of a three-dimensional network of chains of glucose units and some complex glucose derivatives. Cotton is almost pure cellulose, but cellulose is usually manufactured from wood, which is a mixture of cellulose and a material known as lignin. In this process, wood shavings are heated...
with calcium hydrogensulphite to dissolve the lignin and the cellulose is removed by filtration. It can be purified by dissolving it in a solution of ammonia containing a copper (II) salt and then adding mineral acid to precipitate the pure cellulose.

Rayon is the name given to cover all fibres manufactured from cellulose. Cellulose ethanoate, celanese silk, is made by ethanoylating cellulose with ethanoic anhydride. Cellulose ethanoate does not burn readily, and is used to make films, lacquers and varnishes.

Viscose rayon is manufactured by treating cellulose with sodium hydroxide and carbon disulphide. The viscose solution is forced through fine jets into a bath of dilute sulphuric acid, giving a fine thread of viscose rayon. The thread is spun and made into fabrics which are lustrous and supple, and can be easily dyed. Although rayon is cheaper than natural silk, it is not as strong or durable.

Cellophane is manufactured by forcing the viscose solution through slits into the acid.

If cellulose is treated with dilute nitric acid, cellulose mononitrate and dinitrate are formed; the mixture is known as pyroxylin. A solution of pyroxylin in ethanol, ether or propanone is known as collodion, and is used as an adhesive. If pyroxylin is heated with ethanol and camphor, celluloid is formed.


**AFTER READING**

**CONTENT**

1. Where does the name “carbohydrate” come from?
2. Where do we get the carbohydrates we need from?
3. What do plants synthesise carbohydrates from?
4. Where can starch be found?
5. What is sucrose derived from?
6. How do animals get the carbohydrate they need?
7. What do vertebrate animals use carbohydrates for?
8. What are monosaccharides?
9. When is a disaccharide formed?
10. What are sugars like?
11. When are polysaccharides formed?
12. What are the physical properties of glucose?
13. How is energy obtained from glucose?
14. What are the naturally occurring disaccharides?
15. What is the nutritive value of starch?
16. What is cellulose usually manufactured from?
Carbohydrates are formed in plants by the process of photosynthesis from carbon dioxide, water, and energy from the sun.

Carbohydrates are placed in one of the three classes, depending on their molecular size. Glucose (like glucose and fructose) are the simplest monomeric units of carbohydrates and are the building blocks of disaccharides (e.g. sucrose), which contain two monosaccharide units, and of polysaccharides (e.g. cellulose, starch, and glycogen), which are polymers of monosaccharides.

Cellulose is the most abundant organic compound on earth but unfortunately it cannot be used for food by human beings because we lack the enzyme necessary to digest it. Since we cannot digest cellulose we must rely partly on starch as a source of glucose. Our saliva and pancreatic juices contain amylase, the enzyme necessary to break down starch into glucose which is then absorbed into the bloodstream and carried off for eventual oxidation.

**LANGUAGE**

**Vocabulary**

*Which of the words in the boxes match the synonyms/definitions?*

1. idea - ...............................................
2. substance consisting of more elements - ...............................................
3. thing or place from which something is obtained - ...............................................
4. material that produces energy - ...............................................
5. white tasteless carbohydrate food substance - ...............................................
6. aim - .............................................

**commercial** **convenient** **empirical** **general** **historical** **human** **later** **main** **misleading** **naturally-occurring** **several** **structural**
1. giving a wrong idea – ...............................................
2. many – ...............................................
3. most important – ...............................................
4. subsequent – ...............................................
5. happening or existing in nature – ...............................................
6. suitable – ...............................................

1. keep for future use – ...............................................
2. supply – ...............................................
3. connect, combine – ...............................................
4. vary – ...............................................
5. arrange – ...............................................
6. get – ...............................................

**BEFORE READING**

**CLASS DISCUSSION**

Naturally occurring fibres like wool, cotton and silk are gradually being replaced by synthetic fibres. Which of them do you prefer? Use these suggestions to compare the two kinds of fibres.

- cheap
- hard-wearing
- healthy
- soft
- elasticity
- strength
- good moisture absorbing properties
- good wearing characteristics
- good washing characteristics

Look these words up in your dictionary and take note of their different meanings then read the text and for each word decide which meaning best applies to the context: drawback, tacky, brittle, cross-linking, wild, enterprising, to smuggle, to cut off, to bring on, hunt, to duplicate, hose, woven, cord, fish line
Elastomers: rubber
It is almost certain that some of your clothing and many of the objects around you are synthetic, all products of chemistry. In spite of their familiarity, this has been a recent development. Synthetic resins such as Bakelite, fibers such as rayon and plastics such as celluloid were made early in this century. However, a plethora of synthetic polymers has been available since World War II. We now use more plastic than steel, aluminum and copper combined.
As we usually think of it, rubber is not a synthetic polymer: it is a natural substance. Nonetheless, it is useful to describe it briefly here because it is the best example of an elastomer and because attempts to duplicate its properties have heavily influenced the polymer industry. Natural rubber is a polymer of 2-methyl-1,3-butadiene (isoprene) and is obtained from the tree Hevea brasiliensis.
Rubber was first introduced into Europe in 1740, but it remained a curiosity until 1823 when Charles Mackintosh invented a method of waterproofing cotton cloth with a solution of rubber. The mackintosh, as rain coats are even now sometimes called, became extremely popular, despite some major drawbacks: natural rubber is notably weak and it is thermoplastic, soft and tacky when warm but brittle at lower temperatures. The American inventor Charles Goodyear found a way around these difficulties with the vulcanization process.
Crosslinking makes the rubber harder, stronger and less thermoplastic.
With Goodyear’s invention, rubber became more useful, and the demand increased. Unfortunately, the only sources of rubber in the 19th century were wild trees in the jungles of Brazil and the Congo. This problem was solved by an enterprising Englishman who smuggled seeds for rubber trees out of Brazil and planted them in large plantations in Sri Lanka and Malaysia. By 1939, almost 1,400,000 tons of rubber were consumed world-wide per year. World War II intervened, however, and cut off supplies of natural rubber to Europe and the United States. This brought on the hunt for synthetic rubber.
The obvious way to synthesize rubber is to duplicate nature. This is easier said than done, since only recently have catalysts been discovered that will do what a rubber tree does: polymerize isoprene so that all of the substituent groups are cis.
As alternatives to duplicating natural rubber, many different elastomers have been developed, all of which involve butadiene or some derivative of this alkene. For example, 2-chloro-1,3-butadiene (commonly called chloroprene) polymerizes to form neoprene rubber. The high chlorine content of neoprene gives the polymer resistance to heat and flames, as well as to oil and chemicals. It is thus used for hoses carrying gasoline, for protective gloves, and for balloons.

**Fibers**

More than 9 billion pounds of fibrous polymers, some purely synthetic and others based on cellulose, are produced per year in the United States. Some of these are semisynthetic (partly synthetic) and others are purely synthetic fibers. The chief semisynthetic fibers are rayon and cellulose acetate, and there are three main groups of synthetic fibers: polyamides (nylon), polyesters (Dacron), and acrylics (Orlon).

**SEMISYNTHETIC FIBERS**

Semisynthetic fibers are made by modifying cellulose in some way. Cellulose is a linear polymer of glucose molecules. If this polymer is heated in sodium hydroxide with carbon disulfide, the result is a so-called “viscose” solution. If this solution is then forced through very small holes, continuous filaments are formed. When the filaments drop into a sulfuric acid bath, cellulose is regenerated from the viscose, and the fibers are then woven into cloth that we know as rayon.

Cellulose acetate, used in “wash and wear” fabrics, is made by converting some of the —OH substituents of cellulose into ester groups by reaction with acetic acid.

**SYNTHETIC FIBERS**

Nylon was the first fiber to result from a deliberate search for a purely synthetic material, and it was greatly in demand from the beginning. As women’s dresses became shorter about 70 years ago, silk stockings were very fashionable but also very expensive. Late in the 1930s Wallace H. Carothers of Du Pont discovered nylon-66, and it was soon found that nylon fibers could be woven into sheer hosiery. The first such stockings went on sale in October 1939, and they were so popular they had to be rationed. Unfortunately, World War II caused the commercial use of nylon to cease until 1945.

Nylons are polyamides, condensation polymers formed from a diacid and a diamine. About half of the nylon produced is used to make cords for tires. The remainder goes into ropes, cords, rigs, fish nets and lines, clothes, thread, nylon hose, coats, dresses and on and on. Polyesters are also condensation polymers used as fibers and are produced in even greater amounts than nylon. The most common one is sold in the United States is **Dacron**, a polymer formed from a dialcohol and an aromatic diacid.

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**AFTER READING**

**CONTENT**

**Questions about the text.**

1. What is rubber?
2. What are the drawbacks of natural rubber?
3. Who found a way to overcome these problems?
4. What are the effects of vulcanisation?
5. How is neoprene rubber manufactured?
6. What makes it so resistant?
7. How are semi-synthetic fibres made?
8. How is cellulose acetate made?
9. What are nylons?
10. Where is nylon used?
11. What are polyesters?
LANGUAGE

Vocabulary

a) Match words and definitions.

1. balloon
2. demand
3. drawback
4. hosiery
5. hose
6. plethora

- disadvantage
- flexible tube
- knitted underwear
- over-abundance
- requirement
- rubber bag filled with air

b) Use cloth, clothe, clothes, clothing to complete the sentences.

1. Can you please lay the table? The table .......... is in the top drawer.
2. Don’t trust him, He’s a wolf in sheep’s ..........
3. He can barely feed and .......... his family.
4. The dish ........ is under the sink.
5. She always buys a lot of expensive .......... .
6. The police found several items of man’s .......... in the room.
7. We wanted to buy a bigger house but we had to cut our coat according to our .......... .

c) The first of the two sentences in the couples below includes a “false friend”, write its true meaning next to each sentence. Then choose, from the words in the box, the proper one to fill the blank in the second sentence in each couple.

<table>
<thead>
<tr>
<th>compare</th>
<th>container</th>
<th>depraved</th>
<th>disappointment</th>
<th>factory</th>
<th>familiarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>filthy</td>
<td>healthy</td>
<td>if possible</td>
<td>instalments</td>
<td>kidnapped</td>
<td>liking</td>
</tr>
<tr>
<td>need</td>
<td>noise</td>
<td>odd</td>
<td>polite</td>
<td>present</td>
<td>moody</td>
</tr>
<tr>
<td>sensitive</td>
<td>soft</td>
<td>topic</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. a What were his actual words? ..........
   b Who’s the .......... head of the state in the country?
2. a I’m very angry, I’ve just had an argument with the boss. ..........
   b What’s the .......... you would like to talk about?
3. a You are too shy, you should have more confidence in yourself. ..........
   b You should not address your teacher with such .......... !
4. a A policeman often has to confront danger. ..........
   b If you .......... the two poems you will see that the style is quite similar.
5. a I’ve almost forgotten many of the dreams and delusions of my youth. ...........
b To our great .......... it rained on the day of the picnic.
6. a He’s a highly educated man, he’s a Ph.D. in History. ...........
b You have awful manners, try to be more ..........!
7. a In the XX century man has made an extravagant use of natural resources. ...........
b She wears rather .......... clothes.
8. a This silk fabric comes from China. ...........
b The new ..........manufactures leather gloves.
9. a The man is a complete lunatic, you can’t make any sense of his words ..........
b I admit I’m .......... but that’s because I’m meteoropathic.
10. a The paper reported the lurid details of the murder. ...........
b The beggar was dressed in .......... clothes.
11. a She has developed a morbid interest in witchcraft and black magic. ...........
b This wool is so .......... it feels like cashmere.
12. a Did it ever occur to you that you could try to study harder? ...........
b Do you .......... anything else?
13. a He’s possibly the greatest writer of the century. ...........
b Try to get here early, .......... 
14. a She was raped in an underground station. ...........
b Baby Lindbergh was .......... and killed.
15. a There are special reduced rates for children and students. ...........
b I’ve bought a new car and I’m paying for it by monthly .......... 
16. a The postman delivered the parcel to the recipient. ...........
b Keep the .......... tightly closed.
17. a There has been a lot of rumour and gossip in the newspapers about her love-story. ...........
b In the middle of the night I heard a .......... coming from downstairs and got up immediately.
18. a She can’t be kept in the psychiatric ward, she’s perfectly sane! .......... 
b A well-balanced diet is very important for staying .......... 
19. a He gave me a very sensible suggestion. ...........
b This substance is very light .......... 
20. a I feel great sympathy for their sorrow. ...........
b We’ve always had a strong mutual .......... 
21. a The defender gave the forward a vicious kick. .......... 
b She left her husband who had turned out to be a .......... man.